# Backcasting in Transport

## Scenarios for the Future of European Long-distance Transport[1]

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**Despite the ongoing discussion on global warming, oil consumption and greenhouse gas emissions within the transport sector are still increasing. During the last decades, the European transport sector has been characterised by an impressive increase in overall transport volume and by exceeding growth rates in road and air transport. Policy papers and statistical reviews indicate that this trend will continue with increasing speed. By using the so-called backcasting approach, this STOA project discusses scenarios for a sustainable, efficient and less oil-dependent European transport system along with related policy options. The time horizon of the scenarios is 2047. The focus is on long-distance transport (LDT) including both passenger and freight transport. This focus excludes urban transport, which is of a different nature in several aspects and has been addressed in many European studies.**

### 1 Motivation and background

After publication of the last IPCC report on climate change in January 2007 (IPCC 2007), there is almost no doubt about an upcoming period of global warming. Evidently, this is caused by greenhouse gas emissions induced by human activities. Therefore, transport-related greenhouse gas (GHG) emissions are intensively discussed in the public domain. According to the IPCC report (2007), the transport sectors contribute with some 13-14 % to the global GHG emissions. For Europe, the European Environmental Agency states a 21 % share of transport in GHG emissions (EEA 2007) and for Germany, McKinsey calculated 18 % (McKinsey 2007). At the same time, last years extraordinarily high oil prices as well as the corresponding political instability in important oil exporting countries made us aware that nearly the entire transport sector depends on oil – a finite fossil resource.

Despite these developments, oil consumption and GHG emissions within the transport sector are still increasing on a global scale. During the last decades, the European transport sector has been characterised by an impressive increase in overall transport volume and by exceeding growth rates in road and air transport. Policy papers and statistical reviews indicate that this trend will continue with increasing speed (see EC 2001; EC 2006a, b; ASSESS 2005; ifmo 2007). Important driving forces are the enlargement of the EU, the expansion of the economy in modern societies, and an improvement in the general standard of living. An efficient transport system plays a key role in the economic growth and social wealth of modern societies. But the increase in congestions and bottlenecks in the European transport network restricts the free flow of goods and people, especially in the centrally located and densely populated regions of the European Union. At the same time, the increased traffic volume has led to a strong reduction in the quality of life because of the large environmental consequences, including emissions of air pollutants and noise, reduced spaces for living, and the segregation effects caused by the expanding transport infrastructure. So, a paradox is that one of the basic pillars of today's quality of life at the same time reduces that quality. Obviously, future European transport will face a wide range of challenges from various perspectives. Transport will be on the agenda of the European Parliament in the years to come.

Against this background, the STOA project on "The Future of European Long-distance Transport" focuses on the challenges mentioned above in order to contribute to transparency and improved governance in this highly complex field. The project discusses scenarios for a sustainable, efficient and less oil-dependent European transport system along with related policy options. The time horizon of the scenarios is 2047. The focus is on long-distance transport including both passenger and freight transport. This focus excludes urban transport, which is of a different nature in several aspects and has been addressed in many European studies.

It is hardly possible to make reliable predictions over a 40-year period in such a complex field. But the scenarios can give an idea on how the future might be and what is needed in different situations to achieve certain improvements or visions. So, there are two central objectives of this study: to give an idea of the scale of change required for achieving significant improvements in terms of oil consumption and $CO_2$ emissions and to assess and illustrate the potential policy and technology options in the light of different situations (scenarios or images).

## 2 "Backcasting"

A scenario is a description of possible future developments that seem plausible under different sets of assumptions within a chosen time horizon. There are numerous ways of building scenarios as a means to clarify policy options. The 2047 scenarios of the STOA project on the future of long-distance transport are intended to describe a future with a transport system that can meet certain targets – a normative approach was chosen here. It was decided to use the so-called backcasting approach for this project. Backcasting means to design "images" or situations of the future that would meet the targets and then to describe options or pathways to this situation. The idea of shaping the future according to what is preferred is constitutive when focusing on the development of a sustainable transport system – there is always a normative component in such reflections. Several studies on sustainable development or specifically on reducing $CO_2$ emissions in future transport have used the backcasting method, e.g. the POSSUM EU project and the UK VIBAT project (Banister 1998; Steen et al. 2000; Banister et al. 2000; Hickman, Banister 2005).

For a better understanding of the methodology applied for this project, it is helpful to distinguish four different steps in the backcasting process:

1. Identification of problems and targets;
2. Calculation of a baseline to illustrate the scale of change required to meet the targets;
3. Design of "images" of the future (2047);
4. Analysis and assessment of technologies and policy measures to form the trajectories leading from images of 2047 back to the present state and vice versa.

The scenario was worked out together with an interdisciplinary scenario working group established for this project.[2] The group has met several times, organised and managed by the Danish Board of Technology.[3]

## 3 Defining targets for 2047

The targets were discussed and adopted at a parliamentary workshop in the first phase of the project. Two quantitative targets were set: reducing $CO_2$ emissions by 60 % in 2047 and reducing oil consumption by 80 %. The third target "accessibility" is of qualitative character: to provide an efficient, effective transport system at affordable prices. Accessibility must be understood as a qualitative target that can be conceptualised under various aspects. We suggest to define "accessibility" in a rather pragmatic way as it is described in the Transport White Paper: "to help provide Europeans with efficient, effective transportation systems that offer a high level of mobility to people and businesses throughout the Union" (EC 2006a, p. 3). In addition, in this project "accessibility" is extended to concepts of virtual mobility and dematerialisation. It includes "access" to people, information and products via information and communication technologies in the form of video conferences, teleworking, teleshopping, E-books, etc. This means that physical mobility is not the only way to achieve accessibility, but is supplemented by a sort of "functional accessibility" (Åkerman, Hojer 2006). Obviously, the $CO_2$ and the oil targets are strongly linked to each other, whereas the accessibility target may conflict with these two, since increasing accessibility may go along with an increase in emissions and energy consumption.

## 4 Baseline scenario: data and system delimitations

One of the striking advantages of scenario techniques in general, and of backcasting in particular, is that they offer an appropriate framework for the combination of quantitative data with qualitative assessments and discussions. Regarding the quantitative side of the project, a so-called baseline scenario was calculated.

A baseline scenario is necessary to measure the scale of change required to meet the targets in 2047. This baseline was built by projecting data from today into the future of 2047 in a business-as-usual scenario assuming a continuation of current trends. The baseline was calculated on the basis of publicly available data from DG TREN (EC 2006b). Since the focus of this project is on long-distance transport, the first step was to find a suitable definition of long-distance transport.[4] The following "pragmatic" definition was considered appropriate for this project: "Long-distance transport is defined as all movements by modes of transport that exceed a distance of 150 km." The data source had to be adjusted to this definition, which was done on basis of available data and estimations by the working group. Some compromises had to be made. The most important was to exclude international sea transport. The reason for this was lack of adequate data. In general, not only the systems delimitation but also access to relevant data is a big challenge for creating the baseline in this type of EU-covering scenario studies.

The DG TREN data does not only continue recent trends and growth rates over the next 20 years. The data also assumes partial implementation of measures from the White Paper on Transport (EC 2001), and it is expected that these measures will have a positive effect on the growth rates of transport volumes and emissions. Therefore, a certain decoupling of transport growth from economic growth in Europe is assumed until the year 2030 – the time limit for the DG TREN data. It should be noted that the DG TREN 2030 calculations include other important assumptions that cannot be explained here. For the project on long-distance transport, the data set was prolonged to 2047 (2050) by continuing the growth rates assumed by DG TREN for the period 2020-2030.

On this basis, the calculations illustrated in table 1 were made. It shows that continuing the trends by use of the DG TREN data leads to a huge gap between the calculations for 2047 and the targets for 2047. The question is how this gap can be closed, which technologies, behavioural changes and policy measures are needed to break the trend indicated by the DG TREN data. To answer these questions the project moved to the next step in the backcasting process: designing a situation (in the following "image") for 2047 that (from today's point of view) seems to have the potential to close this gap, or, in other words, to meet the targets.

**Table 1: Main settings of three possible images**

| *2047* | *Image 1*<br>*Strong and rich high-tech Europe* | *Image 2*<br>*Slow and reflexive life-styles* | *Image 3*<br>*(contrast image): economic pressure + very expensive energy* |
|---|---|---|---|
| Governance | EU is cohesive and has a leading role in the world | Strong UN has established successful climate instruments | Weak EU, weak UN, limited international cooperation |
| Economy/GDP growth | Roughly 2.4 % | Roughly 1.7 % | Roughly 0.7 % |
| Lifestyles | Consumption-oriented, fast | Focus on health and quality of life | Consumption-oriented, fast |
| Means of accessibility | Air & high-speed rail | Virtual mobility & comfortable rail (and slow air) | Air & virtual mobility |
| Main LDT fuels | Electricity, hydrogen, biofuels, CNG, kerosene | Electricity, biofuels, CNG, diesel, kerosene | Biofuels, CNG, diesel, kerosene |
| Biofuels share 2047 | 30 % | 25 % | 15 % |
| Improvement of carbon intensity for aviation (2005-2047) | 64.3 % | 58.3 % | 58.3 % |
| Improvement of carbon intensity for trucks (2005-2047) | 57.2 % | 44.1 % | 40.1 % |
| Transport volume 2047 compared to baseline[5] | -30 % | -45 % | -60 % |

Source: Schippl et al. 2008

## 5 Three images of 2047

Images in the backcasting process should meet certain criteria (see Banister et al. 2008):

- The images should meet the targets.
- Each image should be plausible but can be relatively extreme.
- They should be clearly different from each other in order to give an idea of the huge variety of possible futures.
- The images should cover a sufficiently wide range of possibilities.
- To keep research manageable a small number of images must be selected.

These images describe the general situation including the most important socio-economic, technological and environmental settings and the most important key drivers. It was decided to develop the three images described below (see table 1). According to their main settings the images have the following titles: 1. Strong and rich high-tech Europe; 2. Slow and reflexive lifestyles; 3. Contrast image: Economic pressure and expensive energy.

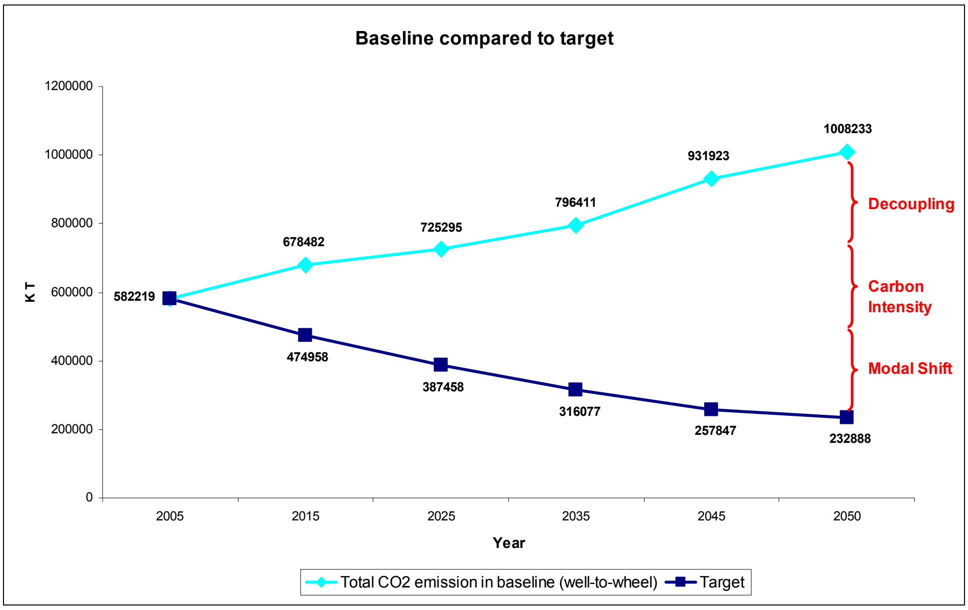
Regarding image 3, it may be debatable to what extent the designed situation is really desirable (see criteria above). However, this image was developed to provide a clear contrast when comparing images 1 and 2. It is referred to as "contrast image" in order to highlight its specific function. Plenty of other "worlds of 2047" are imaginable. Many other situations would be conceivable and probably plausible as well, or the reality of 2047 may come closer to a mixture of these images. But in order to reduce complexity and to keep the project manageable it was crucial to make a selection and keep the number of images as small as possible.

## 6 Strategies to achieve the targets

The baseline scenario is giving an idea of transport volumes, $CO_2$ emissions, and energy consumption for long-distance transport around the year 2047, based on the DG TREN data set. Now, it is important to understand the scale of change required to meet the targets and how the targets could be met, at least in theory. In the following, the focus will be on the $CO_2$ target. Figure 1 illustrates the immense challenge of closing the gap between baseline and target values. As shown, there are basically three strategies that could be used to close this gap and meet the $CO_2$ target (see also Dalkman et al. 2007):

- reducing transport volumes/decoupling of transport growth from economic growth:

**Figure 1: Baseline projections for $CO_2$ (in kilo tonnes) compared to the target for 2047**




* Strategies to close the gap between projection and target are shown on the right side of the figure.

Source: Schippl et al. 2008

avoidance of trips, shorter journeys, virtual accessibility (dematerialisation, teleconferencing), land use strategies;
- changing the specific carbon intensity of the different transport modes (increased system efficiency, including internal combustion engines as well as transport flows, alternative fuels and propulsion technologies);
- changing the modal split: inducing a shift towards less $CO_2$ emitting transport modes.

Examples of options for translating these goals into political practice: A reduction of transport volumes could be achieved through improved demand management. Increasing transport prices could have such an effect. Generating a specific carbon intensity could be achieved by developing new technologies. A modal shift to more energy efficient transport modes requires measures to increase the competitiveness of these modes.

These three parameters were changed in the three images to show how the targets could be met – in line with the settings of the images. The calculations indicate that the three different images or futures require considerable technical innovations to improve energy efficiency and carbon intensity, as well as a strong modal shift towards the rail sector. To have some chance of meeting the targets, a combination of much improved vehicle technology, low carbon fuels, modal shift and strong demand management (reduced transport volumes) is required in all three images. Crucial assumptions made in the images are very "optimistic", e.g. the extremely high share of biofuels in all images. However, the supply (and climate benefit) of biofuels is highly uncertain due to the conflict with food production and the discussion on more efficient use of biomass in power generation and in industrial processes. Also the modal shift and general technological progress assumed in the images are very optimistic and extremely challenging. Some of the figures used here are hardly realistic even if a 40-year time span is assumed, e.g. the improved carbon intensity for aviation of 64.3 % in image 1. However, such assumptions and calculations were required to meet the targets without excessively reducing accessibility. In image 1, transport volumes are reduced by 30 % compared to the baseline (which still means heavy growth compared to 2005).

The baseline calculations highlight the great importance of taking measures in air transport and long-distance trucking, due to their high share of $CO_2$ emissions in the long-distance sector. Trend breaks are needed for these two modes of transport; otherwise it is unlikely that the ambitious targets for $CO_2$ emissions and oil consumption can be met. The working group therefore decided to focus the discussion of policy measures on these two transport modes.

A broad set of policy measures was discussed in the working group. Some of the policy measures are either feasible in image 1 or in image 2. In image 1, there is a stronger focus on technological developments and a stronger need for decisive technological breakthroughs, since only a comparatively low reduction in transport growth rates is assumed. In contrast, the settings in image 2 indicate the need for behavioural changes, e.g. travelling comfortably becomes more important than travelling fast. The settings in image 2 allow a significant reduction in emissions by just reducing travel speeds in the air sector (see also Åkermann 2005).

In general, heavy investment in research and development of cleaner fuels and propulsion technologies is needed on a broad scale, since especially in the long-distance sector it is hardly possible to predict the dominant technology pathway for the next decades (see Schippl et al. 2007; JRC 2006). It is crucial to enable groundbreaking innovations. On the other hand, there are areas in which technologies are available but not consequently implemented because of a lack of regulations and harmonisation of European standards. A typical example is the rail sector which is supposed to carry much of the load in image 1 and image 2, but urgently needs to increase its capacities in order to be prepared for this. Extending and improving the network harmonisation of European rail standards are the most crucial measures in the long-distance sector.

The report illustrates that there is a broad range of options to reduce emissions and oil consumption in the long-distance sector. Still, in each of the three images it seems very difficult to meet all three targets. It is quite ambitious to reduce $CO_2$ emissions and oil consumption without extremely reducing accessibility. Below the line, it can be stated that both demand management and technical solutions are required. A mixture of pricing measures and incentives for the development and commercialisation of innovative technologies is applied in image 1 and 2. Most policy measures cannot be implemented in a "soft" way, because in this way it will not be possible to meet the targets. For example, road pricing on a low level will not change the situation significantly. The fact that certain policy combinations (including pricing) are needed in the different images, i.e. under different surrounding conditions, underlines the great importance of such policy packages.

Pricing measures were discussed in this project as a tool of great potential if used consistently. However, it is clear that public acceptability of policy measures (especially pricing measures) and technical innovation is a crucial factor for the future of European long-distance transport. Therefore, in a third phase of this project, citizens from selected member-states were involved in assessing the possible actions to meet the targets (see Leisner et al. 2008). In general, these European citizens would prefer to have technological solutions for reducing the negative environmental impacts of long distance transport. There are small differences between the selected member-states. Those with the highest standards of living tend to be more positive towards pricing measures and changes in transport behaviour, while the less wealthy tend to give economic growth the highest priority.

## 7 Concluding remarks

The backcasting methodology turned out to be a fruitful but also time-consuming approach to work on such an issue in an interdisciplinary working group. As already mentioned in the introduction, the overall objective of this report is not to make predictions on what the world and the transport system will look like in 2047. It is just impossible to produce reliable data over a 40-year period in such a highly complex field as European transport. There is a clear limit to quantitative approaches in such fields, which is why a scenario approach allowing for the combination of quantitative data with qualitative elements was chosen. Working with scenarios on a 40-year timescale means dealing with a lot of uncertainties. Despite these uncertainties, assumptions have to be made in order to be able to say something about what the world might look like in several decades. It is important to take these assumptions and system delimitations into account when looking at the results of the project.

The scenarios illustrate that the transport system is deeply embedded in the socio-economic environment. Until recently, the transport system was often regarded as an isolated system in the energy sector, since it is mainly running on oil. Whatever technologies will come after the phase-out of oil, the transport system will become much more an integrated part of the energy system.

Many of the transport-related policy measures have far-reaching effects, including rebound effects or unintended side-effects in other areas. Detailed technology assessment with stakeholder participation is required to identify such potential rebound effects or unintended side-effects. Furthermore, stakeholder involvement is crucial in developing a long-term vision of a low-carbon or even carbon-neutral European transport system – such a vision is still missing. Developing such a broadly accepted "guiding vision" again needs a broad basis. Working with scenarios or "images", as done in this project, seems to offer an appropriate framework for such an integrative and highly complex task. However, in spite of the complexity in this field, the main message of the report is rather simple: In order to meet the defined or similar targets in 2047, urgent action is needed right now. It is important to enable a strong modal shift towards the rail sector (both for freight and passenger transport), to invest in cleaner fuels and propulsion technologies, and to test pricing-measures for transport in order to better control the predicted heavy growth in transport volumes.

## Notes

1) This paper is based on the corresponding STOA report; see Schippl et al. 2008.
2) The project was carried out with great support by the scenario working group: Jonas Åkermann, David Banister, Maria Giaoutzi, Henrik Gudmundsson, Otto A. Nielsen, Peder Jensen, Kaj Jørgensen.
3) The project was managed by Ida Leisner, Danish Board of Technology.

4) It should be noted that several definitions do exist but are not used consistently across Europe.
5) Even a 50 % reduction compared to the baseline calculations for 2047 still means a growth in transport volume compared to 2005.

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