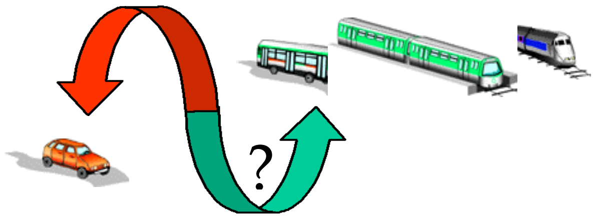

Towards the green environment

Comparison of environmental impacts of urban public transport and automobiles

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Paper for: International Symposium on Technological and Environmental Topics in Transport.
27-29 October 1998, Milan Italy

Abstract:
Over the last decade technological advancements of the car have gone rapidly. Emissions and environmental impacts have been significantly reduced. Even so that the Dutch Ministry of Transport wanted to check if it is still valid to prioritise investments in the public transport over the car system motivated by environmental arguments.

A study has been performed comparing the environmental impacts of car use and public transport in urban areas. Next to the current situation also technological and policy advancements have been taken into account in considering future scenarios for 2010. For this the NEI-FACTS model has been applied (Forecasting Air Pollution by Car Traffic Simulation).
As part of the urban public transport the environmental impacts of busses, trains and trams/metro have been considered. Next to emissions also energy use, noise nuisance, waste materials and use of scare space have been taken into account (MILOV model).

The study shows that notwithstanding the technological improvements by the automobile industries the urban environmental impact of the public transport modes is still less than that of cars. Especially rail systems seems very environmentally efficient. Nevertheless serious attention needs to be paid on the emissions of SO_2 and No_x by the public transport.

Policies like privetising public transport and reductions of subsidies are estimated to work in favour of the environmental impact of public transport although there might be a slower penetration of the market of cleaner but more expensive technologies. This only stresses the need of further internalising of external costs for all modes.

Keywords: emissions, public transport, policy

1 Background of the study

Notwithstanding lots of policy plans, practice over the last decades has shown (in Holland but likewise in other countries) that it is a fiction to believe that mobility can effectively be reduced. In the slipstream of desired economic growth motorised mobility keeps on increasing and is even amplified by demographic changes.

During the same period although, awareness of environmental impacts of increasing mobility has risen. In reaction the automobile industry has proved to be capable of adapting itself in such a way that without increasing real-term prices consumers can obtain vehicles which are significantly less polluting. It is probably due to economy of scale factors that advancements in clean technology have progressed more for cars than for public transport means like busses. This was the reason for the Dutch Ministry of Transport to start a study into the current and expected future contribution of the public transport towards the green environment.

This paper gives a brief overview of the mentioned study. A comparison has been made between environmental impacts of passenger cars and public transport in urban areas. The special focus on the urban areas is determined by fact that environmental problems of transport are most seriously perceived in urban conglomerations.

2 Approach

The study started out to describe the current situation. In order to do so the passenger mobility patterns in urban areas in the Netherlands have been analysed and categorised (type of trips, mode choice use, type of vehicle etc.). Basis for this have been household interviews which are collected on a yearly basis in the Netherlands by the central bureau of statistics (CBS). Out of the Dutch urban mobility characteristics environmental impacts had to be determined.

Environmental aspects included in the comparison of urban public transport and car-use in this study are:

- Emissions
- Energy consumption
- Noise nuisance
- Use of space
- Waste materials production

In order to determine the environmental impacts of car-use and public transport two models have been (further) developed and used by NEI:

- MILOV: Environmental impacts of public transport
- FACTS: Forecasting air pollution by car traffic simulation

The already existing FACTS model was especially adapted with respect to the specific application in this study for urban situations.

After the analysis of the current situation future scenarios have been constructed for the year 2010 including expected technological advancements and impacts of national and international policies on supply and demand. On total three public transport scenarios and two scenarios for the car were constructed.

Study inputs (supply & demand characteristics) and consequently its results are limited to the Dutch situation. It has already been suggested that the developed models could be adapted in their parameters and as such be applied to data for other countries.

3 The Models MILOV and FACTS

NEI has developed the so called MILOV model to make prognoses of emissions for the public transport (bus, train and streetcar/metro) per vehicle kilometre and passenger kilometre in urban areas, under various scenarios with respect to occupation rate and technological developments.

To determine energy use and emission of cars, the FACTS 2.0 model has been used. This model has initially been developed by NEI in collaboration with TNO research in 1992. In 1996 the model has further been elaborated and updated. FACTS can be used to make prognoses of car ownership, -use and emissions under various scenarios of economic and demographic developments, emission standards and government policies with respect to the transport sector. It is based on empirical relationships on the composition and use of the car fleet. The basis of the FACTS (2.0) model has within this study been adapted to the dedicated application for urban circumstances.

Composition of the fleet
To determine the environmental effect of public transport in an urban setting, one has to have insight in the composition of the fleet. Four means of public transport are distinguished: bus, streetcar, metro and train. Within these forms, differences in fuels used (diesel and gas) and techniques are identified. Also for passenger cars, a differentiation is made according to the fuels used and car technique.

Type of rides
In the urban setting, the different sorts of trips can be categorised into a number of what has been called ‘ideal types’ of trips. This is true both for public transport and the car.

The following ideal types have been identified:
A. Big cities:
Intra urban (within the city);
Suburban (between the city and the suburbs);
Corridor rides (between the big cities).

B. Cities:
Intra urban;
Suburban.

These different types of rides are characterised by a vector of parameters like speed, distance and use of stock (for example bus and train).

Ride segments
For bus and car, additional assumptions are made with respect to the composition of the ideal type rides. The ideal type rides are assumed to consist of several segments with their own particular characteristics. For example, a sub-urban ride will partly go through a city and will therefore have a component that is comparable with a city ride. Every ideal type ride thus consists of a combination of trip segments.

In total, three segments have been identified, each with different characteristics, influencing energy use and emission of gases: speed, constancy of speed and the influence of a cold start (additional fuel use). For every ideal type ride, these factors are taken into consideration and together with the relative weights of each segment per ideal type, this leads to average speeds per ideal type of ride.

Occupancy rates
Firstly, environmental effects per vehicle kilometre (car, bus, streetcar, metro) or per seat kilometre are determined. In order to determine the effects per travelled kilometre occupancy rates have to be taken into account. Empirical information on this was available.

Well to wheel effects
Before actual use of fuels the fuels have to be produced and transported. Bases on production statistics well to well correction factors for each specific type of fuels could be produced. For electrical traction only information could be obtained on indirect production of $C0_2$ and indirect energy consumption. Correction factors to primary energy use were produced accordingly.

Figures 1, 2 and 3 illustrate how the environmental effects of respectively car/bus, train and metro/streetcar have been determined.

Figure 1 Determination of environmental effects of the car and of the bus

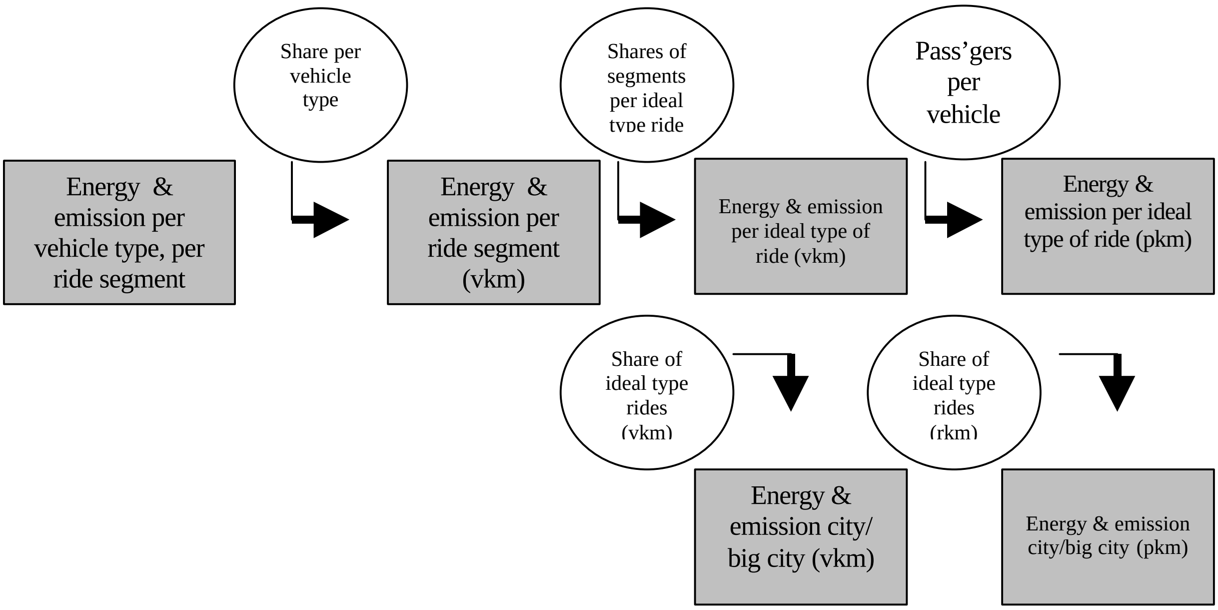


Figure 2 Determination of environmental effects of the train

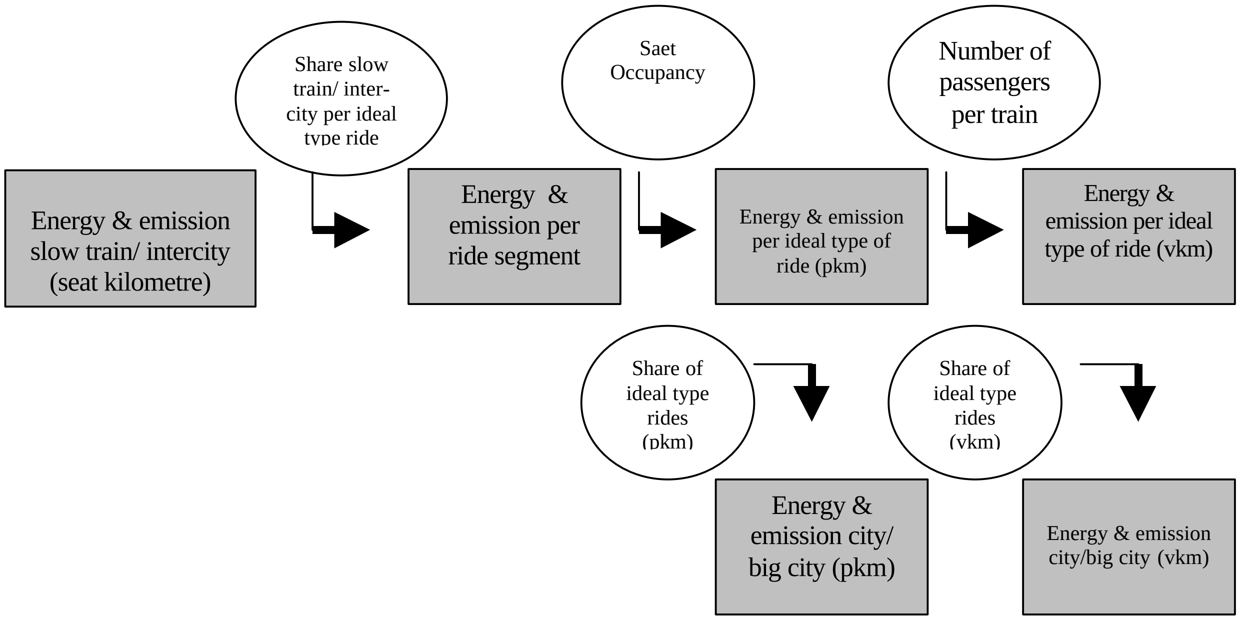
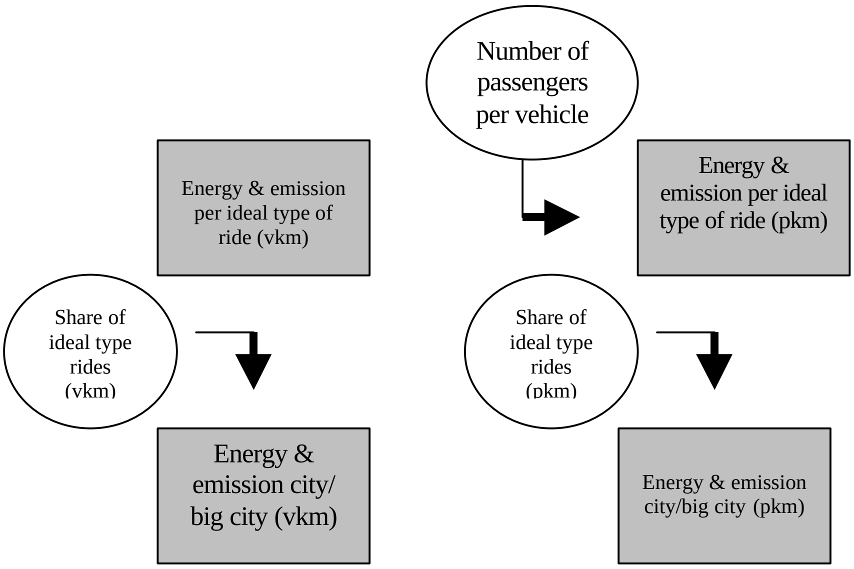
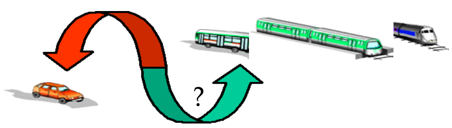


Figure 3 Determination of environmental effects of the metro/ streetcar



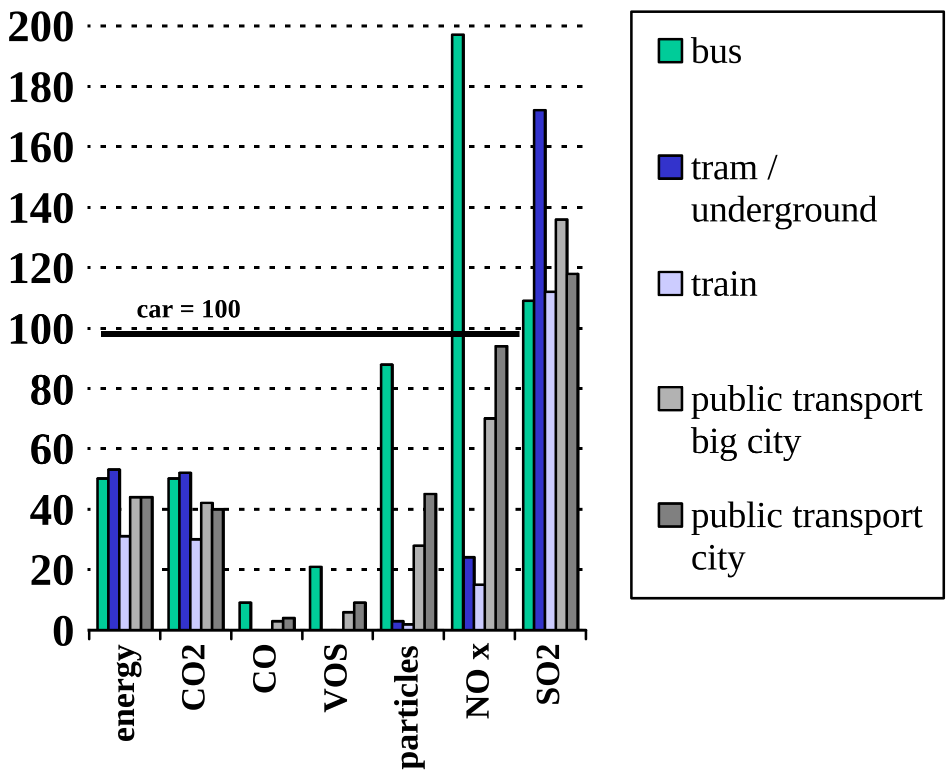


4 Results Public Transport

4.1 Current Situation

The current environmental effects, in terms of emission and energy use, of public transport and the car have been determined and compared. Apart from the individual transport means, bus, streetcar, metro and train, the public transport index figures are determined for the four biggest cities in the Netherlands and for the cities with more than 100,000 inhabitants (urban areas). These are (weighted) average values for public transport in these areas, on the basis of the shares of each public transport means. Different compositions of the public transport fleet in the bigger cities and urban areas would lead to different results. For example streetcar/metro does play a role in the bigger cities, but not in the general urban areas.

Figure 1: Environmental effects (per VMT), public transport compared to car (car=100)



It seems clear that, in the current situation, public transport scores a lot better than the car on most environmental aspects. It has to be realised that daily averages are taken and that the differences are more extreme in the peak hours and less in the off-peak hours. Energy use and CO_2 emission are both on a level that is 50 percent lower than for the car, and also the emission of particles that lead to urban pollution are generally substantially lower. Exceptions are the emission of NOx and SO_2, which also lead to environmental problems on a regional scale (acid rain). The emission of NOx is lower for public transport as a whole compared to emission by car vehicles, but is twice as high for buses. The emission of SO_2 shows a comparative disadvantage for all forms of public transport relative to the car. The importance that is given to reduction of SO_2 is limited, also because of the small share of traffic in total SO_2 emission. The reduction of SO_2 in electricity power stations plays an important role in policy discussions; this has direct relevance for vehicles that make use of electrical traction.

The bus has a substantially higher emission of NOx and a limited environmental disadvantage in SO_2 emission. Whereas the attention of policy makers is hardly paid to reducing SO_2, NOx is one of the determinants in the future norm setting of heavy vehicles like buses. The emission of particles seems to be lower per passenger kilometre than for the car, despite the negative image of diesel buses. Per vehicle kilometre, the emission of the bus is higher though. This is according to the image, which is largely influenced by the experience of standing or driving behind a bus, undergoing the soot of a driving bus.

Within public transport, transport driven by electrical traction (streetcar, metro, train) shows a very positive picture. An exception to this is SO_2 where rail transport has an index number being worse. We mentioned that the emission of SO_2 by electrical power stations receives a lot of attention and that reductions may be expected in the future.

For other environmental aspects, things look positive for public transport. Noise hindrance caused by rail transport (streetcar and metro) is lower than for the car. The bus is more or less comparable to the car, but will cause noise hindrance to a smaller number of people, because of the stronger concentration of traffic flows. Public transport also has a clear advantage with respect to the space occupied per passenger at the current average occupation rate. This is true for the space occupied by the vehicle itself and the infrastructure destined for the vehicle. On the problem of waste, public transport scores much better than the car, because of the longer technical life and the higher utilisation rate.

4.2 Future scenarios

In order to analyse the importance of public transport for the environment in the future, scenarios have been constructed: three for public transport and two for the car. These scenarios reflect possible developments until the year 2010. It has to be stated that the scenarios are heavily affected by national policy plans. Discussions of these are beyond the scope of this paper.

Underlying the scenarios for public transport, are expectations about the development of future demand and technology. A HIGH, MIDDLE and LOW scenario are defined. The core of the demand scenarios is:

- HIGH: according to prognoses of the Ministry of Transport made for SVV2 (national transport policy plans for the coming period);
- MIDDLE: according to the specific plans to increase cost coverage in public transport and privatisation operations for restructuring the sector
- LOW: a declining traffic volume caused by the abolishment of the free public transport access for students.

The technological public transport scenarios (supply scenarios) differ with respect to speed and extent to which new techniques are applied and emission norms become stricter and differences in relative use of vehicles with different sorts of fuels. In the LOW scenario, diesel is foreseen to remain the main fuel type, whereas in the HIGH scenario, gas will become the main fuel type. The MIDDLE scenario takes a real middle position. For the HIGH scenario, more rapid technological developments are foreseen for gas buses. For rail transport furthermore, differences in the use of sustainable resources for the production of electricity is foreseen in the scenarios.

For the car, two scenarios are formulated: a middle, and a high, ambitious one. These scenarios bound the domain in which car development is most likely to take place. Both in the car scenarios and in the public transport scenarios, no attention is paid to technical or technological developments which are unlikely to be introduced on a large scale before the year 2010, like electrically driven cars and buses.

For the middle scenario, the FACTS reference scenario is applied. This is a socio-economic scenario that determines shifts in the car fleet and a technological scenario in which government policy is stricter than before with respect to emission reduction, but that does not stimulate the energy efficiency of cars.

The high scenario anticipates new European guidelines on vehicle fuel use in the year 2005, leading to cars that are 25 to 30 percent more efficient than they are now. The guidelines are in line with the current European Commission's position at the start of the negotiations with the car industry. The emission reduction resulting from less fuel use at car fleet level, are determined from simulations of fuel saving in the FACTS model. If the foreseen reduction will actually be realised, depends upon the eventual norm-/guideline formulation and the way in which policy is implemented. If only fiscal stimulatory measures are taken, there is no chance that the scenario will be realised.

5 The Future Environmental importance of Public Transport

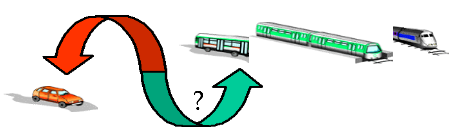
Resulting from the study, a relative environmental advantage for public transport will remain in the future: stabilising or even becoming slightly stronger. The car will make up, a big part of its disadvantage with respect to energy use and CO_2 emission.

Especially rail transport (train, streetcar, metro) will develop in a very positive way. Also its emission of SO_2 will become substantially lower than for the car in the future, through application of emission reducing techniques in electrical power generation.

The bus seems to be more sensitive for the car's technological developments. If the car's development is according to the middle scenario, the bus will keep its relative advantage in most respects (except for NOx and SO_2). If it is according to the high scenario, the bus will lose a big part of its relative advantage. Especially with respect to particles that contribute to souring and influence local air pollution (NOx and SO_2), the bus' relative advantage becomes smaller, particularly if diesel buses form an important part of the total bus fleet (LOW scenario). The environmental function of the bus also becomes smaller with respect to energy use and CO_2 emission, if highly more efficient cars are introduced.

If we do not consider variations in the occupation rate in public transport scenarios, only technological developments, shifts in fuel sorts and emission reducing techniques (brake-energy recycle systems) for the bus can be analysed.

Gas fuels score positively, especially because of reduction of NOx and particles that cause negative environmental effects on an urban scale. The HIGH scenario would lead to strong reductions of those effects. Also from the point of view of CO_2 gas buses are to be preferable on the middle-long term, despite the relative high energy use. However, also introduction of brake-energy recycle systems (with an energy saving potential of 25 percent) are taken into consideration. In the HIGH scenario,



approximately 30 percent of all city buses is assumed to have a system like that. Such a system is not yet marketed, though.

With respect to the environmental aspects noise, space and waste, the results are not so straightforward. All means of transport show a substantial reduction of noise. Especially the bus can consolidate its position if also quieter gas buses are introduced on a large scale. For rail transport, the reduction is expected to be more in line with the one of the car.

In the analysis of space as an environmental factor, the scope of analysis is important. If only the direct space occupied by the vehicle itself is considered, then the occupation of space of public transport and car will develop according to growth or reduction in the occupation rate. A growth in the occupation rate would lead to a reduction in the occupation of space per passenger. From the point of view of infrastructure destined for each transport mode, it is not clear in which direction the trend will develop. The conclusion seems to be contrary to the one made earlier, due to the larger reservation of space for public transport (bus lanes, inner cities closed to cars).

The relative advantage of public transport on waste as an environmental factor, is very large. Car developments will have only slight effects on this relative difference.

6 Conclusions and recommendations

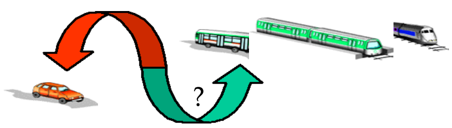
On the basis of the results, it may be rightly concluded that the environmental argument remains an important one for stimulating public transport. Especially for rail transport (train, metro, streetcar) the results are favourable. Only for the emission of SO_2 and NOx, additional measures are necessary to attain an environmental advantage for public transport.

It is important to keep up the environmental argument and to strive for public transport that has maximum environmental sustainability. It is important in order to keep an advantage on the car, but also to contain the absolute emission of transport and traffic in the Netherlands.

The study shows that in general the environmental argument for public transport can be maintained in the foreseen future. Rail transport develops in a positive way, through advancements in electricity generation, but also the bus can contribute to the positive trend though policy directed at the introduction of gas buses. The differences in energy use and emission of CO_2 -even though it is not an urban problem, it has wide societal attention - between cars and public transport will narrow, if cars' energy efficiency will improve at a rapid pace (HIGH car scenario). These developments will not be realised automatically, but will have to be supported by an active government and car industry.

The current transport policy aims at higher cost recovery in public transport, consequently this will lead to a higher rate of occupation and will affect the environmental function of public transport in a positive way. Realisation of a higher rate of occupation will require large efforts from all parties involved. It is implicitly assumed that there will be no impediments stemming from the purchase of more expensive, cleaner technologies, like gas buses. Impediments like this will have to be cleared away, as much as possible.

Bus transport is more sensitive than rail transport for developments in car technology. The environmental advantage of the bus will be surpassed by the car, if car technology should develop rapidly.



One of the elements on which policy can be based, is stimulating the development and eventual application of brake-energy recycle systems for city buses, considering the substantial potential for fuel saving (25 percent) that could be realised through this technique.

Policy that can now already be brought into practice, is stimulating the introduction of gas fuels (LPG, natural gas and for the future possibly DME). This will require that attention is paid to the cost aspects of the more expensive gas buses. The environmental burden of buses can be drastically reduced through further introducing gas fuels. Particularly from the point of view of reducing NOx and SO_2, gas buses are preferred. In this way, the negative perception of city buses (soot of a diesel bus) can be reduced. Gas buses have the extra advantage that they produce less noise than diesel buses, which is of relevance especially in a city environment. The faster introduction of the more expensive gas buses will conflict with the simultaneous goal of cost recovery in public transport. Further research will have to determine to what extent a conflict of goals like that would take place and which measures will have to be taken to prevent it.

Except for the fact that the use of gas buses now already leads to a reduction in the burden on the environment, there are real possibilities to make the buses even more environmentally friendly. The EURO-norms as they will be imposed in the next period will require a large technological progress especially for the diesel buses to meet these norms. According to current views, the diesel motor will just meet these norms. For the cleaner gas buses, the pressure stemming from the norms is much smaller and without supplementary policy much less progress will be made. Already at this moment, an LPG motor is available which emits ten times less polluting particles and NOx than the future diesel bus which meets the EURO norms. The introduction of those cleaner gas buses, will only be realised if supplementary policy measures are formulated and eventually taken. This could for example take place, by introducing on a European level, norms for city buses that are even stricter than the current ones.

Stimulating a quicker progress in gas bus' technology is also sensible, considering the developments which could especially become important in the long term, for the environmental function of public transport like the faster introduction of new car techniques like electrically driven vehicles. Through developments like these, the relatively positive image of public transport could be harmed quickly. Possibilities for substantial improvements of car technology, keep on existing for the long term.