Executive summary

1. General context

This project was carried out at the Centre for Economic & Social Studies of the Environment (CESSE) of the *Université Libre de Bruxelles* and comes under the general heading of the development of methodologies to assess the sustainable aspect of transport with a view to setting up sustainable development policies. One possible approach within this context and in order to contribute to the translation of the concept of sustainable mobility into operational terms consists of assessing the external costs for which the activities of the transport sector are responsible, i.e. the share of the social costs which are generated by these activities, but which are not met by those that occasion them but by others. These externalities mainly involve local, regional and global atmospheric pollution, noise pollution, the consumption of resources (space and energy), traffic accidents and congestion.

This study, carried out by the CESSE as part of the "Sustainable Mobility in the Brussels Region" project is particularly concerned with the development of methodologies to quantify the external effects of the activities of the transport sector and to express them in financial terms. The need for such methodologies is apparent in two main connections.

Firstly, within the context of a policy of internalisation, where external costs are often taken into account via regulations or economic instruments, the assessment in financial terms of the external effects of the activities of the transport sector enables the rate of internalisation to be determined for the various modes of transport.

Secondly, as part of the assessment of projects, policies and initiatives associated with transport, these methodologies make it possible to include the resulting environmental benefits which economic assessments frequently tend to overlook.

2. Objectives

As part of the project we consider the assessment of the external costs of road traffic through looking in particular at the external environmental costs (noise and atmospheric pollution) and focussing on their assessment in urban areas, where the problems posed by road traffic are more acute, and where the effects on the environment are more pronounced.

Apart from increasing our knowledge in this field, an essential aim of the study has therefore been to develop and apply a accounting framework for the environmental externalities connected with road traffic in the Brussels region.

Another important aim has been to develop an aid to decision-making that enables account to be taken of the environmental costs/benefits associated with initiatives in favour of sustainable mobility.

3. The effects of atmospheric pollution

With respect to the assessment of the effects of atmospheric pollution caused by motor traffic in terms of its harmful effects on public health, damage to buildings and the reduction of agricultural yield, for example, the overall methodology employed has as its basis an assessment of the damage costs. Also known as the 'impact pathway' approach, this methodology traces the progress of pollutants from their point of emission to their point of impact by following a series of logical steps.

The assessment of the external effects caused by the transport sector is thus the result of an analysis with four principal stages:

- the assessment of pollutant emissions caused by road traffic;
- the determination of the resulting concentrations of pollutants in the atmosphere (immissions);
- the calculation of the physical damage;
- its expression in financial terms.

The approach, which is particularly favoured by the European ExternE project, was adapted to the situation in the Brussels region through the development of suitable tools to calculate the emissions and to model the emission-immission relationship. Local particularities such as the quantity of material exposed to pollution in the Brussels region were also taken into consideration in this process.

From a methodological point of view specific approaches were considered in function of the levels - local, regional and global - considered. The purpose of these approaches was mainly to establish a relationship between emissions caused by transport and the resulting concentrations, and also to quantify the damage caused.

A specific model was developed for the calculation of emissions from road transport. This calculation was required for the assessment of damage at the different levels. The model in question was the AMORTEC (Aggregate MOdel for Road Traffic Emissions Calculation) model, which is based on the COPERT methodology and which enables emissions from road traffic to be calculated on either an annual or a monthly basis at aggregated national or regional levels. Air pollutant emissions and fuel consumption associated with road traffic in the Brussels-Capital Region were calculated on a monthly basis for 1990-1999 for the different categories making up the vehicle fleet; its development over the period was also taken into account.

3.1 Assessment of damage at local level

A particular model was developed to assess effects at local level; these effects received priority status in the study. The model in question is the "Brussels-Air" model for the assessment of the external costs of atmospheric pollution in the Brussels-Capital Region. This model consists of three modules. The first, which is devoted to emission calculations, establishes a link between the principal economic activities responsible for the pollution of the urban atmosphere (traffic and domestic and office heating) and their respective emission levels. The second module determines the resulting immissions (the concentrations to which the receptors are submitted) by using an econometric type of model to model the relation between these immissions, previously calculated emissions, and the various relevant weather variables. The third module assesses the damage in physical and financial terms by means of appropriate exposure-response and damage functions.

Using this model, the situation in the Brussels-Capital region was assessed in terms of local effects for the 1995-98 period.

Taking 1998 as a reference year, this analysis enabled the estimated cost of damage to health and buildings in the Brussels-Capital region to be placed within the interval [220; 3,526 M€] , with a median value of 882M€ and a degree of probability of 67%.

Of this amount, 92% (811M€) relates to damage to health, with pride of place going to particle-associated deaths, which alone accounted for 651 M€. This extremely high estimate of damage in terms of deaths is linked to the high monetary value attributed to human life (3.1 M€) and years of life lost (84K€ for chronic mortality). In terms of morbidity, the damage associated with atmospheric pollution caused by vehicles is also considerable and runs to some 159M€, of which 62% (98M€) is connected with chronic bronchitis due to fine particles, and 24% to days of reduced activity, also due to particles.

Comparatively speaking, the damage caused to buildings is lighter and in 1998 was assessed at more than 70 M€ for the Brussels-Capital region. The lion's share of this damage is due to particles soiling buildings.

In terms of developments, the analysis highlights an overall 14% decrease in annual external costs between 1995 and 1998. After 1997, this decrease manifested itself mainly as the result of a considerable decrease in the emissions of sulphur dioxide and particles by traffic.

In terms of external costs per km travelled, these estimates point to an average cost of 300 M€ per km covering the whole of the vehicle fleet. A more detailed analysis nevertheless shows a large difference between different vehicle types (cars, vans, lorries and buses) and different types of passenger and freight transport. Considerable differences have also been shown to exist within each vehicle category in function of technological developments.

3.2 Assessment of damage associated with photochemical pollution

In this context a methodology was used that fell back on a determinist model to model weather conditions and the chemical processes leading to the formation of ozone. Use was made of the METHPHOMOD model developed by the numerical modelling group in the Atmospheric & Land Pollution Laboratory of the Lausanne Ecole Polytechnique Fédérale.

The use of this model required the establishment of a register for Belgium covering hourly emissions for a series of 36 pollutants such as methane, carbon monoxide, nitrogen monoxide, nitrogen dioxide and sulphur dioxide as well as 31 types of non-methane volatile organic compounds.

In terms of damage, the approach was limited to short-term effects (episodes) for which exposure-response functions were available. The analysis pays specific attention to repercussions on health in terms of acute mortality and hospital admissions as the result of respiratory problems during periods of photochemical pollution.

To begin with, the methodology enabled a photochemical pollution episode to be modelled. This episode, which occurred on 10th and 11th August 1998, was taken as reference case, and the methodology enabled the damage associated with it to be calculated over a 120 sq. km. zone centred on Brussels. The assessment produced external costs of 2.2 M€, 80% of which were associated with acute mortality.

Three scenarios involving the reduction of precursory gas emissions (nitrogen oxides and volatile organic compounds) were then analysed. The strategies considered consisted of reducing the total emissions in the Brussels-Capital region in three ways, namely NOx emissions alone by 50%, COV emissions alone by 50%, and NOx and COV emissions together by 50%.

On the basis of this analysis it was not easy to decide univocally on the most efficient strategy to adopt with a view to improving the situation. In fact, as far as the most efficient strategy to reduce photochemical pollution is concerned, different conclusions can be arrived at depending on the criterion selected for assessment purposes and the geographical zone involved.

Whereas the reduction of COV emissions in the Brussels region seems to be the most efficient strategy to reduce the peak values observed in the area, the reduction of NOx is the most efficient approach in terms of decreasing the average values over the 8 hours associated with health effects.

The various scenarios considered all point to increases in ozone concentrations in the major urban areas (Antwerp, Brussels, Gent, Charleroi and Mons-Borinage), a factor which indicates that these areas are saturated in NOx and COV.

In the case of the Brussels-Capital region, the least deleterious strategy, i.e. the one which leads to the lowest increase in the concentrations, is that of reducing COV emissions alone.

In terms of damage to health, only the scenario involving a reduction in NOx emission results in a reduction in the external costs associated with the episode in comparison with the reference case. The two other scenarios result in slight increases (less than 1%) in this damage despite the overall effect of reductions in ozone concentrations.

This is explained by the fact that only damage to health is included in the assessment, and that the greatest increases in photochemical pollution occurs in major urban areas. Since the positive effects of a reduction in the precursors in the Brussels region are felt mainly in rural areas, the incorporation of the long term effects on vegetation and crops might well lead to different conclusions.

3.3 Assessment of damage associated with global warming

On the basis of the greenhouse gas emissions (CO_2, CH_4 and N_2O) calculated by AMORTEC and a value of 2.4 €/tCO_2 as favoured by the new FUND 2.0 model for greenhouse-effect-linked externalities, the external costs associated with global warming caused by road traffic in the Brussels-Capital region were evaluated at 1.7 M€ for 1998. It must nevertheless be pointed out that this value is heavily dependent on numerous uncertainties and on the value attributed to the costs associated with each ton of CO_2 emitted. This value has already been revised several times and should be upgraded in the near future in terms of new findings.

A 9% increase could be demonstrated between 1990 and 1999 in connection with changes in the situation in the Brussels-Capital region. Furthermore, a fledgling decrease made its appearance in 1999, a factor which seems to be characteristic of the development of emissions from traffic in urban areas in comparison with traffic on motorways and in rural zones, where the margin on progression is still considerable.

3.4 Analysis of initiatives in favour of sustainable transport

So that it can fulfil its purpose as an aid to decision-making, the study of the effects of atmospheric pollution caused by motor traffic has been complemented by an assessment of the potential effects of various initiatives in favour of sustainable transport.

Three types of initiatives were assessed in comparison with the situation in 1998, which served for reference purposes. These were technological initiatives for general purpose of improving the emission parameters of the vehicle fleet; initiatives encouraging transfers towards cleaner modes of transport; and initiatives to reduce the demand for transport.

To begin with, an analysis of the potential repercussions of the various technical and non-technical initiatives enables to highlight that considerable reductions in emissions can be expected, at least in theory, by the modernisation of the vehicle fleet (the elimination of vehicles dating back to before 1990). Moreover, the margin of progression "guaranteed" by the development of European standards limiting potential emissions in the medium term (Euro IV in 2005) is considerable - a reduction of some 80% for pollutants responsible for local and regional pollution. On the other hand, these norms do not guarantee any reduction in green house gas emissions.

With respect to global warming, we have been able to point to the fact that traditional vehicle technologies (petrol and diesel) do not seem to be able to bring about an effective reduction in CO_2 emissions even when they conform to the strictest standards. With respect to technical initiatives, only the introduction of new vehicle technologies (electric, hybrid or fuel-cell vehicles) or the use of alternative fuels such as LPG seem to be able to reduce CO_2 emissions to an acceptable level to meet the objectives of the Kyoto protocol. Non-technical initiatives are also particularly interesting in this context.

In addition, the new vehicle technologies permit interesting advances to be made in terms of the reduction of local and regional pollution.

As far as the non-technical initiatives are concerned, the effects of a shift, albeit only minimal, towards cycling are particularly interesting in terms of damage reduction.

Finally, the analysis shows that a reduction in freight transport by road or its transfer to cleaner means (waterborne or rail) have a number of potentially significant effects on the reduction of atmospheric pollution despite the relatively small share of freight transport in overall traffic.

4. External costs associated with noise caused by road traffic

In the framework of the "Sustainable Mobility in the Brussels Region" project, the aim was to assess the costs deriving from the noise caused by road traffic in the Brussels-Capital region. Two different approaches were selected for this purpose. On the one hand, there was the initially selected contingent evaluation method and on the other, the hedonic price approach. This latter eventually offered a more extensive view of the situation.

4.1 Contingent evaluation

This method of assessment aims to determine a person's Willingness To Pay (WTP) in order to obtain an advantage, here a reduction in noise levels.

The use of contingent evaluation turned out to be well suited to the situation in the Brussels-Capital region, and the results obtained were rich in lessons. Not only do the inhabitants of Brussels-Capital consider themselves to be seriously incommoded by the noise of the traffic in streets with noise levels above 55 dB(A), but certain of them are ready to pay sometimes far from negligible sums to reduce this daily nuisance. The factors explaining the interviewees' reactions also revealed a large degree of variability in explaining their annoyance and understanding the reasons for their subscribing to the contingent market.

The use of this method enabled the WTP of those questioned to be assessed. In the sample under consideration the average WTP was 224 BEF per month and per household (2,688 BEF per year). If this sum is divided over the members of the household, the average comes out at 114 BEF per month and per person, i.e. 1,368 BEF per person per year (=34€ per person per year).

4.2 Hedonic price method

With the extension of the project from December 2000 to June 2001, it appeared interesting to complement the analysis of the costs occasioned by the noise of road traffic in the Brussels-Capital region by a study of hedonic prices. The so-called hedonic method aims to assess the cost of noise through its repercussions on the property market.

Even though the statistical regression carried out as part of the study showed itself to be generally coherent and significant, because of the current state of the data the analysis, once completed, did not enable any conclusions to be drawn concerning the variable forming the main centre of interest, i.e. the influence of noise levels on housing prices.

It emerges clearly from the results that further study is both necessary and desirable. To be more sure of obtaining more complete results, any subsequent study should be based on a sample which has been constituted in function of the requirements of the method and which, unlike the sample used in the present study, should contained a greater number of dwellings situated along the city's main thoroughfares.