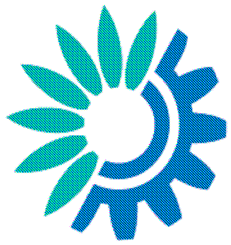
European Environment Agency



Working paper

Images of low carbon transport in 2050: an end-users perspective

October 2010

Abstract: Many studies have been conducted into options for achieving a low carbon transport system; however little attention has been paid to combining expert technical analysis with the perspectives of those who actually depend on the transport sector in their daily professional and personal life: the end users. Yet it is here where the acceptability of options for achieving a sustainable transport system will ultimately be decided, and this is where many of the real changes would actually be experienced.

In 2009 and 2010 the EEA embarked on a novel approach to introduce this perspective, combining a technical scenario study with participatory stakeholder workshops to discuss the relevance, plausibility and desirability of the analysis presented, and to consider the public acceptability of the policy measures needed to move towards a low carbon transport system. This paper summarises that process and the key lessons learnt.

The working paper is an informal paper in the sense that it portrays the outcome of a process of interaction with users. It does not represent the view of EEA on the future of transport. Rather it adds context to the debate on how a future more sustainable transport system could look as well as investigates user reactions to such sustainable principles.

Contents

Preface 3

Summary 3

1. The challenge of low carbon transport 5

1.1 The role of transport in carbon reduction targets 5

1.2 Approaches to carbon reduction in transport 7

1.3 Understanding the scale of change required 8

2. Introducing the stakeholder perspective 12

3. Storylines for 2050 13

3.1 Overview of the storylines 13

3.2 Travels with George – the City Scenario 1

3.3 Following John – the long distance scenario 15

4. Stakeholder responses to the storylines 17

4.1 Improving the plausibility and relevance of the storylines 17

4.2 Implications for society and the economy 18

4.3 Barriers to implementation 20

4.4 Consensus and disagreement 21

4.5 Improving Acceptability 22

5. Conclusions 23

Acknowledgements 24

Annex 25

Preface

Many studies have been conducted into options for achieving a low carbon transport system; however little attention has been paid to combining expert technical analysis with the perspectives of those who actually depend on the transport sector in their daily professional and personal life: the end users. Yet it is here where the acceptability of options for achieving a sustainable transport system will ultimately be decided, and this is where many of the real changes would actually be experienced.

In 2009 the EEA embarked on a novel approach to introduce this perspective, combining a technical scenario study with participatory stakeholder workshops to discuss the relevance, plausibility and desirability of the analysis presented, and to consider the public acceptability of the policy measures needed to move towards a low carbon transport system. This report summarises that process and the key lessons learnt.

Summary

Transport is an essential element of our society, bringing enormous benefits through providing access to jobs, goods and services, education, leisure and tourism activities. Yet transport also accounts for around a third of all final energy consumption in the EEA member countries and for more than a fifth of greenhouse gas emissions, a share that continues to grow as other energy-using sectors reduce their emissions. This means that if current trends continue, and transport is not able to make substantial reductions in emissions, then other sectors will have to make disproportionately greater cuts to compensate if the ambitious targets set by the European Commission are to be met. Indeed, growth in transport alone could result in total CO_2 emissions that are above the minimum needed to achieve the 80% reduction by 2050 that the International Panel on Climate Change has said will be necessary in developed countries.

Transport presents a particular set of challenges in reducing carbon emissions, as it is almost totally dependent on oil. Furthermore, the underlying drivers of demand for transport have historically been closely linked to economic growth, so that achieving a sustainable mobility of people and goods potentials involving major changes in society as well as in technology.

Technological innovation can help in reducing carbon emissions from transport, but there are many difficulties that limit their potential and speed of introduction. Scenario studies conducted by the EEA, the European Commission and others have concluded that technological change by itself is unlikely to deliver the level of CO_2 savings required, so other ways of reducing transport emissions will also be needed to achieve substantial modal shift and demand reduction: we will travel differently, and travel less.

Changes on this scale have far reaching implications for how people live and work, their social relationships and their leisure activities, yet the perspectives of those who actually depend on the transport sector in their daily professional and personal life, the end users, are rarely considered in scenario studies. Yet it is here where the acceptability of options for achieving a sustainable transport system will ultimately be decided.

In 2009 the EEA embarked on a novel approach to address this dimension. The project "Images of sustainable transport by 2050" combined a technical study with a participatory stakeholder-based approach. A group of experts first developed a scoping study using existing scenarios to identify the sort of measures that would be needed to achieve 80% reductions in CO_2 emissions from transport in Europe by 2050. These were used to draft two “storylines” to make it easier for a non-technical audience to visualise the nature and scale of the changes involved, using fictitious characters to illustrate images of what long-distance and city travel might look like and feel like in 2050.

A group of professional and private end-users from across Europe then met at two workshops, focused on reviewing and improving the images, understanding timescales and pathways, identifying the key actors and who would be affected, positively and negatively, and to consider the public acceptability of the policy measures involved.

In discussing the implications of the policy measures involved the participants went far beyond the obvious headline issues that are frequently raised in the popular media, for example assumed public opposition to increased transport costs. The understanding of the wider issues and the difficult decisions that needed to be made were highlighted in the City scenario and some of their concerns over issues usually regarded as controversial were overcome. Conversely, the usually expected strong support for improvements in telecommunications and information technology (IT), and their positive impacts on travel, were moderated by concerns over the effects of IT on generating new travel and the social impacts.

The participants also identified some key issues that were discussed in far greater detail than was originally discussed in the storylines, enabling them to be developed to improve relevance and plausibility. Included here were the greater emphasis put on the regional impacts of greatly reduced long distance travel, with those parts of Europe that are most dependent upon tourism losing out, so that Europe-wide financial transfers would be needed to help compensate, while other areas would benefit from more localised tourism and recreation.

Other issues discussed in greater detail were: moving from private car ownership to shared-ownership, car-clubs and short-term rental, a convergence between public and private transport; new models of retail and distribution; and the social implications of advanced telecommunications.

When considering how to make such radical sustainable transport policies more acceptable, participants focused on key issues relating to *finance*, and the need for accountability and equality; *governance*, and the need for strong leadership as well as action taken at the appropriate level of government; stability and consistency, requiring a long-term strategy so that business can plan for the future, while suffering no competitive disadvantage; and the promotion of policies that offer *wider benefits* to society.

After discussion and debate the end-users were willing to accept large changes to their daily urban travel, especially where wider benefits can be demonstrated, but were less willing to accept larger changes to their long-distance travel, pointing to substantial needs for innovative policy design and communication if significant savings are to be achieved through the sort of measures described in the two scenarios. Nonetheless, despite the wide ranging concerns raised, by the end of the workshops there was a much more positive perspective. The participants were able and willing to engage in a wide ranging and sometimes complex issues on the future of transport that will affect all

people in the EU, and they have also added considerable value to the debate. Projects and approaches such as those adopted here should be used to involve the wider stakeholder communities, as understanding and acceptance are two crucial components of effective implementation.

1. The challenge of low carbon transport

1.1 The role of transport in carbon reduction targets

The transport sector accounts globally for around 13 % of greenhouse gases (GHG)[1] (IPCC, 2007) and 23 % of energy related CO_2 emissions[2]. The IPCC has stated that global cuts in GHG emissions of 80 % to 95 % in developed countries (and up to 50 % in developing countries) will be required by 2050 to keep climate change at non-dangerous levels. They have suggested no sector specific sub-targets, but this nonetheless represents a particular challenge for the transport sector, which is one sector in which CO_2 emissions are continuing to grow. In Europe, GHG emissions from the transport sector have risen by 24% over the period 1990-2008[3] see Figure 1, while total emissions have been reduced by 3 % (EEA-32)[4]. This continuing growth trend is a result of growing levels in the overall demand for transport (both passenger and freight), continued reliance on motorised modes (passenger cars, aviation[5] and heavy goods vehicles) and limited application of technologies to improve the efficiency of vehicles and move to low carbon energy sources. In comparison with industrial and domestic users of energy, transport is almost completely dependent on oil and switching to alternatives is likely to have greater direct impacts on the end user. This is particularly true in the case of aviation, for which alternative liquid fuels such as bio-kerosene offer the only alternative to kerosene, which introduces further concerns about sustainability

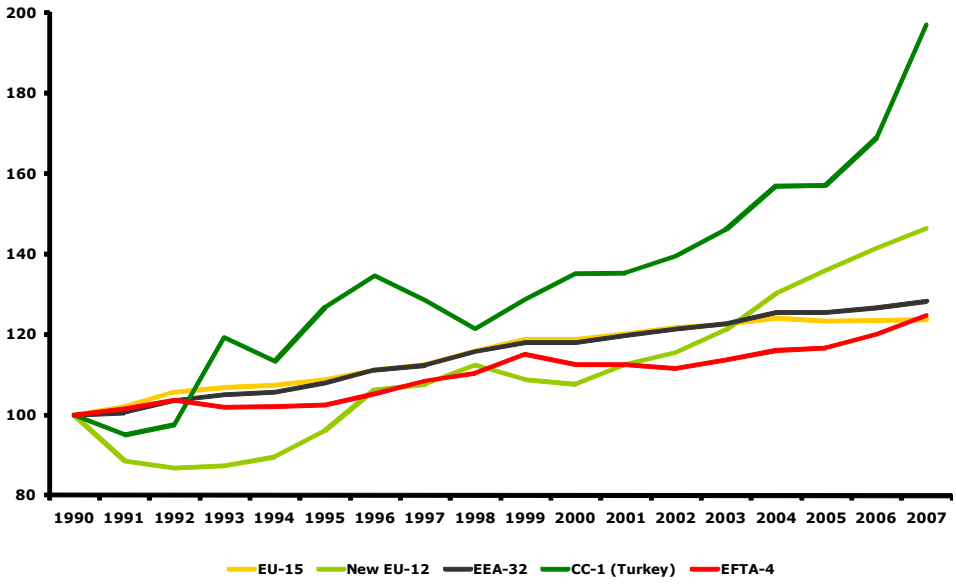


Figure 1: Total GHG emissions from transport (1990- 2007) Source: EEA TERM report 2009

[1] IPCC (2007) Climate Change 2007 Synthesis Report. http://www.ipcc.ch/ipccreports/ar4-syr.htm
[2] IEA (2008) *World Energy Outlook 2008*. International Energy Agency, Paris.
[3] http://epp.eurostat.ec.europa.eu/portal/page/portal/product_details/dataset?p_product_code=TSDTR410
[4] EEA (2009) Transport at a crossroads. TERM 2008: indicators tracking transport and environment in the European Union. http://www.eea.europa.eu/publications/transport-at-a-crossroads
[5] Aviation includes travel by air within the EU27, but not international air travel, and there are no figures here for international maritime transport

The following targets have been set by EU leaders to be met by 2020:

- a cut of at least 20 % in greenhouse gas emissions below 1990 levels; or 30 % if other developed countries also commit to comparable reductions;
- an increase in the share of renewable energy to 20 %; and
- a 20 % reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency.

These are known as the "20 20 20" targets.

Unless other sectors make disproportionately large cuts, the EU cannot meet these targets without real action on transport emissions, and meeting the 80 % to 95 % reduction targets in the long run is very tough. Figure 2 shows total GHG emissions for the EU 27 countries, including international maritime and aviation ("bunkers") projected on linear trajectories towards 80 % and 95 % reduction targets, alongside total transport emissions (including bunkers) assuming current trends continue. This shows that if the current growth in transport emissions continues, then even if all other sectors achieve a 100 % reduction, targets for total emissions will be exceeded by transport alone by 2050. This will put other sectors under even greater pressure if transport does not make its 'fair' share of reductions. Therefore, although no explicit official target for transport has been set, for this project an aspirational target of 80 % reduction in transport has been adopted to align transport with the other energy using sectors.

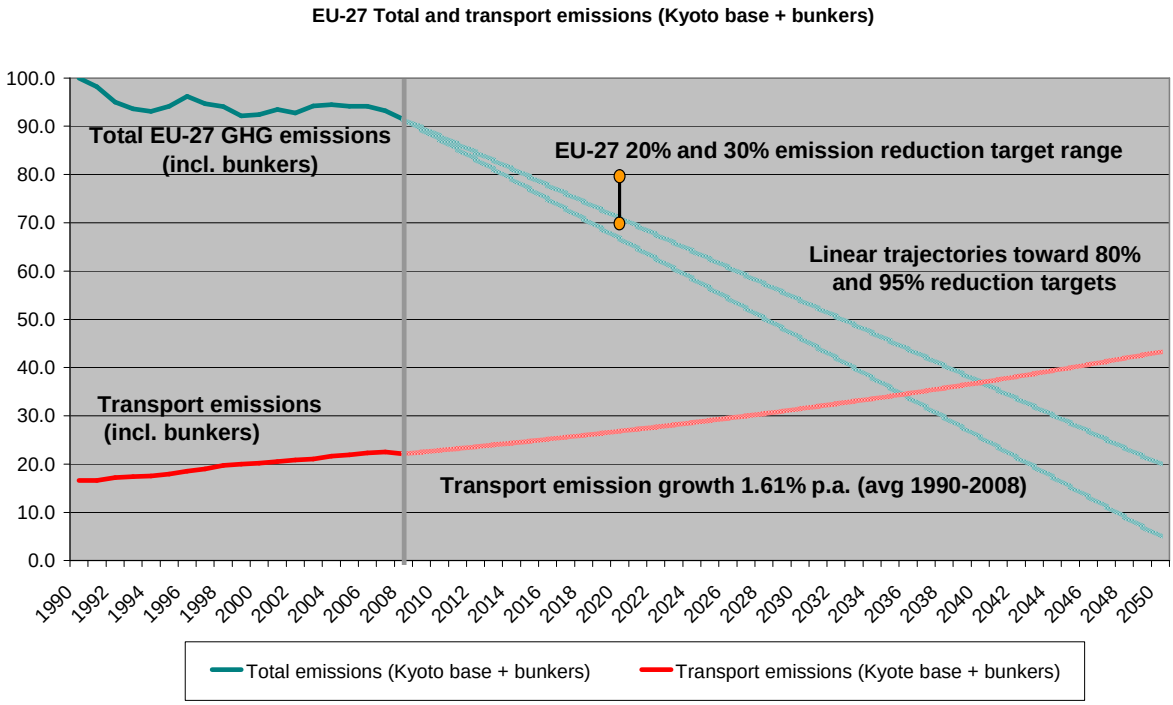


Figure 2: Transport emissions continue to grow while those from other sectors decline (EEA analysis)

1.2 Approaches to carbon reduction in transport

The factors that determine carbon emissions from transport can be considered both on the "supply" side (the modes and technologies employed to move people and goods around) and the "demand" side (the underlying factors that determine how much travel takes place). Action to reduce carbon emissions can be taken at different levels: at the technological level, at the modal level, and at the demand level. This three-level hierarchy has been used to develop a classification of the different carbon reduction measures available for implementation[6]:

- 'Avoid', measures that reduce overall demand for travel, for example by reducing the distance people have to travel to access jobs and services, or by using telecommunication as a substitute for travel;
- 'Shift', measures that shift journeys onto more sustainable, lower emission modes; and
- 'Improve', measures, usually technological, that reduce the carbon intensity of travel through improved vehicle efficiency or finding alternative, low-carbon, sources of energy.

This classification was used by the EEA as a framework for a scenario study to investigate the impact of a range of proposed policy measures and their ability to contribute to a 80% reduction by 2050 if transport is to reduce its emissions in line with what is expected from other sectors. The outcome of the scenario was that technology changes alone will not be sufficient to meet the desired CO_2 savings in transport; and that further savings will have to be achieved through measures from the 'Shift' and 'Avoid' categories. This is partly because little progress has been made to date in finding low carbon energy to power transport; and partly because the gains from predicted efficiency achievements are countered by increased vehicle use, due to rebound effects and the ongoing growth in transport demand. The greatest savings potential was found to be achieved by ambitious, radical policy packages that combine measures from all three categories, as shown in Box 1. Similar conclusions

Box 1 A package of measures achieves greatest savings potential

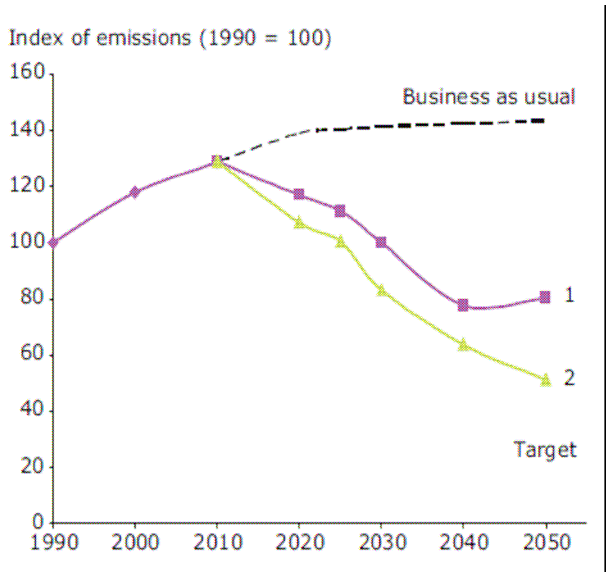


Figure 3 Effect of a combination of 'improve', 'avoid' and 'shift' measures

The EEA has carried out a scenario study to look at the impacts of a range of different policy measures from each of the Avoid, Shift and Improve categories. Figure 3shows the output of one model showing the percentage reductions achieved against 1990 emissions for two different packages of measures, the curve showing the additional effect of adding further instruments.

1 'Improve' package: improved engine and vehicle design, electric cars, low-carbon fuels and technologies encouraging behavioural change.

2 'Avoid and shift' package: road pricing, car clubs, increasing population density in cities, travel planning.

Source: EEA TERM report 2009

[6] Dalkmann, H. and Brannigan, C., 2007. *Transport and Climate Change. Module 5e. Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities*. Available at: www.gtz.de

have been reached by analysis conducted for the EU[7]. While the EEA scenario model involves very large changes in travel patterns as well as in transport operations and technology, it should be noted that the results of the model still did not achieve the 80% reduction, so even greater change will be required in transport if other sectors are to avoid having to make disproportionate cuts.

1.3 Understanding the scale of change required

In November 2009, the EEA convened an expert workshop to discuss the drivers of change, the scale of action needed in the transport sector and the options available for mitigation to achieve an 80% reduction in transport carbon emissions. The main input to this workshop was a scoping study carried out by TRL in conjunction with the Transport Studies Unit at the University of Oxford. The main output from the workshop was an outline of the initial storylines that were then developed for the two user group workshops.

One of the main objectives of the expert workshop was to discuss different futures that looked at trend breaks rather than trend following, as it is clear that innovative thinking is required to reach an 80% reduction target, when the trends are currently increasing the amount of CO_2 emitted from transport (Figure 4). The Avoid-Shift-Improve methodology requires people to travel less, to use different modes, to use more local destinations, and to make sure that the most efficient forms of transport are available. Some of the possibilities that were discussed are summarised in the tables in the Annex to this report.

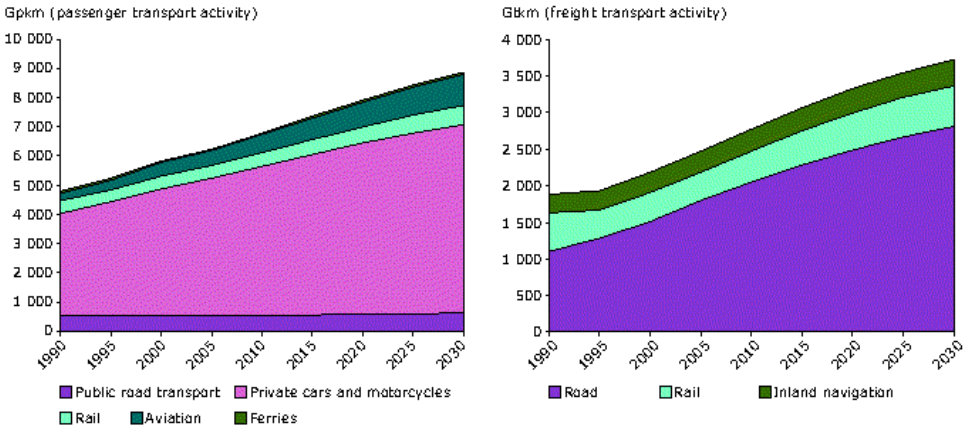


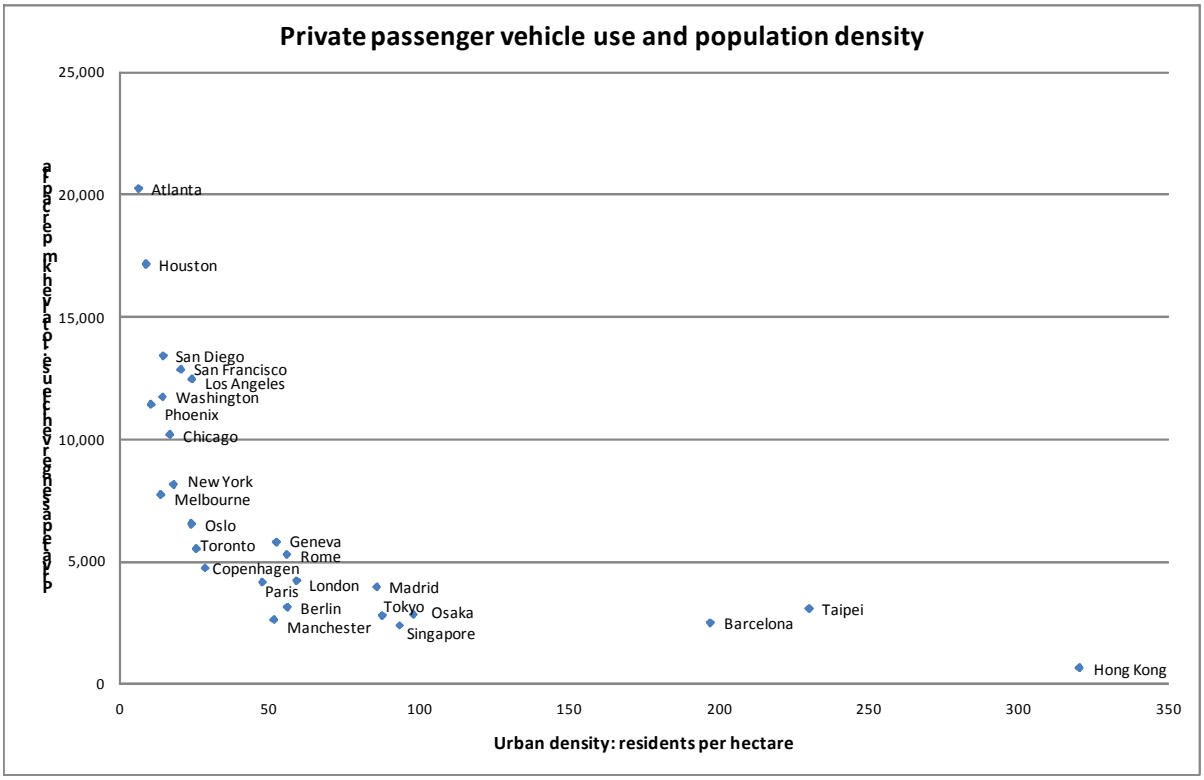
Figure 4: Current and forecast trend for transport demand (EEA, 2010)

The growth in travel demand is regarded as particularly difficult to reverse for a number of reasons. Historically there has been a clear link between economic growth and transport demand. With the increases in wealth, car ownership levels have grown and people have had more choice in where they live, often leading to greater travel distances to work and other activities. Cities have spread in response to the desire for more space (for housing and businesses), and these more dispersed settlement patterns (Box 2) have in turn reinforced more car-dependent travel patterns. These trends are hard to reverse, and the greater choice in shopping and leisure facilities, together with the consolation of health and education facilities into more centralised locations, have all resulted in

[7] Skinner, I van Essen H, Smokers R and Hill, N (2010) *EU Towards the decarbonisation of the EU's transport sector by 2050* European Commission Directorate-General Environment. Available from www.eutransportghg2050.eu

more motorised travel, greater distances and higher levels of carbon use . The challenge is to end the link between travel and economic growth by providing people with the things they need for a good quality of life without having the same need to travel – this is the decoupling argument.

Box 2: Population density and commuting car use



Higher density living

Land use planning is one of the main determinants of travel behaviour, influencing both travel distances and modal choice, as journeys in compact cities are much more easily served by public transport, walking and cycling. The chart (Kenworthy and Laube, 2001)[8] shows how urban density affects the amount of travel by private motor vehicles. Clearly it will be extremely difficult to change these development patterns, particularly in existing cities where the rate of redevelopment means that changes usually take place over decades.

As part of the discussions at the workshop and the follow-up activity, two descriptions were produced of the potential for trend breaks in city transport and for long distance travel (over 150kms). The thinking here was not to produce complex scenarios for transport in 2050, but to focus on key elements where action was needed, and to develop narratives around the possibilities for change. These two descriptions included important wider contextual factors and complementary changes that are likely to influence the achievement of the targets. These included factors like:

[8] Kenworthy, J. and Laube, F. (2001) The Millennium Cities Database for Sustainable Transport. (CDROM Database) International Union (Association) of Public Transport, (UITP), Brussels and Institute for Sustainability and Technology Policy (ISTP), Perth

- 'Peak oil', oil prices (uncertainty and volatility), the price of carbon (over $100), and personal carbon allowances
- 'driving forces' –these include decoupling, globalisation and trade, technological change, demographics and ageing, consumption driven lifestyles, climate change – mitigation and adaptation, the work and leisure time balance, and ICT.
- The risk of financial crises and other forms of global uncertainty (e.g. terrorism)
- Contextual social variables such as trust in governments, business and the media, the confidence of people and markets, engagement of all stakeholders in decision processes, and where the real global power actually resides.

In addition to the descriptions, there was a certain amount of background data and information provided so that the participants were all aware of the trends and the challenges facing decision makers in the transport sector in meeting the 80% CO_2 reduction target by 2050. Summaries of the policy measures and changes that emerged from the expert workshop, and which provided the input to the later stages of the project, are provided in Table 1 and Table 2 below.

Table 1: Low Carbon City Transport – Key Transport Elements

1. Cars to be an average of 50 g CO_2/km, using ultra lean burn small ICE engines – high load factors and leased for each specific purpose – the end of the all purpose car.
2. Public transport to be at least twice as efficient as cars per passenger km – using electricity based on a street distribution system to reduce weight penalties – some potential for hydrogen with on board reformation.
3. Substantial parts of the city could be car free, as all facilities would be available locally and there would be networks of cycle routes and paths for pedestrians.
4. Separation of traffic in cities according to speed. All speeds in cities low (max 30km/hr) and controlled by GPS – possible speed controls on vehicles.
5. Public transport would be universally available, operating at low speeds – densification, mixed land use and highly accessible services and facilities.
6. Network society with universal access to videoconferences and video phones, plus the ability to work at home or at a local centre – high levels of virtual mobility – all homes to have broadband.
7. Personal carbon allowances – considered but may be too problematic to introduce – so carbon allowances for companies.
8. Intermodality a reality with all journeys being viewed in their entirety – integration and information permits this – based on real time and PDAs.
9. Integration key: seamless travel, covering interchanges, information, ticketing, reallocation of space – complementarity and cooperation between modes, not competition.
10. Transport is seen as a service to provide access.
11. Eco driving training and rewards.
12. Congestion and environmental charging for space in city and parking very limited.
13. Urban form and structure conducive to short distances – high densities, mixed land uses, highest densities around accessible public transport interchanges, and good quality local services and facilities - high levels of walk and cycle.

Table 2 Low Carbon City Transport – Key Transport Elements

Long distance Land Transport (over 150kms) 1. Technological efficiency – mandatory standards for all vehicles. 2. Priority for efficient modes – bus and rail – allocation of space for buses on motorways. 3. Integrated total journey planning – slower and more reliable transport. 4. Substitution through telecommunications and technology. 5. Shorten supply chains with knowledge transfer and local production. 6. Local distribution networks and use of technology to source products. 7. Road pricing on all motorways, based on environmental charges that relate to the CO_2 emissions of the vehicle and load factors. 8. Carbon tax on all fuel and long terms commitments and guidance to manufacturers on expectations for achieving low carbon transport. 9. Investment in renewable energy to power the transport system – electric vehicles and a grid system for power distribution. Electrification of rail. 10. Vignettes to be extended to all long distance travel as an interim step to a full road pricing scheme. 11. Road convoys using ITS – grouped at consolidation centres – service stations to become the interchange points. 12. Rail HSR as the main form of intercity travel 13. All road traffic speeds lower (max 80 km/hr) and controlled by GPS. 14. Cars would be HEV and PHEV, with ultra efficient ICE vehicles
Aviation 1. Technological efficiency – design of planes (and size), engines (turbo props and geared turbofans), fuels (biokerosene and biomass to liquid fuels), and operations. 2. Limit access of polluting planes to EU airports – low emissions zone for all EU airspace. 3. Slower air travel and full cost pricing of all fuel (including tax and VAT) to reflect the carbon emissions and radiative forcing effects. 4. No new airport capacity in the EU – encourage holidays nearer to home and promote video conferencing activities and remote working. 5. Improved Air Traffic Control systems to make most efficient use of air corridors and international air space. 6. Full economic pricing of all fares, including taxation, and possible credits (tradable) for flying. 7. Cooperation between air and rail, with transport providers working together to provide quality and low energy transport. 8. Global agreement on carbon emissions in the aviation sector to reduce CO_2 levels by 80% in 2050 through the use of a cap and trade system. If a global agreement is not possible, then there should be an EU wide system (see CEC, 2009). 9. National accounts to include all international aviation, based on an agreed accounting procedure that would allocate proportions of the carbon to countries that were either the origin or the destination of the flight.
Sea Transport 1. Technological efficiency – design of vessels (and size), propulsion systems, energy use and fuels

(clean diesel), use of wind (skysails) – note the long lead time and lifetime of ships.

2. Limit access of polluting ships to EU ports – low emissions zone for all EU coastal waters.
3. Slower sea travel and full cost pricing to reflect the carbon emissions.
4. No new port capacity in the EU.
5. Reduce length of supply chains by introducing a carbon charge related to distance travelled for all freight.
6. Global agreement on carbon emissions in the shipping sector to reduce CO_2 levels by 80% in 2050 through the use of a cap and trade system. If a global agreement is not possible, then there should be an EU wide scheme, as the EU is a large international market[9].
7. National accounts to include the carbon produced in countries that supply goods to EU markets – at present much of the carbon has been outsourced overseas.

2. Introducing the stakeholder perspective

As described in Section 1 it is clear that the kind of changes studies suggest will be needed to meet an 80% reduction in CO_2 from transport would have significant impacts on many aspects of people's lives. Even if all the required savings can be achieved through technology there will need to be great changes in the design of the vehicles people use, and the energy system that supplies them. If technology alone isn't able to do this then people will have to travel differently, and travel less. This has major implications for how people will live, work and spend their leisure time. However, while technical studies can deliver a wealth of technical information on the carbon saving potential of different policy instruments, they often give little consideration to the perspectives of professional and other end-users who will be affected by these measures. To a large extent, these end-users determine the feasibility and acceptability of policy packages, particularly those involving non-technological changes. For this reason the EEA decided to follow on its technical scoping study with a participatory stakeholder engagement process, bringing a group of professional and other end-users from across Europe together to discuss the relevance, plausibility and desirability of the analysis presented, bringing in new perspectives and challenging assumptions.

These stakeholders were an invited group of approximately 15 from a wider range of transport users, covering logistics, tourism, retail, urban planners, express delivery services, consumer organisations, financial services, information and communication technologies, as well as private transport users. If the project was to be successful in engaging such a group, it was necessary to find an effective way of conveying the societal changes implied by the technical scoping study, which did not rely solely on often complex explanations of statistics and trends.

The approach that was adopted was to use the output from the technical scenario as the basis for drafting storylines, which would convey images of the future, using the daily life of a fictitious character to help the stakeholders to visualise the nature and scale of the possible changes in travel behaviour and lifestyles, as well as the potential of the new technology.

The participants then met at two facilitated workshops, each of two days duration, where the discussion focused on reviewing and further developing the storylines, understanding timescales and pathways, identifying the key actors and who would be affected (positively and negatively), and to

[9] Commission of the European Communities (CEC) (2009) Towards a comprehensive climate change agreement in Copenhagen, COM(2009) 39 Final, Brussels, 28.1.2009

consider the public acceptability of the policy measures involved. Between the first and second workshops the storylines were updated to reflect the discussions of the first workshop, and then put back to the delegates at the second workshop, with some supporting documentation to help answer some technical questions that participants had raised. The outcomes of the workshops were then written up for dissemination to decision makers and other interested parties. The process is summarised in the flow diagram shown in (Figure 5).

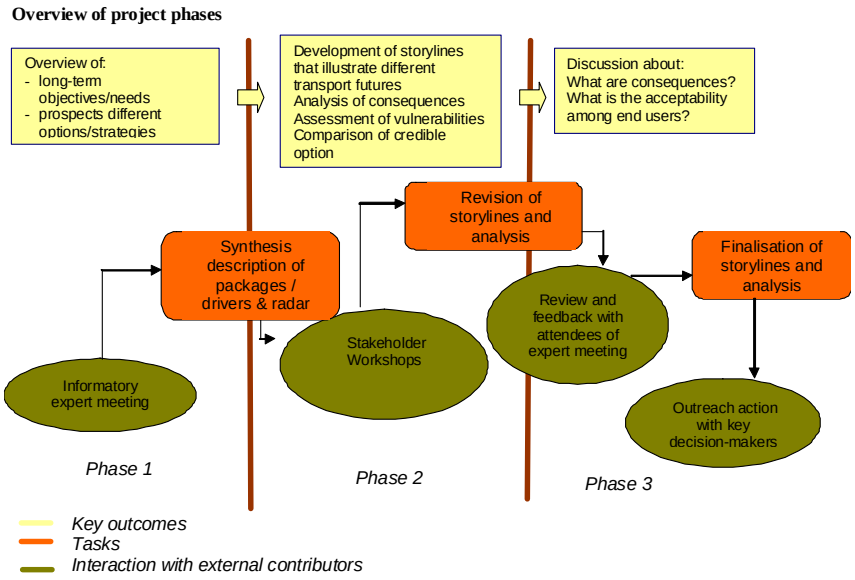


Figure 5: Flow diagram of project process

3. Storylines for 2050

3.1 Overview of the storylines

To help thinking about how the future might look like, scenarios often use qualitative storylines, or narratives, to describe a possible and plausible end-state ("image") and the means by which it might be reached ("pathway").

Two storylines were developed to illustrate the technical conclusions of the expert scoping study that preceded it. The first storyline focuses on 'city' transport, describing local, everyday travel, such as travel to work, to education, to shops and leisure services. The second storyline looked at long-distance travel, focusing on trips longer than 150km, so including the sort of journeys made by air and high speed rail, holiday travel, family visits and business trips. It is important to note that such an analysis is not about predicting what is might happen, or about affirming the outcome of current trends. Rather it is about helping to think about potential future changes that may be required if large cuts in CO_2 are to be achieved, and then to discuss their implications. Both storylines describe a future world where ambitious policy measures (as described in the technical background report provided to participants) have been implemented, involving a far greater level of change than would be expected from current trends in technological change and transport use. However, these storylines are two possible developments out of many.

The storylines aimed at describing key changes in society and transport and their broader social and economic implications. To facilitate the update of information and to help a reader comprehend the

nature and scale of change involved in getting to the 'desirable future' from where we are at the present, the imaginary characters have been devised, and a day in each of their lives used to bring a 'reality' to the storylines and help the participants understand and picture the future.

A low carbon world in 2050

The storylines describe a world in which very significant changes have had to be made in order to achieve 80% reductions in CO_2 emissions from transport. As described in the storylines, by 2050 the world has been very successful in replacing fossil fuels for transport with electricity from renewable sources, and other sources of low-carbon energy. Just to achieve this has required very significant changes in vehicle design and manufacturing, which has had implications for employment and the economy in Europe, as well as the development of a cross-continental electricity supply grid to bring power from new sources (e.g. concentrated solar power from the Desertec project in North Africa, www.desertec.org). However, this has not by itself been sufficient to achieve the level of CO_2 reduction required, so there have also been very significant changes in the way in which land-use and transport are planned, so as to reduce demand for travel and to switch journeys to more sustainable modes of transport. These have led to major changes in people's lifestyles and employment patterns, which are reflected in the storylines used.

Common elements in the storylines

Both storyline feature common elements based on combining *Avoid*, *Shift* and *Improve* measures:

- a significant switch of surface transport to renewable energy, principally through electrification of vehicle propulsion and the development of low carbon electricity generation and distribution networks;
- a large scale shift away from private motoring and aviation towards public transport, walking and cycling and shared ownership and use of low carbon vehicles
- the use of advanced telecommunications to reduce the need for travel
- much greater regulation of private transport, with restrictions on parking, access to road space, speed and safety as well as emissions and energy efficiency
- very different patterns of production, distribution and retail, driven by greater energy costs as well as by different settlement and personal travel patterns

Pricing mechanisms are important, with measures like carbon pricing used to 'internalise' the external costs of transport, which both encourages a switch to alternative modes and reduces overall demand for transport.

3.2 Travels with George – the City Scenario

George & city transport in 2050

- A male mid-level manager
- Works home for a company developing materials for trucks and vans
- Lives in a car-free community – has less space but greater quality of life
- Has most of his daily needs covered within walking and cycling distance
- Trusts his personal travel information system to organise optimal use of efficient, reliant public transport
- Still remembers cars with a combustion engine: but most people share electric cars and few own theirs
- Finds it normal that renewable power is brought to his home from places like North-Africa
- Does business trips when needed – but 3-D-video-conferencing is convenient and fun

Europe has been very successful in replacing fossil fuels for transport with electricity from renewable sources, and other sources of low-carbon energy (making use of a cross-continental electricity supply grid). Urban and transport planning have witnessed paradigm changes towards reducing demand for travel, modal shifts, increased urban density or rethinking about the use of space in cities.

People's lifestyles have changed, featuring the rise of car-free communities, renaissance of local services or intelligent transport information services that optimise travel times, routes and fares. People like George do not buy cars any longer. They buy themselves mobility services that allow them to use a certain amount of kilometres across a broad range of transport systems in the whole of Europe. Public transport networks have vastly improved in quality and reliability, partly to increased funding through environmental taxation and other revenues, partly due to new public-private undertakings and different ownership models.

Smooth as it sounds, this is an all-but-easy transition scenario. Greater restrictions have been placed on private car use and carbon emissions, both through taxation and regulation, and this has played a major role in stimulating innovation and adaptation to changing climate conditions and the needs of an ageing society. A number of sectors needed to make major changes to their products and business models. Jobs in traditional car manufacturing were lost, but many more new ones were created in low-carbon, resource efficient technologies and services, for example the lightweight materials that George's company develops. Very large investments in new technology and infrastructure have presented great political challenges. A combination of carbon pricing, restrictions on car use and new service concepts made private investments into public transport more viable. But funding transfers are needed across Europe to enable necessary changes in poorer countries.

Societal changes are another key driver going hand in hand with policy changes. Public attitudes towards cars have changed in a similar way to changes in attitudes towards smoking, with personal motoring no longer seen as a status symbol. The removal of traffic and congestion has brought many other, underrepresented benefits that have improved the quality of life to the surface, for example health benefits from more walking and cycling. The overall impression of the storyline is one of significant change, brought about by a combination of external and policy-related drivers. Yet the characters see these changes as bringing substantial benefits as well as costs.

3.3 Following John – the long distance scenario

In the world inhabited by John, long distance travel has become much more expensive and less commonplace as carbon pricing and tighter environmental regulation have been introduced. John's family still make long-distance journeys, for leisure and to stay in contact, but this is undertaken

much more often by high speed rail than by aeroplane. However, even by 2050 the rail network is not yet fully complete and many journeys take longer than they used to. Intercontinental aviation is now concentrated into major hubs, served by high speed rail, which can use the largest, most efficient aircraft. Airlines have phased out non-essential short-haul flights, as they became too expensive to be commercially viable. Another driver of change has been the availability of advanced information technologies which led to a widespread take up teleactivities, including teleworking, teleconferencing and telechatting. All of these make use of the new high definition video communications devices. More and more people now work from a variety of different locations, combining work with leisure and changing the work life balance. While short weekend breaks by air are largely a thing of the past, the new working practices have allowed many people to take much longer breaks, fitting work around their holiday travel.

Transport logistics have also vastly changed in the years leading up to 2050. 'Zero-carbon' regulations and increased pricing of vehicle efficiency and load factors together with the end of cheap oil have promoted a shift towards lower-carbon modes and fuels, and increasing the cost overall. Companies now consider the carbon footprint as the primary driver for decisions about where goods are produced and how they are transported. In some cases production has been localised, but in other cases, such as some food crops, carbon footprinting has favoured production in countries with the most favourable climate. Transport has been optimised for carbon efficiency, through using ships that are slower, are built with lighter materials, and make use of wind-power. As well as constraints on transport, pressure to reduce resource consumption has changed the nature of consumer goods towards longer product lifetimes and greater durability.

John & long distance transport in 2050

- A male student of transport logistics
- Avoids a lot of travel by distance-learning, but feels this is at the detriment of personal contacts with other students
- Is being taught at university that carbon efficiency is now the primary driver of transport and logistics planning
- Accepts as normal travel experiences that elderly people like his mother regarded as major changes during their lifetimes: longer journey times, higher costs, less shorter trips and work from different locations
- Is used to taking holidays and leisure activities in his home region
- Enjoys full product information via carbon-labelling

Like the City scenario this scenario is also characterised by substantial cross sector changes resulting from increased costs. The tourism industry needed to adapt to changes in long-distance travel by placing more emphasis on regional tourism and activities such as hiking and cycling nearer to where people live. Authorities and people in more remote regions were facing problems of accessibility and thus economic disadvantage. These have gradually diminished as the new long-distance travel routines, such as spending longer times in tourist locations for both work and leisure activities, and new forms of related infrastructures begin to spread.

While the characters in the long distance storyline describe some of the changes as positive, such as more flexible working patterns, and the benefits of high speed rail travel, it is clear that the reduction in the ease and affordability of longer distance aviation has reduced people's travel choices in comparison with what has become regarded as normal in recent years.

4. Stakeholder responses to the storylines

4.1 Improving the plausibility and relevance of the storylines

Using the two storylines to help visualise the changes outlined by the experts' scoping study, the delegates were first asked to discuss the plausibility and relevance of the storylines. Issues raised included the practicality of some of the technical solutions described, the realistic extent of changes in the urban environment and transport infrastructure; the social impacts of the change and the representativeness of the characters and lifestyles described to the wider population. The storylines helped participants to think about the scenarios in the context of their own lives, and to consider issues relating to age and gender not fully represented by the characters in the story. As a result of these discussions a number of changes were made to the two storylines between the first and second workshops, including:

- Giving greater emphasis to walking and cycling, and more conventional forms of public transport such as buses, as opposed to hi-technology and infrastructure-intensive systems;
- Focusing on what is provided by new technologies and the changes they will lead to rather than trying to provide explanations of how they might work;
- More discussion of the implications of advanced communications on living and working patterns;
- Avoiding over optimistic predictions on the extent to which high speed rail and other major transport infrastructure networks can be built by 2050;
- Considering in greater detail how potential restrictions on long-distance aviation would affect travel behaviour and tourism;
- Discussing in much greater detail the cost implications of the proposed infrastructure and how this could be funded;
- Referencing regional inequalities across Europe and the potential need for financial transfers to support the development of the new infrastructure.
- Providing a more detailed discussion of logistics, retail business models and consumerism.
- Representing a wider range of social groups, lifestyles and journey types in the storylines, for example journeys made by older people or parents with children

The storylines summarised in the previous section reflect the revisions made in response to the feedback of the participants. However, constraints on time meant that it was not possible to take full account of all comments made, but the main themes are picked up in terms of the implications for society and the economy.

4.2 Implications for society and the economy

The delegates were asked to consider the wider implications of the scenarios, the positive and negative impacts and who the winners and losers would be. The table below summarises negative and positive implications that were identified for the key policy measures described in the storylines.

Storyline policy measure	Negative implications	Positive implications
Restrictions on aviation	Regional disadvantage, especially in countries dependent on tourism and those on the edge of Europe	More localised tourism across Europe, for example bringing benefits to former seaside resorts in Northern Europe
Widespread use of teleworking, telecommuting, teleconferencing and teleactivities	Social inequalities between those able to work remotely and those tied to fixed locations, for example manual and service industry workers; Greater energy use in telecoms and potentially in people's homes;	Reduced commuting leads to more cohesive communities where people live. Greater choice and flexibility for those able to work remotely, making it easier to balance work and family life
Increased freight transport costs and regulation	Reduced choice for consumers, job losses in distribution, and in regions dependent upon exports; small businesses will find it harder to adapt, being less able to relocate operations across Europe	More localised production providing more even distribution of jobs; New business opportunities in multi-modal and sustainable urban distribution
Carbon pricing and environmental taxation	Increased costs on industry; Social inequality;	Revenue stream for sustainable investment; New business opportunities and business models
Restrictions on car ownership and use	Loss of individual choice Loss of jobs in car industry	Greater equality of access to transport Improved availability and quality of other transport modes Improved quality of life in urban areas
Planning changes to increase urban density	Reduced living space	Improved accessibility and transport availability Improved local services, reduced need to travel

An interesting outcome of the discussion was that most participants appeared to be more positive about the 'City Transport' storyline than the "Long distance transport"-storyline. Part of the explanation may be that there are good possibilities to adjust lifestyles in cities and to move towards a low carbon future. There is some evidence that this is already taking place, as more people are prepared to live in the city without the car. It is here that the trade-offs between a more carbon intensive lifestyle and one that uses substantially less carbon is attractive as a slower lifestyle, based on local community, high quality spaces and proximity to facilities has much to offer. For the long distance travel, the opportunities for low carbon alternatives are less obvious, and there are many more difficulties in achieving substantial reductions in carbon. The discussants felt that the optimism for the city futures needed to be moderated by the problems of increasing demand for long distance travel.

The “City transport” storyline involves significant reductions in the use of personal car travel. But it offers a great variety of alternatives for travel. The communities described, with their local services and good quality street environments, were attractive to many end-users. In terms of social impacts, the extensive transport systems ensure that mobility is available to everyone. From an overall perspective this was regarded a more equal society than today, in which the adverse impacts of car travel most severely affect the least well off, who are also excluded from services requiring access by car. There was a lot of discussion about the plausibility of the assumed changes in individual city transport culture, especially in cities that have become car-dependent. Yet end users themselves pointed to cities that have been already successful at reducing car use, or have retained a culture of sustainable transport. They regarded these as positive examples that could be replicated.

The “long-distance” storyline was responded to rather negatively. Despite the described improvement in high speed rail the scenario assumes a reduction in long distance travel. This was considered by many end users to be an unacceptable loss of personal choice, as well as having serious impacts on the less accessible parts of Europe, and those most dependent upon tourism. Some suggested that aviation would have to be treated as a special case. This would mean that aviation would not be required to make the same level of savings as other sectors. There was much debate about the extent to which telecommunications could replace physical travel, and estimates varied from slight optimism to pessimism. Participants also raised the issue of wider societal implications in a world where those whose work can be done remotely gain greater freedom in where they live, and the ability to combine business and leisure travel; while those who work manually or are otherwise tied to particular sites will be disadvantaged, with greater social inequality as a consequence.

While freight transport is an important part of the scenarios, the majority of participants were not directly involved in its operations so there was less discussion about the impacts the scenarios would have on the logistics industry. However, a recurring topic concerned the impacts of new models of retail and distribution, combining elements of online purchasing with the desire of consumers to ‘touch and feel’ products in the shop. This could also incorporate return flows from much greater reuse and recycling of waste products, driven by a greater need to make efficient use of resources. Along these lines end-users asked how, in practice, logistics efficiency can be increased, taking into account limitations in rail networks and access, as well as constraints in capacity. With input from a representative of a supplier of consumer products there was discussion about what changes in distribution business models and regulatory practices are needed to facilitate load-sharing and other approaches to improving vehicle utilisation.

Box 3: New business and ownership models

Sharing vehicles and business operations to improve efficiency

A recurrent theme in the discussion was the idea that sharing and cooperation would become more and more important, affecting both individual vehicle ownership and travel and the business models of transport operators. Instead of owning their own cars, which they then use for the majority of their travel needs, people in the storylines use a much wider range of different transport modes and share or rent cars as needed for specific journeys.

To meet this need a new industry of mobility providers has grown up, offering a range of different services on a journey by journey basis, for example public transport, car and bike hire, taxis and lift sharing as appropriate. Effectively this represents a convergence between public and private transport, with the relatively small-scale and pilot car-share and similar schemes that exist at the moment becoming the norm. This gives the user access to a greater range of types of vehicle, enabling the most appropriate specification to be used, according to the distance being travelled, the number of passengers, the amount of luggage needing to be transported etc. One benefit of such a business model is that it provides a market for vehicles designed for more specialist purposes, and so provides a route to market for new technologies that might initially not be suitable for an all-purpose private car, but are fully adequate for a niche application. The multi-modal mobility provider packages together services, information and payment systems for a whole range of different operators, requiring a far greater level of cooperation than is currently the case across Europe and will in some cases require changes in transport regulatory and competition rules if it is to take place.

In retail and distribution increased cooperation is needed to improve the operational efficiency and utilisation of freight vehicles, to permit more efficient multi-modal operation to meet the requirements of sustainable urban freight deliveries, including a far greater level of tele-shopping and deliveries directly to the home. In a manner analogous to the mobility provider for personal travel, the urban delivery provider of the future will share loads and information, coordinate vehicles, organise return loads, for example of waste products to be recycled, using the most appropriate type of vehicle for the purpose being undertaken. Achieving the greatest potential will again require changes in regulation and competition regulation, as well as new business models, but doing so will make it easier for the industry to respond to the pressures of environmental pricing and regulation.

4.3 Barriers to implementation

Participants discussed the main barriers that lie in the way of implementing the measures described in the storylines. Not surprisingly potential public opposition and consequent lack of political support were frequently noted as barriers to fiscal measures and restrictions on the use of private motor vehicles and aviation. However, in the course of the workshops a number of more specific barriers were identified for which potential solutions were proposed. These included:

Barrier	Possible solutions
Lack of public funding for transport infrastructure, likely to be made worse by demographic change reducing the proportion of people that is employment and paying taxes	Re-allocation of roadspace (e.g. bus lanes) and restrictions on car use will give public transport more of a competitive advantage, which will attract more private investment towards it.
Regulatory and competition rules make it harder for different transport providers to work together to optimise vehicle occupancy and provide multi-modal services, especially across borders.	Regulatory and competition reform both at EU level and at member states.
Ingrained car-based thinking amongst politicians and planning professionals and lack of appreciation of the true potential for modal	Better sharing of information on different measures, using successful examples to encourage others, for example cycle use in Copenhagen, and focusing efforts to building on and

shift.	promote cities that have retained high levels of sustainable transport, including many in Eastern Europe.
A perception that CO_2 reduction is too complicated for anything to be done about it at the level of the individual.	There are more simple messages that can help drive home the possibilities for action, however this requires resolution and communication of some key issues of fairness, certainty and predictability ; also how much certainty is needed in the science and the expert views to convince people that action is needed now. Personal carbon allowances were also discussed, which would create a clear link to individual behaviour.

4.4 Consensus and disagreement

The membership of the group was intentionally diverse, reflecting quite wide differences in background, geographical representation, professional background and level of expertise in transport and energy technology. However, this did not prove to be a barrier to constructive discussion, rather the different participants found they were all able to make a contribution and valued what they learned from others. A strong level of consensus emerged by the end of the second workshop, and the conclusions of this report draw upon the consensus opinions. It is also of interest to discuss where consensus was not reached, which was sometimes because of disagreements that were not reconciled, sometimes because participants felt they lacked sufficient information to reach a firm conclusion. Some particular examples included:

- 'North-South' differences over long distance transport, reflecting concerns about the impact of restrictions on aviation on countries dependent on tourism;
- Different views on the role of technology, some optimistic about the potential for new carbon-free energy sources, other pessimistic; although a lot of uncertainty and desire for further information;
- Different views on the potential for telecommunications to replace travel, some welcoming the greater flexibility this could bring, others more concerned about social fragmentation and loss of personal contact;
- Some different 'east-west' perspectives: some reporting a concern from former Eastern European countries about restrictions on new found freedoms, others highlighting the positive example provided by cities that have until very recently predominantly used public transport and could therefore do so again.
- Some quite different perspectives on freight transport between those professionally engaged in transport and others not involved except as consumers, the latter tending to be more optimistic about the potential to shift loads to rail for example.
- Different understandings of the science of climate change and the level of need for action.
- Uncertainty over the extent and rate of development of future technologies and transport infrastructure- see Box 4.

Box 4: How fast and how far can change take place?

Uncertainties regarding new technologies and infrastructure

Throughout the discussion a number of occasions arose where it was difficult for the participants to reach firm conclusions because of uncertainties in the outcome of some key trends, particularly in the development and impact of new technologies, and the construction of new transport infrastructure. These included:

- How far and how fast can the decarbonisation of the electricity supply be implemented, an essential pre-requisite of the widespread use of electrical vehicles?
- What really is the potential for advanced telecommunications to replace travel? The rapid pace of change in this industry makes predictions of future social impacts very unreliable.
- Will the aviation industry be able to develop low carbon liquid fuels in sufficient quantities to avoid the need for significant cuts in the amount of air travel?
- What is the future of long distance road transport, taking account of the potential for driverless cars and advanced traffic management systems like 'platooning', as well as changes in energy supply?
- How extensive a high speed rail network is it realistic to expect by 2050?
- How rapidly is it reasonable to expect the massive changes in land-use planning assumed in the storyline, and the increased urban density in particular, to be implemented?
- What will the impacts be on manufacturing, production, agriculture of greatly increased transport costs and carbon pricing? Will this lead to a significant reduction in choice and availability, or will alternatives become available?

4.5 Improving Acceptability

One of the main objectives of the project was to understand how acceptable stakeholders would find the different types of policy measure that are proposed, and for those considered not to be acceptable, what would need to be done to make people more willing to accept them?

The main issues affecting acceptability can be categorised as follows:

- *Finance:* Many of the changes described involve massive investment, or re-allocations of existing investment. The critical question is, of course, who pays, and how? New sources of funding were suggested, such as carbon taxes, or carbon trading and rationing, and regulation to favour public transport so as to encourage private sector investment. However there are concerns about equity and accountability if such measures are introduced.

- *Governance and leadership*: Who has to act first? Will the public be more willing to take individual changes if governments take significant actions first? At what level is action required, local government for transport planning, Europe for carbon taxes and regulation? There were very different opinions on the extent to which the EU should intervene.

- *Stability, consistency and predictability:* In general it was felt that policies and strategies should provide more long-term stability and clarify expectations. Change, especially to businesses, is more acceptable if they can predict with some certainty how and when change will take place and if it is seen as affecting everyone equally, a 'level playing field'.

- *Wider benefits*- it was recognised that many of the policy measures discussed had benefits that went far beyond carbon reduction potential. In particular, many of the elements of the City scenario were positively received because they created a better quality and healthier

urban environment, or greater equality and accessibility. Better understanding of and promotion of the wider benefits would improve their acceptance by the public; this suggests that measures that offer wider benefits might be implemented before the others, even though they may be less effective in CO_2 reduction.

5. Conclusions

Building on previous scenario studies, a scoping study conducted on behalf of the EEA has concluded that significant reductions in CO_2 emissions from transport are needed if Europe is to meet its ambitious targets without imposing disproportionate cuts on other sectors; and also that technological change alone will not be sufficient to deliver these savings in transport. It will therefore also be necessary to make changes at the level of modal choice and transport demand: we will have to travel differently, and travel less. The policy measures required to achieve such changes have significant implications for society and the economy, so a group of societal stakeholders was invited to discuss, review and challenge storylines written to illustrate what the world might be like if these were implemented.

The process of visualising the changes required by the scoping study provided an effective tool to help the user representatives to explore how different policy measures impact on different groups, to understand relationships between different measures and to identify choices and compromises that might be necessary. The participants also brought a range of expertise from very different disciplines, and this meant that they could add context and detail to the discussions about the social and economic implications of different policies. This is an important consideration as transport is primarily a derived demand, not an end in itself, and our future transport system must meet a wider range of social and economic needs and values than might be fully considered by traditional transport planning.

In discussing the implications of the policy measures involved in the storylines the participants went far beyond the obvious headline issues that are frequently raised in discussions of transport policy in the popular media, for example the assumed opposition to increased transport costs. Participants were able to identify explore wider benefits from traffic restraint measures in the City scenario that are usually regarded as controversial, while identifying potential negative outcomes from improvements in telecommunications that are usually assumed to be positive. The participants also identified some key issues that were discussed in far greater detail than was originally discussed in the storylines, enabling them to be developed to improve relevance and plausibility. Of particular note was the greater emphasis put on the regional impacts of greatly reduced long distance travel, with those parts of Europe that are most dependent upon tourism losing out, so that Europe-wide financial transfers are needed to help compensate, while other areas might benefit from more localised tourism and recreation.

Moving from private car ownership to shared-ownership, car-clubs and short-term rental had been flagged as an important measure, yet end-users needed to know more about incentive schemes and how this shift would provide a route to market for niche vehicles and new technologies. End users stressed that cars would still have a role in long distance travel and that the storyline focused too heavy on aviation and rail. However, the implications for electric vehicle battery technology, and

potential new developments in vehicle control and traffic management, such as 'platooning', in which cars form virtual trains for long distance journeys, were regarded as far from clear.

Two other major items stressed by end-users concern the role of information technology and the critical role of sustainable energy transitions. End users required a better understanding of the potential of advanced telecommunications technology, given that IT is developing much faster than our transport infrastructure and built environment. New advances can cause major social change in under a decade, which seem to be far from fully understood. The links between transport policy and wider energy policy are obvious, as the decarbonisation of surface transport assumes the availability of renewably produced electricity, as well as the development of electric vehicle technologies. Yet end users stated that how the two areas are linked in a long-term perspective remains unclear.

When considering how to make such radical sustainable transport policies more acceptable, participants focused on key issues relating to *finance*, and the need for accountability and equality; *governance*, and the need for strong leadership as well as action taken at the appropriate level of government; stability and consistency, requiring a long-term strategy so that business can plan for the future, while suffering no competitive disadvantage; and the promotion of policies that offer *wider benefits* to society. The key to acceptability is to combine both the need to decarbonise and to improve the quality of life more generally, which requires basing decisions on wider considerations than just the cost per tonne of carbon savings.

In conclusion it appears that end-users were willing to accept large changes to their daily urban travel, especially where wider benefits can be demonstrated, but were less willing to accept larger changes to their long-distance travel, pointing to substantial needs for innovative policy design and communication if significant savings are to be achieved through the sort of measures described in the two scenarios. But the participants were able and willing to engage in a wide ranging and sometimes complex issues on the future of transport that will affect all people in the EU, and they have also added considerable value to the debate. Projects and approaches such as those adopted here should be used to involve the wider stakeholder communities, as understanding and acceptance are two crucial components of effective implementation.

Acknowledgements

The scenario development and preparation of technical documentation for the stakeholder workshops was carried out on behalf of the EEA by the UK Transport Research Laboratory, Oxford University Transport Studies Unit and Aether Consulting. The workshops were facilitated by specialist engagement consultants from IFOK Gmbh.

There were 15 participants from y countries across Europe, with a mix of Northern and Southern, Eastern and Western countries. There were 4 women and 11 men. Professions represented included an architect, consumer organisations, tourist organisations, local councillors, planners and private individuals.

Annex

Tables 3 and 4 provide a summary of 'Avoid', 'Shift' and 'Improve' measures considered in the expert scoping stage of the project.

Table 3: Examples of Carbon Mitigation Measures – Avoid

Measure	Policy Instrument	Passenger /Freight	% C Reduction on Base Case			Comments
			2010	2020	2050	
Increasing fuel prices by 10%	E	Both*	2%	2%	2%	Likely to be highly unpopular, although easy to implement.
National road pricing	R	Both*	6%	5%	5%	Some investment needed to set up the framework. Details of scheme need careful consideration.
Workplace travel plans	P/I	Passenger	3%	3%	3%	Relatively easy to implement.
Increasing population density in cities	P	Both	6%	5%	5%	Predicted to happen, but potential to facilitate through planning.
Teleworking	P	Passenger	3%	3%	3%	Predicted to happen, but potential to facilitate through IT investment etc.
Car sharing (reducing vkm by 30%)	P/I	Passenger	17%	16%	15%	Significant potential for reduction. Requires behavioural change, but little investment needed.
Car clubs	P/I	Passenger	36%	35%	34%	Significant potential for reduction. Requires behavioural change, but little investment needed.
HGV: computerised vehicle routes and scheduling	T	Freight	2%	2%	2%	Likely to be welcomed by Freight operators as results in improved efficiencies and therefore profits.

* The measure here is applied to both, but could be tailored to either passenger or freight.

Table 4: Examples of Carbon Mitigation Measures- Shift

Measure	Policy Instrument	Passenger /Freight	% C Reduction on Base Case			Comments
			2010	2020	2050	
Increasing bus frequency	P	Passenger	7%	7%	7%	Requires some behavioural change and not insignificant investment.
Bringing bus stops within closer proximity of housing	P	Passenger	5%	5%	5%	Only requiring lower levels of investment, and potential to significantly impact on behavioural change.
Reducing walking distance to amenities	P	Passenger	3%	3%	3%	This would be well suited to being accompanied by other measures, to encourage greater modal shift.
Encouraging cycling (reducing vkm by 5%)	P	Passenger	3%	3%	3%	Cheaper cycling option, but likely to be used in conjunction with other cycling measures.
School travel planning	P	Passenger	0.2%	0.1%	0.1%	Limited scope for improvement on current situation.

Table 5: Examples of Carbon Mitigation Measures- Improve

Measure	Passenger /Freight	% C Reduction on Base Case			Comments
		2010	2020	2050	
Cars: Improved combustion efficiency	Passenger	10%	9%	9%	These improvements are likely to be introduced in due course anyway.
Cars: Lighter weight vehicles	Passenger	8%	8%	8%	These improvements are likely to be introduced in due course anyway.
Cars & HGVs: Electric vehicles	Both	32%	30%	30%	Long lead time expected
Cars: plug-in hybrid	Passenger	19%	19%	18%	
Cars: Petrol to petrol hybrid	Passenger	9%	9%	9%	
All vehicles: biodiesel	Both	47%	47%	48%	
All vehicles: bio-ethanol	Both	24%	24%	25%	
All vehicles: hydrogen	Both	60%	60%	61%	Long lead time expected
Cars: switching petrol cars to bi-fuel CNG	Passenger	10%	9%	9%	Seen by many experts as stop gaps until hydrogen and electric vehicles are available
Cars: switching petrol cars to bi-fuel LPG	Passenger	7%	7%	6%	Seen by many experts as stop gaps until hydrogen and electric vehicles are available
Cars & HGVs: Fuel efficient driving	Both	15%	15%	15%	Could be introduced now with little expense
Cars: speed limit enforcement	Passenger	9%	9%	9%	Relatively easily implemented now with little cost
Cars: Improving tyre pressure and rolling resistance	Passenger	2%	2%	2%	Relatively easily implemented now with little cost
Cars: Improved vehicle aerodynamics	Passenger	1%	1%	1%	Expected to be implemented anyway
All vehicles: Active travel management	Both	4%	4%	4%	
Cars: Downsizing engine capacity with turbo-charging or super charging	Passenger	7%	7%	6%	
HGVs: Automatic tyre pressure adjustment monitors	Freight	3%	3%	3%	
HGVs: Reducing aerodynamic drag	Freight	1%	1%	2%	Expected to be implemented anyway
HGVs: Adding spray reduction mud flaps	Freight	1%	2%	2%	
HGVs: Low rolling resistance tyres	Freight	2%	2%	2%	These improvements are likely to be introduced in due course anyway.
HGVs: Vehicle platooning	Freight	8%	9%	9%	
HGVs: Fitting AMTs	Freight	3%	4%	4%	
HGVs: Switching to CNG	Freight	5%	5%	6%	Seen by many experts as stop gaps until hydrogen and electric vehicles are available
HGVS: Switching to	Freight	24%	26%	27%	

biogas					
Rail: hybrid trains	Both	0.1%	0.0%	0.0%	
Rail: Regenerative braking	Both	0.7%	0.7%	0.5%	Already in use
Rail: Electrification	Both	0.4%	0.4%	0.3%	Can be expensive depending on current infrastructure