Institute for Applied Environmental Economics

EX-POST ESTIMATES OF COSTS TO BUSINESS OF EU ENVIRONMENTAL POLICIES

Case study ROAD TRANSPORT

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TABLE OF CONTENTS

		Page
SUMMARY		3
1	INTRODUCTION	5
2	EX ANTE AND EX POST ASSESSMENT OF THE ENVIRONMENTAL COSTS IN ROAD TRANSPORT IN THE NETHERLANDS	6
2.1	Introduction	6
2.2	Methodology	6
2.3	Gasoline and LPG passenger and light duty vehicles	7
2.4	Diesel passenger and light duty vehicles	9
2.5	Diesel heavy duty vehicles	10
2.6	Fuel quality: gasoline	12
2.7	Fuel quality: diesel	13
2.8	Environmental vehicle inspection	14
2.9	Overview for the road transport sector	15
2.10	Comparison with other international studies	17
3	TECHNOLOGICAL PROGRESS AND ENVIRONMENTAL COSTS IN THE TRANSPORT SECTOR	20
3.1	Introduction	20
3.2	Development of costs of a regulated 3-way catalyst	20
3.3	Development of costs of a catalyst converter (“can”)	21
3.4	Conclusions	21
4	WHAT CAN BE LEARNED FOR FUTURE ESTIMATES	23
BIBLIOGRAPHY		24
ANNEX I: DEVELOPMENT OF CONSUMER PRICE INDEX (CPI)		26

SUMMARY

Scope of the case study and time frame
This case study relates to EU vehicle emission and fuel standards for road transport. It focuses on ex ante estimates and ex post realisations in the Netherlands in the period 1985-2001.

Differences between ex-ante and ex-post cost estimates
The introduction of EU vehicle emission and fuel standards for road transport has led to a considerable reduction of emissions from road transport. In the same time new technologies had to be introduced leading to additional costs. In general, early cost estimates (around 1985-1990) have overestimated the cost by a factor 2, but for different technological measures different factors apply.

In the following table the findings of the case study are presented (comparing the estimates for 2001 with the realisations):

Table A
Summary of ex ante and ex post estimates for measures to reduce emission from road transport

Case study item	Ex ante estimate € mln	Ex post realisation € mln	Cost ratio (ante/post)	Key drivers of difference
Total transport	1123	529	2,1	Technological development and economies of scale
Catalyst converters for gasoline passenger cars	506	253	2,0	Unit costs of catalyst have decreased due to resource efficiency and economies of scale
Modifications diesel, passenger cars	136	25	5	Integrated approach rather than add on equipment
Modifications diesel, trucks	208	27	8	Integrated approach rather than add on equipment, slower implementation
Unleaded gasoline	213	25	9	Unforeseen decrease in additional distribution and production costs for unleaded gasoline
Low sulphur diesel	31	118	0,3	Lower sulphur contents than anticipated and higher additional production costs
Vehicle inspection	30	81	0,4	Underestimation of (additional) inspection costs

Source: CBS and TME

Reasons for the differences
It appears that in most cases the ex ante estimate of unit costs for the future is too high: either no attention was given to “normal innovations” (higher resource efficiency; economies of scale) or unforeseen developments leading to cheaper solutions (engine modification in stead of particle traps and oxy catalysts for diesels). In some cases the underlying assumptions about for example vehicle sales or moment of implementation of certain pieces of legislation explain part of the observed differences.

A more recent ex ante assessment of Touche Ross (1995) also overestimates compliance costs for vehicle standards (if compared with CBS statistics), confirming the findings of the case study.

The results of the case study show that in ex ante assessments the development of unit costs (due to technological developments and economies of scale) should be taken on board to arrive at more realistic cost assessments for the transport sector.

1 INTRODUCTION

This report is the result of one of the six case studies that have been carried out in the context of the study “Ex-post estimates of costs to business of EU environmental legislation” (IVM, 2006). The case study investigates the question to what extent the *ex-ante* and *ex-post* estimates of costs to the road transport sector resulting from EU environmental legislation differ, how these differences can be explained, and what the implications are for cost assessments.

This specific case study on road transport aims at giving an overview of ex ante and ex post assessments of the costs of applying environmental technologies in road transport. More specifically the analysis is on the directives on:

- Emissions from motor vehicles, diesel engines, soot, etc (70/220, amen. etc.);
- Lead content of petrol, quality of diesel, sulphur content (85/210, amen. etc).

The basis for the case study is formed by time series (covering the period 1985 – 2001) of ex ante estimates and ex post realisations in the Netherlands:

- the ex ante estimates were derived from a cost-assessment for the second Netherlands National Environmental Programme (TME 1993);
- the ex post realisations are based on CBS-statistics (CBS environmental costs for transport on CBS-Statline).

The case study aims at identifying the additional costs due to the implementation of various parts of the EU legislation for the transport sector, with a focus on the Netherlands. In principle the Dutch legislation follows the EU-standards, but by means of differentiation in excises (for unleaded gasoline and low sulphur diesel) and duties on the sale of new vehicles, the introduction of cleaner transport has been stimulated. This has lead to a slightly faster implementation of EU standards than needed according the EU-directives.

The reason to focus on the Netherlands is that the data that are available allow for a detailed analysis. Moreover, the vehicle fleet in the Netherlands is quite representative for Western Europe, with all major brands well present. Moreover, the way in which the costs for the transport sector are surveyed by the CBS includes analysis and consultation of international data sources.

The differences have been analysed by looking into the basic data used in the ex ante estimates (quantities, additional costs per unit) and the statistical assessment.

The results of this case study have been placed in a broader perspective by also looking at the results of some other studies. Specific attention is paid to the influence of technological change (and economies of scale) on unit costs of environmental equipment.

Finally some attention is paid to the lessons that can be learned from the case study.

2 EX ANTE AND EX POST ASSESSMENT OF THE ENVIRONMENTAL COSTS IN ROAD TRANSPORT IN THE NETHERLANDS

2.1 Introduction

In the Netherlands during the 80-ties and 90-ties of the 20th century studies have been carried out on the costs of environmental measures. For the first National Environmental Programme (VROM, 1989) and Concern for Tomorrow (RIVM, 1988) various scenario analyses were performed. At the same time the Central Bureau for Statistics (CBS) started to collect data on the costs of environmental policies.

By comparing estimations made for the NEP with CBS statistics, differences between ex ante and ex post costs can be tracked and analysed. In this section we will do so for the Dutch transport sector, focussing on:

- gasoline/lpg passenger and delivery vehicles (light duty vehicles);
- diesel passenger and delivery vehicles (light duty vehicles);
- diesel heavy duty vehicles;
- cleaner fuels (gasoline and diesel);
- environmental inspection.

As far as we have been able to investigate, the Netherlands is the only EU member state where the Statistical Office structurally collects data on costs of the application of environmental technologies and measures in transport from 1980 onwards.

2.2 Methodology

Both the ex ante and ex post study that have been surveyed, costs are defined as ¨environmental, compliance costs¨ (see also chapter 3 of the final report “Ex-post estimates of costs to business of EU environmental legislation” (IVM, 2006)). This is a narrow definition of costs and directly links to additional costs due to environmental regulation.

Data on estimated costs are taken from estimates of environmental costs for the second NEP (1993), made by TME for RIVM and the Ministry of VROM (Environment) (TME, 1993). Estimates are made in fixed price level 1993.

Basically the costs of applying environmental technologies in the transport sector were subdivided by type of technology and by type of vehicle or fuel. The following subdivision was used:

- passenger cars, gasoline;
- passenger cars, lpg;
- passenger cars, diesel;
- carbon canisters gasoline cars;
- delivery van, light duty vehicle, gasoline/lpg;
- delivery van, light duty vehicle, diesel;
- heavy duty vehicles, diesel;
- gasoline fuels: lowering lead contents and unleaded gasoline;
- diesel fuels, reduction sulphur contents;
- annual environmental inspection of vehicles.

Costs are estimated by multiplying unit costs of technology[1] (for example the costs of a catalyst per vehicle), share of new vehicles sold equipped with the technology and number of new sold

[1] Excluding subsidies

vehicles per year. No effort has been made to estimate the influence of technological development on costs and efficiency of for example catalysts.
It should be stated that especially for diesel vehicles little to no robust estimates of the costs of technology (particle traps) were available based on realisations in 1993.

Realisations of costs are taken from CBS, Statline. This gives a detailed overview of investments and annual environmental costs for the transport sector in the Netherlands from 1980 – 2001. Costs are in current prices.

CBS assesses environmental costs and investment of transport by (personal communication Wolswinkel, 2005):

- (continuously) assessing and adapting unit (investment) costs of certain technologies or bundles of technologies. This is done by observing the (additional) cost development of catalysts, oxy-catalysts and exhaust recirculation systems, engine modification, etc. Sources of information are specialised (international) literature, specialist of technological institutes, auto-industries, consultancies;
- multiplying the number of vehicles per category of environmental equipment sold per year.

The subdivision given in the CBS tables slightly differs from the subdivision used by TME: for example more information is given on the costs of environmental inspection (exhaust measurement and soot measurement separately), less on annual costs of vehicles (passenger and light duty vehicles are taken together).
Both CBS and TME have used a real interest rate of about 4% per year for assessing capital costs (if investments are depreciated).

To make estimations and realisations comparable, the price level of both assessments needs to be adapted to 2002. This was done by applying the (harmonised) CPI (Consumer price index) (see annex I).

Given the detail of the data of estimations and realisations for 5 cost-categories comparisons of ex ante and ex post cost assessments have been made. These will be discussed in the next subsections.

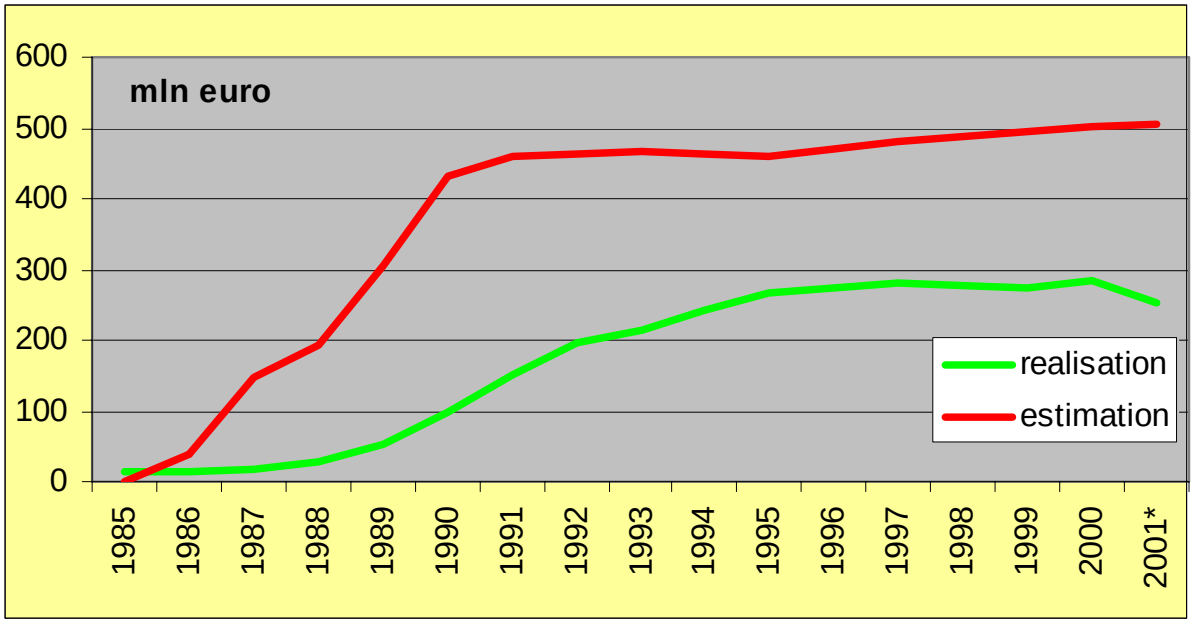
As only cost information was available, it is not clear if the expected environmental effects of the policy (emission reduction) has been realised as projected in the beginning of the 90-ties. However, in general it can be said that the emission reduction in the transport sector has been in conformity with the projections.

2.3 Gasoline and LPG passenger and light duty vehicles

Passenger cars and light duty vehicles (delivery vans) have to be taken together in order to enable an ex ante ex post comparison.

The following figure shows the results for this comparison.

Figure 1
Comparison of ex ante and ex post annual cost assessments of catalysts and adaptation to LPG-installation for gasoline and LPG, passenger cars and light duty vehicles, 1985 – 2001, price level 2002



source: (estimation) TME, 1993 and (realisation) CBS, 2005

When comparing the estimated annual costs with the realised costs, it can be seen that ex ante estimate tends to be about 2 times higher than the realised costs. Also, the realisation of costs shows a slower and more gradual increase over the period 1985 – 1995, whereas in the estimation the cost level of "full implementation" is already achieved in 1990.

There are several reasons why the ex ante costs deviate from the ex post realisations:

- in the ex ante estimation, use was made of fixed unit costs for, for example, catalysts (fl. 1,700 per vehicle at price level of 1993, which translates to € 771 per catalyst);
- CBS has used various – statistically observed – unit costs for catalyst, starting with the same fl. 1.700 in 1985 (€ 771), but for 2001 the costs are about € 230 per vehicle);
- Investments in catalysts for passenger cars are depreciated in 1 year in the TME-estimate, whereas in the CBS-realisation, these investments are depreciated in a period of 9 years. This may explain why the costs of full implementation are reached in 1990 in the TME-estimates (when exhaust limits became mandatory) and only in 1995 in the CBS-realisation.

The following table gives an overview of the development of the costs of a catalyst for a passenger car or light duty vehicle as observed by CBS.

Table 1
Development of the (investment) costs of catalysts (average Netherlands)

Year	Costs of catalyst per vehicle (current prices)
1985	€ 771
1990	€ 771
1995	€ 340
2000	€ 227

Source: based on CBS

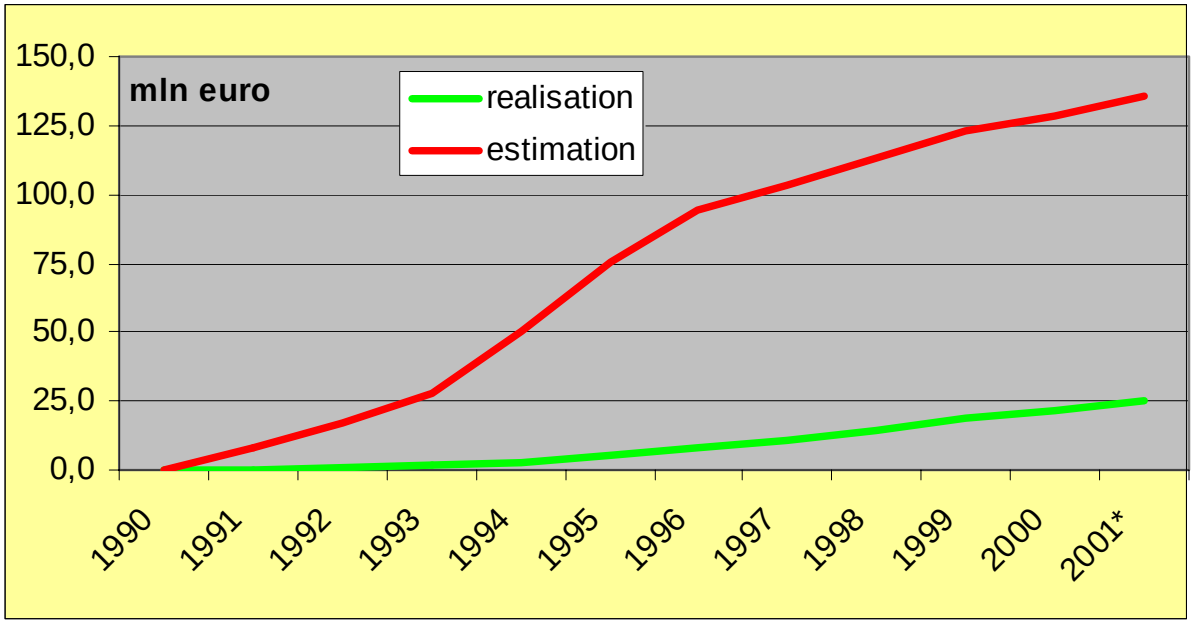
In the ex ante estimate, a fixed cost of € 771 has been used throughout the period of estimation (1988 – 2010).

So the main reason for the overestimation of the environmental costs for gasoline and lpg vehicles is the decrease of unit costs for catalysts between 1985 and 2001 (see also paragraph 1.4 on the influence of technological progress on unit costs).

2.4 Diesel passenger and light duty vehicles

Also for smaller diesel vehicles (passenger cars and light duty vehicles) a comparison is made between the ex ante cost estimates of TME and the ex post realisation of CBS. The results are shown in the next graph.

Figure 2
Comparison of ex ante and ex post annual cost assessments of engine modifications for diesel passenger cars and light duty vehicles, 1990 – 2001, price level 2002



source: (estimation) TME, 1993 and (realisation) CBS, 2005

It can be seen that for smaller diesel vehicles the ex ante assessment has overestimated the costs by a factor 5!

Cost-estimates were based on the following unit investment costs:

- € 817 for passenger cars;
- € 1.588 for light duty vehicles;
- in addition additional fuel use was assumed, which counts for € 7.8 mln in 2001 (prices 1993) or € 9.8 mln in 2001 (prices 2002).

These costs estimates were relatively conservative and at the high end, as little to no information was available on the way in which car producers would respond to the stricter emission limits for diesels. Therefore, costs were taken of an oxy catalyst in those days, whereas in reality the producers for diesel engines have found integrated ways of improving environmental performance of the engines (see for example Touche Ross, 1995, p. 48 – 49).

The figures on the realisation of costs by CBS show:

- no additional fuel costs are incurred;
- unit investments of between € 130 to € 240 per passenger car (for light duty vehicles the costs cannot be estimated from statistics).

In the meantime the sales of light duty vehicles in the Netherlands in 2001 is about 2 times higher (84,000) than assumed when estimating environmental costs in 1993 (it was assumed that in total 44,000 vehicles would be sold in 2001). Assuming that about 40,000 of actual car sales were diesel, the following empirical unit investment costs for light duty vehicles can be assessed.

Table 2
Development of unit investment costs for diesel light duty vehicles, Euro 2, 1997 – 2000

Year	Costs of adaptation per vehicle (current prices)
1997	€ 204
1998	€ 159
1999	€ 113
2000	€ 113

Source: data provided by CBS

It can be seen that unit investments are about a factor 4 lower than the unit investments in the cost-estimate.

2.5 Diesel heavy duty vehicles

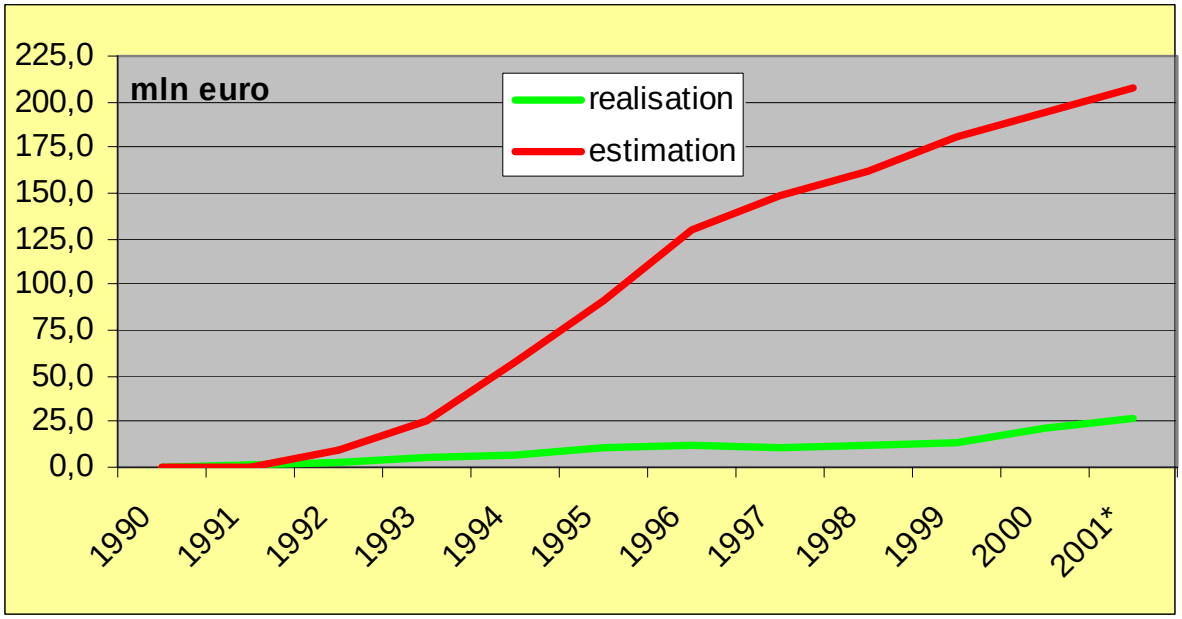
For heavy duty vehicles, new sold trucks have to comply with the following regulations:

- Euro 0: till 1992 the standards for NOx was 9 g NOx/kWh;
- Euro 1: from 1992 – 1996 the standards for NOx was 8 g NOx/kWh;
- Euro 2: from 1996 – 2001 the standards for NOx was 7 g NOx/kWh;
- Euro 3: from 2001 – 2006 the standards for NOx is 5 g NOx/kWh.

The ex post assessment of CBS includes costs for each of these categories, whereas in the TME ex ante assessment these investment costs are not separated. On the other hand, in the TME assessment, an estimate was made for particle traps for busses in public transport.

The comparison of ex ante and ex post assessment of the environmental costs for diesel, heavy duty vehicles is given in the next graph.

Figure 3
Comparison of ex ante and ex post annual cost assessments of engine modifications for diesel heavy duty vehicles, 1990 – 2001, price level 2002



source: (estimation) TME, 1993 and (realisation) CBS, 2005

In the ex ante assessment the following assumptions have been used:

- for heavy duty vehicles fixed unit investments for engine modification of € 3,756 (price level 1993);
- for busses also a fixed unit investment of € 22,725 in particles trap (price level 1993);
- additional diesel use of € 43 mln in 2000.

From the ex post realisation the following table with unit investment costs for heavy duty vehicles can be drawn up:

Table 3
Development of unit investment costs for diesel heavy duty vehicles, 1997 – 2001

Year	Costs of adaptation per vehicle Euro 2 (current prices)	Costs of adaptation per vehicle to Euro 3 standard (current prices)
1997	€ 1,225	
1998	€ 908	
1999	€ 908	
2000		€ 2,950
2001*		€ 2,950

Source: based on CBS
Remark: For Euro 1 no estimate can be made due to lacking statistics on sales of heavy duty vehicles. It can however be roughly estimated that the implementation of Euro 1 standards costs about € 400 – 500 per vehicle.

In both the ex ante and ex post assessment more or less the same numbers have been used for the sales of heavy duty vehicles. The difference in costs therefore depends mainly on deviations between unit investment costs and (in case there are..) operational costs.

The man differences between the ex ante and ex post assessments can be addressed to the following factors:

- in the ex ante estimate only on fixed unit investment cost was assumed, whereas in reality the unit costs per vehicle have gradually developed to the level of 2001. Only stricter standards have induced higher unit cost. These standards are implemented gradually, this was not taken on board in the ex ante assessment;
- it looks as if the investments in particle traps for busses has been overestimated considerably (number of busses equipped with a filter is also not 100%);
- no additional fuel costs are induced by the stricter standards.

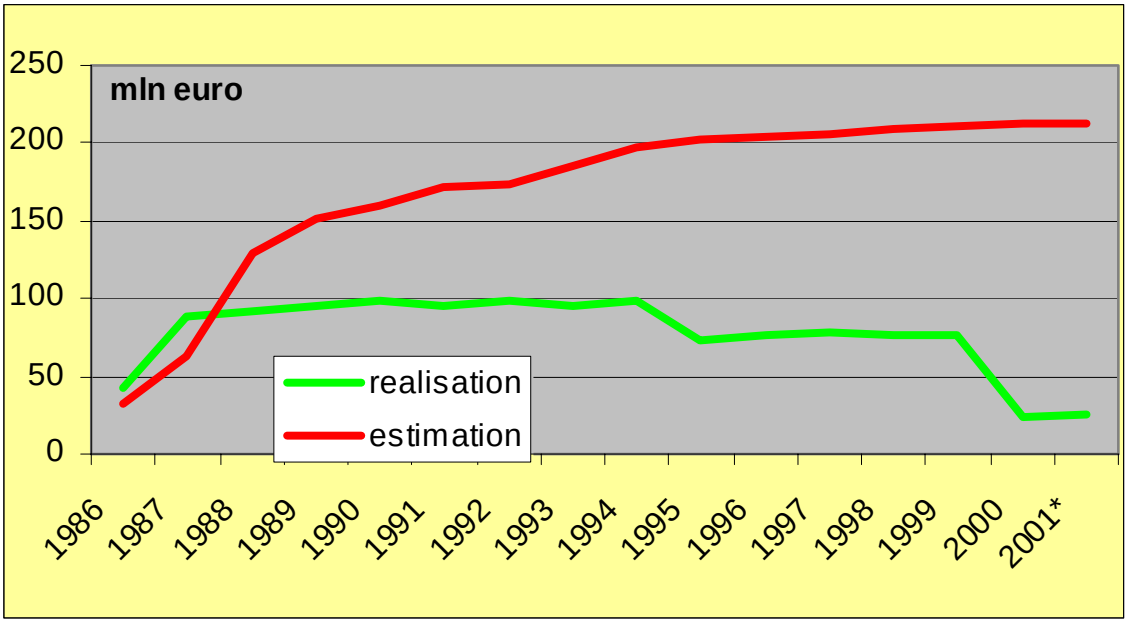
2.6 Fuel quality: gasoline

Unleaded petrol was introduced in 1985 on the Dutch market, also from that period onwards in the Netherlands the sulphur contents of diesel has been reduced gradually.

For the NEP-2 ex ante estimates were made for cleaner fuels (TME 1993), assuming fixed unit costs (in fl/litre) for certain fuel quality improvements. CBS provides us with the estimates of additional costs of gasoline and diesel fuels for transport for the period 1980 -2001 (CBS, 2005). The comparison between ex ante and ex post assessments can be made on the level of fuels. This section deals with gasoline.

The following graph shows the ex ante and ex post estimates for the additional production costs for gasoline sold on the Dutch market.

Figure 4
Comparison of ex ante and ex post annual cost assessments of additional production costs for unleaded gasoline, 1986 – 2001, price level 2002



source: (estimation) TME, 1993 and (realisation) CBS, 2005

The differences between the ex ante and ex post assessment can be explained by the following factors:

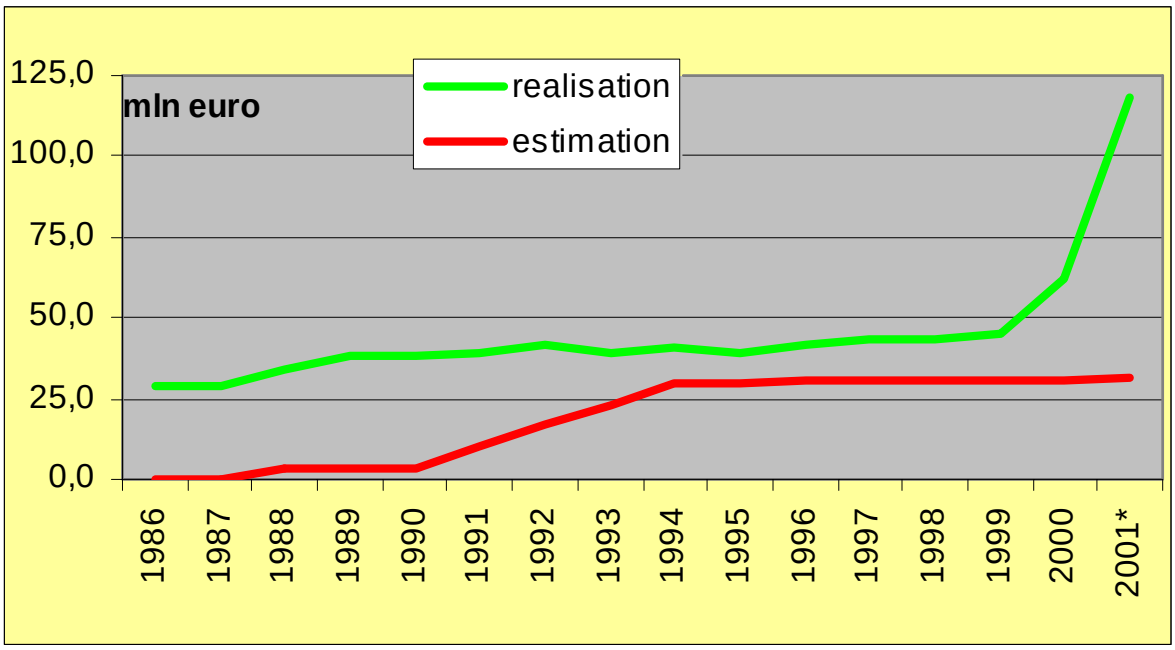
- Whereas in the ex ante assessment the introduction was spread over the period 1985-2000, in reality by 1990 almost all gasoline sold was unleaded. By 1996 leaded gasoline was not on the market anymore. So the implementation of unleaded gasoline went quicker than assumed;
- Also the amount of gasoline sold in the NEP-2 assessment is higher than realised (for example: in 2000 175 PJ of gasoline was sold, whereas it was estimated to be 221 PJ);
- Most important is however the difference in assumed additional unit costs per litre: in the ex ante assessment the additional costs have been assessed at about € 0.028 per litre (price level 2002) for unleaded gasoline. In the CBS realisations the additional costs per litre drop from € 0.021 in 1990 to € 0.0136 in 1995 and € 0.004 in 1999 (price level 2002).

2.7 Fuel quality: diesel

The sulphur contents in diesel fuels for the transport sector has been decreased gradually between 1995 and 2001.

The following graph shows the ex ante and ex post assessments of additional production costs of diesel fuels.

Figure 5
Comparison of ex ante and ex post annual cost assessments of additional production costs for low sulphur diesel fuels for transport, 1986 – 2001, price level 2002



source: (estimation) TME, 1993 and (realisation) CBS, 2005

The case of diesel fuels is one of the few examples where the ex ante costs underestimate the additional costs for the transport sector of lower sulphur contents. There are several reasons for this underestimation:

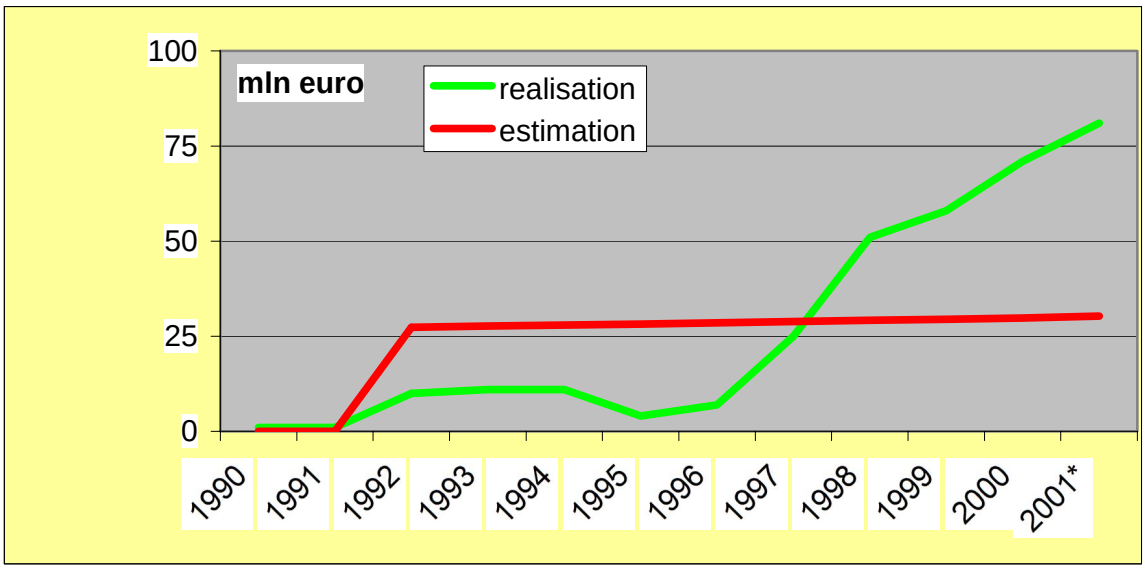
- the ex ante estimate does not take into account the already existing costs of lower sulphur diesel before 1986. This makes a difference of about € 29 mln (price level 2002);

- an other important factor is the underestimation in the ex ante assessment of the use of diesel by road transport (a factor 1.25 in 1990 increasing to 1.8 in 2001);
- in the ex ante assessment it is assumed that additional cost per litre diesel would be increasing from 0.07 €-cent in 1988 to 0.62 €-cent in 1998 (onwards, fixed prices 2002). CBS on the other hands calculates with costs decreasing from 1.15 €-cent in 1990 to 0.82 €-cent in the period 1993-1999, in 2001 due to stricter S-standards additional costs increase to 1.78 €-cent per litre (price level 2002).

2.8 Environmental vehicle inspection

For vehicle inspection only a rough ex ante estimate was made for the NEP-2 (no distinction between gasoline and diesel vehicles nor heavy or light). Also a quite sudden and early introduction was assumed (1992).
The ex post realisation shows that costs start to increase from a much lower level (than the ex ante assessment) only after 1996 and quite steep as shown in figure 6.

Figure 6
Comparison of ex ante and ex post annual cost assessments of additional costs for environmental vehicle inspection, 1990 – 2001, price level 2002



source: (estimation) TME, 1993 and (realisation) CBS, 2005

In 1998, due to introduction of soot measurements for diesel vehicles, the costs of inspection increased from € 25 mln to € 50 mln. The increase from 1999 – 2001 is mainly due to higher costs for environmental inspection of exhaust of gasoline cars.

In the ex ante assessment average inspection costs have been assessed at € 10 per checked vehicle (assuming 50% of the fleet will be checked each year). The ex post realisations show, that costs vary:

- for gasoline cars costs are about € 3 per vehicle from 1992 onwards, with a dip between 1995 – 1997. After 1997 unit costs of inspections increase to € 8.15 in 2001 (current prices);
- for diesel vehicles inspection costs are about € 25 for smaller vehicles (passenger, light duty) and € 50 for heavy duty vehicles. The full costs for these test are incurred in 1998,

which explains why the total realised inspection costs for all vehicles are higher than the ex ante assessment;
- the costs of environmental inspection are estimated by CBS according to internal guidelines, interviews and surveys, and can be expected to more or less represent the real costs made by maintenance shops. Actual costs to car owners may be higher due to profit margins.

2.9 Overview for the road transport sector

The figures below clearly show the main results of this case study:

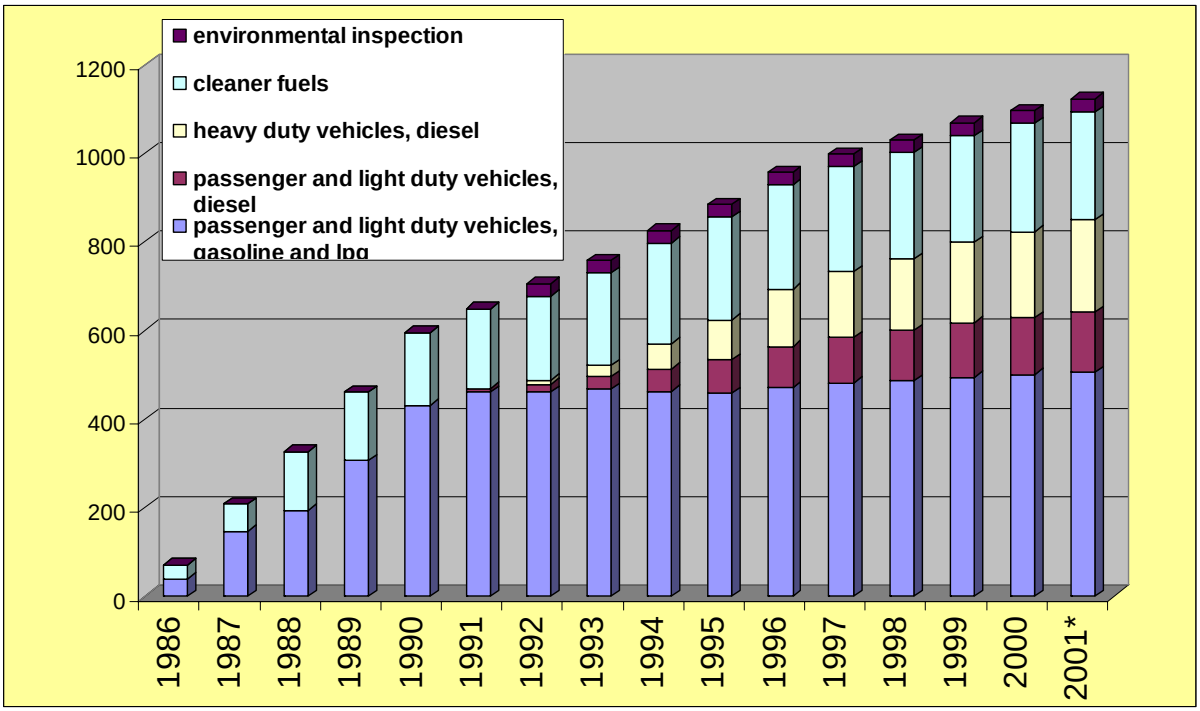
overestimation of in ex ante costs by a factor 2.

The main reason for this overestimation is the assumptions made on unit costs of environmental equipment and measures. Whereas in “ex post” reality these costs often tend to decrease (due to technological and efficiency reasons, see next section), in the ex ante estimates these effects are not considered.

Especially the additional costs to comply with regulations concerning diesel vehicles, the ex ante costs estimates were far too high. The automobile industry was able to supply complying cars at much lower costs than initially thought![2]

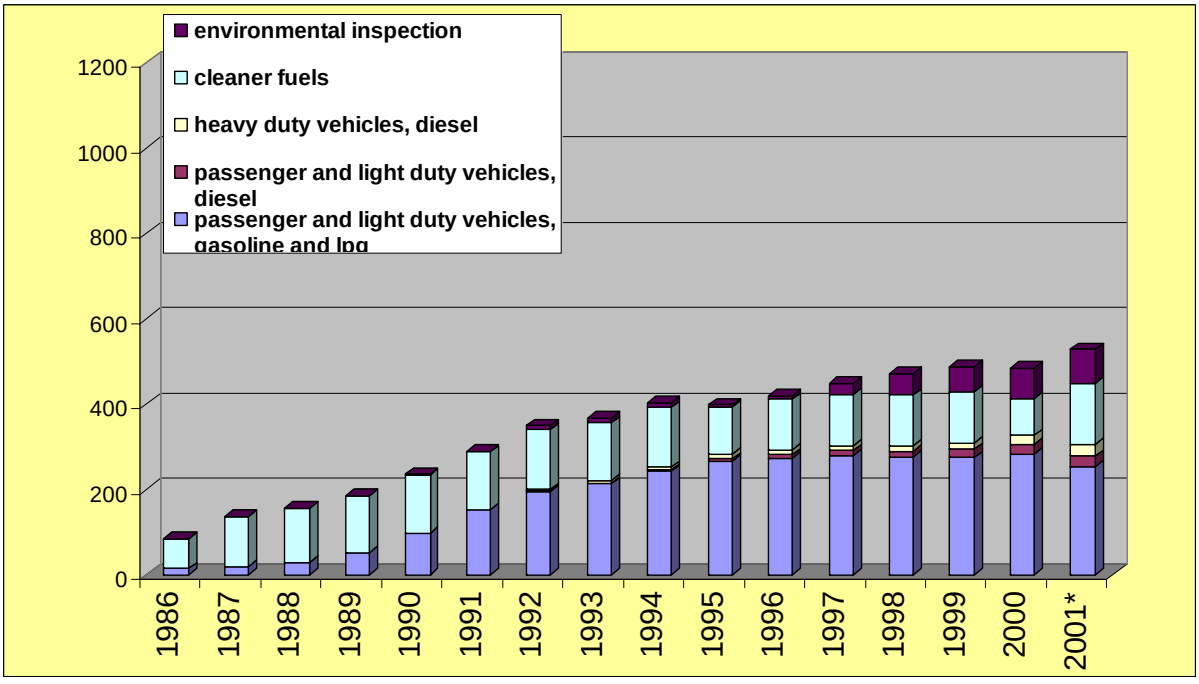
[2] on the other hand the development of new or modified engines will have induced probably invisible research and development costs to the car industry, as the lifecycle of engines was shortened by the environmental requirements.

Figure 7
Total ex ante assessment of annual environmental costs for 3 types of vehicles and 2 types of general costs for road transport in the Netherlands, 1986 – 2001 (price level 2002)



source: estimate by TME (1993)

Figure 8
Total ex post assessment of annual environmental costs for 3 types of vehicles and 2 types of general costs for road transport, 1986 – 2001 (price level 2002)



source: based on CBS (1995)

2.10 Comparison with other international studies

In 1995 a study on the cost-effectiveness of potential measures to reduce emissions from transport was completed for the EU (Touche Ross, 1995). This study investigates amongst others the potential costs of different scenarios to reduce vehicle emissions by technological changes or additions, and by improving fuel quality.(other composition of gasoline, less sulphur in diesel and PAH's.

Although the study does rather investigate various scenarios than a particular policy scenario, the results of this study can be used as a basis of comparison with the cost-assessment for the Netherlands as it covers for example the year 2000.

The study results are based on interview and questionnaires send to stakeholders in the automotive industry as well as to energy companies in Europe. By statistical analyses of the results, the data collected enabled estimates of average costs (in ECU per vehicle) for various types of measures. These were based on packages of technologies defined and discussed with the automobile industry to achieve emission reductions according to 3 scenarios[3]. These scenarios were defined additional to the actual standards for new vehicles and fuel quality that prevailed in 1995.

The main results can be summarised as follows.

For gasoline cars the following estimates of annual total costs[4] (price level 1995[5]) per vehicle (small -> large) (Touche, 1995, figure E5) are made:

- Scenario 1: € 50 - € 85 (80,000 km durability)
- Scenario 1: € 76 - € 128 (160,000 km durability)
- Scenario 2: € 139 - € 211 (80,000 km durability)
- Scenario 2: € 168 - € 256 (160,000 km durability)
- Scenario 3: € 291 - € 418 (80,000 km durability)
- Scenario 3: € 336 - € 483 (160,000 km durability).

Considering that the estimates concern annual costs rather than one time investments (the annual costs have been calculated by dividing the NPV of the total lifecycle costs per vehicle by 15 years), the cost estimates are on the high end. If scenario 1 for example would represent the standards for the period 1995 – 2000, average cost per vehicle would be some € 120 (price level 2002).

But compared with the example of the Netherlands, the average annual costs per gasoline vehicle increase from € 28 in 1990 to € 62 in 1995. But after 1995 until 2001, average costs per vehicle start to decrease to € 46 in 2001. So, although the share of vehicles built after 1995 has increased every year from 1995 onwards, additional costs to achieve more strict emission standards for gasoline vehicles cannot be observed until 2001! On the contrary, the newer the fleet, the lower the average costs.

So it seems that the results of the Touche study for the short term already overestimate costs by at least a factor 2[6].

Also for diesel vehicles such a comparison can be made.

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[3] Originally a 4th scenario was also proposed but rejected as too ambitious.
[4] Including about 20% "welfare costs" (which are excluded in the CBS study).
[5] Conversion to 2002 price level would increase costs by about 20%.
[6] If scenario 1 is taken.

- Passenger and light duty vehicles: scenario 1: between € 70 and € 215 per year;
- Passenger and light duty vehicles: scenario 3: between € 271 and € 648 per year;
- Heavy duty vehicles, scenario 1: between € 394 and € 678 per year;
- Heavy duty vehicles, scenario 3: between € 1260 and € 6044 per year.

Again these estimates are very high in comparison with the realisations for the diesel vehicle fleet in the Netherlands in 2001. In that year the average annual cost per passenger or light duty vehicle are € 16, for heavy duty diesel vehicles annual costs average € 139 per vehicle.

Both figures are well below the lowest cost-estimates of Touche (1995) which indicates that Touche already overestimates costs (which is quite understandable from the evidence on the influence of technological progress on costs).

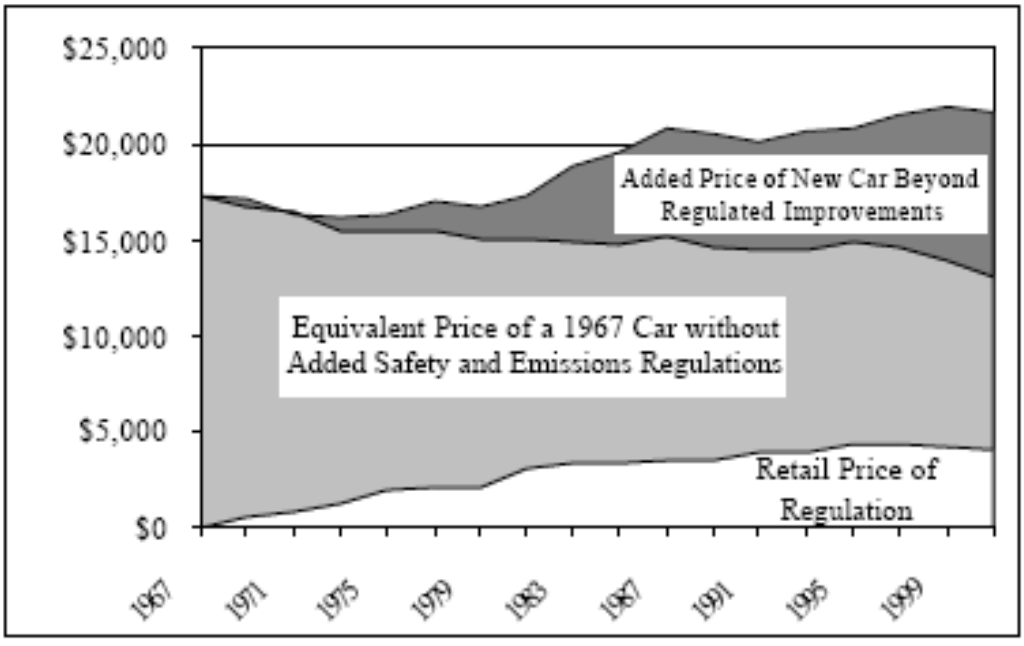
Also for fuel quality the Touche study gives ranges of additional costs. These are (price level 1995):

- for gasoline: between € 0.0042 and € 0.0158 per litre;
- for diesel: between € 0.0025 and € 0.0257 per litre.

This is quite in line with the observed additional costs per litre by CBS for 2001 (resp. € 0.0046 per litre for gasoline and € 0.0178 for diesel).

Another study presents the following interesting finding (see the next graph). This shows the composition of the normalised average transaction price for a passenger car in the United States.

Figure 3 Average Transaction Price for a New Car in 2001$



source: Sperling et al. (2004)

The area marked as “Retail price of regulation” is made up of costs for safety measures (airbags etc.) and environmental regulations (emissions, recycling, etc.). The graph reveals that new “gadgets” (air conditioner, automatic windows, etc.) adds more to the price of a car that all costs of safety and environmental regulation. In fact, if cars would have remained as “sober” as in 1987, the total retail price of a car would have dropped from about US$ 17,000 in 1987 to US$ 14,000. The additional costs of regulation would be more than compensated by the decrease of the “Equivalent price without additions”. Although this graph indicates that the last years the additional costs of regulation have stabilised, the unit costs per vehicle have increased gradually. Here it appears as if there are differences between the outcomes of the case study and the empirical observations in the United States. This however does not have to be the case: the example for the United States also includes measures for safety.

3 TECHNOLOGICAL PROGRESS AND ENVIRONMENTAL COSTS IN THE TRANSPORT SECTOR

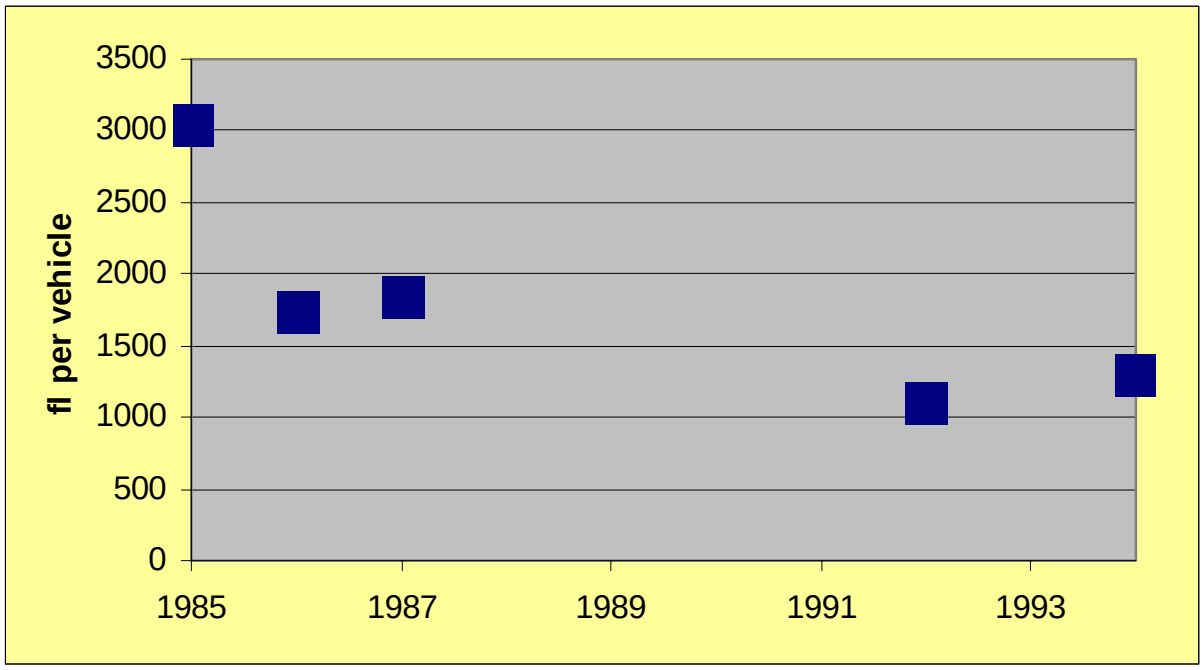
3.1 Introduction

In 1995 a study was completed on the development of unit costs of environmental technologies (TME, 1995). One of the cases investigated was the case of the catalyst. The main results are summarised in the main report (9-10% cost decrease per year), in this section a more specific look at data is made.

3.2 Development of costs of a regulated 3-way catalyst

The next figure shows the development of the costs of 3-way catalysts between 1985 and 1994. The observation for 1985 comes from Japan, the observations for 1986 and 1987 from the EU, the observations for 1992 and 1994 are from the Netherlands.

Figure 9
Development of the additional purchase costs of a regulated 3-way catalyst, 1985 – 1994 (price level 1994)



source: TME (1995) based on OECD (1986), CBS (1991b) Touring Club der Schweiz (1994)

In 1985 the costs a regulated 3-way catalyst were reported to be fl. 3,043[7] in Japan (price level 1994). For the next 2 years (1986 and 1987) 2 observations from Europe were available, at costs of fl. 1,750 and fl. 1,850 per system. For 1992 and 1994 2 observations for the Netherlands were available at unit costs of fl. 1,100 and fl. 1,300 respectively. So in a nine year period the costs dropped from over fl. 3,000 to fl. 1,300: an annual decrease of unit costs of about 9%.

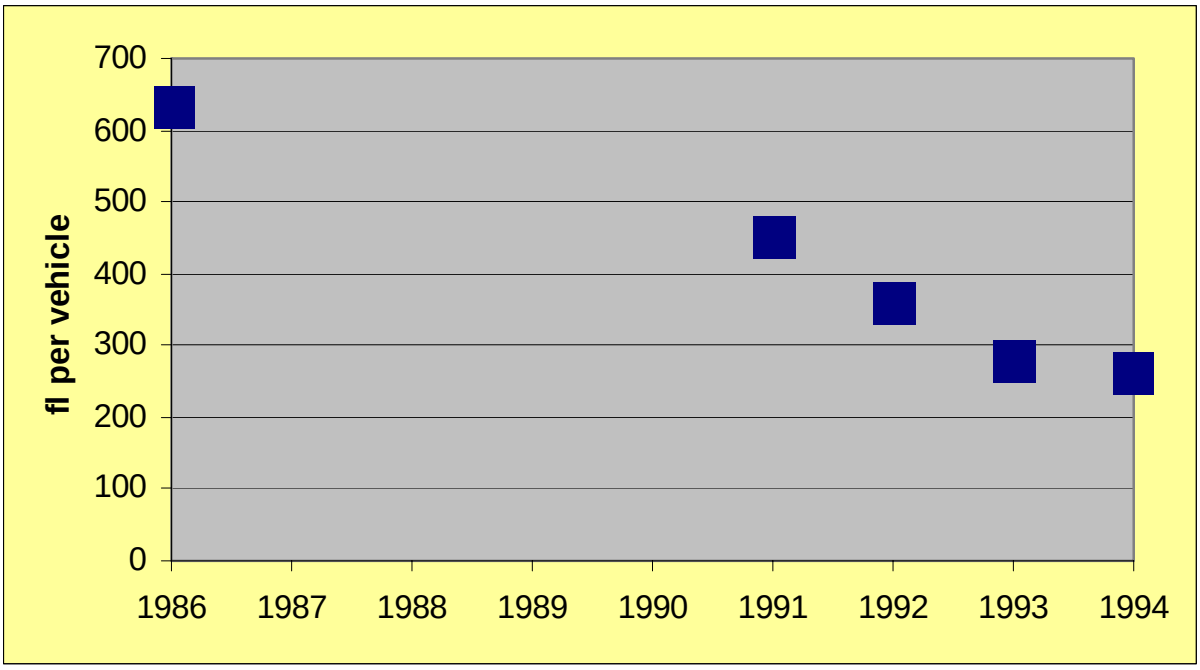
[7] fl. = Dutch Guilder, 1 € = 2.20371 Dutch Guilders

Anderson (1999) quotes costs of regulated catalysts for the United States of being about US$ 800 (Anderson, 1999, p. 14). This figure probably refers to 1995 and is in 1995 price level. This is quite comparable with the results shown in the above figure. In the Touche study (1995) no reference is made to the costs of the base scenario (for standards imposed before 1995), which makes it hard to compare with the above results. However, the study recognises that costs of technologies in the automotive industry tend to decrease rapidly due to "economies of scale" and technological improvements. But in the assessment for potential future measures, the study does not take into account the effect thereof on costs as it would be too speculative.

3.3 Development of costs of a catalyst converter ("can")

Also the costs of the "can" (the catalyst converter) – as part of the total regulated 3-way catalyst system – have been investigated. The costs development thereof is shown in figure 10. Data for 1986 are from the US, for 1991 – 1994 from the Netherlands.

Figure 10
Development of the additional purchase costs of a catalyst converter ("can"), 1986 – 1994 (price level 1994)



source: TME (1995) based on OECD (1986), Auto en Motor techniek (1994)

In this case the decrease of costs is in the same range as for the whole system. The price of a can has dropped significantly from fl 634 in 1986 to fl. 261 in 1994, annually a decrease of unit costs by 11.7%!

3.4 Conclusions

In general it is known that unit costs of environmental technologies have the tendency to decrease over time. RIVM and TME found from various case studies that the rate of cost decrease of environmental technologies (4% - 31% per year) is well above the average "technological progress factor" (of 2%) which is used in macro-economic models.

The case study on transport is no exception to this general findings. As well the studies performed by RIVM (2000) and TME (1995) indicate a high annual rate of decrease of unit costs (around 10%).
This is also supported by the case study on the Netherlands. For example, the costs of (regulated) catalysts per vehicle dropped from € 835 in 1990 to € 291 in 2001, an annual cost decrease of 11.9%!

So it is obvious that in the automobile industry production costs can drop quite significantly for new environmental technologies. All empirical evidence points in the same direction, so the results of these studies should be considered when assessing future costs of advanced technologies in the automotive industry.

4 WHAT CAN BE LEARNED FOR FUTURE ESTIMATES

The results of the case study on road transport in the Netherlands shows that ex ante estimates in general are 2 x higher than the observed ex post costs. The section on technological progress also shows that unit costs of environmental technology have the tendency to decrease over time with quite high annual changes (around 10%).

If technology will be refined, as is assumed in many technological studies, it can be assumed that this decrease of costs will continue. New introduced technologies rapidly become cheaper in use. But another factor will influence the future costs: how will vehicles look like in 5 to 10 years? To what extend hybrid vehicles will become popular? This is hard to predict.
The case with hybrid vehicles is that on the one hand fuel efficiency increases drastically, which lead to fuel- and thus financial savings, on the other hand the incremental costs are higher (about € 8,000 currently). The example already shown in the main report (IVM, 2006, chapter 4) shows that the price of fuels will for a large extend determine the actual additional costs of a hybrid car. High prices lead even to savings, low prices to some costs.

BIBLIOGRAPHY

Dennis Anderson, 1999, “Technical Progress and Pollution Abatement:-- an economic view of selected technologies and practices”, draft, Imperial College of Science, Technology and Medicine, London, June 1999.

Auto & Motor techniek, 1994, “Voorverwarmde katalysator komt sneller in actie”, P. Klaver, 1994, 7/8, pp/ 38-39.

CBS, 1991b, “Milieukosten van het verkeer, 1989 – 1990”, E.J. Dietz, Quarterly [publication Environmental Statistics, Voorburg, 1991.

CBS, Statline, “Milieukosten van het verkeer, 1990 - 2001” (Environmental Costs of Transport), 1980 – 2001, all items selected (investments, operational costs, etc.), 1995.

Citepa, 2003a, “Distribution of gasoline, service stations”, Paris, draft document, 25 July 2003 (as part of about 20 reports on VOC reduction in EU).

Hartman, R.S., D. Wheeler and M. Singh (1997), Applied Economics, vol. 29 p. 759-774.

IVM, 2006, “Ex-post estimates of costs to business of EU environmental legislation”, final report, edited by Frans Oosterhuis (IVM) with contributions of: Véronique Monier and Cécile des Abbayes (BIO), Benjamin Görlach (Ecologic), Andrew Jarvis and James Medhurst (GHK), Onno Kuik (IVM), Robin Vanner and Paul Ekins (PSI), Jochem Jantzen and Henk van der Woerd (TME), Peter Vercaemst, D. Huybrechts and E. Meynaerts (VITO), reviewed by Reyer Gerlagh (IVM), Amsterdam, March 2006.

Krozer, Yoram, 2002, “Milieu en innovatie “ (Environment and innovation), PhD thesis, 9 december 2002, Groningen.

OECD, 1986, “Enclair ’86, Energy and cleaner air: costs of reducing emissions, proceedings symposium October 1986”, Italy, with articles of the Air Quality Bureau Environmental Agency, Japan; Claude Gerryn (Ford Europe), Perrin-Pelletier (CCMC).

RIVM, 1988, “Concern for Tomorrow: Environmental outlook 1985 – 2010”, Bilthoven, 1988.

RIVM, 2000, “Techno 2000; Modellering van de daling van eenheidskosten van technologieën in de tijd”, Honig, E., A. Hanemaaijer, R. Engelen, A. Dekkers, R. Thomas, RIVM, 20001, rapportnummer 773008003, Bilthoven, april 2000.

Sperling, D., Bunch, D., Burke, A., Abeles, E., Chen, B., Kurani, K., and Turrentine, T. (2004) Analysis of auto industry and consumer response to regulations and technological change, and customization of consumer response models in support of AB 1493 rulemaking. UCD-ITS-RR-04-17. Institute of Transportation Studies, University of California, Davis. Prepared for the California Air Resources Board and the California Environmental Protection Agency, 1 June 2004.

TME, 1993, “Estimation of environmental costs for NEP-II”, internal document and estimates made for RIVM and VROM, 1993.

TME, 1995, “Technische vooruitgang en milieukosten, aanzet tot methodiekontwikkeling” (Technological progress and environmental costs, initiative for methodological development), by Jochem Jantzen, Heddeke Heijnes and Pascale van Duyse, The Hague, February 1995,

Touche Ross, 1995, “A cost-effectiveness study on the various measures that are likely to reduce pollutant emissions from road vehicles for the year 2010”, final report to the CEC, DG III,, November 1995.

Touring club de Schweiz, 1994, “10 Jahre Katalysatorauto’s”, Emmen, Swiss, March 1994.
Wolswinkel, 2005, “Personal communication on statistics on environmental costs for transport in the Netherlands”, CBS, Voorburg, 1 november 2005.

N.N., “Cumulative costs of compliance with a regulatory roadmap”, draft June 2005.

VROM, 1989, “Choose or Lose: first National Environmental Plan for the Netherlands”, Leidschendam, 25 May 1989.

ANNEX I: DEVELOPMENT OF CONSUMER PRICE INDEX (CPI)

Year	Harmonised CPI
1980	78
1981	84
1982	88
1983	91
1984	94
1985	96
1986	96
1987	95
1988	96
1989	97
1990	100
1991	103
1992	106
1993	109
1994	112
1995	114
1996	116
1997	119
1998	121
1999	124
2000	127
2001	133
2002	137

Source: CBS, Statline (consumer prices).