

INNOVATION IN TRANSPORT BEHAVIOUR AND TECHNOLOGY

**Annex I Expert Group on the United Nations Framework Convention on Climate Change
Working Paper No. 13**

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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FOREWORD

This Working Paper is one of a series of eighteen studies carried out under the project: "Policies and Measures for Possible Common Action". The project was carried out by the OECD, together with the International Energy Agency, in 1996 and 1997 for the Annex I Expert Group on the United Nations Framework Convention on Climate Change (UNFCCC). The goal of the project was to assess a range of cost-effective greenhouse gas mitigation policies and measures for countries and Parties listed in Annex I to the UNFCCC. The eighteen working papers have been made widely available as analytical input to negotiations under the UNFCCC Ad hoc Group on the Berlin Mandate. The working papers may also provide input to national decision making processes on greenhouse gas mitigation policies. The measures analysed do not necessarily represent policy preferences of Annex I Parties.

The project benefited greatly from substantial input from delegates. Three successive chairmen of the Annex I Expert Group provided outstanding leadership for the project: Doug Russell (Canada); Ross Glasgow (Canada); and Ian Pickard (United Kingdom). The work was supervised by Jan Corfee Morlot (OECD). Fiona Mullins (OECD) drafted the initial framework which was used to structure the eighteen working papers.

The Annex I Parties or countries referred to in this document refer to those listed in Annex I to the UNFCCC: Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Czechoslovakia (now Czech Republic and Slovakia), Denmark, the European Community, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom and United States. Where this document refers to "countries" or "governments" it is also intended to include "regional economic organisations," if appropriate.

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EXECUTIVE SUMMARY

Context

The transport sector is responsible for 25 per cent of global CO₂ emissions from fossil fuel use, and this share is growing. Of all energy-using activities, transport is the area where governments find it hardest to find politically feasible policies that can mitigate greenhouse gas emissions. Projections for Annex I countries indicate that, without new CO₂ mitigation measures, road transport CO₂ emissions might grow from 2 500 million tonnes in 1990 to 3 500 to 5 100 million tonnes in 2020. Annex I countries already have in place a wide range of measures that affect vehicle energy use and CO₂ emissions. National and local governments are also working hard to develop strategies to address the environmental and social problems associated with urban transport, and these strategies can contribute to mitigating CO₂ from vehicles. Many countries have announced new initiatives to reduce vehicle CO₂ emissions since 1990.

The study, “CO₂ Emissions from Road Vehicles”¹, which is working paper 1 in this series of studies, provides an in-depth analysis of several types of measure:

1. Measures whose primary objective is to reduce the energy intensity of cars and “light trucks”²:
 - “feebates”, where purchasers of the most efficient vehicles receive a tax rebate while purchasers of less efficient vehicles pay a tax;
 - “corporate average fuel economy standards” (CAFE);
 - voluntary agreements between governments and car manufacturers to achieve fuel efficiency improvements.
2. Taxes on fuels purchased for use in road vehicles. Three options are considered:
 - “vehicle tax reform”, where existing charges on cars and light trucks are reduced, and fuel taxes are increased to keep total tax revenue constant;
 - “full budgetary cost pricing”, where fuel taxes are modified to improve the extent to which car and truck drivers pay the full costs to the public budget of their driving;
 - “externality adders”, where fuel taxes are modified to include externality adders, so that the full social costs of driving are reflected to car and truck drivers.

¹ Working Paper 1 in the Tranche 1 series of studies. The Tranche 1 studies are available on the internet at www.oecd.org/env/online.htm, or from the OECD Secretariat.

² “Light trucks” are mentioned here, but the coverage might include a variety of vehicle types, including “vans” or “minibuses”, “sports utility vehicles” and four-wheel drive vehicles.

These measures were found to offer substantial greenhouse gas mitigation opportunities in the road transport sector, if implemented at levels that might be justified on economic efficiency grounds.

Description of Measures and their Policy Objectives

This study complements the Working Paper No. 1 analysis by considering an additional range of measures that can encourage innovation in transport behaviour, institutions and technology to achieve:

- a) large reductions in traffic relative to projected levels,
- b) large reductions in the energy intensity of vehicles;
- c) a switch to fuels with a very low fossil carbon content; or
- d) a shift to transport modes with lower greenhouse gas emissions.

Measures addressed in the previous study can help to provide the market context and the direction for innovation. Some measures discussed in Working Paper No. 1, such as “full cost pricing” to internalise externalities, might be encouraged as aspects of innovation in local government policy. This study emphasises innovation strategies rather than individual measures. The study uses a framework for considering government policies which applies to all types of innovation, in behaviour, institutions and technology. The first step in an innovation strategy is for government to establish a “vision” or set of goals for sustainable development including climate change mitigation. The elements of an innovation strategy are summarised below in Box 1.

Approach

The study considers: the potential impact of transport sector innovation on CO₂ emissions; the possible economic effects of innovation; the other environmental and social policy issues associated with policies to encourage innovation in transport; issues that need to be considered by central governments aiming to encourage innovation; the potential advantages and disadvantages of common action to encourage innovation; and the possible approaches that Annex I countries might take to implement a transport innovation strategy³.

This study is based on a review of recent literature, including a large amount of material submitted by reviewers, in several areas including: innovation processes and policies; local transport policies and their effects; and alternative fuel and alternative technology vehicles. Some of the specific measures are summarised in Table 1 below. A large number of examples are used, mostly based on published literature, to illustrate and develop the policy messages in the study and in particular to identify implementation approaches that are likely to succeed. The examples cover technologies, local government policies and strategies, and national government policies and strategies. They include instructive failures as well as success stories.

³ These are the elements identified for consideration in the Framework for Analysis of the Common Actions project.

Box 1. Possible Elements in an Innovation Strategy

1. Encouraging the development and discovery of new ideas, technology, concepts and behaviours. Part of central government's role may be to absorb the local financial risks of technological and other research and development which, in aggregate, is likely to result in long-term benefits. Relevant measures might include: monitoring range and level of ongoing research and development. Funding and incentives for basic science, as well as greenhouse gas-related research and development, partnership programmes for collaborative research; social sciences research into travel behaviour etc.; research into methods for assessing technology, transport system changes etc.
2. Facilitating the exchange of ideas among firms, communities, local governments, departments of national government, etc. New ideas and discoveries often occur in places where they cannot be used. The chance of an idea leading to a successful innovation is greatly increased by a continual exchange of information. Relevant measures might include: information, partnership programmes (firms, universities, government research etc.) to encourage exchange of ideas and research results; ensuring patent laws provide incentives for creativity and application of good ideas.
3. Supporting experimentation with new ideas, possibly selecting for those that could contribute to greenhouse gas mitigation and other policy objectives. Again, government can play a role by increasing the potential benefits of success. Those carrying out the experiment bear the political risk associated with possible failure — but local actors are likely to be less sensitive to this risk than central governments. Meanwhile, central government encourages a broad portfolio of experiments which, as a whole, minimises this political risk.. Relevant measures might include: Monitoring and support for demonstration projects, community experimentation etc.; financial incentives, technology prizes or other rewards for successful projects, provision of methodological and other support.
4. Facilitating replication of successful innovations. Innovations often occur in special situations where they are particularly appropriate, but after some replication and development to “move up the learning curve” and achieve economies of scale, they may be more broadly applicable. Relevant measures might include: limited term financial support; information and best practice programmes to encourage replication of successful projects; modification of national legislation where necessary to permit use of new approaches (e.g. road pricing).
5. Providing a market framework that encourages greenhouse gas mitigation along with other policy objectives. This includes the measures considered in the Working Paper No. 1 study to internalise externalities, provide targets for energy efficiency improvement, etc. Co-ordination of different policy areas to develop compatible strategies for addressing multiple goals is also an important step. This may mean, for example, that policy on land-use takes account of implications for transport and the environment. Specific measures might include: monitoring, consultation with firms and local government to understand needs and capabilities; applying market instruments — fiscal and regulatory incentives, information, education, etc., emphasising objectives of sustainability; market regulation to minimise barriers to entry and encourage competition.

Table 1. Examples of Policies and Measures

Local Govt and Business and Community Strategies	National Government Strategies
<p>Modelling studies</p> <p>UK: Impact of transport policies in several cities: cordon charges, parking fees, reduced public transport fares, reduced parking space, fuel price increases.</p> <p>Netherlands: Impact of transport policies in the Randstad: parking fees and constraints, fuel price increase, road pricing, cordon charges, reduced road-building, improved public transport, park and ride facilities, high-occupancy vehicle lanes, traffic management.</p> <p>US: LUTRAQ approach in Portland, Oregon: land use changes, parking fees, improved public transport, improved pedestrian and cyclist access.</p> <p>Implementation studies</p> <p>UK: “All Change” in Central Region, Scotland: community consultation process to develop a new transport plan.</p> <p>Norway: Trondheim toll ring: a cordon charge for entering the city, varying according to the time of day.</p> <p>Sweden: Greening freight transport: freight companies responding to customers’ demands for cleaner freight services.</p> <p>Singapore: Area Licensing Scheme: cordon charges, a range of fiscal measures, a vehicle quota system, settlement planning, and other measures.</p> <p>Global Action Plan: a non-governmental organisation promoting the “Ecoteam” approach; where neighbours, colleagues, etc., work in small groups to meet environmental goals.</p>	<p>Strategies to encourage local government policy innovation</p> <p>US: Intermodal Surface Transportation Efficiency Act: Requires metropolitan planning organisations to alter their planning processes to improve co-ordination among authorities, develop procedures for community involvement, and address environmental objectives.</p> <p>US: Travel Model Improvement Program: Aiming to develop a new generation of transport models.</p> <p>EU: The Citizen’s Network: A wide range of mostly information-based measures to help improve provision for environmentally friendly forms of transport.</p> <p>Norway: TP10: A government scheme for ten cities, aiming to make environmental goals a premise of transport planning, to co-ordinate land-use and transport policies, increase the use of public transport and reduce car use.</p> <p>Strategies to encourage technological innovation</p> <p>US: Clean cities: a government-sponsored network of cities promoting alternative fuel and alternative technology vehicle use. PNGV (partnership for a new generation of vehicles): a collaborative research and development programme between government, industry and independent research organisations.</p> <p>British Columbia, Canada: demonstration of fuel cell buses.</p> <p>EU: the DRIVE programme, developing information technology for use in transport.; and the COST programme, supporting studies on propulsion systems, alternative fuels, alternative forms of public transport.</p> <p>Brazil: government strategy to encourage the use of ethanol from sugar cane as a gasoline substitute.</p>

note: many of the initiatives listed in this table were not designed for greenhouse gas mitigation

Greenhouse Gas Reduction Potential, Costs and Timing

Greenhouse gas effects

The nature of innovation is such that it is not possible to forecast its effects on greenhouse gas emissions or on the economy. An innovation strategy aims to increase both the economic and the technical potential for greenhouse gas mitigation. It also aims to encourage attainment of the economic potential. The potential for behavioural changes is particularly uncertain. Several case studies of local government transport policies and of policy evaluation exercises indicate that greenhouse gas emission reductions in the range of 10-20 per cent are achievable with strategies currently considered reasonable. However, this probably understates the potential for greenhouse gas mitigation if Annex I country governments were to co-operate to build up a consensus on the need for innovation to achieve deeper reductions. The technical potential for reductions in vehicle energy intensity by 2020 is in the region of 20-50 per cent, while switching to alternative fuels could reduce greenhouse gas emissions per unit of energy by 80 per cent or more. The economic potential is much smaller: only 10-40 per cent emission reductions are achievable

through energy efficiency improvements and fuel switching without increasing the overall cost of transport.

While the greenhouse gas mitigation potential is considerable, many of the technological and behavioural options considered in the study have disadvantages. Alternative technologies may be more expensive or have poorer performance than current technology, and they may increase some environmental problems. Alternative behaviour patterns may not meet current lifestyle expectations. Some of the local transport strategies considered may reduce individuals' freedom to drive, or may benefit one group to the disadvantage of another group. By providing a framework for innovation as described in Box 1, governments encourage local actors to find ways around these disadvantages.

Economic and other policy effects

Innovation is increasingly seen as a key factor in economic success. Policies to encourage innovation are, in general, likely to reduce the economic and social costs of meeting greenhouse gas emission constraints. Governments can reduce the risk of future economic and social disruption due to climate change by ensuring that innovators are aware of the magnitude of that risk, and by encouraging innovations that reduce it. Most of the policies and measures considered in this study as part of an innovation framework have the potential to contribute to a wide variety of policy objectives. Within the transport sector, these might include reducing air pollution, accidents and traffic congestion. The strategies discussed may also be able to contribute to a wide range of policies, including those aiming at social objectives, urban regeneration, and regional industrial development. Co-ordination among government ministries is an important element in providing clear signals about the direction for sustainable development. Co-operation between policy-makers may lead to more cost-effective approaches to achieve the full range of government policy objectives.

Timing

New ideas, discoveries and behaviour patterns can spread in a few months or take many decades to achieve widespread acceptance and use. Innovation policies implemented before 2000 might take at least 10 years, and perhaps much longer, to achieve noticeable effects.

Implementation Issues

Relationships between local, regional and national government agencies, and between planning and environmental agencies are important for policy implementation to change travel behaviour. Involving communities in local transport policy can be hard work, but may be the key to introducing environmentally sustainable strategies. The preferences of communities can change once they fully understand the alternatives available to them.

With regard to vehicle technology innovations, the study identifies a number of key barriers that national programmes need to overcome:

- cost and risk barriers to market entry for vehicle manufacturers, such as the costs of retooling production lines, the investment required to achieve economies of scale in vehicle production, and the risk attached to that investment;

- absence or inadequacy of refuelling networks has been mentioned as one of the main disadvantages of alternative fuels for consumers;
- concern about safety can be an important barrier — fears about the toxicity of methanol or the explosiveness of hydrogen may prevent their use for private vehicles;
- lack of standards and norms for alternative fuel vehicle (AFV) equipment make the market more uncertain and expensive for component manufacturers;
- the position on the learning curve for manufacturers, technicians and consumers is far more advanced for gasoline than for other vehicles. This means that manufacturers are able to optimise gasoline vehicles for consumer needs much more effectively than alternative fuel vehicles.

Conclusions

Policies and measures addressed in this study could be considered for common action alongside the measures considered in the Working Paper No. 1 study. Each of the five elements of the framework for innovation described in Box 1 might form part of a common action, which could contribute to cost-effective greenhouse gas mitigation in various ways:

- by sharing the costs and benefits, and hence the risks of research, development and demonstration programmes;
- by allowing cross-fertilisation of ideas and approaches to occur among countries, improving the chances of finding successful and cost-effective solutions;
- by enlarging the potential market for any new technology, allowing economies of scale to be achieved more easily;
- by giving clearer market signals to manufacturers and fuel suppliers operating in an international market.

Many of these advantages of common action are likely to be greatest for states in the same region, especially those sharing a common border.

Common action may also face a variety of barriers and may have disadvantages. Some types of common action — for example, those that involve sharing information on industry practices or research results — may be opposed by national industries on the grounds that their competitiveness would be compromised by sharing proprietary information. Premature convergence on a technical standard can prevent competition that would otherwise have led to the emergence of a better technology. Additional costs could also arise if incentives were made too rigid, and could not be adapted to national circumstances, in which case, inappropriate solutions might be forced on some countries.

Replication of successful measures

Many initiatives already exist to help replicate successful initiatives internationally. These include outreach by individual countries and co-operative efforts among groups of countries (such as IEA

Implementing Agreements, European Conference of Ministers of Transport and the European Union). The IEA/OECD Climate Technology Initiative (CTI) is one such initiative. A common action might build on existing approaches to create an international network of firms, local governments and communities interested in innovation. The network might share information on research findings, technologies, demonstration projects, and the implementation of technologies and practices. It could also provide access to technical support and guidelines. One approach would be to make more systematic use of the national communication process under the UNFCCC to share information on innovations in technology, behaviour and institutions. National communication guidelines could be extended to include recommendations to this effect.

Agreement to take action in the transport sector toward an aim or target

Common actions in this area might take the form of agreements to achieve some target, such as reversing the upward trend in greenhouse gas emissions from urban transport or achieving a certain level of greenhouse gas mitigation through alternative fuel and vehicle introduction. Alternatively, the agreement might be to aim for a principle, such as “fair and efficient pricing in urban transport” or “full community consultation in local transport planning”. Advantages of such a common action would include the creation of common aims in local transport policy or vehicle manufacturers’ innovative efforts, extending beyond national borders. International agreement on aims and targets would give added contextual stability, which can contribute to a “climate for innovation”. A transport sector greenhouse gas mitigation target could be negotiated through the UNFCCC, building on initiatives such as ECMT Ministers’ declaration aiming to reduce vehicle CO₂ emissions.

Co-ordination to implement the same or similar measures

Measures that might benefit from co-ordination include the experimentation with road pricing, intermodal freight technologies or intelligent vehicle and highway systems, where there would be advantages in the long-run from the adoption of standardised technology. Co-operation in the form of information exchange, joint funding of demonstration programmes, and collaboration on research and development, would allow countries to learn from each other’s experiments and move towards consensus on the best technology for later standardisation. Governments might also co-operate in the development of information networks, research and development and training schemes. Agreements to co-operate on research and development could include co-funding for major research programmes, collaboration among researchers from universities, firms and government agencies in different countries. International co-ordination in these areas could add value and reduce the costs of national programmes. Governments could also co-ordinate the incentives they provide for new technology to ensure that manufacturers are receiving the same signals from several markets. The levels of incentives would not need to be harmonised to provide a clear signal.

Specific policies and measures implemented together

The main areas where harmonisation might be appropriate are those relating to vehicle technology, because vehicles can move among countries. Important areas for harmonisation include safety and technical standards for alternative fuel vehicle components, refuelling technologies, and fuel specifications. Common standards would also permit manufacturers to produce technologies for niche markets such as urban bus fleets, airport and marine port fleets in a number of countries. It may also be important that road pricing, intelligent vehicle and highway systems, intermodal technologies, etc., are

“inter-operable” — i.e. that vehicles designed for one system can operate within another. In addition to allowing inter-operability, harmonised standards might lead to reduced costs by reducing the need for one-of-a-kind systems and facilitating competition between companies from different countries.

Much of the impetus for the development of alternative fuels and vehicles derives from concern about employment, the survival of specific industries, local environmental issues and energy security. As the relative importance of these issues varies widely among countries, harmonised policies beyond the more easily agreed basic technology specifications are unlikely to be cost-effective or politically feasible, and different types of incentives may be appropriate for different countries. Meanwhile, standardisation of the approach to technology development might result in a loss in diversity of new approaches, which is an essential ingredient for innovation.

POLICIES AND MEASURES TO ENCOURAGE INNOVATION IN TRANSPORT BEHAVIOUR AND TECHNOLOGY

Local Transport Initiatives / Transport and Urban Infrastructure / Alternative fuels and Vehicles

Context: The Role of Innovation in Transport Sector Greenhouse Gas Mitigation

The transport sector is responsible globally for about 25 per cent of global CO₂ emissions from fossil fuel use, and this share is growing. Of all energy-using activities, transport is generally the area where governments find it hardest to find politically feasible policies that can mitigate greenhouse gas emissions. Projections for Annex I countries indicate that, without new CO₂ mitigation measures, road transport CO₂ emissions might grow from 2 500 million tonnes in 1990 to 3 500 - 5 100 million tonnes in 2020 (WEC, 1995; Michaelis, 1996). This compares with world road transport CO₂ emissions growing from about 3 500 million tonnes in 1990 to 4 200 - 7 900 million tonnes in 2020 (IPCC, 1996).

Annex I countries already have in place a wide range of measures that affect vehicle energy use and CO₂ emissions. National and local governments are also working hard to develop strategies to address the environmental and social problems associated with urban transport, and these strategies can contribute to mitigating CO₂ from vehicles. Many countries have announced new initiatives to reduce vehicle CO₂ emissions since 1990.

The Working Paper #1 study: “CO₂ Emissions from Road Vehicles” (Michaelis, 1996)⁴, provided an in-depth analysis of several types of measure. These measures were found to offer substantial greenhouse gas mitigation opportunities in the road transport sector, if implemented at levels that might be justified on economic efficiency grounds — that is, at levels that might bring social welfare gains, given the current stated and revealed “preferences”⁵ of citizens, and given currently available or anticipated technology. In the Working Paper No. 1 analysis, the measures fall into two groups:

The first group of measures has a primary objective of reducing the energy intensity of cars and “light trucks”⁶:

⁴ Working Paper 1 in the Tranche 1 series of studies. The Tranche 1 studies are available on the internet at www.oecd.org/env/online.htm, or from the OECD Secretariat.

⁵ In this report the word “behaviour” is mostly used rather than “preferences”. Behaviour is often used in economics as an indicator of “preferences”, but in practice preferences cannot be observed except subjectively.

⁶ “Light trucks” are mentioned here, but the coverage might include a variety of vehicle types, including “vans” or “minibuses”, “sports utility vehicles” and four-wheel drive vehicles.

- “feebates”, where purchasers of the most efficient vehicles receive a tax rebate while purchasers of less efficient vehicles pay a tax;
- “corporate average fuel economy standards” (CAFE);
- voluntary agreements between governments and car manufacturers to achieve fuel efficiency improvements.

The Working Paper No. 1 study found that the potential for energy efficiency improvements in new vehicles that would be cost-effective for users probably lies in the range 5-20 per cent in North America and 10-25 per cent in Europe. The assessment of the “cost-effective” energy savings level for any standard, feebate or similar measure is likely to vary among countries, and this type of measure may only be relevant for some groups of countries within the Annex I group.

The second group of measures includes various options for reforming or increasing the taxes on fuels purchased for use in road vehicles. Three options were considered:

- “vehicle tax reform”, where existing charges on cars and light trucks are reduced, and fuel taxes are increased to keep total tax revenue constant;
- “full budgetary cost pricing”, where fuel taxes are modified to improve the extent to which car and truck drivers pay the full costs to the public budget of their driving;
- “externality adders”, where fuel taxes are modified to include externality adders, so that the full social costs of driving are reflected to car and truck drivers.

The study found that “tax reform” from 2000 might reduce light duty vehicle greenhouse gas emissions in 2010 by around 10 per cent or more in several OECD countries. “Full budgetary cost pricing” from 2000 could reduce emissions from light duty vehicles in 2010 by about 5 per cent and emissions from heavy duty vehicles by over 10 per cent in some countries, but in others, no increase in fuel taxes would be justified on budgetary grounds alone. “Externality adders”, introduced in 2000, based on externality estimates in France, Japan and the United States, would reduce emissions from all vehicle types in 2010 by 15 per cent or more

This study complements and extends the analysis in Working Paper No. 1, by considering strategies aiming to achieve greenhouse gas mitigation through:

- a) large reductions in traffic (vehicle-kilometres) relative to projected levels;
- b) large reductions in the energy intensity of vehicles;
- c) a switch to fuels with a very low fossil carbon content; or
- d) a shift to transport modes with lower greenhouse gas emissions.

Conventional engineering and economic analysis tends to predict that these options are likely to be costly in reduced social surplus or welfare. This is based on the assumption that consumers’ current behaviour patterns (“revealed preferences”) are unlikely to change: they will continue to wish to buy larger, higher performance cars and to spend a fairly stable share of their growing income on travelling in those cars.

The OECD held two expert workshops and a policy meeting on travel behaviour during 1996/97, aiming to develop a better understanding of influences on travel behaviour and in particular the role of government in developing transport patterns⁷. A number of key conclusions emerged:

- Travel behaviour depends on habit and circumstances: the link to personal values is complex and unpredictable. Changes in travel behaviour can occur without individuals feeling that any sacrifice has been made.
- Local expertise, initiative and experimentation is important. Central governments are unlikely to be able to develop strategies that can fully address local circumstances. Firms and local governments may be able to accomplish substantial innovations in technology, institutions and behaviour that national policies cannot.
- Central governments can play a role by creating a policy framework that provides encouragement and direction for innovation by local governments, communities, and the private sector. Goal-setting and providing concrete scenarios of a sustainable future are important government contributions and can represent the first step. Better integration of policy objectives would also send clearer signals. This might require the development of co-ordinated strategies among environment, transport and industry and other ministries.
- A wide range of policy instruments are needed to develop an effective framework supporting all stages of the process of innovation and providing a coherent set of signals to citizens. They are likely to include fiscal and regulatory measures, information, education, best practice programmes and awards, as well as supports for research, development and demonstration.

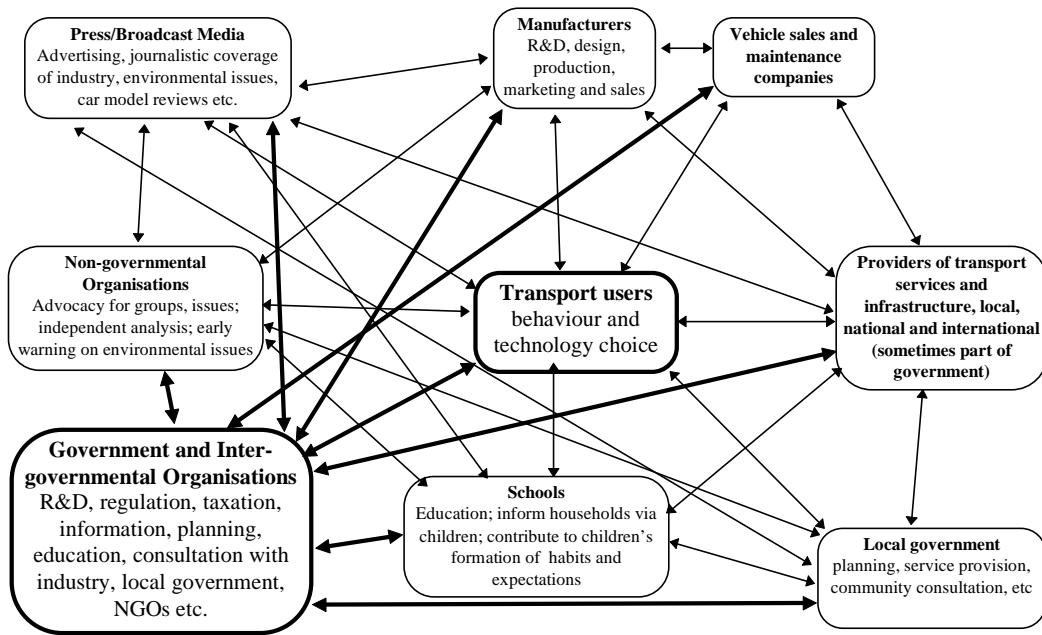
Measures addressed in the Working Paper No. 1 study can help to provide the market context and the direction for innovation. For example, some measures discussed in Working Paper No. 1, such as “full cost pricing” to internalise externalities, might be encouraged as aspects of innovation in local government policy. Meanwhile, national policies including environmental taxes, technology standards and targets can form part of the context for innovation.

Governments aiming to promote innovative changes need to work within a complex web of interactions among institutions that influence transport sector behaviour and technology (see Figure 1). Policies may be needed that can improve relationships between these various institutions, and also within them, to develop stronger consensus on societal aims, including greenhouse gas mitigation, which can guide innovation.

While the study focuses on the role of central government in developing strategies, most of the individual measures discussed require the involvement of the wide variety of actors concerned with the transport sector, including industry and local government.

⁷ The workshop reports are available as OECD “General Distribution” documents: OCDE/GD(96)199 and OCDE/GD(97)1.

Figure 1. Government in the Web of Transport Sector Relationships



Source: Based on Lutzenheiser and Shove, 1996

Measures Considered, Policy Objectives, and Approach to Analysis

The focus of this report is on the role of national and international governmental actions to encourage innovation in technologies and local measures that might allow large reductions in transport greenhouse gas to be achieved in an economically efficient way. Other policy objectives that might be addressed by the same initiatives could include those of: improving energy security; reducing the negative environmental and social impacts of transport, such as congestion, accidents, noise and air pollution; as well as improving the ability of the transport system to meet the needs of its users.

The report is divided into two main parts, addressing:

1. the development of local initiatives in urban and transport infrastructure and transport management, including transport pricing; and
2. the development and use of alternative fuels and vehicle technology including electric and very energy-efficient vehicles.

Table 0 identifies a number of the local initiatives and technologies examined, and also the government strategies being used to encourage them, but does not attempt to offer a complete list.

Table 2. Examples of Policies and Measures

Local Govt and Business and Community Strategies	National Government Strategies
<p>Modelling studies</p> <p>UK: Impact of transport policies in several cities: cordon charges, parking fees, reduced public transport fares, reduced parking space, fuel price increases.</p> <p>Netherlands: Impact of transport policies in the Randstad: parking fees and constraints, fuel price increase, road pricing, cordon charges, reduced road-building, improved public transport, park and ride facilities, high-occupancy vehicle lanes, traffic management.</p> <p>US: LUTRAQ approach in Portland, Oregon: land use changes, parking fees, improved public transport, improved pedestrian and cyclist access.</p> <p>Implementation studies</p> <p>UK: “All Change” in Central Region, Scotland: community consultation process to develop a new transport plan.</p> <p>Norway: Trondheim toll ring: a cordon charge for entering the city, varying according to the time of day.</p> <p>Sweden: Greening freight transport: freight companies responding to customers’ demands for cleaner freight services.</p> <p>Singapore: Area Licensing Scheme: cordon charges, a range of fiscal measures, a vehicle quota system, settlement planning, and other measures.</p> <p>Global Action Plan: a non-governmental organisation promoting the “Ecoteam” approach; where neighbours, colleagues, etc., work in small groups to meet environmental goals.</p>	<p>Strategies to encourage local government policy innovation</p> <p>US: Intermodal Surface Transportation Efficiency Act: Requires metropolitan planning organisations to alter their planning processes to improve co-ordination among authorities, develop procedures for community involvement, and address environmental objectives.</p> <p>US: Travel Model Improvement Program: Aiming to develop a new generation of transport models.</p> <p>EU: The Citizen’s Network: A wide range of mostly information-based measures to help improve provision for environmentally friendly forms of transport.</p> <p>Norway: TP10: A government scheme for ten cities, aiming to make environmental goals a premise of transport planning, to co-ordinate land-use and transport policies, increase the use of public transport and reduce car use.</p> <p>Strategies to encourage technological innovation</p> <p>US: Clean cities: a government-sponsored network of cities promoting alternative fuel and alternative technology vehicle use. PNGV (partnership for a new generation of vehicles): a collaborative research and development programme between government, industry and independent research organisations.</p> <p>British Columbia, Canada: demonstration of fuel cell buses.</p> <p>EU: the DRIVE programme, developing information technology for use in transport.; and the COST programme, supporting studies on propulsion systems, alternative fuels, alternative forms of public transport.</p> <p>Brazil: government strategy to encourage the use of ethanol from sugar cane as a gasoline substitute.</p>

note: many of the initiatives listed in this table were not designed for greenhouse gas mitigation

In many cases, there are overlaps between transport management initiatives and technological innovations. For example, local transport policy-makers can encourage the use of alternative fuel and

electric vehicles through exemption from parking and access restrictions for low-emission vehicles. Conversely, information technology developments may be required before certain types of road-pricing can be introduced.

Common action has a major potential role to play in innovation: to share risk; to achieve a cross-fertilisation of new approaches; and to achieve economies of scale in research and development and information provision. This paper addresses common actions by central governments at four levels:

1. replication of successful measures: this type of common action might involve establishing networks, best practice programmes and common assessment approaches to encourage replication of successful local government policies, or to encourage the spread of successful technological innovations.
2. agreement to take action in the transport sector toward an aim or target: these might include targets for mitigation of greenhouse gas emissions through urban transport measures; or through the introduction of alternative fuels and vehicles; or for the achievement of specific milestones in switching to alternative transport modes or alternative technologies.
3. co-ordination to implement the same or similar measures: this might apply to the co-ordination of experimental approaches in both transport management and technology.
4. specific policies and measures implemented together; harmonisation might be relevant for technology standards, in areas such as transport information technology or alternative fuel vehicles.

Section 3 of this report addresses measures to encourage and guide local transport initiatives, based on case studies summarised in Appendix A. The case studies relate to specific instances where the greenhouse gas, economic and other effects of individual measures or packages of measures have been estimated, where local transport initiatives have been implemented, or where central governments have introduced policies to encourage local initiatives. Section 3 draws on these case studies to provide indications of the range of greenhouse gas emission reductions that might be achieved through implementation of individual measures and packages of measures that might be introduced at a local level. The report briefly reviews what is known about economic effects, which is relatively scant, and case study findings on the factors that facilitate successful implementation of local initiatives to change transport systems in ways that benefit the environment. **Section 4**, on alternative fuel and vehicle technology, draws on the literature on the technical and economic potential for greenhouse gas mitigation through energy efficiency increases and alternative energy use in vehicles.

Section 5 then considers the role of central government in encouraging and guiding such local initiatives and the potential advantages and disadvantages of international action in this area. It also draws on experiences in past and ongoing national and international programmes for innovation in the transport sector (summarised in Appendices A and B). Finally, it attempts to identify areas where the costs of these programmes might be reduced or their effectiveness enhanced through additional international co-operation.

Measures to Encourage and Guide Local Transport Initiatives

The Working Paper No. 1 study (Michaelis, 1996) reviewed the possible effects of reflecting transport sector external costs through fuel taxes which might be imposed by central governments. While

greenhouse gas emissions and some other externalities might be directly related to fuel consumption, this is not the case for many transport sector externalities, such as the effects of traffic congestion and accidents, as well as many types of pollution. Communities have always played a strong role in innovation to address transport externalities, partly because it is at the local level that most of these transport externalities have their effect. Experimentation with new approaches is often easier for local government than for national government, which might face considerable political barriers and highly motivated lobby groups that are less focused at a local level. Local government is more likely to be responsive to community groups and local industry.

Thus, Wallace (1995) describes how Japan became the first country to require the use of three-way catalytic converters because of initiatives by metropolitan authorities concerned about local air pollution. Similarly one of the most advanced initiatives in urban road pricing within the Annex I group of countries, the toll ring in Trondheim, Norway, is the result of an initiative of the city council, drawing on technology from a local company (see Appendix A for a full discussion).

This section evaluates local measures that can reduce or internalise externalities, and estimates their potential effects on greenhouse gas emissions. Its main focus, however, is on measures that national governments can take to facilitate local governments and communities that wish to address their own concerns and priorities in the transport sector, through user fees or other innovations in local transport policy.

Effects of local measures on transport demand and greenhouse gas

Many of the measures considered in this section are applied to urban areas, or to the central business districts of cities. They may have large effects on traffic and greenhouse gas emissions in the areas where they are applied, but less effect on aggregate transport sector emissions. Local measures are likely to be more effective if accompanied by regional and national measures, because traffic controls in city centres may tend to shift traffic and greenhouse gas emissions elsewhere. Where possible, the effects of local measures are discussed here on both a local and a national basis.

Role of local authorities in transport pricing

The introduction of this study emphasised the local nature of many transport sector externalities. In economic terms, the most efficient way to address these externalities is through the price mechanism, either by establishing markets (e.g. through private or franchise provision of town-centre parking spaces) or by applying user fees to reflect the externalities. Extensive reviews of transport sector externalities and policies to internalise them have been published by ECMT/OECD (1994) and more recently by the European Commission in its Green Paper “Towards fair and efficient pricing in transport” (EC, 1996b). Studies reviewed in Working Paper No. 1 indicate that policies to address externalities other than climate change could achieve substantial reductions in CO₂ emissions. A United States study (DRI, 1996) found that congestion charges on commuting could reduce national light duty vehicle CO₂ emissions by 12 per cent. A French study (Orfeuill, 1995) found a 12 per cent reduction in CO₂ emissions from road transport overall, resulting from policies to address several externalities.

Local authorities may be able to impose charges of various types on road users. The most common are charges for parking and tolls for using infrastructure where there are few access points, such as bridges, tunnels and motorways. Technical developments make it increasingly feasible for local authorities to consider road pricing where charges are linked to the distance travelled on congested roads, or cordon

charges on entering or leaving a particular zone. Cordon charges, the most feasible form of road pricing, have so far been applied in only a very few cities, notably Bergen, Oslo and Trondheim in Norway, as well as in Singapore (see Appendix A, Sections 3.2, 3.4). Road pricing based on distance travelled (i.e. implying continuous or frequent electronic monitoring and payment) has not been attempted except on an experimental basis.

Studies reviewed in Appendix A Section 1 indicate that doubling parking prices in various United Kingdom towns could reduce CO₂ emissions from urban traffic by 1.6-3.7 per cent, while similar measures in urban centres of the Randstad region in the Netherlands could result in a 1 per cent reduction in national road traffic CO₂ emissions. Cordon charges have also been studied for several cities, indicating that a charge of 5 Gld for Randstad cities could reduce national road traffic CO₂ emissions by 1.8 per cent. Studies in the United Kingdom find that a similar magnitude charge of £2 could reduce urban traffic by 4.3-5.9 per cent, depending on the city.

Road pricing has been strongly advocated by transport economists for many years now, including policy analysts at the World Bank and in many OECD Member countries. Road pricing schemes have been considered and abandoned, or at least postponed, in numerous cities, including Cambridge, United Kingdom; Bonn/Cologne, Germany; and Hong Kong. These cases illustrate the potential barriers to road pricing which include:

- national laws that prevent local governments from charging for road use;
- differences in policy objectives between different parts of government (e.g. road authorities may see road pricing as a means of raising road-building funds, while city councils see it as a means of regulating traffic);
- the technical difficulties and expense involved in installing a reliable and efficient system;
- public opposition to the charges;
- opposition to accounting systems that keep track of vehicle movements.

The introduction of full cost pricing through user fees is likely to depend on a number of innovations to overcome these and other barriers at the local level. The innovations might include developments in:

- Institutions: It may be necessary to develop new approaches to negotiation and discussion between local, regional and national government agencies; it may also be necessary to find new ways to increase public involvement in decision-making;
- Technology: While road pricing technologies have been demonstrated, the only technologies that are in commercial use are automatic toll-collection systems. Continuous charging, charging related to vehicle emissions, and charging related to the actual congestion level have been tested on an experimental basis but not implemented.
- Individual/Community Behaviour: Individuals play an important part in new local policies, through their voting behaviour, responses to consultation, and direct responses to the measures. The success of measures may depend on individuals' accepting that the public policy goals being addressed are sufficiently important to warrant the charges. Success may

also depend on the extent to which changes occur as a result of collective decisions by communities in which individuals are fully engaged.

National approaches to encouraging such developments are considered in Section 5.

Role of Infrastructure: urban and transport infrastructure

Urban layout both affects, and is affected by, the predominant transport systems. It is also strongly influenced by other factors, such as people's preference for living in low-density areas, close to parks or other green spaces, away from industry and close to schools and other services; and preferences for access to public transport or road networks.

Early cities were based on pedestrian and animal-drawn traffic, and are very dense, with numerous narrow alleyways and stepped streets. In cities where an urban rail or metro system is the predominant transport mode, homes, services and companies tend to become concentrated in the city centre and along corridors around the suburban lines. Growing motorisation and especially car ownership has led to a decline in populations in the centres of many cities, especially in industrialised countries, with increasing suburban sprawl as car-owners' mobility gives them more flexibility in their choice of home location.

Urban structure also affects people's choice of transport mode and the viability of public transport systems. In highly dispersed settlements, travel on any one route may not be sufficient for bus or train services to be profitable, and non-motorised modes may be too slow to cover the distance between homes, jobs and services. Changing approaches to settlement planning and regulation have been proposed as means of reducing car use and encouraging public transport and non-motorised travel.

The link between settlement patterns and energy use for transport can be explored in several ways:

1. **National Survey Information.** In the United Kingdom, Londoners use more energy for transport than people in smaller cities, but people living in rural areas use about 50 per cent more energy than Londoners, partly because they travel further and partly because they are more reliant on cars. In the United States, people living in rural areas use about a third more energy than people living in city centres, and there is an inverse correlation between state population density and transport energy use (DOE, 1996).
2. **International Comparison of National or City Surveys** A survey of cities around the world (Newman and Kenworthy, 1989) found that population density was strongly and inversely correlated with transport energy use. Energy use rises dramatically when density falls below 29 people/ha. Newman and Kenworthy argue for cities with strong centres and highly concentrated suburbs which can be served by high quality public transport.
3. **Detailed Settlement Studies.** Banister (1992) notes a number of studies that find a much weaker role for urban density than the Newman and Kenworthy study. Detailed analysis of travel patterns in specific settlements reveals more complexity, with transport energy use influenced by the size of the settlements, proximity to other settlements, location of workplaces provision of local facilities and car ownership. One study of the determinants of travel behaviour in Portland, Oregon, is of particular interest (PBQD, 1993). This study shows how the amount of travel and choice of mode are influenced by a number of inter-linked factors (see Appendix A Section 1.3).

While there does appear to be a correlation between urban density and transport energy use, this does not necessarily mean that high urban density causes low transport energy use. Nevertheless, Armstrong (1993) using Newman and Kenworthy's data on a time-series basis finds good evidence for a causative link (Newman and Kenworthy's study was based on a cross-sectional analysis). Meanwhile, the trend towards lower urban density may result from people purchasing homes in locations with lower land prices where they have an improved quality of life: attempts to reverse this trend may be very difficult to implement and, indeed, undesirable.

It is easier for local governments to determine the layout of the transport system itself than to modify urban density. They can also influence the way existing buildings are used. Local authorities are increasingly trying to design roads to discourage through traffic in residential and shopping areas, and to develop mixed activity patterns so that homes, services and jobs are close to one another. The conclusion many researchers are reaching (e.g. Birk and Zegras, 1993; Buxton, 1996; May, 1995; Michaelis *et al.*, 1996) is that more attention is needed to the range of planning decisions that shape a city to ensure that transport implications are taken into account.

Changes in planning practices may be important in mature towns and cities, as well as in those under rapid development. Central governments may have limited authority to influence local planning, although they can provide information and support, operate best practice programmes, or provide local government funding for particular measures. European countries, such as Norway (Ministry of the Environment) and the United Kingdom (DoE/DoT, 1994), have recently produced new guidelines for local transport planning that increase the emphasis on mixed development and provision for non-motorised and public transport modes. Meanwhile, adjustments in planning regulations can lead to changes in the use of existing buildings, leading to more diversity within zones. There may be greater potential for changes in land-use planning for green-field developments in countries with rapid population growth, such as the United States and Australia, and in those with economies in transition.

There are few robust efforts to estimate the greenhouse gas impacts over time of changes in land-use policies. One such is the "LUTRAQ" assessment in Portland, Oregon. This very detailed modelling exercise indicates that changes in planning could achieve a 5 per cent reduction in regional greenhouse gas emissions in 2010, relative to a business-as-usual baseline.

Role of local authorities in transport planning and regulation

While changes in land use are relatively slow, taking place over decades rather than years, changes in the transport system itself can be much more rapid. Transport system capacity can be rapidly changed by implementing new control systems for traffic lights, by changes in traffic priority, and by establishing corridors for non-motorised and public transport.

Local authorities commonly impose restrictions on parking, road and lane access. Several transport modelling studies which evaluate the effects of such measures are reviewed in Appendix A. These studies indicate that halving the parking space in various cities might reduce city-centre traffic by about 2-5 per cent, with slightly larger reductions in CO₂ emissions from city traffic. It is likely to be important to join parking and access restrictions for cars with improved access by public transport, including park-and-ride services. It may also be necessary to introduce pricing and other measures that discourage driving outside city centres. Otherwise, services and the associated car traffic may be displaced to out-of-town centres.

Improving public transport priority through the establishment of high-occupancy (HOV), bus and cycle lanes, and priority at signals, can have the dual effect of reducing road capacity for cars and making public and non-motorised transport more attractive. HOV lanes (limited to multiple occupancy cars) are

estimated by Replogle (1993) to be able to reduce traffic in Washington, DC by 0.7 per cent overall. In the Netherlands installing HOV lanes on highways is estimated by NOVEM (1992) to achieve about 3 per cent reduction in national road transport greenhouse gas emissions (see Appendix A Section 1.2).

Role of local government in transport services provision

The works of Banister (1992), Armstrong (1993), PBQD (1996), MVA (1995) and others show that improved public transport can play an important role in reducing car traffic and greenhouse gas emissions. Public transport use can be increased through increases in service's geographical coverage and frequency, but also by providing better information about services, reducing fares, and improving the quality of the service. Flexible services, such as shared taxis and "dial-a-ride" minibuses, can play a role and are an essential part of the approach considered for Portland, Oregon.

Public transport improvements and fare reductions could reduce local greenhouse gas emissions relative to business-as-usual levels (see Appendix A Sections 1 and 2). The reductions range from about 0.4 per cent from increased service provision in the Randstad region of the Netherlands, through 1-2 per cent from halving fares in several British towns, to 5 per cent from service improvements in the London area. Effects are, of course, dependent on the definition of the measures concerned as well as local circumstances, so these results are not transferable to other situations. Meanwhile, if service improvements and fare reductions were achieved with the help of government subsidies, greenhouse gas emission reductions would not necessarily justify the cost.

Improvements in public transport have rarely proved an effective means of stemming the rise in private transport use unless combined with measures to limit car travel, such as access and parking constraints or fees. Experience in Hannover, Zurich, and other cities indicates that such combined approaches can be successful (Brög, 1993; Ott, 1993). Lessons learned in these cities may have particular relevance for cities in Central and Eastern Europe (Suchorzewski, 1993).

Integrated Strategies

The most effective policy packages in reducing greenhouse gas emissions appear to be those that combine charges for road use with public transport improvements: this combination of measures is found to be more cost-effective in reducing emissions than either type of measure alone. Appendix A, Section 2.1 summarises a number of studies which model the effects of transport system measures, and packages of measures. In particular, NOVEM (1992), MVA (1995) and CSI & PBQD (1996) explore the effects of a variety of policy packages in extended metropolitan areas — the Randstad region of the Netherlands, the London area and the metropolitan area of Portland, Oregon respectively. In the case of the London study, some traffic reductions, and hence CO₂ emission reductions, are found to be achieved outside the area in which road-use charges are applied. The London study by MVA explores how the economic benefits of policies vary with the level and type of charges, and finds charge levels (for example, about £6 for a cordon charge for entering central London) that maximise the benefits. These three studies find that CO₂ emission reductions in the region of 10-20 per cent would be possible in the regions subject to the charges that are part of the policy packages.

There are few regions where integrated transport strategies have been implemented and where reliable monitoring has been carried out to estimate the effects of the strategies on energy use and CO₂ emissions. One well-known case is that of Singapore, where a wide range of measures has been introduced to reduce car ownership, traffic and energy use. These measures, summarised in Appendix A Section 3.4, are

estimated by Ang (1992, 1993) to have reduced gasoline use in the city by about 40 per cent. This implies that overall road transport CO₂ emissions have been reduced by about 30 per cent. While Singapore is a case of actual policy implementation, the CO₂ emission reduction can still only be estimated based on assumptions and modelling to estimate “without-measures” emissions.

Another approach to estimating the effects of local strategies is to make direct comparisons between similar regions with different policies. Some such comparisons are available (e.g. see box below) although the need remains for more monitoring and analysis to estimate the relationship between policies and outcomes.

Hannover and Essen

In 1976, travel patterns in Hannover and Essen were very similar. However, in Hannover, efforts have been made for years to slow the increase of car use and promote the use of public transport and cycling. Essen has not adopted such policies. The results can be seen below. Hannover appears to have succeeded in its aims of promoting public transport and cycling, and in slowing the growth of car use. Car use has still grown, but not as much as in Essen. (Brög, 1993)

Table 3. Travel Patterns in Hannover and Essen

Trip Shares: (per cent)	Hannover		Essen	
	1976	1990	1976	1990
Walk	36	23	39	27
Cycle	9	16	3	5
Motorcycle	1	0	1	0
Car Driver	26	30	27	42
Car Passenger	12	9	13	11
Public Transport	16	22	17	15
Trips per day	2.9	2.8	2.7	2.7
Distance per day (km)	16	19	16	18

Economic and other policy effects of local measures

Congestion charges are often advocated as an economically efficient means of allocating road space to users, and raising funds for roads. MVA (1995) evaluates the effects of congestion charges on both London residents and the urban economy (employment and commercial activity). The study finds that low income households relying on public transport would benefit more than other London residents. For many of the charge schemes considered, high-income households with high car use might suffer net disbenefits. The economy of central London would not be affected much by increased car travel costs because most of the commercial activity is in the form of services, and most commuters travel to work by public transport. On the other hand, more commuters to businesses in the larger “inner London” region travel by car. Meanwhile, with a higher share of light industry and retail businesses, commercial activity in this region is more dependent on road transport. Businesses will incur costs associated with congestion charges, but also benefits from improved transport speed and reliability. The net effect of congestion charges in this region on business costs depends heavily on the design of the scheme and the use of the revenues. MVA also notes that congestion charges might affect residential and employment patterns slightly, leading to a greater concentration of both jobs and households in central London.

While it is not possible to generalise about the economic effects of the local measures considered in this study, local initiatives could help in achieving the full range of policy objectives associated with transport.

These objectives might include reducing pollution, noise, accidents and traffic congestion, improving the quality of transport services, and stimulating economic activities in new areas. Transport planners are accustomed to balancing up the costs of new investment with the effects of congestion and accidents. These congestion and accident effects are often integrated into transport investment cost-benefit models as shadow costs. The effects of pollution, noise and climate change are much harder to model, as are the broader economic impacts of changed transport patterns.

It is not possible to draw general conclusions on the economic costs and benefits of individual local transport measures and strategies. However, in the long run, welfare benefits are likely when central governments introduce policies that: facilitate innovation by local governments and communities; provide incentive structures that reflect externalities such as climate change; and encourage discussion of local externalities; and encourage action to be taken where communities consider it to be justified.

Implementation issues

Implementation processes need careful consideration to achieve the greenhouse gas emission reductions mentioned above. Many of the measures that can substantially reduce urban transport greenhouse gas are likely to result in a reduction in car use. This can be consistent with the priorities of local communities, who find the growth in traffic and congestion detracts from their quality of life. However, some of the solutions discussed above, such as cordon pricing and reduced parking provision, can be controversial. Reductions in road expenditure to shift emphasis to provision of public and non-motorised transport facilities meet opposition from a number of powerful stakeholders in the transport planning process. This makes it particularly difficult for central governments to impose such changes in emphasis.

While central governments may find it hard to impose change on local communities, they may be able to help catalyse change. Recent initiatives in several countries aim to do this, including Norway and the United States (See Appendix A, Section 5). These countries have issued new transport planning requirements for local authorities that require them to take account of environmental priorities and to undertake a process of community consultation.

Local issues in implementation of innovative approaches

For Norway, the case of Trondheim shows how a local authority with a particular set of concerns, and with the expertise to address their concerns, was able to undertake a significant innovation in local transport policy, in the form of a high-technology toll ring. Conversely, the case of TP-10, the Norwegian national government initiative to get local communities involved in the planning process, and introduce environmental objectives into the process, shows how innovative approaches can fail if institutional and other barriers are not adequately addressed, and if motivation arising from local concerns is not adequately tapped. The case of the “All Change!” programme in Central Region, Scotland, shows how an intensive process of consensus-building might allow local governments to change direction.

A number of lessons can be learned from these case studies:

Relationships between local, regional and national government agencies, and between planning and environmental agencies, are important. Local governments and communities are more likely to pursue pricing to address local externalities if the proceeds from pricing will then be available to address local spending priorities. In Trondheim, Norway, there was broad agreement among agencies that road traffic forecasts represented a problem, although some agencies would have preferred increased road building while others preferred demand management along with investment in public transport and other

environmentally-oriented spending. The toll ring was expected to meet the wishes of both of these groups.

The preferences of local communities can change once they fully understand the alternatives available to them. In Trondheim, the majority of the community did not support the toll ring before it was implemented, but 75 per cent supported it once they had had experience with it. In Central Region, Scotland, initial surveys indicated that the community favoured fairly conventional transport solutions. After an intensive process of consultation to ensure that local people had a full understanding of the implications of different solutions, it was established that a radical shift away from road building towards public transport support was preferred.

Involving communities in decision-making processes can be hard work, but may be worth it in the end. The Central Region initiative involved three successive stages of community outreach, comprising workshops, staffed information desks in shopping centres, and postal questionnaires. Initial results were disappointing, but once understanding of what was being done grew, the community involvement was very rewarding. Independent, professional help was also important in gaining community support. Central Region succeeded by bringing in outside consultants to develop transport scenarios and work with the community to develop a consensus transport plan.

The availability of local expertise and information is important. TP-10 failed to introduce a change in local transport policy in Norwegian cities, partly because the environmental and community groups with an interest in change were ill-equipped to participate in the planning process. Trondheim succeeded with local expertise and locally available technology.

Role of individuals and communities

The success of innovations ultimately depends on the response of individuals and communities to them — and, indeed, all innovations start with an individual action or good idea. Much of the strength of an approach to transport policy that encourages local initiatives is that it provides a means for local communities and individuals to participate more directly in the planning process.

Communities' involvement in the planning process has typically been through representation by special interest groups — consumer and environmental organisations. However, initiatives such as “All Change!” in Central Region, Scotland bring the planning process much closer to individuals. Another initiative that may have succeeded in bringing about innovation at the individual level is the Global Action Plan (GAP) discussed in Appendix A, Section 4.

Measures to Encourage and Guide Innovation in Fuel and Vehicle Technology

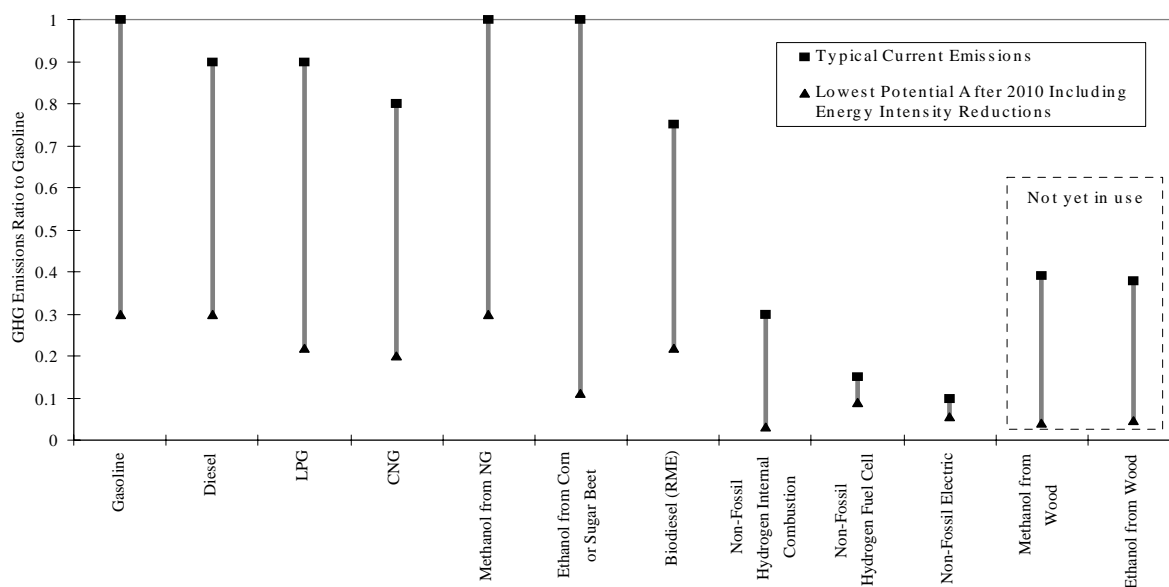
Businesses are responsible for the majority of technological innovations, but governments also play a role. Appendix B briefly summarises two areas of vehicle and powertrain technology where manufacturers are currently involved in developing and commercialising innovations: the gasoline direct injection (GDI) engine (being developed by Toyota and Mitsubishi of Japan) and the fuel cell (being developed by Ballard Power Systems of Canada). The GDI engine, claimed to offer 30-35 per cent fuel savings, would probably have been developed regardless of government interventions. Indeed, its commercialisation in some countries may take some time because it is hard for a GDI engine to comply with existing government NO_x emission standards. Conversely, the fuel cell, with a potential for over 50 per cent fuel savings, would not have reached its current state of development without government support for research,

development and demonstration. It is not yet possible to predict which, if any, of these two technologies will be responsible for most greenhouse gas mitigation in the future.

Given the risks and uncertainties inherent in technological development, some governments prefer to leave the process to market forces. Others have put substantial investment and ongoing subsidies into specific technologies, often because they were faced with a short-term need to reduce dependence on imported fuel (Appendix B mentions programmes that have supported the use of ethanol and CNG, for example). Given the long-term nature of the risk of climate change and the mitigation strategies needed, and the unpredictability of technical change, this report considers ways in which governments can support and provide a long-term direction for technological innovation by businesses.

Figure 2 illustrates typical current full-fuel cycle greenhouse-gas emissions from a range of alternative fuel vehicle types in comparison with gasoline. It also illustrates possible emission levels for future technology operating on each energy source *including potential reductions arising from energy efficiency improvements*. As the figure shows, the greatest mitigation is obtained through energy efficiency improvements combined with fuels such as alcohols or hydrogen derived from wood or non-fossil electricity

Figure 2. Scope for Innovation to Reduce GHG: Illustrative Figures Only



Note: this figure is illustrative: “typical” emissions from currently available technology and potential for improvement are based on the author’s judgement, drawing on a wide range of sources: see Michaelis *et al.*, 1996, for further details.

The major alternative fuels fall in roughly three categories:

1. Fossil fuel-derived alternatives that offer no greenhouse gas mitigation. These include reformulated gasoline; methanol (and other synthetic fuels) from natural gas; and various synthetic fuels from coal which are not shown, but which have roughly double the full-fuel-cycle greenhouse gas emissions of gasoline. Some ethanol production from grain may fall in this category where the conversion process is coal-fired. This category might also include electric

vehicles in regions where the marginal power source is coal-fired (IEA, 1993, 1994; DeLuchi, 1991, 1993; Martin and Michaelis, 1992).

2. Fossil fuel-derived alternatives that offer a small amount of greenhouse gas mitigation. Alternatives to gasoline include diesel, LPG and CNG. These fuels have full-fuel-cycle greenhouse gas emissions that can be as much as 30 per cent lower than those from gasoline although in some circumstances (e.g. for CNG where natural gas leaks are high) emissions could be higher than those from gasoline. Some biofuels, such as ethanol produced from grain or sugarbeet using fossil fuels for processing, could also fall in this category. So might blends of biofuels with gasoline which can be used in existing engines (McNutt *et al.*, undated). This category might also include electric vehicles in regions with a mix of generation from coal, gas and non-fossil sources (IEA, 1993, 1994; DeLuchi, 1991, 1993; Martin and Michaelis, 1992).
3. Non-fossil-fuel-derived alternatives that can offer 50 per cent or more greenhouse gas mitigation, such as RME, ethanol produced from grain or sugarbeet using agricultural wastes for process energy, or wood-derived fuels (IEA, 1994). This category might also include electric vehicles in regions where electricity is mainly generated from non-fossil sources (DeLuchi, 1991, 1993; IEA, 1993; Martin and Michaelis, 1992).

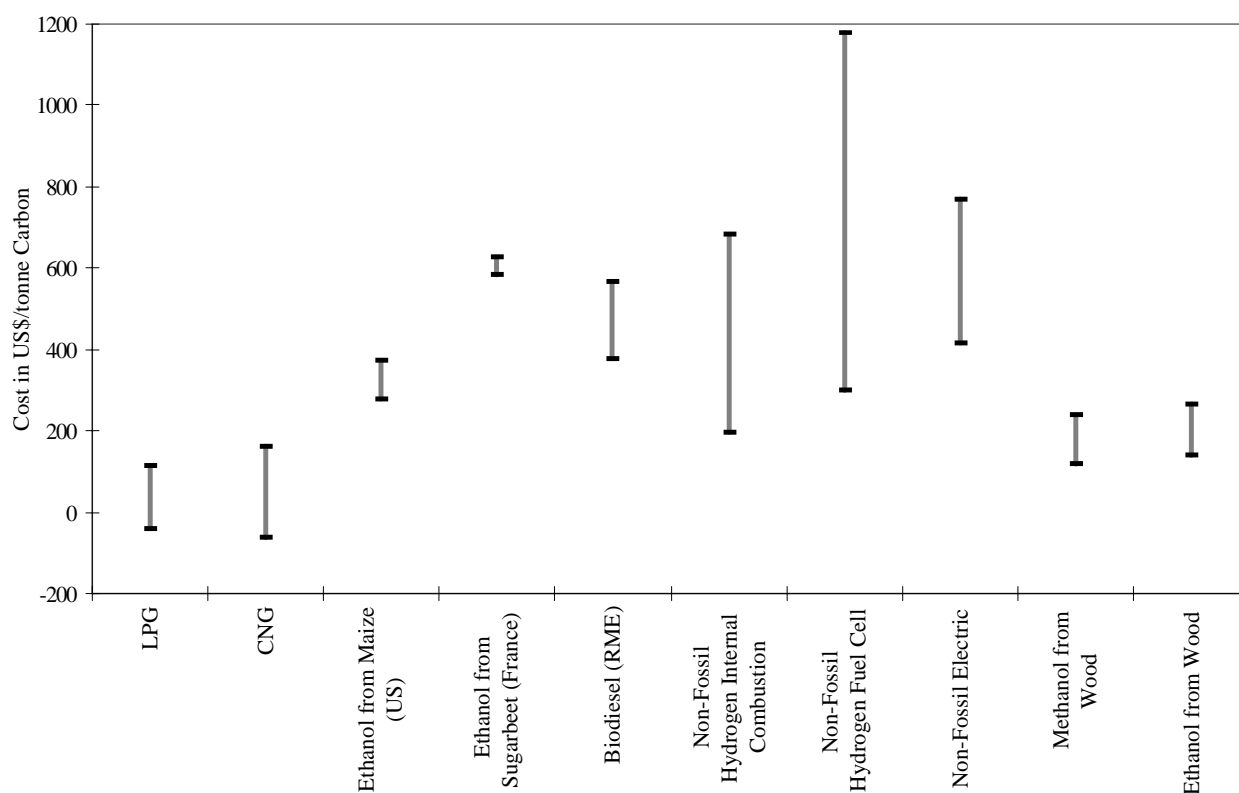
While biomass-derived fuels offer substantial greenhouse gas mitigation potential, the greatest potential lies in fuels and technologies that are so far commercially unproven, either because of high costs or because of technical and safety barriers.

Figure 3 shows estimates of the costs of using alternative fuels and vehicles assuming that they could be produced on a large scale in the near future. per tonne of CO₂-equivalent mitigation are highly variable among alternative fuels, and depend heavily on circumstances for individual fuels. Thus, non-fossil-derived hydrogen costs can vary by a factor of more than three, depending whether the hydrogen is produced from biomass (by gasification) or from non-fossil-generated electricity (by electrolysis of water). The location and size of the alternative fuel production facility can strongly affect the cost of producing the fuel. Methanol from wood is the cheapest of the alternative energy sources offering greenhouse gas emission reductions over 80 per cent relative to gasoline. Methanol might need subsidies or tax incentives in the region of 30¢ per litre of gasoline-equivalent to make it cost-competitive with gasoline (IEA, 1994). While such incentives are provided for alternative fuels in some countries, they are usually justified by objectives other than greenhouse gas mitigation. The most important of these objectives usually relate to maintaining agricultural production and employment.

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Diesel, LPG, and CNG, all of which are used on a large scale and can be cost-effective for their users in some circumstances, offer relatively little greenhouse gas emission reduction using current technology. Methanol from natural gas (mainly used as an input to produce MTBE, a gasoline additive) and ethanol from corn are both favoured in some government alternative fuel policies, but offer little greenhouse gas mitigation with current technology.

Figure 3. Levelised cost of greenhouse gas mitigation relative to gasoline car using mass-produced technology in 2000-2010



Costs are given in US\$ per tonne of CO₂-equivalent mitigation relative to gasoline cars. They are estimated based on typical ownership and operating costs in Europe (see IEA, 1993a for calculation method) with a life of 10 years, 13 800 km/year, 8 per cent discount rate. Cost estimates for biofuels from IEA, 1994a; other fuels/technologies from Michaelis *et al.*, 1996.

Some biofuels produced with current technology can offer substantial greenhouse gas mitigation, but apart from limited low-cost sources, they are typically 3-6 times as expensive as gasoline (IEA, 1994a). Nevertheless, biofuels such as ethanol from sugar cane and maize might become cost-competitive in certain parts of the world (notably regions with efficient agriculture and low land prices) if the price of gasoline were to double. They would become consistently cheaper to use than gasoline on a large scale only if the price of crude oil increased about five-fold relative to 1995 levels (IEA, 1994a).

Meanwhile, large amounts of alcohol could become available at prices comparable with that of gasoline if technology to produce ethanol from lignocellulose (woody biomass) feedstocks were successfully developed and commercialized. McNutt *et al.* (undated) estimate that 1 billion gallons of ethanol could be produced from agricultural and forest wastes in the United States at a cost of 50 US¢/gallon which is close to current gasoline wholesale prices. This is close to the current level of ethanol production from maize (corn) in the United States and could substitute around 2 million tonnes of gasoline, or about 0.5 per cent of current United States road transport fuel demand. McNutt *et al.* further estimate that 70 billion gallons of ethanol could be produced at below 90 US¢/gallon, allowing for the substitution of about a third of gasoline at moderate costs.

A key conclusion from the comparison in Figure 2 is that energy intensity reductions in gasoline vehicles may offer as much greenhouse gas mitigation as alternative fuels such as CNG, LPG and some types of biofuel. The main argument against such energy intensity reductions has generally been that consumers do not want the other characteristics that come with energy-efficient vehicles (e.g. Nivola and Crandall, 1995). Similarly, studies by Segal (1995) and Bunch *et al.* (1993) have found that consumers would place a lower value on electric vehicles or natural gas-fuelled vehicles of the types currently available than on gasoline vehicles. The studies find that consumers place a very high financial premium on the range and short refuelling time of gasoline vehicles. Hence, using alternative fuel vehicles might be expected to have a high cost in the welfare of those consumers. This welfare loss would take the form of inconvenience because of refuelling problems, and reduced driving because consumers would try to avoid refuelling.

Conversely, Turrentine and Sperling (1992) found that consumers would, indeed be interested in purchasing electric vehicles, provided they had some experience of driving them. This implies that the approaches used by Segal and Bunch *et al.* may not reveal permanent values, but just attitudes at the time the surveys were carried out.

Many criticisms can be levelled at any attempt to form generalisations from either type of study. However, Turrentine demonstrated that preferences can change. Other studies (e.g. Goodwin, 1985) have also shown how consumer attitudes change when circumstances change, and Stern (1986), Jacobs (1994) and others criticise the conventional approach to policy analysis that assumes preferences are both fixed, and revealed by behaviour. People often develop attitudes that support the choices they make, *ex post*. This can be used as an argument for government incentives and mandates for alternative fuel and technology use, as means of giving consumers an initial taste of the new technology.

While consumers may be able to develop a taste for small, light, manoeuvrable, non-polluting cars, they may not be prepared to pay much more for them than they do for conventional cars. Manufacturers may not be prepared to invest in the development and retooling costs associated with radical changes in design unless they see a strong demand in the market for these changes. Such costs can run to several US\$ billion per car model. Andrews *et al* (1996) suggest that manufacturers may need to see a payback from such costs within about three years of launching a new product. Hence, the short term barriers to introducing new technology are quite considerable.

There are three major challenges for vehicle and fuel technology innovation.

- The first is to achieve the technical breakthroughs that would make very efficient alternative fuel vehicles available at a reasonable cost and/or allow large scale, low cost production of ethanol and methanol from woody biomass;
- The second is to overcome the barriers to market entry for new technology;
- And the third is to achieve breakthroughs in behaviour so that consumers choose to purchase and use those vehicles.

The next section considers a range of policies that can help to meet these challenges.

Policies for Technology Innovation to Contribute to Greenhouse Gas Mitigation: Candidate Measures for Common Action

This section identifies a range of policies that might form part of a framework to encourage innovation in transport technology, behaviour and institutions that can contribute to greenhouse gas mitigation. The discussion of the various policies here draws on the Appendices, which review experience with local transport initiatives and also with alternative fuel and vehicle policies in several countries. The first step in an innovation strategy is for government to establish a “vision” or set of goals for sustainable development including climate change mitigation. The elements of an innovation strategy are summarised in Box 1. As the box indicates, the process of innovation may be influenced by a very wide range of government actions to facilitate the flow of information, support new initiatives, and provide overall direction.

Many of the policies considered in this section might be ineffective if adopted individually in isolation. Success may depend on a wide variety of measures being introduced that give a clear signal about the need to innovate and the objective of that innovation. A variety of new policies and institutional reforms may also be necessary to facilitate innovation and reduce the associated risks to individuals.

While many governments have a well-developed framework for innovation in technology, there are so far relatively few examples of this type of approach to encourage local transport initiatives. The United States federal government’s programme to implement the Intermodal Surface Transportation Efficiency Act (ISTEA; see Appendix A, Section 5.1) contains many of the elements, but has not yet been in place long enough to have a clear picture of its effectiveness. Nevertheless, ISTEA has already stimulated and funded a large number of local projects. The European Commission’s Green Paper, *The Citizen’s Network*, proposes a networking approach to promote innovation and best practice in public transport, also contains many of these elements.

Each elements of the innovation framework and its potential for common action is considered below. Throughout this discussion, it should be remembered that one of the most important roles governments can play in establishing a climate for innovation is that of establishing a clear vision for sustainable development and greenhouse gas mitigation. Agreeing on that vision across all government ministries, and at all levels of government, would make a considerable contribution to creating a climate that nurtures innovation.

Encouraging and exchanging new ideas

Policy discussion on innovation has traditionally focused on technology research and development. However, the social and behavioural sciences may also play a key role in identifying potential changes in lifestyles, institutions and technologies. For example, anthropological research by Turrentine and Sperling (1992) has developed insights into the circumstances under which consumers will accept the changes in technology performance associated with electric vehicles. The development of a residential area for non-car owners in Bremen followed from an academic study to evaluate how families would cope without a car.

Research, development and demonstration policy has made a transition in recent years in many OECD countries. In the 1960s and 1970s, much research and development was carried out in universities or in government laboratories, with government funding and sometimes government oversight. At the same time, firms carried out their own research and development which might interface with university programmes at conferences and through literature, but projects were rarely collaborative, although government and industrial research did overlap in nationalised industries.

Box 1. Possible Elements in an Innovation Strategy

1. **Encouraging the development and discovery of new ideas, technology, concepts and behaviours.** Part of central government's role may be to absorb the local financial risks of technological and other research and development which, in aggregate, is likely to result in long-term benefits. Relevant measures might include: monitoring range and level of ongoing research and development. Funding and incentives for basic science as well as greenhouse gas-related research and development, partnership programmes for collaborative research; social sciences research into travel behaviour etc.; research into methods for assessing technology, transport system changes etc.
2. **Facilitating the exchange of ideas** among firms, communities, local governments, departments of national government, etc. New ideas and discoveries often occur in places where they cannot be used. The chance of an idea leading to a successful innovation is greatly increased by a continual exchange of information. Relevant measures might include: information, partnership programmes (firms, universities, government research etc.) to encourage exchange of ideas and research results; ensuring patent laws provide incentives for creativity and application of good ideas.
3. **Supporting experimentation with new ideas**, possibly selecting for those that could contribute to greenhouse gas mitigation and other policy objectives. Again, government can play a role by increasing the potential benefits of success. Those carrying out the experiment bear the political risk associated with possible failure — but local actors are likely to be less sensitive to this risk than central governments. Meanwhile, central government encourages a broad portfolio of experiments which, as a whole, minimises this political risk.. Relevant measures might include: Monitoring and support for demonstration projects, community experimentation etc.; financial incentives, technology prizes or other rewards for successful projects, provision of methodological and other support.
4. **Facilitating replication of successful innovations.** Innovations often occur in special situations where they are particularly appropriate, but after some replication and development to “move up the learning curve” and achieve economies of scale, they may be more broadly applicable. Relevant measures might include: limited term financial support; information and best practice programmes to encourage replication of successful projects; modification of national legislation where necessary to permit use of new approaches (e.g. road pricing).
5. **Providing a market framework that encourages greenhouse gas mitigation along with other policy objectives.** This includes the measures considered in the Working Paper No. 1 study to internalise externalities, provide targets for energy efficiency improvement, etc. Co-ordination of different policy areas to develop compatible strategies for addressing multiple goals is also an important step. This may mean, for example, that policy on land-use takes account of implications for transport and the environment. Specific measures might include: monitoring, consultation with firms and local government to understand needs and capabilities; applying market instruments — fiscal and regulatory incentives, information, education, etc., emphasising objectives of sustainability; market regulation to minimise barriers to entry and encourage competition.

More recently, several factors have led to a reconsideration of this approach and to a much closer integration of the research programmes of private companies and governments. This is particularly important in facilitating the exchange of ideas among firms and among different types of institution. Japan has been a leader in this style of research and product development, with very close co-operation between government and private industry. In the United States, the Partnership for a New Generation of Vehicles (PNGV) is one example of the collaborative efforts that have emerged (see box below). In the European Union, research carried out with European Commission support usually involves several partners, including universities and companies from different Member countries.

A further important feature in recent years has been the development of government research and development programmes that are focused on results. The United States Partnership for a New Generation of Vehicles, described above, aims to develop new technology that meets a particular set of objectives. Targets and milestones are also an important feature of research and development Programmes in Japan, the European Union and elsewhere.

Partnership for a New Generation of Vehicles (PNGV)

PNGV is a partnership between 11 government agencies and the US Council for Automotive Research, a co-operative research effort between Chrysler, Ford and General Motors. It aims to develop commercially viable vehicle technology that can, over the long term: preserve personal mobility; reduce the environmental impact of light duty vehicles; and reduce US dependence on foreign oil. The partners hope that PNGV will establish the model for future joint government/industry ventures.

PNGV has three goals. The first is to improve the international competitiveness of US industry through more flexible and advanced manufacturing methods. The second is to ensure that technological innovations are applied in vehicles when they are commercially viable. The third, and perhaps the best known, is to develop a vehicle that can achieve 80mpg while maintaining the performance and cost of ownership of current cars.

PNGV focuses on four technological areas:

- Reducing weight through the use of polymers, composites and lightweight metals
- Power sources including direct injection internal combustion engines, gas turbines and fuel cells
- Energy storage in high power batteries, flywheels and ultracapacitors
- Electrical and electronic devices including motors, actuators, power conditioners and controllers.

Specific goals to achieve an 80 mpg car with performance and cost equivalent to a '90s car achieving 26.6 mpg are: 40 per cent weight reduction relative to the typical '90s car weight of 3 200 lb; reducing the drag co-efficient from 0.32 to 0.20; reducing the rolling resistance co-efficient from 0.008 to 0.005; and replacing current internal combustion engine with fuel cells, gas turbines, or advanced engines coupled with energy storage devices.

The partnership has established four milestones towards the production of the 80 mpg car:

1. Evaluate competing technologies by the end of 1997
2. Develop a concept vehicle by 2000
3. Prepare a production prototype by 2004
4. Start producing vehicles following the necessary product lead time.

PNGV has been warmly welcomed by US industry. The partnership allows the industry to make use of military and space technology that has emerged from government research programmes and not normally available to private firms, and provides government funding for developments where the financial returns are too small or too risky for the private sector to pursue them alone. On the other hand, it allows industry, with its better feel for the market, to help identify the products most likely to succeed.

Just as national governments can co-operate with industry to undertake technology research and development, they can collaborate with local governments, universities and others to undertake research and development in the social sciences. The US Travel Model Improvement Program (Appendix A, Section 5.2) is an example of such an initiative.

Many of the research programmes in Annex I countries address common themes. Thus, Japan, the EU and the United States are all working on lightweight materials, alternative engine concepts, hybrid (ICE-electric) vehicles, fuel cells, batteries, motors and other key technologies. Countries in all regions have research programmes on travel behaviour.

Some countries or regions have particular strengths. The Canadian company Ballard (see Appendix B) is the world's main producer of solid polymer fuel cells; Japan is at the forefront of research on ceramics for engines; a British company has been the main developer of the "switched reluctance motor" (a very efficient motor design); European car engine manufacturers have considerable experience with high-speed direct injection engines; German car manufacturers have worked extensively with hydrogen storage and use in internal combustion engines; and the United States has increasing experience of electric vehicle development. Similarly, countries have strengths in their experience with experimental approaches to changing travel behaviour. The Netherlands originated the concept of "traffic calming" (road layouts to slow traffic in residential areas); the United States has numerous programmes to develop transport models; Norway has been a leader in establishing toll rings (cordon charge systems). Common actions to address R, D and D might reduce duplication, take advantage of diversity in existing national programmes, and help achieve economies of scale.

Encouraging Experimentation

Regulations and financial incentives can play a dual role in the innovation process: they can provide the impetus for innovation in a particular direction; and they can provide the long-term framework that sustains technologies and behaviour patterns that reduce greenhouse gas emissions. This section focuses on the first of these roles. The second is considered in the section on "Providing an Environment for Replication of Innovations".

Incentives for experimentation may be provided in many ways. Those already in existence to encourage the introduction of new technology in Annex I countries include:

- reductions in fuel duty, vehicle taxes, tax credits and cheap loans for alternative vehicle purchasers — these incentives are sometimes applied to a single technology or fuel, and sometimes to a range of technologies and fuels;
- subsidies, tax credits and cheap loans for alternative fuel and vehicle suppliers, again applied to a single technology or to a range of technologies that are thought to contribute to policy objectives;

- vehicle standards, e.g. for emissions and energy efficiency, and targets perhaps extending over several years into the future;
- mandates for certain groups of vehicle users to purchase alternative technologies — usually from some permitted list;
- awarding prizes to successful innovators — for example, offering a large government procurement contract for the first company to achieve a target level of energy efficiency.

Governments can and do also use incentives and support to encourage changes in behaviour and institutional practices:

- establishing “high occupancy vehicle” lanes on main roads, which can only be used by cars carrying three or more people;
- requiring employers to provide staff with free public transport passes;
- linking local government funding to the achievement of environmental practices;
- giving environmental awards to towns and cities that achieve particular targets;
- monitoring and support for demonstration projects, community experimentation etc. This might include financial rewards or recognition for successful projects.

To achieve results in the most efficient manner possible, such incentives should be linked to specific policy objectives, rather than to a chosen technology or planning solution.

Removing disincentives for innovation

Vehicle manufacturers often comment that government regulations make it harder for them to introduce technology that reduces greenhouse gas emissions. As part of a framework for innovation, it is important that regulations and other measures are regularly reviewed to ensure that they support the full range of government policy objectives. In some cases, compromises may be necessary — for example, vehicle safety may require the use of equipment that adds weight and hence increases fuel consumption. In others, technical standards or other measures that are no longer relevant can be revised.

Local initiatives may be constrained by regulations on the way local governments can use grants from central government or funds raised from road user fees. This was a key issue in the implementation of the Trondheim toll ring (Appendix A, Section 3.2) and has prevented such experimental measures elsewhere. An important new feature of many national programmes, such as the US Intermodal Surface Transportation Efficiency Act, is that they allow local governments to use grants for purposes other than road building. One of the most important barriers to a change in planning approach is the requirement in many countries for all new housing and office developments to have a minimum number of parking spaces.

Providing an environment for replication of innovations

This section considers three features of the environment in which innovation occurs, and discusses ways in which governments can help to generate an environment where innovations that reduce greenhouse gas emissions are regulated. It considers three main aspects of the environment: 1) pricing, or the existence of financial incentives to reduce greenhouse gas emissions; 2) regulations; and 3) the availability of information, support and networks. As fuel pricing and vehicle standards have already been considered in some depth in Working Paper No. 1 (Michaelis, 1996), this section pays most attention to the role of the third group of policies.

Financial incentives

In theory, the most economically efficient way to link financial incentives to greenhouse gas emissions would be through a general carbon or greenhouse gas tax on fuels. Working Paper No. 1 considered the potential effect of fuel taxes on greenhouse gas emissions in some depth (Michaelis, 1996). Taxes linked to the life-cycle greenhouse gas emissions associated with alternative fuel could result in mitigation additional to that identified in Working Paper No. 1. To provide sufficient incentive to reduce the cost of using alternative fuels offering substantial greenhouse gas emission reductions below the cost of using gasoline, such taxes would need to exceed about \$200/tonne of CO₂-equivalent emissions (based on Figure 1). If applied to the life-cycle emissions from gasoline use, this level of tax would amount to around 50 US¢ per litre of gasoline. Appendix B discusses a number of cases where governments have used taxation policies to encourage alternative fuels. In general it finds that, to achieve substantial penetration of alternative fuels requiring a change in vehicle type, tax incentives need to make them very much cheaper than gasoline. However, fuels that can be used in existing vehicles such as gasoline-alcohol blends can be introduced with much smaller price incentives.

In practice, because of a variety of market failures and imperfections, it may be more effective to introduce financial incentives other than fuel taxes to influence decisions that affect the use of fuel. The examination in Working Paper No. 1 of vehicle feebates (a scale of vehicle purchase taxes and subsidies to reflect fuel economy) provides one example of such an approach (Michaelis, 1996). Incentives could also be provided for decisions in other areas — e.g. linking local government grants to reduction in greenhouse gas emissions against an agreed baseline.

Pricing measures that reflect a range of social costs, including local air pollution, might also encourage the use of alternative fuels and shifts in transport patterns. Fuel taxes are one, rather crude instrument to reflect the social costs of transport.

Incentives and standards that focus on the social costs to be avoided, rather than on a specific technology or change in behaviour, itself, may have results that governments could not predict. For example, local vehicle emission standards developed by the California Air Resources Board were expected to result in the introduction of alternative fuel vehicles. In fact, the car companies have quickly developed gasoline vehicles that meet the standards. Similarly, incentives to reduce greenhouse gas emissions may lead to the use of energy-efficient gasoline vehicles rather than to the use of alternative fuels. The use of such incentives could give local governments the choice between reducing transport demand and introducing alternative technology.

Regulations

Some governments have introduced regulations of one type or another requiring the use of alternative fuel vehicles, for example in national and local government fleets (see Appendix B). These are mostly focused on achieving objectives other than greenhouse gas mitigation. The most efficient way to use regulations to reduce greenhouse gas emissions is likely to be through regulations on those emissions, rather than regulations that specify a particular technology to reduce emissions. Technology-neutral regulations on new cars would, in principle, offer technology users a choice between improved energy efficiency and alternative fuels. This has been achieved to some extent in the United States' CAFE regulations, where manufacturers can obtain credits by selling alternative fuel vehicles (see Appendix B). A similar concept could be used with a focus on greenhouse gas mitigation, instead of or in addition to reducing petroleum consumption. For example:

- Establishing a full-fuel-cycle greenhouse gas limit at 80 per cent that of gasoline for alternative fuels to qualify for support would have little effect on current alternative fuel vehicle choices in most countries. However, it might rule out some existing coal-fired production of ethanol, and it would constrain future developments, preventing the introduction of methanol from natural gas.
- A greenhouse gas emission limit at 50 per cent that of gasoline would only allow the non-fossil-derived fuels and electricity to qualify for credits. Most of these fuels are currently being produced and used only on a demonstration or trial basis. Nevertheless, such limits might be announced as future targets for part or all of the alternative fuel vehicle fleet.

Full-fuel-cycle greenhouse gas limits would have different effects in different countries. In particular, this applies to electric vehicles, which would be more likely to be favoured in countries with predominantly non-fossil or natural gas-fired electricity production. Emission limits might have to be defined relative to gasoline vehicles that are equivalent in interior space, level of performance, safety, and perhaps other parameters.

Full-fuel-cycle greenhouse gas emission limits could be considered for part of a common action on alternative fuel and vehicle technology. Given the diversity of existing national programmes, such limits could be an add-on component to existing measures. If greenhouse gas emission reduction is a key policy objective, then countries might continue with their current programmes but undertake a common action in which they introduced greenhouse gas limits for fuels and technologies to qualify for support under those programmes.

There is a delicate balance between imposing constraints that prevent innovation, and providing a stable set of ground rules that contribute to a climate for innovation. Central government may have a role in setting technological and safety standards, for example for road pricing systems and traffic calming devices. Government may also need to set minimum standards for public consultation procedures and other aspects of the local government planning process.

Information, support and networks

This section aims to address the point at which local governments or potential users of a new technology become aware of the availability of the new option and either take it or leave it. The challenge for governments in this area is to make sure that innovations that meet greenhouse gas and other objectives have the maximum possible chances of success, while also ensuring that users have the opportunity to choose the innovations that best meet their needs in the long term. Thus, it is not just a marketing

challenge, but rather the challenge of finding ways to encourage individuals and communities to become involved in the process of innovation. Central government can play several roles in this area:

- Monitoring of, and consultation with, local governments, communities and firms to understand existing practices and needs.
- Providing information, establishing networks to encourage exchange of ideas — creating fora such as conferences, working groups, internet sites, etc., in which local authorities, firms and individuals can discuss their concerns and needs among themselves and with central government; funding personnel exchange programmes among local governments and between local and central government and businesses.
- Developing networks, information packages and best practice programmes to encourage replication of successful projects — this might include newsletters, libraries, use of the internet, workshops, training programmes, etc.

Car manufacturers and other producers of consumer products test the market routinely, through questionnaires, contact groups and other processes to help them to design and market new products. However, there is an important difference between the product development normally undertaken by manufacturers and the process being considered here. Manufacturers are normally prepared to take consumer priorities at face value, and optimise their product to meet those priorities⁸. They may, through marketing, add to the emphasis placed by consumers on certain attributes and de-emphasise others. The choice of attributes to emphasise will typically depend on the market segment being targeted. Manufacturers do not usually try to introduce new priorities. greenhouse gas mitigation is not normally a factor in car marketing although energy efficiency and local environmental issues have been emphasised in the past. Generating a market for vehicles with low greenhouse gas emissions may depend on an initial education process so that consumers understand what they are being offered, the reasons they are being offered it, and how the new vehicle technology will perform against the criteria they normally use for choosing vehicles.

Information and education of consumers are likely to play an important role in encouraging the use of low-greenhouse gas-emitting technology and in achieving changes in behaviour. An increasing amount of research is being carried out on the effectiveness of different approaches to information provision and some clear messages are beginning to emerge. The context in which information is provided can strongly affect the extent to which that information is absorbed and acted upon. In particular (Stern, 1986):

- People sometimes ignore information even when it is widely available and costs-less;
- Information is more likely to change behaviour when it is specific, vivid and personalised — hence visual, concrete, context-embedded information, such as a demonstration of an alternative fuel vehicle, is likely to be more effective in selling such vehicles than an article describing the environmental advantages of such vehicles
- Information that attracts the consumer's attention is more effective than information with the same content that does not. Perhaps the well known and controversial billboard advertising for Benetton's (a clothing manufacturer) is an example of this.

⁸ Based on presentation by Steve Barnett at the first OECD Workshop on Individual Travel Behaviour, 1996.

- The source of information, particularly its trustworthiness, can make a great difference. Thus, consumers might be more likely to trust information on alternative fuel vehicles that comes from government sources than that from car companies (although this is likely to vary among countries), and more likely to trust information from close friends than from official sources.

Personal experience may be the most important factor in determining consumers' willingness to embrace new technology. Turrentine carried out a series of lengthy (and expensive) interviews to explore with consumers how they used their existing vehicles and how they might use an electric vehicle, and took them for test drives in electric vehicles (Turrentine and Sperling, 1993). At the end of this process, many of the interviewees preferred the electric vehicles to conventional vehicles. The Bremen experiment had similar findings for families living without cars (Appendix A, Section 5.4).

In the first instance, new technology vehicles are likely to be used mainly by fleet operators, including local government, utilities, etc. It makes sense for a broader alternative fuel vehicle policy to start by targeting such niche markets as it is possible that, once alternative fuel vehicles become a familiar sight on the streets, consumers will be prepared to buy them. In the United States, the fleet market has been targeted, and is perceived to offer the main opportunity to introduce alternative fuel vehicles into the market at large. While federal government mandates play an important part in the uptake of new technology, these mandates do not specify the vehicle type to be chosen by fleet operators. Outreach programmes are essential to help state and municipal agencies to understand the advantages and disadvantages of the various options open to them, to learn from each other's experience, and to provide feedback to the federal government and to manufacturers. There are several models for outreach, some of which are briefly described in Appendix A, Section 5 and Appendix B, Section 2.

Possible common actions, their advantages and disadvantages

Given the conceptual framework presented in the introduction to Section 5 for innovation strategies, many types of government measure could be considered for common action:

1. research and development funding, planning and collaboration aimed at greenhouse gas mitigation;
2. exchanging and disseminating information on the research and development and demonstration programme results;
3. pilot and demonstration programme funding, planning, collaboration, provision of information and methodological support for local governments and others wishing to experiment with technology for greenhouse gas mitigation;
4. providing fiscal incentives, mandates and information to encourage the adoption of low-greenhouse gas emitting technologies and fuels in the market place.

Common action to encourage innovation would contribute to cost-effective greenhouse gas mitigation in various ways:

- by sharing the costs and benefits, and hence the risks of research, development and demonstration programmes

- by allowing cross-fertilisation of ideas and approaches to occur among countries, improving the chances of finding successful and cost-effective solutions
- by enlarging the potential market for any new technology and replicating successful changes in behaviour and institutions and by allowing economies of scale to be achieved more easily
- by giving clearer market signals to manufacturers and fuel suppliers operating in an international market

The main disadvantages of common action would arise if incentives were made too rigid and could not be adapted to national circumstances, in which case inappropriate solutions might be forced on some countries.

While each of the types of measures listed above could be candidates for many different forms of common action, this section will consider only a few of the more promising options. They are considered here under four headings, corresponding to the types of common action outlined in the Framework for Analysis of the OECD/IEA project on Policies and Measures for Common Action.

One of the main conclusions of this study is that greenhouse gas mitigation through innovation would be encouraged most effectively by implementation of a wide range of measures giving similar signals, and providing various types of support for innovative processes. Thus, no single measure would be “best” for common action instead, the “best” approach would be to adopt several measures as part of a common action.

Replication of successful measures

Many initiatives already exist to help replicate successful initiatives internationally: the United States has already begun to develop its Clean Cities programme internationally; various networks have been developed to share information among European Union Member countries; the IEA CADDET Implementing Agreement carries out a similar role, producing reports and fact sheets about energy technology innovations in Member countries.

International recognition and rewards for best practice in greenhouse gas mitigation could provide an additional incentive for communities to incorporate climate policy objectives in local transport plans. Annex I countries could build on existing international initiatives. For example, the International Council for Local Environmental Initiatives (ICLEI) produces fact sheets about environmental initiatives in cities around the world. The European Commission’s Green Paper on the Citizen’s Network may lead to future action in this area. Past ECMT/OECD work, in particular, the 132 city study on *Urban Travel and Sustainable Development* (ECMT/OECD, 1995) could form a basis for an ongoing network and database.

A common action in this area might also build on the CADDET approach, or on the US Clean Cities programme, to create an international network of communities and firms interested in the development of alternative fuels and vehicles. The network could share information on fundamental research findings, new technologies, demonstration projects, and implementation of technologies in the market place. It could also provide access to technical support and guidelines for project assessment and implementation.

Networks and best practice-type programmes are an essential part of alternative fuel and technology policies in several countries. Sharing information on an Annex I wide basis might reduce the cost of

experimentation and learning from mistakes, and might also help good ideas and approaches to be replicated.

There are unlikely to be significant disadvantages from this type of approach, although one potentially major disadvantage might occur if communities replicated inappropriate approaches. Thus, it is particularly important that methodological support is provided for communities to identify strategies that best meet their local needs. Concerns might also arise if a country or firm hoped to gain some advantage by commercialising a technology in advance of overseas competitors, and did not wish to share information.

Annex I Parties might also consider making more systematic use of the national communication process under the UNFCCC to share information on initiatives by communities and firms. The communication guidelines could be expanded to include a recommendation to this effect.

Agreement to take action in the transport sector toward an aim or target

Common actions in this area might take the form of international agreements to achieve some target, such as reversing the upward trend in greenhouse gas emissions from urban transport. Alternatively, the agreement might be to aim for a principle, such as “fair and efficient pricing in urban transport” or “full community consultation in local transport planning”. Targets might also be defined to achieve a certain level of greenhouse gas mitigation through alternative fuel and vehicle introduction, perhaps to introduce a certain number of alternative fuel vehicles to the national fleet, or for alternative fuels to supply a certain share of road transport energy use.

One advantage of such a common action would be the creation of a common cause for local transport policy extending beyond national borders. International agreement on aims and targets would give added stability to the context in which local policy-makers consider their options, which can contribute to a “climate for innovation” (Wallace, 1995).

Technology measures in this area could be linked to some of the options considered in Working Paper No. 1, addressing vehicle fuel economy. Thus, they might build on the ECMT declaration aimed at reducing vehicle CO₂ emissions, or on the European Council’s agreement to aim for average fuel consumption levels of 5 L/100 km in gasoline cars in the period 2000-2010.

Again, the main possible disadvantage of agreements on aims and targets might arise if the terms of any target were inappropriate to some local circumstances. This might mean that targets should be stated in fairly general terms, to be fleshed out locally or nationally, or that any agreement should be restricted to principles.

A transport sector greenhouse gas mitigation target could be negotiated through the UNFCCC, building on initiatives such as ECMT Ministers’ declaration aiming to reduce vehicle CO₂ emissions.

Co-ordination to implement the same or similar measures

Measures that might benefit from co-ordination include the experimentation with road pricing, inter-modal freight technologies or intelligent vehicle and highway systems, where there would be advantages in the long run from the adoption of standardised technology. Agreements to co-operate on research and development could include co-funding for major research programmes, collaboration among researchers from universities, firms and government agencies in different countries.

Governments could also co-ordinate the incentives they provide for new technology to ensure that manufacturers are receiving the same signals from several markets. The levels of incentives would not need to be harmonised to provide a clear signal.

Information measures, such as provision of technical and methodological support, would also be appropriate for co-ordination, although the type of support provided might vary in its detail among countries.

International co-ordination in these areas could add value and reduce the costs of national programmes, allowing countries to learn from each other's experiments. In some cases, it might be possible to move towards consensus on the best technology for later standardisation.

It might again be possible to build on the work of ICLEI which, for example, has produced a planning guide for local authorities in Europe to work towards Agenda 21 objectives (Hewitt, 1995).

Specific policies and measures implemented together

Areas for harmonised implementation of policies might include establishing safety and technical standards for alternative fuel vehicle components, refuelling technologies, and fuel specifications. Such common standards would permit manufacturers to produce technologies for niche markets, such as urban bus fleets, airport and marine port fleets, in a number of countries. This would help them to achieve economies of scale and perhaps reduce costs to levels that are acceptable in the wider vehicle market. It may also be important that road pricing, intelligent vehicle and highway systems, inter-modal technologies, etc., are "inter-operable" — i.e. that vehicles designed for one system can operate within another. Harmonised standards for such systems might also reduce costs by avoiding the need for one-of-a-kind systems and facilitating competition between companies from different countries. Other types of measure could be implemented jointly — for example technology prizes (as in the IEA/OECD Climate Technology Initiative), energy challenges, and multilateral project funding are all candidates.

It has been emphasised throughout this report that much of the impetus for the development of alternative fuels and vehicles derives from concern about employment, the survival of specific industries, local environmental issues and energy security. As the relative importance of these issues varies widely among countries, harmonised policies beyond the more easily agreed basic technology specifications are unlikely to be cost-effective, and different types of incentives may be appropriate for different countries. Meanwhile, standardisation of the approach to technology development might result in a loss in diversity of new approaches, which is an essential ingredient for innovation.

APPENDIX A. CASE STUDIES OF INNOVATION IN TRANSPORT SYSTEMS AND BEHAVIOUR

Effects of Individual Measures

United Kingdom: impact of transport policies in five cities

The UK Transport Research Laboratory has analysed a range of transport policies in five cities in the United Kingdom: Leeds, Bristol, Sheffield, Derby and Reading (Dasgupta *et al.*, 1994). These five cities were selected based to some extent on the availability of detailed transport data, and to some extent by the aim of obtaining a representative sample of different city types. Thus, Bristol and Sheffield are at opposite ends of the mode split spectrum, while Leeds represents the average: car use is very high in Bristol, whereas bus use is very high in Sheffield. A “two-zone” model was used to assess six options:

- Reduce public transport fares by 50 per cent;
- Increase fuel costs by 50 per cent;
- Double the charge for parking in the city centre area;
- Halve the number of public and private parking places in the central area;
- Introduce a cordon charge for entering the central area, at £2 in peak traffic, £1 off-peak;
- Combine halving public transport fares with doubling parking charges.

Table 4 shows the estimated effects of these measures in each of the five cities on total traffic and total CO₂ emissions. It should be noted that these measures are not intended to be equivalent in any way.

Table 4. Effect of Transport Measures in 5 Cities in the United Kingdom (% Change)

Policy	Leeds		Bristol		Sheffield		Derby		Reading	
	Traffic	CO ₂	Traffic	CO ₂	Traffic	CO ₂	Traffic	CO ₂	Traffic	CO ₂
Halve fares	-1.5	-1.6	-0.7	-0.8	-1.2	-1.3	-1.3	-1.5	-1.7	-2.0
50 per cent fuel price rise	-3.7	-3.7	-3.7	-4.1	-3.2	-3.4	-2.6	-3.0	-3.8	-4.4
Double parking fees	-1.2	-1.6	-2.8	-3.6	-2.3	-2.8	-1.5	-2.3	-3.1	-3.7
Halve parking space	-4.0	-4.8	-3.6	-4.2	-4.8	-5.5	-2.9	-3.6	-3.0	-3.5
Cordon charge	-4.0	-4.6	-3.4	-4.3	-5.1	-5.9	-4.7	-5.9	-4.2	-5.2
Combined half fares and double parking fees	-2.7	-3.2	-3.4	-4.3	-3.5	-4.1	-2.8	-3.8	-4.7	-5.6

Source: Dasgupta *et al.*, 1994

The Netherlands: The Randstad Region

The Randstad region in the western Netherlands includes Rotterdam, Utrecht, Amsterdam and The Hague. Traffic congestion in the region is growing. Traffic (vehicle-km) in the Netherlands is projected to increase by 70 per cent between 1990 and 2010. The Government is seeking policy strategies to reduce the growth to about 35 per cent. Several studies of the transport system and policies' probable effects have been undertaken. The results of some of these studies have been used by NOVEM for an analysis of possible strategies for the Randstad as a contribution to the IEA publication *Cars and Climate Change* (IEA, 1993a; NOVEM, 1992).

A transport network model was used to examine the impact of policy measures on traffic and hence on CO₂ emissions in the Netherlands. The Netherlands and Belgium are represented in the model by 958 zones, each treated as a starting point and destination for trips. The Randstad region is broken down into 724 very small zones and Belgium into ten large zones.

The model estimates the number of trips starting and ending in each zone based on demographic factors. It then assigns trips to routes through the transport network using a resistance network approach, choosing between modes on a cost basis, and taking account of congestion delays and the waiting time for public transport sections of trips as an additional cost. It then calculates fuel use and CO₂ emissions for cars based on emission factors cars, per vehicle-kilometre and per hour spent in congestion.

The model can be used to test the effects of transport policies, such as increases in costs for a given mode or constraints on road use or parking. The 14 policy measures considered in the study, and their calculated effects on traffic and CO₂ emissions, are shown in Table 5.

Table 5. Modelling Results for Transport Measures in the Netherlands: Effects in 2010.

Case	Description	Urban Areas Traffic Index	Netherlands Total		
			Traffic Index	Speed Index	CO ₂ Index
0	Reference Case (2010, No Measures)	100.0	100.0	100.0	100.0 ⁹
1	Double parking fees, extend parking fee area	98.3	99.1	101.5	99.0
2	Limit parking accommodation	97.8	98.7	100.6	98.8
3	Increase fuel price 30 per cent	95.2	93.9	99.1	94.3 ¹⁰
4	Road pricing (raise driving cost by 50 per cent in cities, 25 per cent elsewhere)	92.8	92.6	99.1	93.3
5	Charge Gld 5 tolls to enter city area)	98.2	99.1	98.3	99.4
6	Do not build new roads to meet increasing traffic demand	89.0	98.6	103.4	98.5
7	Provide roads to meet demand	113.3	108.3	98.5	107.3
8	Limit traffic in residential areas			Not modelled	
9	Improve public transport	99.6	99.4	100.2	99.5
10	Provide park and ride facilities			Not modelled	
11	Designate lanes for high-occupancy cars	96.8	96.8	100.6	96.4
12	Improve traffic management			Not modelled	
13	Lower speed limit 30 per cent	91.8	88.1	85.4	96.0
14	Lower speed limit 10 per cent	100.2	98.4	95.7	100.3

Note: 1Gld = US\$0.569 in 1992.

⁹ Base CO₂ emissions = 3659 tonnes.

¹⁰ The Randstad model does not allow for changes in vehicle technology resulting from higher fuel prices. The actual reduction in CO₂ emissions would probably be greater than this.

United States: The Pedestrian Environment in Portland, Oregon

A study in Portland in Oregon investigated the role of a variety of factors in “the pedestrian environment” that influence the extent to which people walk rather than use motorised modes (PBQD, 1993). These factors were:

1. Ease of street crossing (depending on street width, frequency of traffic signals, volume of traffic)
2. Sidewalk continuity
3. Street connectivity
4. Topography (hilliness)

Each of 400 zones in Portland was given a rating (1 to 3) for each of the factors, and the four ratings were added to give a total “Pedestrian Environment Factor” rating of 4 to 12. As Table 6 shows, the PEF was found to be strongly correlated with car use and mode choice,

Table 6. Total Car Use and Travel Mode Choice vs. Pedestrian Environment Factor in Portland

PEF Score	Car Use (Daily VMT per person)	Share of trips (per cent)			
		Car	Transit	Walk/Cycle	Other
4	16.3	94.2	2.5	2.2	1.2
5	14.3	94.7	2.3	1.6	1.4
6	13.8	94.3	3.4	1.4	0.9
7	12.8	91.3	5.0	2.2	1.5
8	11.3	92.3	3.8	2.9	0.9
9	9.7	86.7	7.8	3.5	2.0
10	9.9	83.3	10.6	4.3	1.8
11	7.9	76.3	12.6	9.6	1.6
12	8.1	79.6	10.7	7.4	2.3
Average	12.8	88.9	6.0	3.7	1.4

Much of the link between PEF and driving may be explained by the link between PEF and household density, which affects the viability of modes other than car use (see Table 7).

Table 7. Household Density vs. Mode Split in Portland

Household Density (no. per acre)	Share of trips (per cent)			
	Car	Transit	Cycle	Walk/Other
0-1	95.2	2.0	2.0	0.8
1-2	93.0	3.3	2.0	2.0
2-3	91.1	5.4	2.5	1.0
3-4	88.5	7.5	2.3	1.7
4-5	84.9	8.5	4.8	1.8
>5	75.0	12.8	10.0	1.7
Average	88.9	3.7	1.4	1.4

Both household density and the PEF are also likely to be correlated with other factors that affect car use, including household income, household size, employment levels, car ownership, accessibility of

employment, etc. A model was constructed to identify the role of each of these factors. The results are summarised in Table 8

Table 8. Effects of Variables on Vehicle Use

Change in Explanatory Variable:	Impact on Daily Household Vehicle Travel
Unit increase in zonal PEF	-0.7 miles
Increase from 3 to 4 households per acre in zone	-0.5 miles
20,000 increase in jobs accessible within 30 minutes by car	-0.5 miles
20,000 increase in jobs accessible within 30 minutes by transit	-0.6 miles
\$5000 increase in household income	0.8 miles
Unit increase in household size	3.0 miles
Unit increase in workers per household	1.4 miles
Unit increase in cars per household	1.8 miles
Average daily VMT per household	28.2 miles

Local Transport Policy Packages: Modelling Studies

The Netherlands: The Randstad Region

The Randstad study discussed above (NOVEM, 1992) also considered the effects of four packages of measures. The results are summarised below.

Table 9. Effects of Combined Measures

Case	Description	Urban Areas	Netherlands Total			
		Traffic Index	Traffic Index	Speed Index	CO2 Index	Cost (bn Gld)
1	Parking Control Package (higher fees, limited area plus improved public transport)	92.7	94.3	102.4	94.4	7
2	Price Policy Package (fuel price increase, road pricing and parking fees plus improved public transport)	83.0	83.7	102.1	83.3 ¹¹	7
3	Do-nothing Package (no investment in roads but improve public transport)	85.0	94.6	103.9	94.7	7
4	Meet-Demand Package (invest in roads to meet demand and improve public transport)	109.5	104.6	97.4	104.3	14

Note: 1Gld = US\$0.569 in 1992.

Table 9 shows the effects of the measures in the model if they are combined together in packages. It also shows the estimated costs of the packages.

In addition to the overall effects of the policies shown in these tables, NOVEM found that:

- Parking control measures can have unexpected results and have to be designed with care. People making short trips are more likely to be discouraged by parking difficulties than those making long trips. Displacing short-trip traffic, where parking capacity is a constraint, creates more parking space for long-trip traffic.

¹¹ Ibid.

- Fuel price increases result in a greater decrease in vehicle-kilometres overall than in the urban area. Higher fuel and road use costs tend to reduce long trips, freeing road capacity in the urban centres for more short trips. Improved public transport mainly attracts long-distance commuters and so affects the system as a whole more than urban areas.
- The "do-nothing" package reduces CO₂ emissions by 15 per cent in urban areas, as increased congestion discourages car use, but only 5 per cent overall.

United Kingdom: congestion charging in London

A study for the United Kingdom Government Office for London by the MVA Consultancy investigates a range of options for congestion charging in London. The study uses various models, but the main results derive from a coarse network model of transport in the London area, MVA's "APRIL" model.

MVA examined a wide range of bases for charging, including: congestion metering (using in-vehicle devices to measure the extent of stop-start driving and to charge the driver accordingly); distance-based charges (again using in-vehicle computers to measure the distance travelled in particular zones at particular times of day); cordon or point-based charging (where vehicles are charged every time they cross a cordon or pass a charging point); and supplementary licenses for travel within a particular area.

MVA found that charges related to the congestion encountered or distance travelled by individual vehicles were technically feasible, but that the technology required has not yet been developed sufficiently to be completely reliable in a full scale application. Further experimentation is required in this area.

A system of charge cordons, or "toll rings" around the city, is already technically proven, and would be feasible. MVA therefore examined various possible cordon locations and charge schedules. The principal options considered were cordons around central London, "inner" London, and a somewhat larger part of the Greater London Area.

Supplementary licenses would be a relatively inefficient instrument, as the charge paid by drivers bears no relationship to the amount they drive, but such licenses would be easy to implement.

MVA investigated the effects of congestion charges on traffic levels, traffic speeds, accidents, emissions of carbon monoxide (CO) and carbon dioxide (CO₂). They also estimated economic effects, principally in the form of the value of reduced travel time and total cost of charges to drivers, and the value of revenues and costs of implementation and operation of the scheme to government. The study considers broader effects on the economy of different parts of London, but does not provide quantitative results.

Table 10 illustrates some of the findings of the MVA study with regard to the effects of different charging strategies on traffic and benefits to travellers, mainly in the form of time saved. The study examines several complementary measures which could be introduced along with congestion charging, including the introduction of an expanded bus lane network, improved public transport service provision, and a combination of new public transport infrastructure (rail and underground lines) and improved service provision. The last option was found to have the greatest economic benefits, and results are shown for this option only. As Table 10 shows, CO₂ emission reductions are quite substantial in the central London zone, especially in the "high" charge cases. Whereas reduced congestion leads to CO emission percentage reductions larger than the reduction in traffic, reductions in CO₂ emissions are slightly smaller than the

reductions in traffic at the high charge levels. The percentage reductions in traffic and CO₂ emissions are smaller for the larger “Inner” London zone, and smaller still for “Outer” London.

Table 10. Effects of Some Congestion Charging Strategies in London

Central London all-day/Inner London peak charge	No Congestion Charging	Central London Cordon Inbound		Central and Inner London Cords Inbound	
		“Low” Charge £2/£0	“High” Charge £8/£0	“Low” Charge £2/£1	“High” Charge £8/£4
Congestion Charging Alone					
% Reduction in Vehicle-km Central*	-	-8	-22	-8	-20
Inner	-	-1	-3	-3	-9
Outer	-	-1	-1	-1	-3
Benefits to travellers †, £ million per annum	-	109	159	167	278
Net increase in annual government revenues ‡, £ million	-	140	420	265	770
Net overall annual benefits ††, £ million	-	25-50	55-75	5-45	60-100
% Change in CO Emissions in Charged Area	-	-20	-47	-9	-20
% Change in CO ₂ Emissions in Charged Area	-	-8	-21	-4	-11
Public Transport Infrastructure and Service Improvements					
%Reduction in Vehicle-km Central	-4	-12	-30	-12	-28
Inner	-5	-7	-9	-9	-11
Outer	-5	-6	-6	-6	-7
Benefits to travellers †, £ million per annum	939	1014	1047	1078	1097
% Change in CO Emissions in Charged Area	-	-31	-58	-19	-25
% Change in CO ₂ Emissions in Charged Area	-	-12	-26	-9	-12

* Central London is the zone within the Inner Ring Road
 Inner London is the zone within the North and South Circular Roads
 Outer London is the zone within the M25 motorway

† Mainly reduced congestion effects.

‡ Includes congestion charge revenues, parking fees, and public transport revenues.

†† Net benefits to travellers (including disbenefit of paying charge) plus government revenues, minus cost of implementation. Ranges allow for different types of charge collection technology.

Note: £1 = US\$ 1.53 in 1994

MVA finds that the overall economic benefits from congestion charges increase as the charges increase to a certain level (near the high levels shown in the table) and then decrease as the distortion in travel patterns induced by marginal increases in the charge causes costs that outweigh the benefits from further reduction in congestion.

United States: LUTRAQ study in Portland, Oregon

Portland, Oregon is world famous as a city that has embraced integrated land-use and transport system planning as an approach to address its citizens’ needs for accessibility and quality of life (ECMT/OECD, 1995; Michaelis *et al.*, 1996; EC, 1996a). For the United States, Portland’s LUTRAQ project (*Making the Land Use, Transportation, Air Quality Connection*) is a national demonstration project (CSI&PBQD, 1996). It takes the case of a proposed bypass around the Portland region to develop methods for evaluating alternative suburban land-use patterns and design standards, and for evaluating their impacts on:

- car dependency

- mobility
- air quality
- energy consumption, and
- greenhouse gas emissions.

One aspect of this work is the research and model development described above (see Section 1.3 on *The Pedestrian Environment*).

Five main alternative strategies are considered in the study:

No Build. This is the base case of present conditions and travel projections.

Highways Only. This “supply side” solution involves increasing road capacity to meet demand.

Highway/Parking Pricing. In this alternative the “Highways Only” approach is combined with parking pricing, subsidies for transit passes for commuters, and implementing demand-responsive transit systems including dial-a-ride, shared ride and shuttle services.

The LUTRAQ Alternative. This alternative involves changing planning procedures in the region. New development is mainly located in new “transit-oriented developments”, with new jobs, shops and homes are clustered near transit lines. The alternative includes transit improvements, parking pricing and transit pass programmes as in the Highway/Parking Pricing alternative. It also includes measures to improve pedestrian and cyclist access, and some roadway improvements.

The LUTRAQ/Congestion Pricing Alternative. This option combines the LUTRAQ alternative with a \$0.15 per mile charge for commuter trips. It also includes more provision for pedestrians, and additional growth in transit oriented developments.

The characteristics and some of the modelling results for the five main alternatives are summarised in Table 12 on the following page.

Local Transport Initiatives: Implementation Case Studies

United Kingdom: “All Change!” in Central Region, Scotland

In 1991, the Council of Central Region in Scotland undertook a review of its transport policy (Macaulay *et al.*, 1993) in which public consultation played a central role. The review involved several steps of public consultation to identify priorities, analysis of policy options against those objectives, presentation of the results to the public to obtain feedback, and modification of the options being considered followed by new analysis and public presentation. Independent consultants from outside the region were hired to carry out the analysis and consultation process.

The consultants identified a number of transport policy goals, and a longer list of objectives in achieving those goals, which were first discussed with community groups in workshops throughout the region. Seven goals were identified which included, for example, the need for improved transport links with

adjacent regions; provision of good access to town centres; improved road safety; meeting the transport needs of disadvantaged groups. Seventeen objectives towards meeting these goals included, *inter alia*: maintaining road standards; improving lighting for footpaths; and implementing traffic calming measures.

Turnout at the workshops was poor, so the exercise was repeated by means of a postal questionnaire sent to 1 000 people throughout the region. About one third replied. The workshop and questionnaire results were consistent, placing high priority on maintaining services, including buses, and low priority on environmental improvements, rail services, and facilities for bicycles.

Table 11. The LUTRAQ Alternative: Assumptions and Results

	No Build	Highways Only	Highways/ Parking Pricing	LUTRAQ	LUTRAQ/ Congestion Pricing
Land Use	Existing plans	Existing plans	Existing plans	Transit-oriented	As LUTRAQ
Transit	Existing plan for LRT	As "No Build" + additional LRT and express buses	"Highways Only" + demand-responsive transit	"Highways/Parking Pricing" + additional LRT, express buses	As LUTRAQ
Roads	Only existing fully funded projects	Some additional roads including bypass	As "Highways Only"	Selected improvements, no bypass	As LUTRAQ
Walk/Bike Facilities	Existing	Existing	Existing	Existing + improvements in transit oriented developments and LRT corridors	As LUTRAQ + improvements in bus corridors
Demand Management	None	None	Parking charges/ transit passes for workers	As "Highways/Parking Pricing"	As LUTRAQ
Road Pricing	None	None	None	None	Peak period charge of \$0.15/mile for work trips
Car ownership per household in 2010	1.91	1.9	1.9	1.82	1.79
Trips/household-day	7.53	7.5	7.29	7.17	7.07
Trip shares (%): Walk/Bike	3.8	3.7	3.7	4.3	4.7
Car	89.1	89	87.7	86	84.8
Transit	7	7.3	8.6	9.7	10.5
Vehicle miles travelled change	Base	+1.6%	-0.4%	-6.4%	-13.2%
CO ₂ (kt)	4.81	4.89	4.80	4.51	4.18

Four transport scenarios were developed for the region, with policies evaluated against the various goals and objectives. The scenarios were: 1.) minimise spending; 2.) continue road building; 3.) promote public transport, and 4.) improve the environment. These were developed into a public exhibition showing how the four strategies would affect the daily life of a family. This was shown in shopping centres, around the region, with staff on hand to discuss the display with shoppers, and handouts including a response form.

A series of workshops was also held, with much better turnout than the first series. Participants worked in small groups to decide on priorities among the four directions.

Findings from the workshops and exhibitions were consistent, indicating that the first priority in the transport strategy should be to improve public transport, and the second to improve the environment. This difference in prioritisation appeared to result from differences in perception of what “the environment” meant. In the first review, “environmental goals” were understood as implying landscape improvements, whereas in the second, they were seen as implying improved quality of life. Building of roads was given low priority — most people felt that the growth of traffic should not be allowed to continue. Minimising spending was not seen as a serious option, as people thought that there were problems to be solved and reducing spending would not help.

A transport strategy, “All Change!”, was developed by the consultants, which would implement the priorities identified in the consultation process. This involved a shift in expenditure from 90 per cent on roads to only 33 per cent, with 18 per cent on pedestrian facilities, 13 per cent on traffic calming, 12 per cent on buses, 9 per cent on rail and 4 per cent on cycling and parking. A press conference was used to launch a further public consultation process. Documents describing the proposed strategy were widely distributed and several presentations and public meetings took place to obtain reactions. At the public meetings, the audiences were split into groups of no more than six people, who were given a number of questions to discuss. The groups were presented with the proposed spending breakdown and asked to make their own proposals. They were also asked several further questions about their priorities in the transport sector.

The questionnaire results indicated a need for a slight adjustment in the spending split. They indicated strong support for the consultation process and for the changes in priority it had indicated were needed.

Central Regional Council adopted the All Change! strategy.

Macaulay *et al.* place particular stress on the role of the three-phase public consultation exercise in achieving the successful outcome of the All Change! process.

Norway: The Trondheim Toll Ring

Although cordon charge schemes have been evaluated in many cities, the only actual experience with such schemes in Annex I countries is in three Norwegian cities, Bergen, Oslo and Trondheim. Of the three schemes, that in Trondheim is the most sophisticated and has been the subject of most research. This report draws on papers by Meland (1994) and Langmyhr and Sager (1997) to consider the effects of the toll ring and the political and planning process behind its implementation.

The Trondheim toll ring was initiated in 1985, during the preparation of a new transportation plan for Trondheim, involving the County Roads Office as well as national and local politicians. Traffic congestion was a major concern at the time, and the City Council asked for a study into the feasibility of raising local funds for road construction, with the intention of attracting complementary funds from the national government. Two years of public debate followed, along with negotiations with the national authorities and studies of various charging systems and possible uses of the revenues. Three fund-raising options were considered — a toll ring, fuel taxes and a licence fee. However, it was found that only a toll ring could be introduced without legislative dispensation from the national government.

The scheme received broad political support, partly because the national government agreed to provide 40 per cent of the funding for the infrastructure projects for which the user fees were intended. The County Roads Office also provided strong support. 75 out of 85 city council members voted to proceed with the project in 1987.

By the time the toll ring was implemented in 1991, the locus of support had shifted somewhat from the road-building and mobility lobby towards the environmental lobby. This was a result partly of the emergence of the environment as a key political issue in the late 1980s, partly of a downturn in traffic because of economic recession, and partly of a shift in the balance of power in the City Council. In 1990, the City Council, in its proposal for the fee structure for the toll, stated the objectives of the ring as: fund-raising to improve the transport system; traffic demand management (influencing mode choice and trip timing); and the avoidance of adverse secondary effects. These objectives were to be addressed through the use of a charge that varied by time of day (peak, non-peak, and zero charge). The sale of monthly or other passes was ruled out, as these would remove the variable cost aspect of the fees for those making frequent trips. Langmyhr and Sager (1997) note that the application of user fees with the aim of demand management is not sanctioned by Norwegian road law, which allows only for fees to raise funds for infrastructure investment. Official support for the Trondheim scheme rested on the rationale that peak traffic determines new infrastructure needs.

Automatic electronic charging was adopted using technology developed by a local company. Payment options include manual and automatic pay stations taking cash or magnetic strip cards carrying various levels of credit. Drivers can also obtain (at no charge) passive in-car transponders (electronic tags) which are detected by beacons at the charge points resulting in the users being debited in a central accounting system. Tag users can either pay either in advance or by direct debit from their bank accounts.

Table 12. Charge Structure for Trondheim Toll Ring

Method of payment	Toll Period (Mondays to Fridays)	
	06h00-10h00	10h00-17h00
Manual (cash)	10	10
Subscription: prepaid NOK 500	8	6
NOK 2500	7	5
NOK 5000	6	4
Direct debit	8	6

Notes: Charges apply to vehicles under 3.5 tonnes. Heavier vehicles pay double. Subscribers pay for no more than one crossing in any one hour, and only for first 75 crossings of the cordon per month. Multiple car households are allowed two transponders on one subscription.

In 1992, 1 NOK = US\$0.161.

Following implementation of the scheme, the City Council proposed that the revenues should be used mainly for “green modes” in the short term, with the original road-building plans postponed. An investment plan was agreed in 1995, combining some new construction with environmentally-oriented investment. Langmyhr and Sager (1997) describe how the shifting political climate influenced the nature of the compromises that were necessary within the City Council, and among the City Council, the County Roads Office and the national authorities. They note in particular that the original proposal for the scheme was accepted by all involved partly because its objectives were fairly vague. Later in the process political support diminished.

Most aspects of the scheme (apart from the actual location of the cordon) were actively debated in public. The majority of citizens had originally been against the scheme according to surveys, although public meetings had been influenced by “expert assessments” indicating that growing traffic and congestion demanded radical action. Public opinion changed after implementation of the scheme, with only about a quarter opposing it.

The effects of the ring on overall traffic and hence greenhouse gas are somewhat ambiguous, although peak traffic has certainly been reduced. Meland (1994) describes travel surveys carried out a year before

(1990) and a year after (1992) charges were introduced, along with the results of weekly traffic counts. Peak traffic was 10 per cent lower in 1992 than in 1990, although traffic during the zero charge period was 8 per cent higher. Meanwhile, traffic outside the ring increased during peak periods. Thus, traffic was clearly shifted in both time and space. Meland (1994) estimates the effect of the toll ring on traffic crossing at one access point: immediately after the toll ring was opened, it caused a traffic reduction of around 11.6 per cent relative to the trend, but in the longer term, this reduction was in the range 6-9 per cent. Travel survey results are not entirely consistent with this finding, indicating a 4.4 per cent reduction in trips inbound across the ring between 1990 and 1992, but a 12.2 per cent reduction in trips overall. Overall in the Trondheim region, public transport trips increased by a statistically significant 8.4 per cent, while car driver trips decreased by 5.6 per cent.

Although opponents had argued before the scheme was implemented that it would damage city centre business, this argument was rare following implementation. Shops did not in fact lose business, although this is partly because they adjusted to the ring by extending their opening hours into the toll free period after 5 p.m. This appears to have led to significant changes in shopping patterns, and, in particular, has allowed workers to make more shopping trips during the week than before the ring was established.

Singapore: The Area Licensing Scheme¹²

Singapore is a small island state with 2.8 million people in an area of 633 km² (44/ha). Since the early 1970s, it has adopted a variety of measures to control the traffic problems associated with high population density and rapid economic growth:

- Computerised traffic signal systems have been widely implemented in the central business district (CBD).
- The Area Licensing Scheme (ALS), a cordon charge scheme introduced in 1975, aimed at reducing morning peak traffic in the CBD. Drivers were required to purchase windscreen stickers which were checked on entering the ALS zone. The program immediately reduced the number of vehicles entering the zone during the morning peak and shifted many people's morning commute habits. The success of the scheme led to its extension to include evening peak hours from 1989, and then to the whole day from 1994. In 1996, an electronic road pricing system replaced the ALS.
- The Weekend Car Scheme was introduced in 1991. Owners of cars registered under the scheme can normally drive only at weekends, and receive a rebate on vehicle registration fees and import duty. They can purchase day licenses to operate their cars during the week, in peak or off-peak hours.
- Fiscal measures, including high import duty, vehicle registration fees and annual road tax have been implemented to discourage car ownership. In 1994, import duty and registration fees amounted to 195 per cent of car import values.
- The Vehicle Quota System was introduced in 1990, limiting new registrations of cars and other vehicles. New vehicle buyers have to bid for quota allocations in a monthly public auction

¹² This section is reproduced from Michaelis *et al.* (1996).

- Road tax increases with engine capacity, encouraging the purchase of small, energy efficient cars.
- Fuel tax is approximately 40 US cents/litre.
- Public transport is of high quality, with buses providing a 20km/h average service. there is a 67km mass rapid transit system with more than half of Singapore’s homes and work locations within 1 km of the route.
- The road network has been upgraded and the capacity expanded constantly to provide more efficient transport links and maximise the effectiveness of the road system.
- Settlement planning is systematic, with co-location of homes, shops, schools, recreational facilities, factories and offices in each of 17 new towns or housing estates.

The result of this combination of measures on traffic and energy use has been estimated by Ang (1992) and is summarised below:

Table 13. Estimated 1990 Fuel Consumption in Singapore Without Car Constraint Policies

	Gasoline	Diesel	CO ₂ Emissions
	million litres		million tonnes
Actual consumption/CO₂ emissions	741	465	3.0
<u>Impact of not having policy:</u>			
Passenger traffic increase	+153		
Modal shift	+218	-84	
Shift to larger cars	+52		
Traffic congestion	+122	+77	
Consumption/emissions without policy	1286	458	4.3
Estimated impact of policy on consumption/emissions	-42%	+2%	-30%

Sources, Ang, 1992,1993. CO₂ emissions estimated by OECD.

Community and Business Initiatives:

*Global Action Plan*¹³

“Global Action Plan for the Earth” (GAP) is an international environmental organisation that distributes the EcoTeam Program. GAP has set environmental goals for 2000 and translated these into quantitative goals at a household level. These are: 65 per cent reduction in production of household waste; 30 per cent reduction in consumption of electricity, natural gas and water; 40 per cent reduction in transport energy use. GAP starts from the assumption that many people have attitudes consistent with moving towards environmentally sustainable behaviour, but that they do not have sufficient information to do so, nor do they believe that they alone can make a difference.

The EcoTeam approach provides three essential elements that provide the environment for individuals to change their behaviour:

13. The Global Action Plan is based on a report by Staats and Harland (1995).

A peer group or community, in the form of the EcoTeam. These are groups of 6 to 10 people who might be neighbours, members of the same church, or members of some interest group or club. They meet once a month and discuss ideas, experiences and achievements related to the EcoTeam programme. The programme is based on a workbook which addresses six areas in turn: waste, gas, electricity, water, transport and consumption. The programme takes a total of eight months. Each team is supported by a coach or by a reporting centre.

Information is provided to each EcoTeam member via a Workbook and a logbook in which Team results are recorded. The Workbook explains each theme, the goals of GAP, and a number of actions that can be taken by households to reach those goals.

EcoTeam members work towards becoming “global citizens” by changing aspects of household behaviour. The emphasis is on the household rather than the individual, so that EcoTeam members work with other household members to change behaviour in areas such as waste separation and recycling, water use, energy use, and transport.

GAP has set up EcoTeams in several countries and has developed Workbooks and support material for different countries. While GAP monitors the results of its programme, the most detailed evaluation has been carried out in the Netherlands.

European business initiatives for a greening of freight transport

The European Federation for Transport and Environment has carried out a project reviewing initiatives by businesses seeking environmentally cleaner freight services. The final report (Holman, 1996) includes examples from the United Kingdom, Sweden, Norway, Germany and the Netherlands. Three types of measure are identified by the report:

- those aiming to reduce the amount of freight transport;
- those aiming to switch freight transport to more environmentally friendly modes such as rail and water;
- those aiming to reduce emissions and noise from each mode.

Holman suggests that a prerequisite for environmental management by business is for a company’s Board to put care for the environment high on its agenda. Only in this case will the rest of the organisation give environment the attention it deserves. Regular environmental audits are needed to assess the firm’s impact on the environment, to enable appropriate targets for improvement to be set, and to monitor whether those targets are being met. It is also important for firms’ environmental management systems to be integrated with their other management systems. Several environmental management standards are being developed in the ISO series 14000, operating on similar principles to the ISO 9000 series of quality standards.

One example of a company that has placed the environment high on its agenda is the Swedish company, Bilspedition Transport and Logistics (BTL), which has developed a company policy designed to “contribute to a sustainable development by offering and developing efficient transport with the least possible effect on the environment”. BTL’s strategy includes: developing staff training and awareness; influencing and working with other companies, authorities and organisations; improving utilisation of

resources; supporting and participating in research and development on fuel, transport technology and logistics; and viewing environmental measures as long-term investments.

Several companies have environmental targets:

- The Swedish retailer ICA has specific targets for reductions in emissions of local air pollutants by 2000
- The German mail order company Otto-Versand aims to reduce its transport CO₂ emissions by 30 per cent during 1994-2005, through a number of operational targets.
- The German rail company Deutsche Bahn aims to reduce the primary energy consumption of its motive power units by 25 per cent between 1990 and 2005.

There are also examples of companies that have imposed conditions on their suppliers and contractors:

- In the future, ICA aims to buy transport services only from companies with an environmental management system.
- IKEA intends to use only companies that meet ISO 14001 requirements from 1997.

Holman also cites examples of company policies that reduce the amount of freight moved. One approach adopted by many retailers is to discriminate in favour of local produce. This may not be primarily motivated by environmental concerns, but can contribute to a range of local environmental, social and economic objectives.

A range of measures aimed at improving the efficiency of production and transportation can also help to reduce the total amount of freight traffic. For example:

- one Scottish brewery (Scottish Courage) has introduced a computerised distribution system, reducing vehicle kilometrage by 8 per cent and increasing vehicle load factor by 11 per cent. Holman also gives several examples of on-board computer and tracking systems that allow improvements in vehicle utilisation.
- the Norwegian wholesaler Joh. Johansen has increased its freight efficiency by 20 per cent, by co-ordinating its operations so that stores in a particular region receive deliveries on the same day.
- consolidation of delivery systems (such as the introduction of hub-and-spoke systems) is claimed to reduce CO₂ emissions by as much as 20 per cent: Holman provides several specific examples of retailers that have introduced such systems. Encouragement of return loading can also substantially increase vehicle load factors and reduce traffic.

While road transport has higher greenhouse gas emissions per tonne-km than other surface freight transport modes, this is not generally a major consideration for companies which place a higher premium on flexibility, speed, reliability, security, price and accessibility. Nevertheless, transport by train and ship have a role to play:

- the British supermarket chain, J. Sainsbury, uses rail transport for regular consignments from southern Europe, although unexpected fluctuations in demand are met by road transport which is more flexible
- a number of companies, including Audi, Bosch and Ford, have set targets to increase their use of rail and water transport.

Other business initiatives reviewed by Holman include efforts to introduce new vehicle technology with lower environmental impacts, collaborative efforts among companies such as the European Auto-Oil programme, and the development by companies of new analytical tools, such as life-cycle analysis.

National and International Policies to Encourage and Support Local Initiatives

United States: ISTEA

The United States Inter-modal Surface Transportation Efficiency Act of 1991 (ISTEA, pronounced like “iced tea” by Americans in the know) is perhaps one of the largest initiatives underway at present with the aim of introducing stakeholder participation to a policy process. It is not possible to do justice in the current draft to the literature that this process has generated but a brief summary follows based on FHWA/FTA (undated).

ISTEA essentially requires Metropolitan Planning Organisations (MPOs) to alter their planning processes to improve co-ordination among authorities, develop procedures for community involvement in decision making, explicitly address a range of objectives including environmental objectives, and to develop long term transportation plans.

The planning process introduced by ISTEA should lead to the production by each MPO of a long term Transportation Plan (TP) covering 20 years, and a short term Transportation Improvement Program (TIP) covering three years. In producing these plans MPOs are expected to undertake:

1. a proactive and inclusive **public involvement process**;
2. consideration of **16 specific planning factors** to ensure that the planning process reflects a variety of issues and considers other concerns such as land-use planning, energy conservation, and environmental management;
3. **major investment studies** to address significant transportation problems in a corridor or sub-area which might involve use of Federal funds;
4. development and implementation of **management systems** including:
 - inter-modal management system
 - congestion management system
 - public transit facilities management system
 - pavement management system
 - bridge management system
 - safety management system
5. development of **financial plans** for implementing the transportation plan and TIP; and

6. assurance that **the transportation plan and TIP conform** to the State Implementation Plan (SIP) pursuant to the standards of the CAAA.

The ISTEA requirements are currently in the process of being implemented by States and MPOs. Lyons (1994) provides an early review of implementation. He finds considerable variation among MPOs. For example, the Twin Cities (Minneapolis/St Paul, Minnesota) MPO and Portland, Oregon MPO have successfully undertaken consultation processes to develop plans consistent with ISTEA and CAAA requirements. In other cities, the process did not work so well because divisions of responsibility between MPOs and States made it harder for MPOs to act as co-ordinators. Some MPOs, especially those with severe air quality problems, are having difficulty reconciling their CAAA commitments with other objectives, including their financial means.

While the quality of ISTEA implementation may be variable among MPOs, the Act has led to funding of a wide range of new initiatives:

- cycle and pedestrian programmes in numerous cities
- congestion pricing projects in Seattle and at the Maine Turnpike, as well as an educational project on congestion pricing in Portland, Oregon and a toll on the San Francisco-Oakland Bay bridge
- innovative transit projects including a segregated busway in Miami, an information system for Denver’s bus system, an alternative fuel bus fleet in Boise, Idaho, and electric shuttle buses in Chattanooga, Tennessee.
- intermodal freight and transit projects including intermodal freight terminals in Maine and Stark County, and an intermodal passenger terminal in Worcester, Massachusetts.

Minor modifications were made to the Act in 1995, and ISTEA is being further reassessed in preparation for reauthorization in 1997. greenhouse gas impacts of ISTEA are currently being assessed by the federal government as part of the preparation for reauthorization.

United States: The Travel Model Improvement Program (TMIP)

One activity being carried out to support implementation of CAAA and ISTEA is the US Travel Model Improvement Program (TMIP), which was initiated in 1992. The programme has as its main goal “fundamentally revolutionising the state of the practice in transportation modelling” (Wachs, 1996).

TMIP has four tracks (Shunk, 1996):

- A) Outreach. This aspect of the programme aims to help practitioners improve their policy assessment methods through training, technical assistance, research co-ordination, and providing a clearinghouse for research findings.
- B) Near Term Improvements. This track involves supporting local and state transportation departments to implement and improve on state-of-the-art modelling techniques that are not yet widely practised.
- C) Long Term Improvements. Fundamentally new approaches to transport modelling are being considered in this track.

- D) Data Collection. This element of the programme focuses on identifying, designing and developing improved data collection procedures.

A review panel provides programme guidance. This panel is made up of experts from a range of organisations, including state and metropolitan transportation departments, environmental regulators, universities and environmental non-governmental organisations. The panel has made a range of recommendations for the transport planning process and the use of models in that process. Key issues in these recommendations are the need to improve understanding of human behaviour, communities, technology, land-use, environmental impacts and the role of policy in affecting all of these.

Work has been under way on the programme since 1992. The four tracks are being pursued by separate contractors. Track A and B are well underway. Track C is being developed, and a number of preliminary studies have been published indicating possible directions of model development (Spear, 1996). Track D has just started.

European Union: The Citizens' Network

In July 1996, the European Commission published a Green Paper entitled *The Citizens' Network* (EC, 1996a). This report identifies current and potential actions by the Commission to help improve provision for relatively environmentally friendly modes of transport, including public transport, non-motorised transport and motorised two-wheelers.

The Green Paper reviews a number of actions being taken to promote the use of public and non-motorised transport by European Union (EU) Member states, and by regional and local governments and transport service providers.

The Commission already provides support for innovation in transport through a large number of programmes, including:

- the DRIVE programme on telecommunication and information technology for use in transport (telematics);
- co-financing for the POLIS network of cities interested in the use of transport telematics to address transport problems;
- the European COST programme, which has supported studies on propulsion systems, alternative fuels, energy use, demand for interregional transport, low-floor buses, urban goods transport, and the complementarity between high speed rail and air transport;
- elements of the THERMIE energy technology research programme that relate to transport technologies such as fuel cells and alternative fuels;
- elements of the SAVE programme for promoting energy efficiency and conservation, which has included pilot projects to improve the energy efficiency of urban goods and passenger vehicles, and will contribute to the creation of energy agencies in regions and cities.

It also identifies a number of actions that can be taken at EU level. These include:

- supporting information networks for groups of transport providers and users

- setting environmental and other targets for the transport sector
- developing criteria for land-use planning
- establishing criteria for transport system quality ratings
- consolidating existing databases on research and development as well as practices and experiences in the EU and elsewhere
- providing awards for innovative practices in transport operation or planning
- building consensus through a “Citizens’ Network Forum”
- co-ordinating the research activities of the Commission, Member countries and industry to maximise the benefits of research and development and improve transparency for the public
- bringing together transport users and providers to assess needs, priorities and actions in research, development, demonstration and dissemination of inter-modal technologies and infrastructure approaches
- providing planning, implementation and financial support for “first of a kind” projects
- establishing the regulatory framework for transport service provision
- establishing standards for access for people with reduced mobility
- establishing standards for transport equipment, vehicles and fuels
- setting limits for air pollution and noise levels

European Sustainable Cities: Good Practice Guide

The European Commission’s Expert Group on the Urban Environment put together a Policy Report and a “Good Practice Guide” to initiatives in European cities (EC, 1996c), as part of the Sustainable Cities project which ran from 1993-1995. The guide is now accessible on the Internet at <http://cities21.com/europractice>. This guide includes:

Examples of general travel management policy:

- Copenhagen, Denmark, where the municipal authority has made particular efforts to increase the cycle network while reducing parking space. The road capacity has been kept almost constant since 1970, with an emphasis on traffic management rather than road provision. The prioritisation of modes — first non-motorised, second buses — differs from that in many other capital cities, where the most supported transport mode is the metro system.
- Zurich, Switzerland, where the city, canton and state authorities have worked to improve tram and rail service provision while encouraging intermodality through park-and-ride facilities and co-ordination among transport operators. Road construction and parking supply is strictly limited.

Zurich has achieved a shift in modal split from cars to public transport during the period 1984-1992.

- Gröningen, the Netherlands, where the city authorities have followed an integrated travel management and urban planning policy aimed at privileging the use of “green modes”. Provision of facilities for non-motorised transport and restrictions on driving have led to a modal split within the city of 48 per cent by bicycle, 17 per cent pedestrian, 30 per cent car and 5 per cent public transport.

Examples of specific policies:

- the toll ring in Oslo, Norway, which has achieved 5-10 per cent reduction in traffic through the toll stations;
- the development of an intermodal link between trams and the railway in Karlsruhe, Germany, allowing trams to use the main railway line. This has increased the public transport share of total trips from about 5-7 per cent to 35-45 per cent;
- development of the pedestrian network in Perugia, Italy, with the development of a city-centre pedestrian zone, controlled traffic zones with residents-only access, and a number of mechanised pedestrian walkways. 80 per cent of trips to the city centre are made on foot;
- car sharing in Berlin, where a network (Stattauto) set up in 1988 now has 1300 members, who have access to a fleet of 80 vehicles. Stattauto is a key organisation in a wider European Car Sharing network in Germany, Austria and Switzerland. Car sharing is a means by which people can have reliable and cheap access to a car without having to own one — although without policies to reduce car ownership and use, it may lead to an increase in car access and be a first step to car dependency;
- the Bremen model (see also Enquete Commission, 1995), in a research project in Germany, six families with children volunteered to live without a car for four weeks and to keep daily diaries on the experience gained with alternative transport modes but to travel by public and non-motorised transport. Following the experiment, five of the families decided that they no longer needed their car. Inspired by this outcome, the city of Bremen is establishing a new development of 300 dwelling units in Hollerland, about 7km from the city centre, where inhabitants will not own cars. The development will have a limited number of parking spaces (about 30) and those wishing to use a car will have to participate in car-sharing schemes.

Norway: TP10

TP10, the Norwegian Integrated Land-Use and Transport Planning Scheme, was launched in 1989 in response to concern about the environmental effects of traffic in Norway’s cities (Stenstadvold, 1995). The scheme was a joint initiative of the Ministry of Environment, the Ministry of Transportation and the National Public Roads Administration. The ten largest Norwegian cities were asked to participate. TP10 had several goals including:

- environmental goals were to be a premise rather than a consequence of planning;
- land-use and transport policies were to be co-ordinated;

- increased attention to public transport;
- clarification of measures to reduce the increase in car use;
- development of scenarios for alternative transport systems;
- co-ordination of different measures within a common budget framework.

The central authorities laid a framework for the planning process by issuing guidelines intended to bring together all parties interested in transport and land-use policies, including local politicians, regional Public Roads Administration representatives, public transport authorities, the state environmental agency, public health and social welfare organisations, and NGOs. The central government emphasised that planning should be a local effort, and so restricted their own role to providing information and funding.

The guidelines imposed some limits on the planning process, including the need to co-ordinate actors in the sector, the timing of the planning process (to be completed by 1991) and the need to include long-term policy recommendations. Plans were to be based on the development of three scenarios: Trend, Public Transport, and Environment.

Stenstadvold (1995) describes a number of areas where the process did not achieve its objectives:

- The guidelines were interpreted “flexibly” by local actors;
- Environmental goals defined by the central government were redefined to suit local needs: plans concentrated in local environmental priorities and ignored global problems;
- The intended level of co-ordination was not achieved. Conflicts between goals were often ignored, and contentious problems sometimes defined as being outside the scope of the plan. Road construction programmes predating the plan were perceived as unchangeable in the light of the consultation process;
- Participation and public involvement was poor, with planning dominated by professionals from the Public Roads Administration and the municipal planning organisations;
- Most regions had difficulty keeping to the time limit, so that the best developed parts of the plans were those that were familiar to the local planners;
- Budgetary constraints were ignored.

Most of the resulting plans involved major road investments, while environmental and public transport measures were referred to in a more general manner. Plans for environmental projects were seldom developed in detail, and often made contingent on unrealistic budget levels. The resulting plans were very similar to traditional road plans but with a longer planning horizon. They were mainly used by local authorities as a means of positioning themselves in relation to the national budget for road building.

Stenstadvold describes several reasons for the failure of this scheme to achieve its objectives. The planning process was implemented by professionals from the existing administrations in the cities — these people’s primary loyalties were to their administrations and their long-standing goals. The Public Roads Administration representatives dominated the process because of their long-standing experience with transport planning and well-developed positions. New participants in the planning process did not have time, resources or expertise to counter the road administration resources. Stenstadvold identifies a fundamental clash of objectives between the TP10 objectives and those of the Public Roads Administration.

Solutions proposed by Stenstadvold essentially involve an institutional reform to shift the balance of power between road planning authorities, public transport authorities, and local politicians.

Germany: research into environmental traffic management

In 1980, three German federal ministries (Town Planning, Transport, and Interior — now “Environment”) and their research institutes agreed to carry out a joint research and demonstration programme on large scale environmental traffic management strategies. These strategies were aimed at:

- traffic safety
- non-motorised mobility
- neighbourhood development
- local environmental improvement

The programme was unusual in 1) including arterial routes in the experimental strategies; 2) paying particular attention to developing non-motorised transport and 3) aiming for cost-effectiveness through the use of a small number of simple measures.

Over 200 towns wished to participate and 100 submitted detailed applications, of which six were selected covering a wide range of sizes and characteristics: Berlin, Borgentreich, Buxtehude, Esslingen, Ingolstadt and Mainz. Döldissen and Draeger (1990) report on the project in Buxtehude.

In Buxtehude, the main emphasis was on establishing a complete cycle network and improving safety and priority for pedestrians and cyclists. Measures include: the establishment of pedestrian-only and pedestrian/cycle routes; providing cycle routes against the traffic flow in one-way streets; designing streets and junctions, in particular, to protect and give priority to cyclists; and the use of traffic calming techniques to reduce traffic speed.

Public relations was an integral part of the project in Buxtehude. Several public meetings were held, articles were published in the local newspapers and leaflets were produced explaining the new measures.

Döldissen and Draeger were able to report only a few results of the effects of the measures in Buxtehude. As a result of the measures, cycle traffic increased by about 40 per cent from a previous 16 per cent of trips. While cycle accidents have increased by 32 per cent, accidents involving pedestrians have decreased by 46 per cent.

APPENDIX B. ALTERNATIVE FUELS AND VEHICLES

Alternative fuels and electric vehicles have so far been used mainly by those with a particular interest in their demonstration (e.g. electric and gas utilities) or as a result of local or national policies that make the fuels cost-competitive for users. Such policies are usually motivated by concerns other than greenhouse gas mitigation, including the need to improve urban air quality, a perceived need to improve energy security, and other local objectives, such as maintaining employment in agriculture or manufacturing industry.

Potential greenhouse gas Mitigation through Alternative Fuel Use

Table 14 shows information from a review of the literature (Michaelis *et al.*, 1996) on life-cycle greenhouse gas emissions and costs of alternative fuel and electric vehicles.

The Role of Business

Most technological innovation is the result of business initiatives. The following sections briefly outline just two of many areas where manufacturing companies are involved in developing and commercialising new technology.

The gasoline direct injection engine

The Working Paper No. 1 study on *CO₂ Emissions from Road Vehicles* in this series on *Policies and Measures for Common Action under the UNFCCC* evaluated a range of measures that might encourage energy efficiency improvements in vehicles. The study drew on a range of literature estimating the cost and possible effectiveness of a range of technologies to reduce vehicle energy intensity. Comments on the study from car manufacturers and some governments suggested that the technologies mentioned in the study, and estimated to offer a potential of 5-25 per cent energy savings through cost-effective energy efficiency improvements, would not really be cost-effective.

Since that study was completed, two Japanese car and engine manufacturers — Toyota and Mitsubishi — have announced plans to commercialise a new technology: the gasoline direct injection (GDI) engine. This technology has been under development in many countries by engine manufacturers but was described in the Working Paper No. 1 study as being “far from commercialisation”. It is not included in the assessments reviewed by the study on cost-effectiveness of energy efficiency improvements.

The GDI engine uses high pressure fuel injection to introduce fuel directly into the engine cylinder, forming a “stratified charge” under normal operating conditions. This means that the fuel-air mix varies throughout the cylinder, whereas normally in a gasoline engine the aim is to produce a homogeneous mixture. In the GDI engine, the mixture is fuel-rich near the spark plug, but lean elsewhere. A rich mixture is needed for ignition to occur, but by having a stratified charge, a very high ratio of air to fuel in the cylinder can be achieved. This, along with some other features of GDI operation, makes the engine very efficient. The Toyota engine also uses variable valve timing — a technology that was included in the

Table 14. Life-cycle Greenhouse-Gas Emissions and Costs for Alternative Fuel and Electric Cars

Fuel	Greenhouse-gas emissions in g/km CO ₂ equivalent: average driving cycle. GWPs are for 100 year time horizon: CH ₄ , 26; N ₂ O, 70; CO, 3; VOC, 11; NO _x , 0. These differ from the latest IPCC values (IPCC, 1995) but the effect on total life-cycle emission estimates is negligible.				Pre-tax costs. Based on Renault Clio 1.4 litre. 13 800 km per year. 10 year life. 10 per cent d.r. ^b			
	Vehicle manufacturer ^c	Fuel supply ^d	Operation ^e	Total	Vehicle cost (\$)	Fuel cost (\$/litre gasoline equiv.)	Fuel use for cost calculation (L/100 km)	Cost in excess of gasoline vehicle at 29US¢/km (US¢/km)
Gasoline	25-27	15-48	182-207	222-282	15 168	0.26	7.6	0.00
Reformulated Gasoline	25-27	17-63	180-193	222-283	15 168	0.28-0.30	7.6	0.18 - 0.32
Diesel	27-29	7-35	139-202	173-266	15 168 - 17 443	0.26 - 0.26	6.08	-0.35 - 3.64
Liquefied Petroleum Gases (LPG)	26-28	7-20	147-155	180-203	16 083 - 15 384	0.19 - 0.26	7.27	-0.55 - 1.02
Compressed Natural Gas (CNG)	29-31	5-68	130-154	164-253	16 083 15 600	0.18 - 0.24	7.27	-0.28 - 0.90
Methanol from Coal	25-27	250	149	424-426	16 128 - 15 168	0.25 - 0.35	7	-0.72 - 1.45
Methanol from NG	25-27	76	149	250-252	16 128 - 15 168	0.25 - 0.35	7	-0.72 - 1.45
Methanol from Wood	25-27	25-38	15-16	65-81	16 128 - 15 168	0.68 - 0.82	7	2.30 - 4.79
Ethanol from Sugar Cane	25-27	30-80	15-16	70-123	16 128 - 15 168	0.35 - 0.38	7	-0.17 - 1.89
Ethanol from Corn	25-27	50-220	15-16	90-263	16 128 - 15 168	0.94 - 1.03	7	4.61 - 6.74
Ethanol from Wood	25-27	25-38	15-16	65-81	16 128 - 15 168	0.68 - 0.82	7	2.79 - 5.27
Liquid Hydrogen ICEV	26-28	0-48	3-12	29-88	19 968 - 18 048	0.38 - 1.44	6.5	4.10 - 13.97
Liquid Hydrogen FCEV	44-48	0-24	0-5	48-77	20 324 - 30 000	0.38 - 1.44	3.25	6.22 - 25.64
EV using electricity generated from:	Emissions based on urban cycle, consuming 200-300Wh/km from mains (IEA, 1993a; Martin and Michaelis, 1992; DeLucchi, 1993; Eyre and Michaelis, 1991).							
American Average	44-48	135 - 202	0	179-250				
European Average	44-48	107 - 160	0	151-208	24 768 - 20 928	0.48 - 0.96	2-3	6.81 - 14.74
Coal	44-48	180 - 375	0	224-423				
Oil	44-48	170 - 255	0	214-303				
Gas (CCGT)	44-48	90-134	0	134-182				
Nuclear	44-48	15	0	59-63				
Hydro/renewables	44-48f	0	0	44-48				

a) Both the work of the IEA and that of Pischinger are based on a model developed by DeLucchi (1991, 1993).

b) Levelized cost calculations based on (IEA, 1993)

c) Assumes current industrial practices. Ranges reflect differences between regions

d) Ranges reflect differences between primary energy sources and conversion technologies.

e) Ranges reflect differences in vehicle technology, maintenance and operation.

f) DeLuchi (1991) and the IEA (1993) ignore emissions associated with electricity generating plant and electricity grid construction. In fact some CO₂ emissions will occur during plant construction, both from energy use and from cement manufacture. Emissions may also result from the flooding of land for hydroelectricity production.

(Based on: DeLuchi, 1992; 1991; IEA, 1993a^a; Martin and Michaelis, 1992; Pischinger and Hausberger, 1993; Goldemberg and Macedo, 1994; DOE, 1991; 1990; 1989)

Working Paper No. 1 study on cost-effectiveness assessment. Toyota claims that fuel consumption is at least 30 per cent lower than in conventional engines, while Mitsubishi claims a 35 per cent reduction.

GDI engines do have a drawback compared with conventional gasoline engines. Whereas conventional engines use a “stoichiometric” ratio of fuel to air — that is, they use exactly the right amount of air to burn the fuel — GDI engines use much more air than is needed. This means that the exhaust is “oxygen-rich”. Under these circumstances, a conventional three-way catalyst is unable to reduce NO_x in the exhaust. However, GDI engines produce lower levels of NO_x in the combustion process than conventional engines, and Mitsubishi claims to have developed a “lean- NO_x ” catalyst, reducing NO_x emissions to acceptable levels. The engines will also be more expensive than conventional gasoline engines — with costs at least in line with those of diesel engines. However, the commitment of the manufacturers means that there is at least a good chance that the initial hurdle of production line investment may be overcome.

While cars with the Toyota and Mitsubishi engines have yet to be certified in European and United States emission test cycles, they demonstrate the potential for quite substantial technological developments that are not anticipated in government policy analysis.

The Ballard fuel cell

The fuel cell has been under development for over 150 years. It is the engineer’s dream, converting the chemical energy stored in fuel directly to electrical energy — like a battery, but it can be operated with a continuous supply of air and fuel. Fuel cells have been used in space missions and in submarines, but have yet to find a large scale commercial application.

Fuel cell-powered vehicles using hydrogen fuel have the key advantage that their only emissions are of water vapour — although fuel cell systems using other fuels might produce very small amounts of NO_x and other pollutants. Fuel cell-electric vehicles are also more efficient than internal-combustion-engine vehicles. The efficiency of electricity production from a fuel cell can exceed 80 per cent, depending on the fuel¹⁴. In practice, the drive-train efficiency of a fuel cell vehicle could be in the region of 40-50 per cent, resulting in energy consumption about 50-60 per cent lower than that of a conventional gasoline car, and about 25-30 per cent lower than that of a diesel bus. The main drawback so far has been the high cost of fuel cells, with estimates of the cost of a mass-produced fuel cell car in the range \$5 000 to \$15 000 more than that of a gasoline car (Michaelis *et al.*, 1996).

One firm might be about to realise the dream — Ballard Power Systems Inc. of Vancouver, Canada. Ballard has been the focus of much of the automotive industry’s recent efforts to develop the fuel cell. The Ballard cell has been used by car companies, including Daimler-Benz, General Motors and Mazda. Funding for demonstration projects from several governments has played an important role, but so has the commitment of the company to develop and commercialise the technology. New fuel cell buses will be delivered in Vancouver and Chicago during 1997, and Ballard plans to begin commercial production of their fuel cells in 1999.

¹⁴ The thermodynamic limit on the efficiency with which a fuel cell converts chemical to electrical energy is 83% where hydrogen is the fuel, and over 100% where methanol is used (an ideal methanol-powered fuel cell would absorb heat from its environment). In practice, efficiency levels are much lower than this, especially at practical levels of power output.

The Role of Governments

One of the most comprehensive approaches to alternative fuel and vehicle development is that adopted by the United States federal government, through a range of legislation including the 1990 Clean Air Act Amendments and the 1992 Energy Policy Act.

United States policies do not differentiate among fuels on the basis of their full-fuel-cycle greenhouse gas emissions, so that there is no guarantee that they will lead to lower greenhouse gas emissions. Some of the alternative fuels that could be promoted by the policies, such as synthetic fuels from coal, could result in very much higher greenhouse gas emissions than gasoline. Nevertheless, initial indications are that the main fuels being chosen by federal government fleet operators and private vehicle owners are LPG, CNG, methanol and ethanol from corn. These fuels offer full-fuel-cycle greenhouse gas emission reduction relative to gasoline of up to about 40 per cent per vehicle-km driven (see Appendix A), although in some circumstances they can result in higher greenhouse gas emissions than gasoline. If the government's target of 10 per cent petroleum displacement by 2000 is achieved, this will mean a reduction in road transport greenhouse gas emissions of 4 per cent at the most, assuming that alternative fuel vehicle subsidies do not result in additional driving. The Energy Policy Act target of 30 per cent petroleum displacement by 2010 could mean greenhouse gas emission reductions of up to about 2 per cent, again assuming no induced increase in driving.

Private vehicle owners may prefer to use more convenient liquid fuels rather than gases. Unfortunately, liquid fuels such as methanol and ethanol produced from wood, which have much lower full-fuel-cycle greenhouse gas emissions per vehicle-km than gasoline, are also much more expensive than gasoline. Methanol from natural gas is potentially cost-competitive with gasoline and might be the preferred fuel among the alternatives, but offers no greenhouse gas mitigation. Nevertheless, by 2010, it is possible that technologies for liquid fuel production from wood might have been demonstrated on a large scale. If wood-derived fuels were widely used, the greenhouse gas mitigation resulting from alternative fuel vehicle use could be substantial.

Alternative fuel vehicle policy in the United States

Research and development

The United States Department of Energy has supported research into alternative fuels, batteries, fuel cells and electric vehicles for several years. Recently, the government has moved towards closer co-operation with industry to demonstrate emerging technologies, with the "Advanced Battery Consortium" and the "Partnership for a New Generation of Vehicles".

Mandates

In 1990, the Clean Air Act Amendments (CAAA) established targets for the introduction of "clean fuel" vehicles in fleets of 10 vehicles or more, in 22 air quality non-attainment areas, starting from 1998 (16 of these areas opted out of the programme). As the primary concern in CAAA is to achieve air quality standards, the choice of energy source for "clean fuels" is not important. Fuels such as reformulated gasoline and synthetic fuels from coal are allowed, provided that the vehicles meet "clean fuel vehicle" standards. This means that the CAAA mandates do not necessarily lead to reductions in greenhouse gas emissions.

In 1992, the Energy Policy Act (EPACT) introduced much more broadly applicable mandates for alternative fuel vehicle use in federal fleets from 1993, and state and “fuel provider” fleets from 1996. EPACT added concern for energy security to that for the environment. Thus, reformulated gasoline, which fulfils CAAA requirements as a clean fuel, does not fulfil those of EPACT as an alternative fuel. EPACT sets targets for alternative fuel use at 10 per cent of total motor fuel consumption by 2000, 30 per cent by 2010.

The mandates contained within CAAA and EPACT were further strengthened as a result of an executive order by President Clinton in 1993, although another executive order removed funding for alternative fuel vehicle development.

Fiscal incentives

The United States federal government, as well as many states, supports alternative fuel vehicle and electric vehicle use through a variety of tax exemptions, credits and deferrals, and also through direct subsidies. EPACT provides for up to \$2 000 tax deduction per vehicle for purchasers of light duty alternative fuel vehicles, and \$50 000 for heavy duty trucks, buses and vans. Electric vehicle purchasers can obtain credits of up to \$4 000 per vehicle. Fuel suppliers can obtain tax credits of up to \$100 000 for each new alternative fuel facility. In most cases, these credits are sufficient to make alternative fuel and vehicle use cost-competitive with conventional technology. The electric vehicle credit is an important exception, with an electric vehicle costing around \$10 000 more than a comparable gasoline vehicle. State subsidies augment the federal subsidies, in some cases doubling the incentives for alternative fuel vehicle and electric vehicle purchase. The federal and many state governments also impose reduced levels of excise tax on bioethanol, and some states provide subsidies for ethanol production.

Regulatory incentives

As an additional incentive for car manufacturers to produce alternative technology vehicles, each alternative fuel vehicle or electric vehicle sold by a manufacturer counts as a credit towards its corporate average fuel economy rating: thus, manufacturers can make a trade-off between producing more fuel-efficient vehicles and producing alternative fuel vehicles.

Information, support and networking

In addition to the fiscal incentives for alternative fuel vehicle and electric vehicle use, CAAA and EPACT requirements are being implemented in co-operation by several government agencies. One element of this effort is the “Clean Cities” programme. This is essentially an information-sharing network set up by the Departments of Energy and Transport (DOE and DOT). Clean Cities has an Internet site (<http://www.cities.doe.gov/>) which provides access to a newsletter, digests of federal and state legislation, information on current alternative fuel vehicle activities in each state, and technical information and advice on introducing alternative fuel vehicles and electric vehicles.

Results

The number of alternative fuel vehicles in the United States grew from 251 470 in 1992 to 363 190 in 1995, with an anticipated 420 000 in 1996 (DOE, 1996) representing about 0.25 per cent of the United States fleet. Much of this growth has taken place in federal government fleets — including the postal service. However, the growth in private alternative fuel vehicle ownership has been greater than was anticipated as a result of EPACT.

United States alternative fuel vehicle and electric vehicle policy is primarily motivated by air quality and energy security concerns and is not expected to have much effect on greenhouse gas emissions. If EPACT targets are achieved, greenhouse gas emissions from the light duty fleet might be reduced by 2 per cent in 2010 (DOE, 1996). CAAA and EPACT do not differentiate among fuels on the basis of their greenhouse gas emissions. As well as encouraging the use of biofuels, CNG and LPG, these laws provide incentives for the use of both methanol produced from natural gas or coal, and coal-generated electricity, which can result in full-fuel-cycle emissions higher than those from gasoline (DeLuchi, 1991, 1993), and for the use of CNG and LNG in buses, with higher greenhouse gas emissions than those from diesel buses. Other measures in the United States, notably subsidies for the use of bioethanol, do have greenhouse gas benefits, provided the energy for the ethanol fermentation and distillation process derives from a low-carbon source such as natural gas (IEA, 1994; DeLuchi, 1991, 1993).

State policies

State government initiatives have played an important role in alternative technology development in the United States. The California Air Resources Board (CARB) introduced the Clean Fuels and Vehicles Plan in 1990. The plan imposes progressively lower emission standards on vehicles from 1994 onwards. VOC emissions must be cut 80 per cent below 1994 levels by 2000. Under the legislation, vehicles are given one of four new emission classifications: transitional low-emission vehicle, low-emission vehicle, ultra-low-emission vehicle, zero-emission vehicle. Manufacturers' sales-weighted VOC emissions calculated from their sales of each vehicle type must not exceed a prescribed level in a given year. A banking and trading system permits manufacturers to earn marketable low-emission credits.

Alternative fuels are being promoted by CARB and through the United States federal California Pilot Vehicle Program. The fuels are expected to help satisfy low-emission requirements. They include M100, M85, CNG, and LPG. At least 90 Southern California filling stations must supply alternative fuels by 1994, rising to 400 by 1997. From 1994, 200 000 new low-emission vehicles per year (about 10 per cent of the state's new-car fleet) must be sold in California. Alternative-fuel use is also being encouraged through tax exemptions.

Electric vehicles were originally required to make up a minimum of 2 per cent of new car sales from 1998 by companies selling more than 30 000 cars per year in California. The share was scheduled to rise gradually to 10 per cent by 2003. The 1998 mandate has now been withdrawn, but the 2003 target is being maintained. Electric vehicle use in California is likely to result in greenhouse-gas emissions significantly lower than those associated with gasoline vehicle use because much of the power generation in the state is from non-fossil-fuel sources or natural gas.

Alternative Fuel Vehicle Tax Incentives and Subsidies

There is now considerable experience in several countries with the use of LPG and CNG. These are both fuels that have characteristics — limited availability, longer refuelling times — that detract from consumer utility, according to the studies by Segal (1995) and Bunch *et al.* (1993). Governments encouraging the use of these fuels have often provided very substantial excise tax reductions in order to achieve moderate market shares.

Diesel and LPG cars in Europe

Several countries have accumulated a great deal of experience with the use of diesel fuel in passenger cars. Diesel fuel is often subject to lower duty than gasoline, largely to avoid placing too heavy a tax burden on commercial vehicle operators. Some governments have also seen the use of diesel in passenger cars as a means of reducing energy use, because diesel cars use about 10 per cent less fuel on an energy basis than gasoline cars. However, a combination of lack of experience in small diesel engine production and a higher level of mechanical complexity and higher quality requirements than gasoline engines, along with relatively small production runs, have meant that diesel engines are more expensive than gasoline engines.

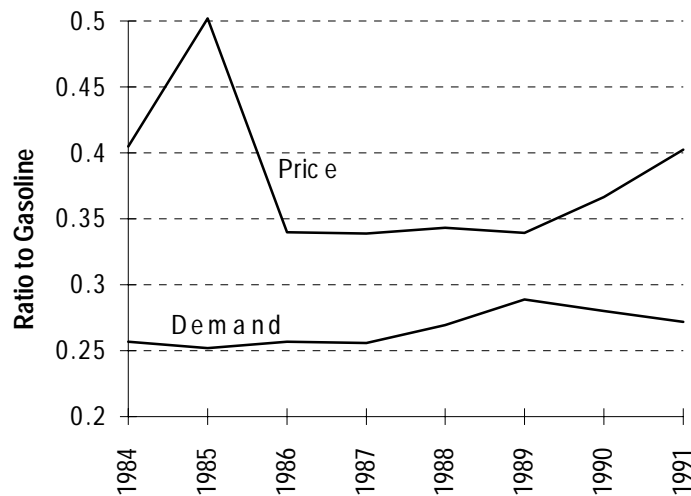
Sustained low diesel prices have led to substantial demand for diesel cars in Europe, especially France, as manufacturer and consumer experience with the technology has grown, and as the choice and quality of diesel vehicle models has increased. In some countries in recent years, governments have reduced or removed the tax differentials that favoured diesel, in some cases (notably Germany) because research findings that indicated significant health problems associated with the high particulate matter emissions in diesel exhaust.

It was mentioned in Part I of Working Paper 1 that a study in France has shown that people who switch from gasoline to diesel tend to be high-kilometrage drivers (on average 16 000 km per year, whereas gasoline car drivers average 12 000 km). Diesel car owners on average drive 20 000 km per year. Thus, half of the difference between diesel car drivers and gasoline car drivers is thought to derive from independent factors, and half from the differences in fuel price (Orfeuil, 1996). The 25 per cent increase in driving thought to arise from the low fuel price is consistent with an elasticity of travel with respect to fuel price of about -0.4. The induced driving more than outweighs any greenhouse gas mitigation resulting from the lower energy intensity of diesel cars.

Some of this experience may be relevant in considering possible future markets for alcohol and gaseous fuels which, like diesel, require specially adapted vehicles¹⁵. The diesel experience also illustrates the potential for new safety and health concerns to arise that can halt development of a new technology. Methanol may in the future not be marketable in the long term because of concerns about its toxicity.

¹⁵ In the long run, it is likely to be possible to produce methanol and ethanol vehicles at the same cost as gasoline vehicles. However, in the short term, lower production volumes are likely to result in higher costs for such alternative fuel vehicles.

Figure 4. Price and Demand of LPG: Ratio to Gasoline in the Netherlands



Source: IEA Statistics

Experience with these fuels indicates that many consumers will adopt them provided that they are much cheaper than conventional fuels (for example, see Figure 1 for the Netherlands). LPG and CNG are marketed in many countries at prices in the region of one-third that of gasoline, the large price incentive being required to encourage consumers to invest in a vehicle conversion and accept the relative inconvenience of the fuel. Countries with high LPG use include Australia, Canada, Italy, Japan, the Netherlands, and the United States.

Individuals are generally likely to respond to the low price of fuels such as LPG and CNG by consuming more of them than they would if they were priced at the same level as gasoline. A first indication of this response might be obtained using a price elasticity-based approach. For gasoline drivers in aggregate, the elasticity of distance driven with respect to fuel price is in the region of -0.1 to -0.3 (Michaelis, 1996). This elasticity range may not be directly applicable to drivers who choose to use dual-fuel cars. On the one hand, these drivers may be more price-responsive than average — hence their choice of the fuel; on the other hand, the longer refuelling time and relative difficulty in finding fuel might act as a disincentive to driving. With these caveats in mind, using an elasticity of -0.2 would imply that a two-thirds reduction in fuel costs would result in 25 per cent more driving. Thus, LPG and CNG price incentives of this size, which exist in some countries, might result an increase in driving that eliminates any greenhouse gas advantage from using the alternative fuel.

Consumers may choose to use liquid fuels such as alcohol-gasoline blends without a price incentive if these are marketed as “clean” or “green” fuels and can be used without engine alterations. But consumers have not generally been prepared to pay extra for a “green” fuel (Greene, 1989; IEA, 1993).

Ethanol in Brazil¹⁶

Brazil has used small amounts of ethanol for decades as an octane enhancer in gasoline and as a by-product market for the sugar industry. However, in the late seventies, rising oil prices combined with high interest rates and a crash in the world sugar market to create a foreign-debt-servicing crisis. This compelled the Brazilian government to look at ways of reducing petroleum imports.

From 1975 to 1979, the government-sponsored program, Proalcool, increased the ethanol percentage in gasohol to 20 per cent. Then from 1979 to 1985, Proalcool promoted the use of dedicated ethanol vehicles. In 1986, ethanol vehicles comprised 90 per cent of new car sales, but a further expansion of the program was put on hold because of the drop in the price of oil. In the first phase of the program, the government provided up to 75 per cent subsidies for ethanol-producer investments and assured a 6 per cent return on the investments. However, at this stage, car manufacturers were unwilling to produce ethanol-only vehicles. In the second phase, consumer incentives were introduced for vehicle purchases, and the pump price of ethanol was guaranteed to be no more than 65 per cent that of gasoline. The car industry was encouraged by the government's commitment and started producing ethanol vehicles. Despite initially poor redesign of engines, the consumer take-up was very high.

In late 1980, the world sugar market was improving, and the government began to increase the ethanol price from 40 per cent of the of gasoline price towards the 65 per cent limit. Credit subsidies for distilleries were also suspended. The result was a rapid fall in ethanol-vehicle purchases. The government later regained public confidence by restoring incentives.

Ethanol production in Brazil costs are around 25 to 28¢/L of gasoline displaced, compared with world market prices of gasoline in the region of 17¢/L (pump costs are usually about 10¢/L higher). The government's current limit on the pump price of ethanol is 80 per cent of the gasoline price.¹⁷

CNG in New Zealand¹⁸

The New Zealand government launched a CNG programme in 1979, aiming to convert 150 000 vehicles to CNG by the end of 1985. The main motivations for the programme were to enhance New Zealand's energy security and to improve the balance of payments. Incentives were provided in the form of grants and loans for vehicle conversion and for filling station development. The cost of car conversion at the time was about NZ\$1500 (US\$750 in 1984 prices), and the government provided NZ\$150. Initial take up was poor, but improved in late 1980 by an increase in the grant to NZ\$200, and increased subsidies to fuelling stations, along with tax benefits to consumers.

A large increase in government support in 1983 included a low interest loan for conversions. By 1986, 110 000 vehicles (11 per cent of all cars and light trucks) had been converted and New Zealand had 400 filling stations. CNG comprised 4.6 per cent of road transport fuel.

The rise in conversion rate was halted in 1985 when the government reduced support for the programme because of a perception that CNG was sufficiently favoured by its low price relative to gasoline, that the CNG industry was sufficiently well established and no longer required government support, and that

16. extract from Michaelis *et al.*, 1996.

17. Sources: Sathaye *et al.*, 1989; Goldemberg and Macedo, 1994.

18. extract from Michaelis *et al.*, 1996

world oil markets were more stable and less emphasis was needed on the development of indigenous energy sources.

The vehicle conversion rate fell from 2400/month in 1984 to 150/month by 1987. By 1993, CNG sales fell to 42 per cent of their peak level in 1985, contributing only 2 per cent of road transport fuel. In addition to the withdrawal of government subsidies to CNG, a number of factors have contributed to this demise. One is the increase in CNG prices from less than half to about two thirds the gasoline price, at a time when oil markets have been quite stable. Another possible factor is a negative public perception of CNG, following a number of faulty installations in the early 1980s, and a cylinder explosion in 1989. A third possible factor is a lack of industry enthusiasm for marketing the fuel, bearing in mind that most of the retail outlets are oil company-owned filling stations.¹⁹

Climate/energy challenges

Consumer familiarity with advanced technology can be developed through events such as the World Solar Challenge, a race for solar-powered vehicles. Since the Solar Challenge was first organised in Australia by Hans Tholstrup in 1988, similar events have taken place around the world, sponsored by various government agencies. Major car manufacturers take part in these events — the General Motors Impact electric car was developed from the Sunraycer, a car built for the Solar Challenge.

The primary aim of the Challenge is to provide a stimulus for development of new technology and to popularise that technology. Solar and Energy Challenges are modelled on Formula 1 racing rules as competitive events, and they have succeeded in capturing the imagination of the press and media.

Clean Cities

Clean Cities is an outreach programme for municipal and state authorities responding to the United States federal mandates for the introduction of clean and alternative fuel fleets. The programme is co-ordinated by USDOE, with local decision-makers from the public and private sectors as partners. Its main function is to act as a network for communication among stakeholders involved in the introduction of alternative fuel vehicles. The Clean Cities programme has its own Worldwide Web site, providing links to information on alternative fuels and including a newsletter and case studies on local experience with alternative fuel vehicles. It has produced a large amount of printed material and also has six regional offices to assist local efforts.

To be a Clean City, a metropolitan area has to go through a consultation process with local stakeholders and develop a Memorandum of Understanding to introduce clean vehicles. So far there are over 50 “Clean Cities” in the United States, with a further 15 or more preparing to become “Clean Cities”. The Clean Cities Web site at [<http://www.cities.doe.gov>] includes a number of success stories from the programme including:

- the introduction of a fleet of 100 CNG buses in Sacramento;
- the requirement for the Massachusetts Bay Transportation Authority in Boston to purchase only alternative fuel buses for its bus fleet;

19. Sources: Sathaye et al., 1989; New Zealand Ministry of Commerce, 1994.

- the conversion of several hundred postal service vehicles to CNG in Denver, Missoula, Louisville and Austin;
- the use of CNG refuse trucks in Long Beach, NY.

Vehicle manufacturers are pursuing Clean Cities markets; Ford is introducing alternative fuel vehicles in 36 cities, while Chrysler has focused on two “Super Clean Cities”, Atlanta and Philadelphia.

The “Clean Cities” programme has also worked on establishing alternative fuel vehicle and electric vehicle refuelling infrastructures, established training programmes for alternative fuel vehicle technicians, and has worked on publicity for the local community.

OPET

Organisations for the Promotion of Energy Technology (OPETS) were set up in the early 1990s by the European Commission. Several of the OPETs were based at existing national energy agencies, but many were consultancies or other organisations with a background in energy technology analysis and outreach. At the height of the OPET programme, there were about 35 OPETS scattered around the European Union. The OPETs carried out a range of activities to support the dissemination of technology for energy conservation and alternative energy use, for example, organising seminars and conferences on alternative fuels and urban transport issues, carrying out studies and producing reports. The various OPETs co-operated in each other’s events, helping information transfer among countries and regions.

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GLOSSARY

AFV	Alternative Fuel Vehicle
CAAA	The US Clean Air Act Amendments of 1990
CARB	California Air Resources Board
CNG	Compressed Natural Gas
EC	European Commission
ECMT	European Conference of Ministers of Transport
EPACT	The US Energy Policy Act of 1992
EU	European Union
EV	Electric Vehicle
ICE	Internal Combustion Engine
ICLEI	International Council for Local Environmental Initiatives
ISTEA	The US Intermodal Surface Transportation Efficiency Act
LPG	Liquefied Petroleum Gas
MPO	Metropolitan Planning Organisation
UNFCCC	United Nations Framework Convention on Climate Change