Non-CO_2 Greenhouse Gases (NCGG-4), coordinated by A. van Amstel

Costs, cost-effectiveness and emission reductions of non-CO_2 greenhouse gases: achievements and expectations for the Netherlands

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ABSTRACT: In the Netherlands several measures were implemented to reduce the emission of non-CO_2 greenhouse (NCG) gases in the period 1990-2003. Without the implementation of these measures emissions of NCG gases in 2003 would have been 11 Mton of CO_2-eq. higher. Roughly 20% of achieved reductions can be attributed to specific Reduction Plan on NCG gases. The net government cost-effectiveness of policies in the field of NCG gases is favourable: almost the half of the emission reductions can be achieved for less than 5 euro per ton CO_2-eq..
This paper analyses achieved reductions, investments costs, government costs and cost-effectiveness of these measures. These achievements are compared with the expectations on reductions, costs and costs-effectiveness for reduction measures on NCG gases at the time the Climate Change Action Plan (CCAP) was published in 1999. For this comparison we present an analytical framework to analyse the different factors affecting the implementation of NCG gases reduction measures. Analysis shows that differences between achievement (ex-post) and expectations (ex-ante) can mainly be explained by lack of data on the costs of reduction measures at the time the ex-ante evaluation was drawn up. Other differences can mainly be explained by changes in market circumstances and government policies.

1 INTRODUCTION

Several measures were implemented in the Netherlands to reduce the emissions of NCG gases in the period 1990-2003. This paper provides an overview of the achieved reductions, investment costs related to the reduction measures, the government costs and the costs-effectiveness. These achievements are compared with the expectations on reductions, costs and costs-effectiveness for reduction measures on NCG gases at the time the Climate Change Action Plan (CCAP) was published in 1999 (Vrom, 1999). This CCAP amongst others resulted in the introduction of a separate action programme for NCG gases called the Reduction Programme NCG gases (ROB-programme). For analysing the differences between achievements and expectations we will introduce an implementation framework for NCG gas reduction measures.

2 IMPLEMENATION FRAMEWORK

The market implementation of measures to reduce the emissions of NCG gases is influenced by a large number of factors. We have categorized these measures into three clusters:

- Government policies / regulations
- Structural characteristics of the sector
- Feasibility of the measure on the company level

These factors and their mutual relationship are outlined in figure 1. The figure shows that in theory there are a large number of cause-impact relationships between the different clusters and the market implementation of reduction measures (defined in cluster 4). This describes the cause-impact relationships and will make clear that a lot of factors affect the potential emission reductions and cost-effectiveness of implemented measures.

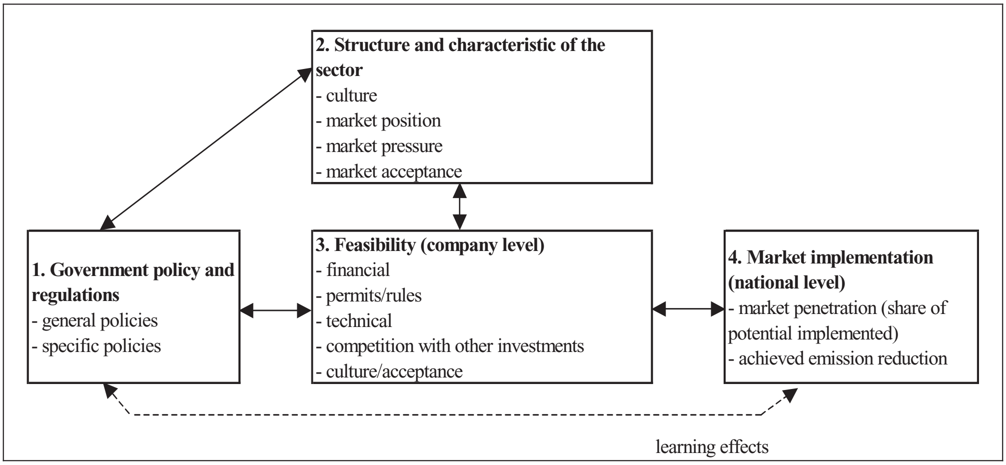

Figure 1. Outline of the implementing framework of NCG gas emission reduction measures

2.1 *Cluster 1 Government policies and regulations*

The feasibility on a company level is affected by generic and specific government policies and regulations; financially (e.g. through government support), permit wise (e.g. through government regulations regarding permits in order to be able to operate an installation or does the implementations of NCG gases reduction measures conflict with local permits), technically (e.g. through grants for R&D or technical setting standard, which stimulated research into technologies), cultural acceptance (e.g. by financing demonstration projects and information centres/campaigns). Government policies and regulations on the other hand can affect the structure of specific markets, like regulations regarding liberalization of energy markets and agricultural policies. The regulations may result in changes in the room to invest in reduction measures and/or the power to innovate.

2.2 *Cluster 2 Characteristics of the sector*

Specific characteristics of a sector affect the feasibility and as a result the market implementation of a reduction measures as well. Limited progress might be expected for a NCG-gas in a sector consisting of a large number of small conservative companies, with no room for investments or power to innovate. On the other hand, a much higher reduction of NCG-gas emissions will be achieved for a small number of large international companies with good international contacts, room for investments, own funding for research and development and especially if they experience pressure from non-governmental organizations to limit their emissions.

2.3 *Cluster 3 Feasibility on the company level*

If an emission reduction measure is feasible on a company level market implementation on a national level will increase. Feasibility on the company level is determined by a number of factors such as

- Financial feasibility (does the investment meet internal criteria for this kind of investments),
- Permits/rules (e.g. is the investment necessary in order to obtain a permit and what is the time span to obtain required permits),
- Technical (e.g. is the measure a proven technology, how does it affect the primary production process),
- Local constraints (e.g. room and safety).
- Competition with other investments (e.g. what are the constraints with respect to the investment budget companies must prioritise their expenses),
- Culture (e.g. is a sector innovative and at the forefront of technological developments or conservative and a late adapter of new technologies) and acceptance.

Government policies and regulations might be updated as a consequence of better feasibility on the company level. Next to this an improvement of the feasibility can lead to a further development of the technology market. As a result suppliers of the technique will increase and improve their supply. As a result the rate of return will improve and affect the feasibility of the measure positively.

2.4 *Cluster 4: Market implementation*

Government policies and regulations might be updated as a consequence of higher market penetration. Through higher market penetration the knowledge on the technique will be more easily available. Also more companies within the sector will implement the measure (learning effects). Furthermore the government might decide to adapt the existing policies to reflect these new circumstances e.g. by switching to more generic instruments or downscaling the amount of available subsidies.

3 CALCULATION OF ACHIEVED REDUCTIONS

When mapping out the effects, costs and cost-effectiveness of emission reduction measures the choice of the reference situation is a crucial step. We defined the reference situation as the situation that would have occurred in the absence of policies aimed at reducing the emissions of NCG gases since 1990 (for CH_4 and N_2O) or 1995 (for fluorinated-gases). In order to be able to determine the reference situation two questions that had to be answered:

1. Which technology would have been implemented in the absence of policies aimed at reducing the emissions of NCG gases? We applied the Dutch guidelines for monitoring and evaluation that state that the reference technology is ‘the best available technique on the market’ in case no environmental policies would have been in place (VROM, 2004).
2. Which part of the sector would have implemented the reference technology also if no policies aimed at reducing the emissions of NCG gases would have been introduced? Not all reductions may be the result of implemented policy instruments, because part of the reductions may also have occurred in the absence of policies (e.g. because they are cost-effective). In principle this means that the effectiveness of policies has to be determined.

The emission reductions of NCG gases were determined by applying a pragmatic two-step approach.

1. In the first step we determined the ‘gross’ emission reduction potential. The ‘gross’ emission reductions are determined by subtracting emissions of the reference technology from the actual emissions. Emissions for the reference technology are calculated by taking the actual production levels in the years 1990 to 2003 (e.g. produced amount of aluminium or amount of waste

dumped) and multiply this with the emission factor of the reference technology (e.g. PFC emissions per tonne of produced aluminium).

2. In the second step we made a rough estimate of the 'net' emission reductions, by determining which part of the 'gross' emissions would also have been implemented in the absence of policies aimed at reducing NCG gases. The 'net' emission reductions are the gross emission reductions minus autonomous emission reductions, which are reductions that also would have been realised in the absence of policies aimed at reducing the emissions of NCG gases since 1990.

4 COSTS AND COST-EFFECTIVENESS FROM DIFFERENT VIEWPOINTS

Within the framework of environment policy evaluation in the Netherlands three different viewpoints are distinguished when discussing the costs and costs-effectiveness of measures that are implemented to reduce emissions (VROM, 1998).

4.1 *End-user*

The costs for the end-user provide an indication of the costs as experienced by the end-user responsible for the implementation of the reduction measures. These costs are defined as all *additional* costs that have to be made by the end-user compared to the reference situation in case no environmental policies would have been in place. Additional costs include additional investments, staff-costs, overhead costs, energy costs (which are negative in case of savings) and transfers (e.g. paid taxes but also granted subsidies and fiscal profits which are defined as negative costs). The cost-effectiveness (euro per ton of CO_2-eq reduced) for the end-users provides insight on the cost and benefits of the measure for the end-user and is calculated by (i) depreciating the additional once-only costs made by the end-used over the lifetime of the technology, (ii) subtracting from the calculated capital costs the annual additional costs or savings on e.g. energy or (raw) materials and (iii) divide this number by the calculated gross reductions.

4.2 *Society*

The costs for the society as a whole are defined as all additional costs that have to be made by the society as a whole compared to the reference situation in case no environmental policies would have been in place. These include the same costs as mentioned for the end-user however excluding transfers, because the transfers for the society as a whole are a zero-sum-game. The national cost-effectiveness provides insight in the costs and benefits of implemented emission reduction measures for the society as a whole. The national costs method is mainly used to make reduction measures comparable. The cost-effectiveness for the society is calculated by depreciating the once-only costs against a 'social' interest rate of ~4%.

4.3 *Government*

Costs for the government are defined as all expenditures that have been made by the government, which can be related to the implementation of the reduction measures. Government expenditure includes budgets for subsidies and fiscal measures, grants for research and development, costs for monitoring and the administrative machinery. The cost-effectiveness for the government provides insight on the efficiency of the implemented government policies. Efficiency of policies refers to ratio between the costs for the government and the emission reduction achieved through the implementation of the instrument. The cost-effectiveness for the government is calculated by (i) depreciating the total government expenditure using the social interest rate of 4%. By depreciating the cost for the government the fact is taken into account that the government is profiting several years from her once-only spending, and (ii) dividing the found number by dividing it by either the gross (to determine the gross cost effectiveness) or net reductions (to determine the net gross effectiveness) of NCG gases.

4.4 *Limitation to the definition of costs*

The costs as defined in VROM (1998) and used in official policy evaluations only take into account the direct ‘out of pocket’ costs. All kinds of indirect costs, which are in most cases more difficult to monetarise, such as costs for collecting information on the reduction measure and time-losses, are not taken into account. We have tried to capture these types of indirect costs in our analysis of implementation con-text in which we take into account a whole range of factors affecting the implementation degree.

5 ACHIEVED GROSS REDUCTIONS IN THE NETHERLANDS

Measures implemented in the period 1990-2003 resulted in emission reductions of approximately 11 Mton in 2003 compared to the reference situation. This means that without the implementation of these measures emissions of NCG gases in 2003 would have been 51 Mton instead of 40 Mton of CO_2-eq.. In figure 2 it is shown that arge reductions are achieved with (Harmelink et al, 2005):

- The emissions of HFC-23 through the implementation of an after burner with the manufacturer of HCFC-22,
- The emissions of PFC through the modernisation of the production sites with both aluminium producers in the Netherlands,
- The emissions of CH_4 through the implementation of several reduction measures with the oil and gas industry,
- The emissions of CH_4 through the collection, and utilisation of landfill gas at waste dumping sites.

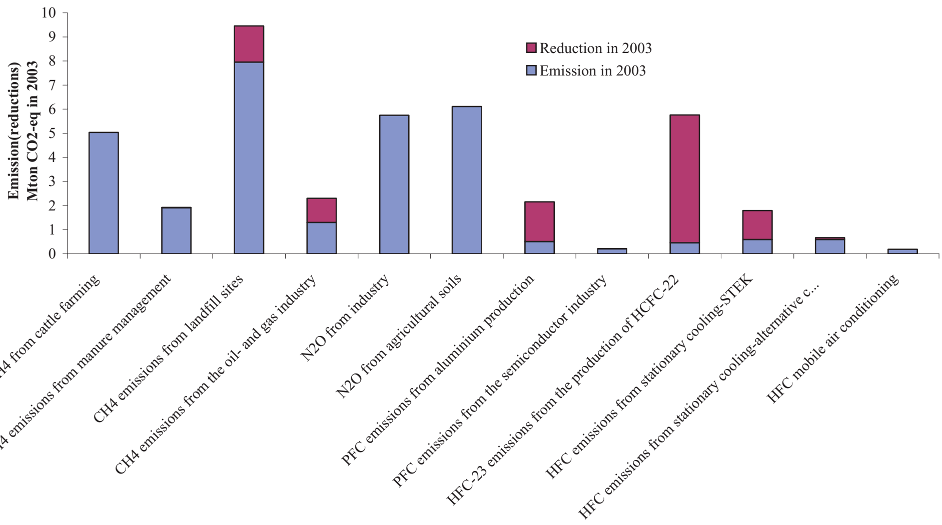

Figure 2. Emissions and achieved gross reductions through the implementation of reduction measures by the end of 2003 compared to the reference situation. Source: Harmelink et al (2005)

Most reductions were driven by policies already in place before the Kyoto target was set. These reductions have been reinforced with the introduction of the Dutch Reduction plan on NCG gases since 2000. Roughly 20% of achieved reductions in 2003 can be attributed to this specific Plan.

6 COSTS AND COST-EFFECTIVENESS

6.1 *End users and the society*

Total investments aimed at reducing emissions of NCG gases amount to approximately 149 million euro in the period 1990-2003. It must be stressed that investment figures are surrounded by large uncertainties as a result of, limited and partly unreliable data. For some sectors no estimates could be made at all because of lack of data. The most important investments missing in our overview are the investments in the oil and gas industry. From our analysis the top-4 of measures accounting for 85% of the investments over the period 1990-2003 is:

1. Reductions of PFC emissions in the aluminium industry.
2. Collection and utilisation of landfill gas
3. Switch to natural cooling agents with stationary cooling installations
4. Good housekeeping measure in the cooling sector

For the society as a whole the bulk of implemented reduction measures were achieved against national costs below 5 euro per ton of reduced CO_2-eq (see figure 3). This is low compared to e.g. the realised cost-effectiveness of energy savings achieved in the household sector in the period 1995-2002 which ranged from 40-120 euro per ton of reduced CO_2 (Joosen et al, 2004).

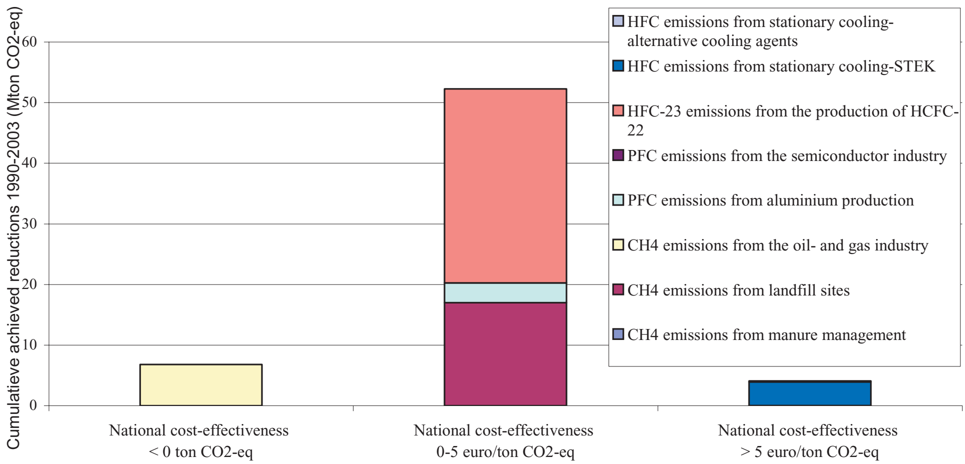

Figure 3 A split of achieved reductions (~63 Mton) into different categories of national cost effectiveness Source: Harmelink et al (2005)

6.2 *Government*

Total government expenditure in the period 1990-2003 is estimated at about 40 million euro. Figure 4 provides an overview of the split-up of the government expenditures for the period 1990-2003 over the different government instruments and over the different sectors.

- Approximately 70% of the budget went to investment support in reduction measures, whereas 30% was used to finance all kind of activities to initiate, stimulate and/or facilitate the implementation of reduction measures (this is the chart pie 'ROB other activities' in Figure 4).
- More than 40% of the government expenditure went to support implementation of reduction measures at landfill sites. Most of these costs were made in the beginning of the '90. This is also the sector with the second largest reductions achieved over the period 1990-2003.
- Almost 17% of the government expenditures were to support the market transition to natural cooling agents, which so far led to limited reductions.

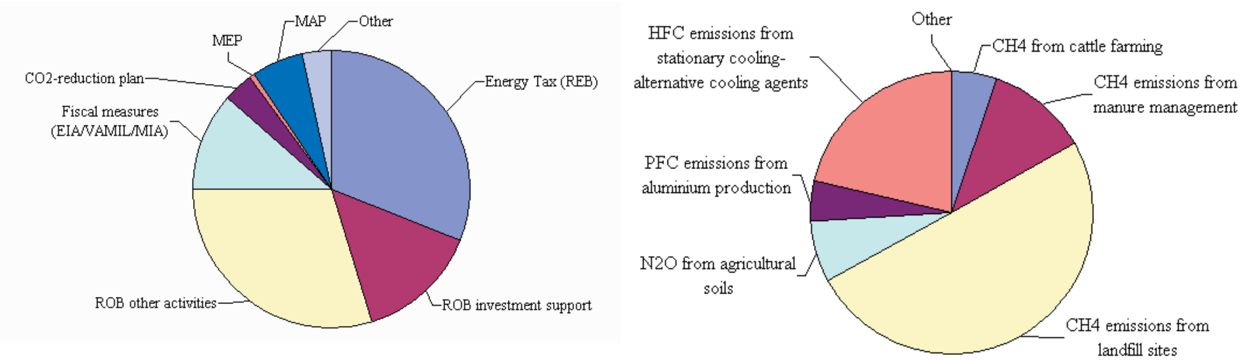

Figure 4. Split of government expenditures over different government programmes (left) and emission sources (right)

The overall cost-effectiveness for government expenditures ranges from 0.5 to 1.7 euro per ton of CO_2-eq. The lower limit (gross cost-effectiveness) represents the situation in which it is assumed that all reduction measures result from the implementation of policy instruments (i.e. no measure would have been implemented if no policy measure would have been in place). Whereas the upper limit (net cost-effectiveness) represents the situation in which the effects are corrected for 'autonomous' developments (i.e. the effectiveness of policies was taken into account and an estimate was made of the reductions that also would have been realised in the absence of policies). The cost-effectiveness of policies in the field of NCG gases is favourable compared to policies on CO_2 emission reduction. For example the cost-effectiveness of government programmes in the household sector ranged from 4 to over 300 euro per tonne of CO_2-eq.

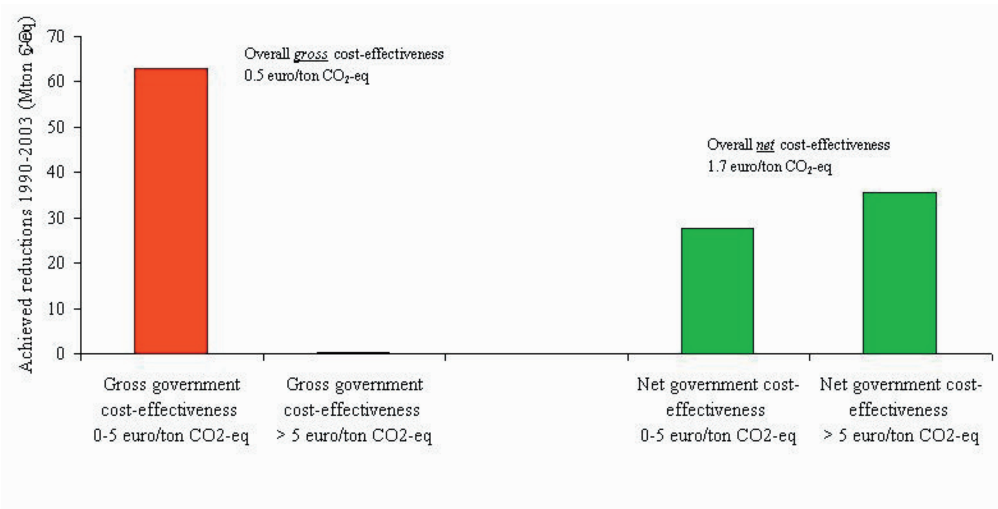

Figure 5 A split of achieved reductions (~63 Mton) into different categories of *gross* and *net* cost-effectiveness for the government in the period 1990-2003. Source: Harmelink et al (2005)

7 COMPARING EXPECTED AND REALISED COSTS

There are substantial differences between the estimated costs and emission reductions mentioned in the Option document (ECN, RIVM, 1998) and the actual reductions and costs resulting from our analysis. This document was the foundation for the Climate Change Action Plan. These differences arise from changes in the implementation context since the time the Option document was drawn up. The most important differences are:

- Differences with respect to effect of "autonomous" market developments. E.g. in the Option document it was assumed that in the absence of strict policies foam producers all would use HFC as a blowing agents. Because of (i) the current tight market for HFC leading to high prices producers, and (ii) to avoid the risks of regulations producers are already switching to alternatives like CO_2, butane and pentane without strict policies in place.
- Differences with respect to the pace in which technologies were expected to be introduced to the market. E.g. in the Option document it was assumed that all new cooling installations as of 2000 would be using natural cooling fluids and/or new installations would have a leakage rate of 1%. Current trends however show that this is not the case and that not all sold cooling installations use natural cooling agents.
- Differences with respect to the type of applied technology. E.g. in the Option document it was assumed that no co-digestions of manure would take place in the Netherlands because of the strict regulations with respect to the use of remains from the co-digestion process. Analysis of the developments in the period 1990-2003 however shows that co-digestion of manure is the only way to make this options profitable because if without the use of co-digestions products methane production is much lower. The options documents furthermore assumed that the produced methane would be used in boilers to produce heat, whereas current developments are to use to methane in a gas engine to produce heat and electricity. These differences led to different pictures for environmental and financial yields to reduce emissions from manure management.
- Differences with respect to feasibility and investments costs of reduction measures. E.g. the costs anticipated in the Option document to install an after burner to reduce the emissions of HFC from the production turned out to be much higher than anticipated. Furthermore it turned out to be more difficult to install a reliable after burner.
- Government policies affect the cost-effectiveness for the end-user and the cost-effectiveness for the government itself. E.g. government policies in the field of renewable energy production led to chances in the cost-effectiveness of manure co-digestion and use of landfill gas for energy production.

8 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendation can be drawn from our analysis.

- Substantial emission reductions have been achieved in the period 1990-2003, without implemented measures emissions in 2003 would have been 11 Mton CO_2-eq. higher. Government policies have played a crucial role in initiating reductions of NCG greenhouse gas emissions in the period up to 2003 in the Netherlands.
- Total investments in the period 1990-2003 amount to about 150 million euro, where government expenditure amounts to ca. 40 million euro. Bulk of the reductions was achieved against costs below 5 euro per ton for the society as a whole. The overall cost-effectiveness for government expenditures ranges from 0.5 to 1.7 euro per ton of CO_2-eq. Compared to CO_2 reduction measures the cost-effectiveness of measures in the field of NCG gases is favourable from the viewpoint of the society as whole as well as the government.
- The concept of cost-effectiveness is a useful tool in the hands of the government to evaluate ex-ante and ex-post the efficiency and effectiveness of her own policies and make comparisons

across sectors and gases in order to set priorities in her climate change policies. The current definition used in preparing government policies seems appropriate for this evaluation.

- The concept of cost-effectiveness is however far more difficult to apply in discussions between the government and individual companies because companies often use of much broader definition of costs which can lead to a completely different picture on the cost-effectiveness of reduction measures. This means that figures for cost-effectiveness found in literature have to be interpreted carefully before conclusions can be drawn and comparisons can be made with other sectors and measures. Furthermore measures that seem cost-effective from an end-users point of view are not implemented automatically because they have to be weighed against other investments of the company (which may be more profit-able) or may be hampered by other barriers. This means that discussion on the company level will focus on the complete implementation context and not just on the 'bare' cost-effectiveness.
- Comparison between ex-ante and ex-post evaluations show that the ex-ante evaluation was mainly hampered by lack of data on the costs of reduction measures, which sometimes turned out to be cheaper (e.g. foams sector) and sometimes turned out to be more costly (e.g. the installation of an after burner). Furthermore the implementation context changed, which led to differences in anticipated reductions and costs. This means that the government should closely watched market circumstances in order to be able to timely anticipate with changes in policies.

REFERENCES

ECN/RIVM, 1998. *Options to reduce the emissions of greenhouse gases (Optiedocument voor emissiereductie van broeikasgassen).* ECN/RIVM: October 1999.

Harmelink, M, Joosen S. & Harnisch J. 2005. *Cost-effectiveness of non-CO_2-greenhouse gas emission reduction measures implemented in the period 1990-2003.* Utrecht; Ecofys.

Joosen, S. Harmelink M & Blok K. 2004. *Evaluation of climate change policies in the built environment in the Netherlands 1995-2002 (Evaluatie van het Klimaatbeleid in de Gebouwde Omgeving 1995-2002).* Utrecht, Ecofys.

VROM, 1998. *Costs and benefits of environmental policies – Definitions and calculations methods (Kosten en baten van milieubeleid – Definities en berekeningsmethoden).* The Hague: Ministry of Vrom, Publicatiereeks Milieustrategie1998/6.

VROM, 1999. *Climate Policy Implementation Plan (CPIP) Part I.* The Hague: Ministry of Vrom.

VROM, 2004. *Assistance for monitoring and evaluation of climate policies (Handreiking voor monitoring en evaluatie van klimaatbeleid).* The Hague: Ministry of VROM.