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The stakes of air pollution in the transport sector

Robert JOUMARD

French National Institute for Transport and Safety Research, Lab. Transport and Environment
INRETS, case 24, 69765 Bron cedex, France. joumard@inrets.fr

Abstract

The main pollutants are listed for today and the future according to the progression of air quality, as measured in France and in the European Union during the 90's, to the progression of pollutant emissions of road transport in France, as calculated for the period 1970-2020, and to the progression of public concern regarding air pollution and environment. These pollutants are headed by carbon dioxide, followed by nitrogen oxides and fine particulates. The stakes in terms of technology and transport supply and demand are assessed. These stakes for society allow us to propose several directions of research in the field of air pollution that respond more to current problems than those of the past.
Keywords*: air pollution, transport, emissions, air quality, stake, technology.*

Introduction

One specific characteristic of research into air pollution and more generally into the environment is that the subjects dealt with strongly depend on social demand. This was the case for research into acid rain and then into the greenhouse effect, as well as into visibility over North American cities. Furthermore, the directions proposed by researchers cannot be confined to scientific interrogation alone (understanding that which is not understood), but must take into account the public stakes involved in the area concerned. Regarding air pollution generated by transport, the progression of air quality, as well as that of emissions, which has the advantage that it can be extrapolated fairly reliably for the next twenty years, provide a wealth of information. Here, we attempt to highlight the present and future stakes of air pollution by examining the French case, which is much the same as that of the European Union, and by consequence the priority subjects for research.

1 – The progression of air and road traffic emissions

Air quality

We now have a series of air quality measurements under comparable conditions over a sufficiently long period to be able to evaluate the progression of air quality with fairly good precision: more than four decades for sulphur dioxide SO_2 and black smoke, about fifteen years for most pollutants, though a little less for ozone O_3 (Airparif, 1999, Stroebel et coll., 2003).

Thus in the Paris region concentrations of SO_2 have fallen by a factor of about twenty since the 50s. Carbon monoxide and total hydrocarbon HC contents have decreased by a factor of four over the last ten years, whereas concentrations of black smoke fell by nearly 80% from the fifties to eighties before stabilising. PM10 contents appear to have fallen considerably. Nitrogen dioxide NO_2 contents remained fairly stable during the 90s and appear to have fallen over the last few years; the phenomenon appears to be more marked for peak urban nitrogen pollution. On the contrary, concentrations of carbon dioxide CO_2 have risen. Lastly, ozone concentrations have not undergone significant changes over the last six years; however, although the averages do not appear to have changed much at all, the median of the annual averages has tended to increase. This could result in a geographical extension of the periods of photochemical pollution whose clouds often cover several thousand kilometres.

Consequently, it can be considered that air quality has improved globally, though not systematically. However, this appreciation does not correspond to the perception of the public, the majority of which considers, at least in France, that air quality has never been so bad and problematic. The environment is in fact an essentially personal conception based on the personal perception of the stakes involved, through our perception based on our senses (vision, smell) to which we add intellectual elements stemming from technical and scientific information we receive from the education system and the media (van Staëvel, 2000).

This personal construction is then organised by long term vision. Thus 65% of French people consider that technical progress in the 21st century will be made to serve sustainable development (Maresca & Hebel, 1999), which consists in handing on a viable environment and nature that is not a wilderness to future generations. Since the population is now far more aware of environmental stakes and the risks of pollution, air pollution considered as an environmental problem has therefore deteriorated, despite a relative decrease of concentrations.

Emissions

Although transport plays a minor role in SO_2 emissions, it contributes nearly one third of carbon dioxide emissions and almost two thirds of CO, NOx and the precursors of photochemical pollution, with substantial differences between regions. However, globally, transport has undergone strong growth (European Communities, 2002): in the European Union, all modes taken together, passenger transport – expressed in passenger-kilometre – has progressed respectively by 3.2 then 1.8% per year during the 70s, 80s and then 90s, with very similar figures for road transport taken alone. Moreover, with a progression of 6% per year since 1970, the increase of air transport is even greater. During the 90s this corresponded to a doubling of traffic every 42 years for road transport and every 12 years for air transport.

In parallel, all modes taken together, goods transport – expressed in ton-kilometre – increased by 8% per year throughout the last three decades of the century, and by 3.5% for road transport alone, corresponding respectively to a doubling of traffic every 27 and 20 years.

The progression is positive though contrasted for air quality, with strong simultaneous increases of traffic and concern over the environment. It is useful to give close examination to the progression of pollutant emissions to evaluate the consequences of increased traffic and technological improvements on air quality. This evaluation was carried out for the French situation, using the European inventory model Copert3 (Hickman et coll., 1999). This model uses emission factors stemming from measurements made on vehicles up to the Euro 2 emission standard applicable until 2000. After this, emission factors must take into account the Euro 3 and Euro 4 standards, the latter standard being applicable from 2006. Due to the lack of any concrete project with a longer time frame, no hypothesis for a further standard has been introduced. No specific account has been taken of innovative technologies such as particle filters, hybrid engines and fuel cells, likewise with accessories such as air-conditioning. Road traffic forecasts up the year 2020 are derived from the median scenario (B) of the French Ministry of Transport (SES, 1998).

The results (Lacour and Joumard, 2002 - cf. figure 1) show that following near stagnation during the 70s and 80s, CO and HC emissions fell by a factor close to three in ten years. This very positive trend should continue in the years to come. It is due to the introduction of 3-way catalytic converters on gasoline vehicles and the increased number of light diesel vehicles that emit less CO and HC. It should be remembered that over the last thirty years, nearly one out of two vehicles sold in France is diesel.

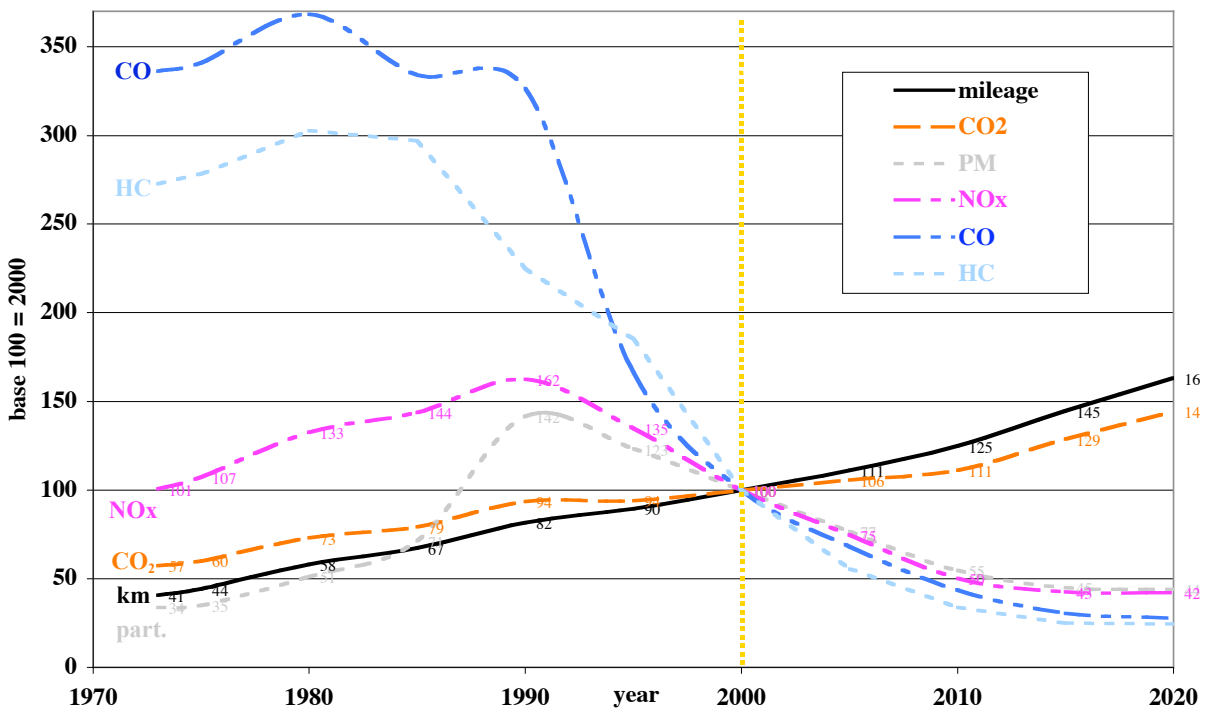

Figure 1: Relative evolution according to the figures of 2000 for French road traffic emissions from 1973 to 2020. Base 100 = year 2000.

The progression of NOx and particles is slightly different: they increased until the mid 90s (particles increased by a factor of four in twenty years), then they decreased by nearly a third, a trend that should become firmer. This configuration can be explained by effects that act in contradiction with each other: the growth of traffic, increased use of diesel – a diesel engine emits three times more NOx than a gasoline engine with a catalytic converter – and very efficient catalytic converters. Progression in the future should be even more apparent for particles, due to the gradual introduction of very efficient filters, of which no account has been taken. For these two pollutants, emissions from two-wheeled vehicles are absolutely negligible, while heavy goods vehicles emitted respectively 37 and 22% of the total in 2000.

On the other hand the situation is particularly worrying for CO_2, the main greenhouse gas. Emissions of this gas progressed by 75% from 1973 to 2000, and should progress by nearly 50% by 2020. This forecast does not take into account the possible introduction of technologies that consume only small amounts of fossil fuel such as hybrid cars and those equipped with fuel cells. Neither do they take into account the air-conditioning that equips most of the cars sold today, resulting in an additional 10% of CO_2 and up to twice the emissions of the other pollutants (Barbusse et coll., 1998 ; Ademe, 1999 ; Barbusse & Gagnepain, 2003).

Although progressions are favourable for all the pollutants, apart from CO_2, the emission levels of all forms of transport are nonetheless much higher than those of the first half of the 20th century. The Swiss Environment Office (OFEFP, 1995) showed that emissions are now nearly five times higher for CO and THC, and resp. ten and twelve times higher for CO_2 and NOx than during the first half of the 20th century. These factors reach respectively 50, 10 and 20 in comparison to 1900.

2 – Technological stakes

Unit emissions

CO_2 emissions increase slightly less than traffic, meaning that on average unit emissions decrease. Figure 2 shows that this is the case for light vehicles whose aggregate emission factor fell from 273 g/km in 1973 to 215 in 2000. This progression is due to the combination of highly significant improvements in engine technology with a parallel increase in vehicle weight, power and comfort which act in the opposite direction. On the other hand, average unit emissions and consumptions

have increased for motorised two-wheeled vehicles, increasing from 83 to 99 g/km in 27 years due to the increased numbers of powerful motorcycles that are partially replacing mopeds. Likewise, emissions by heavy duty vehicles have increased, rising from 935 to 1002 g/km from 1973 to 2000. This growth should continue at a more moderate pace in the future.

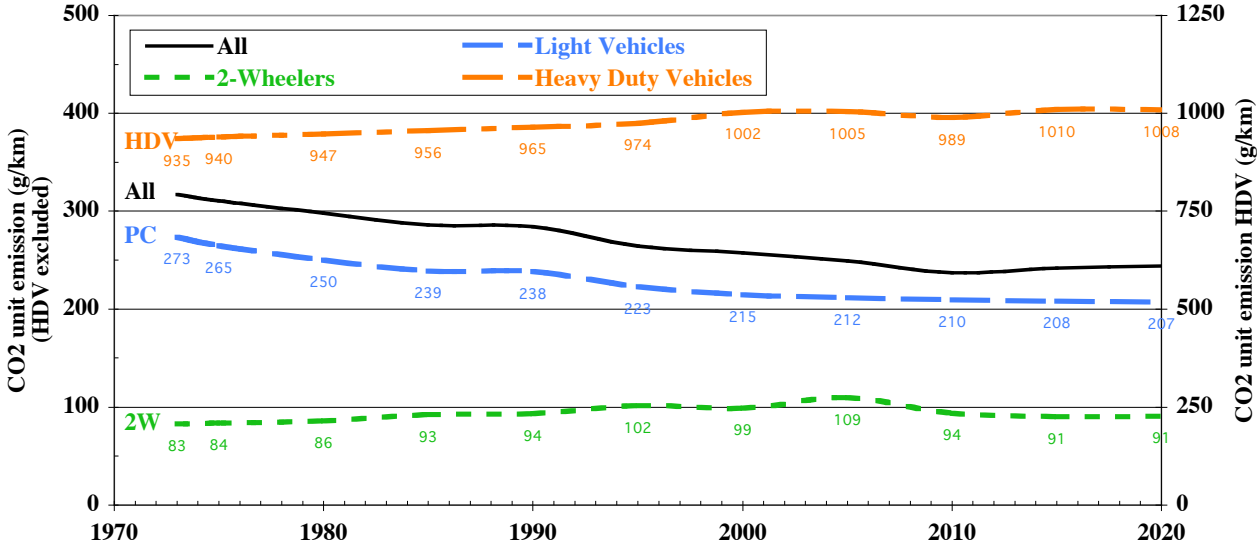

Figure 2: Evolution of average CO_2 emission factors per type of vehicle.

The situation is more favourable for NOx, for which the average emission factor for light vehicles (gasoline and diesel together) has been cut by more than half since the 70s and should fall by a factor of around four from now to 2020. For heavy duty vehicles, buses and cars, the emission factor has only fallen by a third and should fall again by a factor of nearly 3 in the next twenty years. However, the emissions of two-wheeled vehicles have increased, more than doubling in the last 30 years, though they are still nine times lower than those of cars. Nonetheless, by 2020 they will be only just a little less.

Technologies

The main challenge concerns the reduction of unit emissions of carbon dioxide from light vehicles, motorcycles and heavy duty vehicles, and the continued reduction of nitrogen oxides and fine particles emitted by light diesel and heavy duty vehicles, without increasing emissions of other pollutants. These reductions should be considered for the entire lifecycle of vehicles and infrastructures, at least by incorporating the energy production system used and the real uses of the vehicles.

European automobile constructors have undertaken to reduce the consumptions and average unit emissions of CO_2 of new private cars by 21% from 1995 to 2008 (ACEA agreement), gasoline and diesel taken together. However, this agreement does not take into account car air-conditioning. Besides its negative effects on CO_2 emissions and other exhaust gases, air-conditioning suffers from leaks of cooling liquids that are also powerful greenhouse gases. This could ruin ten years of effort to reduce fuel consumption on the one hand, and considerably lessen the positive progressions expected for the other pollutants. By taking into account cooling liquid leaks, Ademe estimates that the ACEA agreement will not lead to the expected decrease of 2% of greenhouses gases emitted by private cars, but to an increase of 8% from 1995 to 2020 (Ademe, 1999). Technological improvements therefore have to be considerable in order to ensure that this demand for comfort does not result in local pollution and significant increases in the greenhouse effect. There is no doubt that an efficient way of spurring these improvements would be to incorporate air-conditioning in emission and fuel consumption standards, though this is not the case in Europe at present.

Several technologies can or will be capable of reducing pollutant emissions.

The substitution of fuels. Increased use of diesel vehicles will lead to a probable reduction of CO_2 by 10 to 20%. The use of liquid petroleum gas (LPG) and natural gas would permit a reduction of CO_2 by 10 to 25% compared to gasoline, though this comparison would be slightly unfavourable in the case of diesel (IEA, 1999).

The filter for diesel vehicles traps particles at the exhaust outlet but gradually becomes clogged. Therefore it is vital to regenerate it periodically, something that appears to have been solved in a reliable way (Barbusse & Plassat, 2002). Many of the buses and heavy duty vehicles in circulation as well as new vehicles can be equipped with filters whose resistance is guaranteed through time. According to a large number of independent studies, all emissions of particles can be reduced, especially the finest which are most harmful for health, with an efficiency ranging from 90 to 99.9%. For private cars, the only system on the market today is progressively being used to equip new cars constructed by Peugeot-Citroën. It requires direct injection with a common rail and the use of an additive based on cerium. During the short regeneration of the filter about every 700 km, emissions increase from 10 to 100% for the gases and by a factor of 30 for the particles. Thus the result is very positive for exhaust emissions, as well as for the cerium which is completely recovered on the filter. The other constructors intend to follow suit and Ford and Renault announce this technology for 2003. The filter developed by the latter does not use an additive but a catalyser to achieve the same level of efficiency. Diesel vehicles thus equipped should emit fewer particles than gasoline vehicles.

Direct gasoline injection aims at improving the engine's yield by injecting the fuel directly into the combustion chamber rather than into the intake manifold of the gasoline engine or into the combustion pre-chamber for diesel engines. Widely used for diesel engines, this technology appears promising for gasoline engines, though the first models on the market show only small savings for combustion and an increase of particle emissions. Savings in consumption from 10 to 15% are expected in time.

S*upercharging* consists in compressing combustion air. This permits the injection of higher volumes of fuel into a cylinder of equal volume and therefore increase the vehicle's power. Future developments aim for gasoline vehicles to use supercharging to reduce engine volume without increasing power. Since consumption under urban conditions is practically proportional to engine volume, this permit reducing consumption.

Electric cars. The energy efficiency of electric motors is twice as high as that of heat engines, i.e. 90% as opposed to 35 to 40%. Furthermore, the efficiency of heat engines depends on driving conditions, which is not the case for electric vehicles. At present two main directions are being taken to introduce electric vehicles: hybrid vehicles and fuel cells (Yonnet & Badin, 2002).

The introduction of *hybrid vehicles* that associate a gasoline power train with an electric power train aims at making up for the heat engine's shortcomings. The goal is to store the energy generated by the brakes in the batteries of the electric power train. This energy is lost in a traditional engine. It is also possible to charge the batteries by running the heat engine at a speed that guarantees its optimum efficiency, which is rarely the case under urban traffic conditions. This provides a saving of 30% under urban conditions, but none on the highway (Jeanneret et coll., 1999).

Fuel cells constitute a direction for completely electric vehicles. They convert the chemical energy of hydrogen and oxygen directly into energy. When the vehicle consumes hydrogen, local emissions are nil. However, the only significant element is a balance that takes into account the hydrogen production section, which plays a major part. This well to wheel balance of cars propelled by fuel cells currently shows a saving close to 30% (if once considers the compressed hydrogen obtained from natural gas in the European Union), which may be cancelled in the next ten years by the progress made by traditional technologies (Antoine et coll., 2003).

3 – The stakes of mobility

Greenhouses gas will certainly remain a major challenge and one that causes increasing concern,

since technological improvements do not offset the growing demand for comfort, which is very energy expensive, combined with growth in traffic. The OECD estimates that even the accelerated introduction of hybrid vehicles and fuel cells will not suffice to achieve ecologically viable forms of transport by 2050 (Wiederkehr, 2000). Only 40% of the effort required should focus on technology while the remaining 60% should focus on managing demand for transport and the adoption of more sustainable modes of transport. This implies major modal transfers to less pollutant modes such as walking, cycling and public land transport, and above all control over demand for the mobility of people and goods.

Some people think that demand for transport does not exist in itself and that it stems from infrastructures; in other words it is the traffic that adapts itself to the supply of infrastructures. Thus at least in the medium term, efforts should be made to control infrastructures. Without strong political will, none of these orientations will bear fruit.

What is more, the place of the environment and problems of atmospheric pollution in the decision-making process has changed. The environment is initially taken into account in environmental impact assessments (EIA) aimed at providing an objective evaluation of a project's impact on the environment, then possibly introducing corrective measures, but without bringing into question the main decision. Strategic environmental assessments (SEA) are carried out from the design phase of a project, before the main decision is taken. Thus the environment takes on a strategic role since it is one of the components of decision in the same way as technical and economic aspects are. We can only really speak of an approach that incorporates the concept of sustainable development if the decision-making process also takes into account environmental, economic and social aspects. This is currently more an objective than a reality, since although environmental aspects are always taken into consideration, long term impacts are hardly ever mentioned and decisions are usually taken with priority given to economic arguments.

4 – The stakes of research

Apart from fundamental research, which remains necessary though participates little in research into air pollution in the field of transport, most of the research carried out on the subject has finalities, that is to say it explicitly aims at reducing the impacts of transport and its emissions of gases and particles into the atmosphere. This requires understanding of the psycho-sociological mechanisms at the core of the perception of the nuisances, the physical, chemical and biological mechanisms triggered by the impacts of pollution on different environments, including human, the mechanisms of emissions (from energy to transport economics), and lastly the political mechanisms involved in decision-making. The problems of this research are therefore directly linked to the nature of the impacts and importance of the stakes.

The problem of transport-generated air pollution is not that of the 70s or 90s and will be even less so in the next ten to twenty years, when the results of the research carried out today will have been applied. Therefore we must give priority to pollutants, impacts and the development of tools that are at the core of major challenges and progressively leave the other subjects to one side, even though uncertainty calls for prudence and thus very active monitoring.

In terms of pollutants, priority must first be given to greenhouse gases and especially carbon dioxide and thus the consumption of fossil fuels; secondly, NOx and the precursors of photochemical smog, since its progression can hardly be considered as being positive; and thirdly, fine particles while awaiting the near disappearance of diesel emissions.

Regarding impacts, the greenhouse effect is undoubtedly the most important stake. Thus we should improve our knowledge, especially by taking into account a larger number of pollutants whose effects can vary as a function of their place of emission. The second impact in terms of magnitude is undoubtedly sensorial (odours, smoke, soiling) into which very little research is carried out, although all the surveys show that this is considered to be a major nuisance by the population. However, this aspect is somewhat lessened by the reduction of smoke emissions. Following this, mention can be made of photochemical pollution that is decreasing less than its precursors, which is

rather astonishing, then the impacts on fauna and flora. Lastly, the problem of synergies between impacts, between different aspects of air pollution and different impacts on the environment has hardly been touched upon.

In terms of tools, a distinction can be made between emission tools and decision-aid tools. For emissions, priority should be given to macroscopic aspects by taking a life cycle type approach to the transport service. It should incorporate emissions from the production, utilisation and destruction of infrastructures, energy and vehicles. Socio-economic aspects are essential since, although unit consumptions are almost stable, the growth of traffic and its relation with economic growth raises problems.

As for decision-aid tools, we cannot content ourselves with the analytical approach dear to the world of science, since it does not provide clear and simple answers, that is to say in an aggregated way, to the simple questions asked by both decision-makers and the community. It is particularly urgent to aggregate the different impacts composing air pollution, including pollution sensitive to the greenhouse effect and photochemical smog and even to take a systemic approach to the environment, for which the concept of sustainable development appears to be promising. This approach would gain from researchers sharing a common culture vis-à-vis all aspects of transport generated air pollution, the environment and transport.

Conclusion

Uncertainties regarding the progression of concentrations of different pollutants remain important given the short time-span involved, and when taking into account the large number of pollutants for which no regulations exist, this time span is very short. Certain of these pollutants may become apparent soon, such as carbon dioxide, which has transformed from an inert gas into a major pollutant in a few years. These uncertainties are as great for emission inventories, for non-regulated pollutants and also because we may have ignored an important source of emission, as can be seen today with automobile air-conditioning.

We should therefore be careful when making conclusions and orienting research. In particular it would be unwise to abandon areas of research that may become important in a few years, contrary to current thinking. However, several strong and unquestionable directions of research remain, focused on the problem of the greenhouse effect, which we are beginning to understand but do not know how to solve. Moreover, systemic approaches to air pollution and the pair environment-transport appear interesting. They should allow better response to the problem of sustainable development than current approaches of an essentially analytical nature.

This analysis is based on Western European realities which can vary significantly from those of Eastern Europe, and emerging and developing countries. Therefore conclusions cannot be extrapolated without analysis.

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References

Ademe (1999) : Impact comparé de la mise en place de l'accord ACEA et de la pénétration de la climatisation automobile (Compared impact of the ACEA agreement and of the automobile air conditioning penetration). Ademe note, Paris, 27 May 1999, 11 p.

Airparif (1999) : Les tendances de la pollution de l'air en Île-de-France (Trends of air pollution in Paris region). Airparif actualité, June, Paris, 6p.

Antoine L., E. Martorana & F. Badin (2003) : Hydrogène : du puits à la roue (Hydrogen: from well to wheel). Inrets report, Bron, France, n°LTE 03nn, 220 p.

Barbusse S, D. Clodic & J.P. Roumégoux (1998) : Climatisation automobile, énergie et environnement (Automobile air conditioning: energy and environment). Rech. Transp. Sécurité, n°60, p. 3-18.

Barbusse S. & G. Plassat (2002) : Les particules de combustion automobile et leurs dispositifs d'élimination (The automotive combustion particles and their elimination). Ademe report, Paris, 42 p.

Barbusse S. & L. Gagnepain (2003) : La climatisation automobile, impact énergétique et environnemental (Automobile air conditioning: energy and environmental impact). Données et references, Ademe report, Paris, 8 p.

European Communities (2002): EU energy and transport in figures, statistical pocketbook 2002. EC, Luxembourg, 207 p.

Hickman J., D. Hassel, R. Joumard, Z. Samaras & S. Sorenson (1999): Meet - Methodology for calculating transport emissions and energy consumption. European Commission, DG VII, ISBN 92-828-6785-4, Luxembourg, 362 p.
http://vergina.eng.auth.gr/mech/lat/ ou www.inrets.fr/infos/cost319/index.html

IEA (1999): Automotive fuels for the future. Int. Energy Ag. report, Paris, 92 p.

Jeanneret B., F. Harel, F. Badin, R. Trigui, F. Damemme & J. Lavy (1999) : Évaluation des performances du véhicule Toyota Prius (Evaluation of the performances of the Toyota Prius car). 4e conf. C-VELEC, Grenoble, 3-4 nov. 1999, INPG, Grenoble, France, p. 168-178.

Lacour S. & R. Joumard (2002) : parc, usage et émissions des véhicules routiers en France de 1970 à 2020 (Fleet, use and emissions of road vehicles in France from 1970 to 2020). Inrets report, Bron, France, n°LTE 0208, 89 p.

Maresca B. & P. Hebel (1999) : L'environnement, ce qu'en disent les Français (Environment, what tell the French). Doc. Française, Paris, 218 p.

OFEFP (1995) : Émissions polluantes dues à l'activité humaine en Suisse de 1900 à 2010 (Pollutant emissions due to human activities in Switzerland from 1900 to 2010). Cahier de l'Environnement, n°256, 122 p.

SES (1998) : Les données détaillées du SES - le marché des véhicules (Detailed data of the vehicle market). Ministère des transports, DAEI-SES, Paris, 1998.

Stroebel, R., Bouallala, S., Colosio, J., Fangeat, E., 2003. Quelques données sur l'évolution de la qualité de l'air en France (Some data on air quality evolution in France). Pollution Atmosphérique, special issue, Nov. 2003, 9-21.

van Staëvel E. (2000) : Cultures environnementales contemporaines et pollution (Present-day environmental cultures and pollution). Rencontres européennes pour une histoire de l'environnement, Clermond-Ferrand, France, 4-6 mai 2000.

Wiederkehr P. (1999): Environmentally sustainable transport: report on phase II of the OECD EST project. OECD report, ENV/EPOC/PPC/T(97)1/final, Paris, 100 p.

Yonnet JP. & F. Badin (éd.) (2002) : Véhicules électriques et hybrides, enjeux technologiques et perspectives (Electric and hybrid vehicles: technology stakes and prospects). 5e colloque C-VELEC, Grenoble, 25-26 juin 2002, actes Inrets, n°84, Bron, France, 200p.