Energy research Centre of the Netherlands

An assessment of the potential for achieving climate targets and energy savings up to 2020

Analyses with the Options Document for energy and emissions 2010/2020

B.W. Daniëls[1]

J.C.M. Farla[2]

(co-ordinators)

[1]Energy research Centre of the Netherlands

[2]Netherlands Environmental Assessment Agency

Milieu en Natuur Planbureau

ECN-E--08-045

MNP 773001040

February 2006

Preface

This is one of the two reports published as a result of the project 'Options Document for Energy and Emissions 2010/2020' ('*Optiedocument energie en emissies 2010/2020*'). This project was carried out at the request of the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM) and the Dutch Ministry of Economic Affairs (EZ). An interdepartmental supervisory commission consisted of representatives of the Dutch Ministries of EZ, VROM, LNV (Agriculture, Nature and Food Quality), V&W (Transport, Public Works and Water Management) and Finance. We thank them for their critical, constructive contributions. This report is the translation of report ECN-C--05-106 and is registered at the Energy research Centre of the Netherlands (ECN) under report number ECN-E--08-045 and project number 7.7595 and at the Netherlands Environmental Assessment Agency (MNP) as number 773001040.

In addition to the co-ordinating authors, various other researchers of ECN and MNP have contributed to the project. These are L.W.M. Beurskens, Y.H.A. Boerakker, H.C. de Coninck, A.W.N. van Dril, R. Harmsen, H. Jeeninga, P. Kroon, P. Lako, H.M. Londo, M. Menkveld, L.C. Pronk, A.J. Seebregts, G.J. Stienstra, C.H. Volkers, H.J. de Vries, F.G.H. van Wees, J.R. Ybema (all from ECN) and J.A. Annema, J.C. Brink, G.J. van den Born, R.M.M. van den Brink, J.D. van Dam, H.E. Elzenga, A. Hoen, E. Honig, J.A. Oude Lohuis, D.S. Nijdam, C.J. Peek, M.W. van Schijndel, W.L.M. Smeets, K. van Velze, R.A. van den Wijngaart en H. van Zeijts (all from MNP).

Petten / Bilthoven, February 2006.

Abstract

The Ministry of Housing, Spatial Planning and the Environment and the Ministry of Economic Affairs in the Netherlands have requested ECN and MNP to assess the potential and cost consequences to reduce Dutch greenhouse gas emissions in 2020 and to assess the potential and costs of increasing the rate of energy efficiency improvement between 2010 and 2020. Over 150 measures to limit emissions and energy consumption have been assessed and used as the basis to analyse the possibility to reach three indicative emission targets (220, 200 and 180 Mton of CO_2 equivalents). The measures have been combined and ranked based on minimising the national cost of emission reduction. It appears that the identified measures can be combined to represent a technical emission reduction potential of 90 Mton CO_2 eq emissions in 2020. This implies a theoretical potential to reduce the national greenhouse gas emission from 251 Mton, as projected in the Global Economy scenario (variant) for 2020, to 160 Mton. Several emission targets, ranging from 220 to 180 Mton CO_2 eq have been studied in detail. In a cost minimising package to limit emissions to 180 Mton CO_2 eq, the largest contribution will come from energy savings followed by CO_2 capture and storage and nuclear energy. It must be noted that the feasibility and availability of policy instruments to overcome the barriers to implement these measures have not been studied or taken into account. In the packages for emission reduction the rate of energy efficiency improvement will be increased from 1.0% in the baseline to 1.4-1.6% per year. An energy efficiency improvement rate of over 2% per year can theoretically be reached on the basis of the measures that were assessed. Several sensitivity analyses were performed. They show that the national mitigation costs depend amongst others on the assumptions for CO_2 storage capacity, and acceptance of the nuclear option. Furthermore, higher oil prices do not strongly influence the feasibility of reaching the indicative emission targets or energy efficiency rates. However, they lead to a decrease of the overall costs.

Layout: 11 June 2008

Foreword

Climate change and a dependency on finite stocks of fossil fuels may involve great risks to society. Minimising these risks requires reducing the growth of greenhouse gas emissions and the use of fossil fuels. This report provides a basis for the discussion on how the Netherlands can contribute to this.

The problems sketched above are topical and there is a great need for solid, quantitative information. In this report, ECN and MNP provide an inventory of the technical possibilities for reducing domestic emissions of greenhouse gases and energy use up to 2020. It comprises an analysis based on the Options Document for Energy and Emissions 2010/2020 (*Optiedocument energie en emissies 2010/2020*).

The analysis examines the various options available for reducing emissions such as energy saving, renewable energy, the capture and storage of CO_2 emissions and nuclear energy. The interaction between options is also taken into account. The analysis also describes the relationship between reducing the emission of greenhouse gases, air pollution and energy saving measures.

The study has its limitations: for example, the availability of policy instruments, societal basis, sustainability aspects and the consequences for industry have only been partially examined. The financial consequences for Dutch society have been estimated by presenting the national cost for the various option packages rather than the costs for the various sectors. This is a partial approach that does not, for example, consider the damage avoided by reducing emissions. Aspects that either cannot be expressed in costs or only with difficulty have also been left out. In this respect, one might consider aspects such as hindrance caused by wind turbines, a possible reduction in biodiversity with the import of biomass, further depletion of fossil fuel reserves resulting from CO_2 storage and the long-term storage of radioactive waste and the risk of accidents at nuclear power plants.

The discussion about energy and climate policy is about choices. The costs of specific options play a role as well as the availability of policy instruments and the many advantages and disadvantages associated with the options. Both ECN and MNP will support the discussion regarding the social and political considerations relevant to the individual options in other studies.

In our opinion, this study provides a good overview of the Dutch options for energy and climate policy. We assume that this analysis provides constructive support for the social and political discussion.

Dr. A.B.M. Hoff
Director of the
Energy research Centre of the Netherlands

Prof. N.D. van Egmond
Director of the Netherlands
Environmental Assessment Agency

Summary

At the request of the Dutch Ministry of Housing, Spatial Planning and the Environment and the Ministry of Economic Affairs, the Energy research Centre of the Netherlands (ECN) and the Netherlands Environmental Assessment Agency (MNP) created the Options Document for Energy and Emissions 2010/2020 (*Optiedocument Energie en Emissies 2010/2020*). With the help of the data of the Options Document, this present report assesses the options for domestic reductions in greenhouse gas emissions and energy saving up to 2020.

The analyses have been carried out against the background of an updated version of the Global Economy (GE) scenario from the Reference Projections for Energy and Emissions 2005-2020 (*Referentieramingen energie en emissies* 2005-2020 – Van Dril and Elzenga, 2005), which includes recent developments in the policy for sustainable energy. For example, in the updated variant (GE^{act}) the power yield of offshore wind energy is lower than in the Reference Projections. Moreover, variant (GE^{hi}) was also analysed with a higher oil price of approximately \$ 40 per barrel in addition to this update.

This report will answer the following policy questions:
1. What are the possibilities for domestic reductions in greenhouse gas emissions for the year 2020?
2. What are the possibilities for increasing the rate of energy saving for the period 2010-2020?

A question derived from these issues concerns the effect of a higher oil price on the maximum effects and costs of measures for emission reduction and energy saving.

Three indicative targets have been calculated for the emission of greenhouse gases in 2020, namely 220, 200 and 180 Mton CO_2 equivalent. The level of 220 Mton corresponds to a stabilisation of greenhouse gas emissions between 2010 and 2020. The indicative targets of 200 and 180 Mton correspond to a drop of 6% and 15% respectively in the emission of greenhouse gases compared with the reference year (1990/1995) of the Kyoto protocol. These indicative targets are shown in the figure below. Without additional policies, the updated GE^{act} scenario will lead to an emission of 251 Mton CO_2 eq. in 2020.

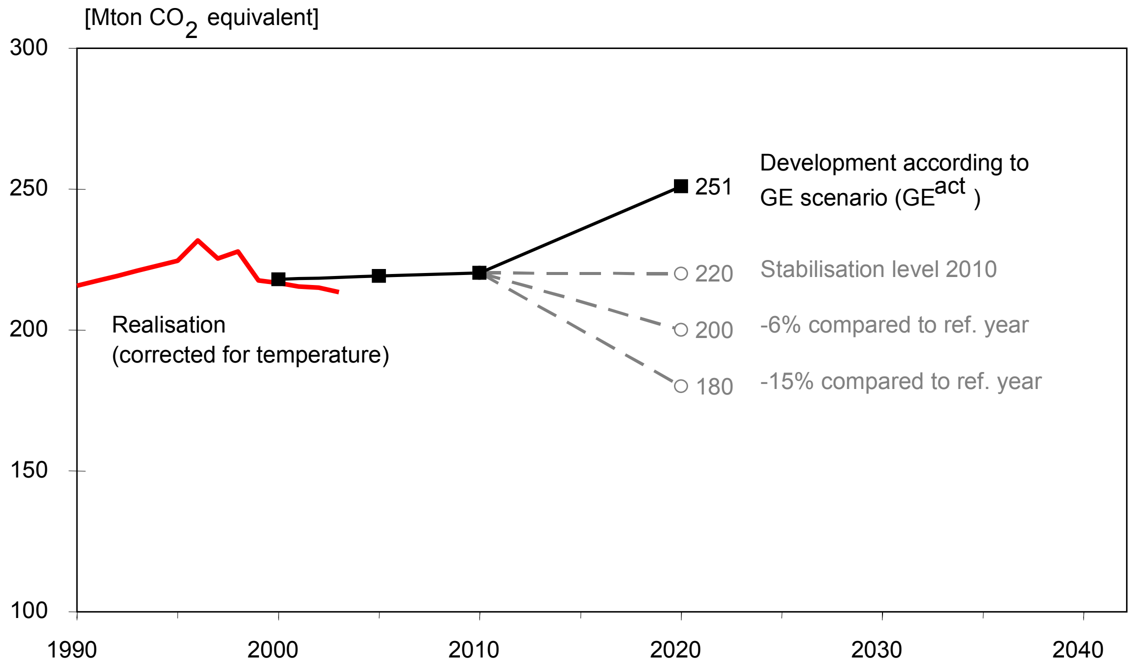

Figure S.1 *The emission of greenhouse gases in the period 2005-2020 according to the GE scenario (updated variant GE^{act}) and the indicative targets*

> The results of this analysis are closely related to the Global Economy scenario: relatively high economic growth and high population growth result in high energy consumption and high emissions. The option packages presented have been put together in such a way that (based on the technical potentials) they satisfy the indicative targets at the lowest possible cost (maximising cost-effectiveness from a national perspective). Other considerations such as availability of policy instruments, support and sustainability aspects do not play a role in these option packages. Examples of the sustainability aspects not taken into account in the option packages are nuisance caused by wind turbines, a possible reduction in biodiversity as a result of importing biomass, the further depletion of fossil fuel reserves through CO_2 storage and the long-term storage of radioactive waste and the risk of accidents at nuclear power plants.

In putting together the option packages for the analyses, account was taken of the expected limits and limitations. For example, the contribution of CO_2 storage is limited because of the storage capacity available in the Netherlands. The capacity of nuclear energy is limited to 2,000 MW_e based on the required new construction of power plants. Options that limit consumer freedom of choice are excluded. In 2020, the option packages must also satisfy tighter emission requirements for air-polluting substances such as NO_x, SO_2 and particulate matter.

Only domestic measures have been examined. Measures taken abroad, such as those used, for example, in European Emissions Trading and the Kyoto mechanisms ‘Joint Implementation’ and ‘Clean Development Mechanism’ have been left out.

S.1 Technical potential for reducing the emission of greenhouse gases

There is sufficient technical potential to stabilise domestic emissions of greenhouse gases in 2020 at the level of 2010, or to reduce them by 6-15% compared with the reference year.

- The maximum technical reduction potential is approximately 90 Mton CO_2 eq. in 2020. Thus, greenhouse gas emission in 2020 could be reduced to 160 Mton CO_2 eq. This means that there is still some room compared with the most ambitious indicative target level of 180 Mton (-15%).

The total national costs of an option package that leads to a 15% emission reduction compared with the reference year (180 Mton) are € 1.5 billion per year higher than the cost of a package with which emissions between 2010 and 2020 are stabilised (220 Mton).

- The option packages have been put together in such a way as to achieve the indicative emission targets at the lowest possible national cost. A major role in the total cost is played by options with 'negative costs' (net profits, by such things as saved energy costs). For the indicative emission target of 220 Mton CO_2 eq., the total cost of the option package is, on balance, even slightly negative, for 200 Mton CO_2 eq. the total costs run up to approximately € 300 million per year and for the target of 180 Mton to € 1.4 billion per year.

Table S.1 *Annual costs of the option packages with which the indicative emission targets will be reached and which will satisfy the tightened emission requirements for NEC substances and particulate matter*

Indicative target 2020	Emission reduction needed 2020	Annual cost of option packages 2020 [billion €/year][a]		
			Of which measures with:	
[Mton CO_2 eq.]	[Mton CO_2 eq.]	Balance	Negative costs	Positive costs[a]
220 (stabilisation level 2010)	31	-0.0	-0.6	0.6
200 (-6% compared with reference year)	51	0.3	-0.6	0.9
180 (-15% compared with reference year)	71	1.4	-0.6	2.0

[a] Including the costs of achieving the higher targets for NEC substances and particulate matter in 2020, which drop from approx. € 0.6 billion per year for the emission level 220 Mton to € 0.4 billion per year for the emission level of 180 Mton.

- Application of the options with a negative national cost-effectiveness would, in theory, lead to a cost saving on a national scale. In spite of this, these measures will not be used in the background scenario. This is because it is difficult to implement policy instruments for these options (influencing behaviour, for example) or because support for them is limited (distance-related road pricing, for example).
- The marginal cost-effectiveness of the option packages in achieving the indicative targets of 220, 200 and 180 Mton CO_2 eq. emissions in 2020 are 8, 23 and 81 € per ton of CO_2 eq. respectively. This means that to achieve the emission level of 180 Mton in 2020, it would be necessary to use all options with a cost-effectiveness up to and including 81 € per ton of CO_2 eq.

Energy saving, nuclear energy and CO_2 storage plays a major role in the option packages

- Judging by the option packages for emission reduction, it appears that energy saving, nuclear energy and CO_2 storage are important measures, with large potential and relatively low cost. Only after emission reduction targets are tightened will more expensive energy saving measures and renewable energy emerge in the option packages.

Table S.2 *Contribution per category of measures to the emission reduction of the option packages*

Category of measure	Target level [Mton CO_2 eq.]		
	220	200	180
Saving in the broad sense	17	22	24
Of which saving according to energy saving protocol	*12*	*16*	*19*
Of which volume/structure effects and fuel substitution	*5*	*5*	*5*
CO_2 storage	0	12	15
Renewable energy	1	1	12
Nuclear energy	8	9	9
Other	5	6	10

- Examples of measures that play a role in the option package for achieving the target level of 180 Mton are: building new nuclear power plants (1600 MW_e; approximately 3 times the capacity of the nuclear power plant in Borssele), installing 5,500 MW_e of extra offshore wind energy (compared with the 2,000 MW_e in the background scenario), capturing more than 15 Mton CO_2 (corresponding to approximately 20% of the CO_2 emissions from electricity generation in 2020) and introducing road pricing for private vehicles. Energy saving measures will be broadly applied and play an important role, but individually they usually have a minimal effect.
- Nuclear energy and CO_2 capture play a key role in achieving large emission reductions at relatively low cost. If both of these solutions are excluded, the total potential is clearly lower and achieving a 15% emission reduction (180 Mton) will cost almost € 2.9 billion per year extra.
- The option packages have been composed in such a way as to also satisfy tightened emission requirements for the air pollution (NO_x, SO_2, NH_3 and NMVOC) and particulate matter in 2020. For this purpose, the so-called 'medium ambition' of the European Commission's *Clean Air for Europe* programme was taken as the starting point. If this precondition is not included, no special measures for the NEC targets need to be taken and the yearly costs will be approximately € 0.4 to a maximum of € 0.6 lower.

The largest emission reductions can be achieved in industry and the energy sector

- The option packages achieve the largest emission reductions in the industry and energy sectors. This is irrespective of whether the reductions are calculated on the basis of the sector where the measures are applied or where the measures have an effect. For example, measures such as saving electricity and combined heat and power in other sectors (the services sector, for example) lead to emission reductions in the energy sector.

S.2 Technical potential for energy saving

There is a technical saving potential with which an energy saving rate of more than 2% per year can be achieved between 2010 and 2020

- There is a maximum technical saving potential that corresponds to an average energy saving of 2.1% per year between 2010 and 2020. Including options that are not included in the definition of saving according to the Energy Saving Monitoring Protocol *(Protocol Monitoring Energiebesparing*), but do lead to a reduction in energy consumption (i.e. a saving in the broad sense), increases the maximum energy saving rate to 2.3% per year.

Based on the criterion of minimising costs, the option packages comprise only the saving measures needed to achieve an energy saving rate of a maximum of 1.7% per year

- Energy saving is a major component of the option packages that have been put together for arriving at an emission reduction at the lowest possible national cost. These saving measures raise the saving rate to above the level of 1% per year in the Reference Projections, to an average of 1.4 to 1.6% per year between 2010 and 2020 for the various indicative targets. For 'saving in the broad sense', this percentage is slightly higher: 1.5 to 1.7% per year.

Table S.3 *Energy saving as from 2005 (according to the Energy Saving Monitoring Protocol in the broad sense) in the option packages for the indicative targets*

		Greenhouse gas emission level in 2020 [Mton CO_2 eq]		
		220	200	180
Saving according to protocol	[PJ]	190	250	300
	[%/yr][a]	1.4	1.5	1.6
Saving in broad sense	[PJ]	240	300	350
	[%/yr][a]	1.5	1.6	1.7

a The average saving rate (%/year) between 2010 and 2020 is given.

- If an extra tight energy saving target is enforced on top of the emission reduction target, the costs for the option packages will be higher due to the fact that this will lead to the inclusion of saving options in the package that would not be included when the objective is to minimise costs. The national cost of the option packages will rise by approximately € 0.4 and 0.2 billion per year respectively if an energy saving of 2% (in the broad sense) has to be achieved in addition to the indicative target of 200 or 180 Mton CO_2 eq.

S.3 Achievability of the option packages

In practice, part of the technical potential for emission reductions and savings either cannot be achieved or only with difficulty

- Owing to limitations arising from practical feasibility, support and rate of implementation, the 'realistic potential' for emission reduction and energy saving is probably smaller than the 'technical potential'. In this study, there was no analysis of the (possible) policy instruments for achieving the technical potential. However, it is clear that to implement a full option package focusing on achieving an emission level of 180 Mton, substantial barriers will have to be overcome. In this respect, one might consider the opposition to nuclear energy, large-scale implementation of offshore wind, and traffic measures. For this reason, achieving the lowest emission levels involves a considerable policy effort.

- The indicative target levels do not exploit the total technical potential. The indicative target of 180 Mton CO_2 eq. for domestic greenhouse gas emissions (a 15% reduction compared with the reference year) would still be feasible if an average of approximately 20% of the total calculated potential were omitted in the implementation programme. For an emission target of 200 Mton (6% reduction), a maximum of approximately 40% of the reduction potential could be omitted. In general, if part of the reduction potential is omitted, it means that the average cost of the remaining potential increases.
- In many cases, the potentials of the options are based on decision-making in 2006. If decisions to implement measures are delayed, the potential for emission reduction will gradually decrease.

*It is expected that neither the Energy Report 2005 (*Energierapport 2005*) nor the Dutch Labour Party's Action Plan on Energy Saving (*PvdA Actieplan Energiebesparing*) will achieve an annual saving rate of more than 1.5% per year between 2010 and 2020*

- To achieve an energy saving target averaging 2% per year (in the broad sense) a maximum of approximately 20% of the reduction potential in the Options Document may be omitted in the implementation programme. To achieve a saving target averaging 1.75% per year (in the broad sense), approximately 40% of the reduction potential may be omitted.
- The measures in the Energy report 2005 and the PvdA Action Plan have been evaluated. If an up-to-date estimate of the feasibility of the measures in both plans is taken into account, a saving rate of 1.5% per year cannot be achieved in either plan. In theory, further elaboration of the instrumentation may lead to a higher saving rate.

S.4 The effect of higher oil prices

A higher oil price will make little difference to the (technical) potential for emission reduction and energy saving, but the cost of the option packages will decrease

- To establish the effect of a structurally higher oil price, calculations assume average oil prices of $ 40 per barrel as from 2015, in accordance with the oil prices in *Maatschappelijke kosten-batenanalyse over wind op zee* (Verrips et al., 2005) (Social Cost-Benefit analysis for offshore wind energy). Higher energy prices will lead to increased saving in the end-user sectors. However, as a result of this higher price, there will be a shift in the energy sector towards more coal capacity and the market situation for (gas-fired) combined heat and power will deteriorate. Together, these developments will lead to a reduction in greenhouse gas emissions in GE^{hi} of 4 Mton CO_2 eq. in 2020, compared with GE^{act}.
- Higher oil prices do not result in a higher (technical) potential for emission reduction in 2020, however, the cost of the option packages will be lower. The net costs of energy saving, renewable energy and nuclear energy will decrease because, in the case of higher prices, reducing the consumption of oil and gas will reduce costs. Therefore, the cost of the option packages will be approximately € 0.2 to 0.4 billion per year lower for the indicative levels of 220 and 180 Mton CO_2 eq. respectively.
- The potential for energy saving for 2020 will also not differ much in the case of a higher oil price: there will be slightly more savings in the background scenario and the remaining potential will therefore be smaller.

Contents

List of tables

List of figures

1. Introduction

1.1 Background

This report assesses the possibilities for domestic reduction in the emissions of greenhouse gases up to 2020 and, associated with this, the possibilities for increasing the rate of energy saving. It contains the first analyses with options from the Options Document for Energy and Emissions 2010/2020 (Daniëls and Farla, 2006).

The analyses of climate targets and energy saving were carried out at the request of the Dutch Ministry of Housing, Spatial Planning and the Environment and the Dutch Ministry of Economic Affairs. The Ministry of Housing, Spatial Planning and the Environment wishes to assess the possibilities for climate policy after the Kyoto period (2012). The results will be reported this year in the 'Environment Road map' (*Toekomstagenda Milieu*). In its Energy Report 2005 (EZ, 2005), the Ministry of Economic Affairs presented its general strategic lines for energy policy. During the parliamentary discussions on the Energy Report, the Minister of Economic Affairs offered to assess the possibilities of a rate of energy saving higher than that of the policy package proposed in the Energy Report 2005. This was in response to the parliamentary motion of Van der Ham/Spies on 22 March 2005 (TK, 2005) in which they requested that the Dutch target for energy saving should be raised to an average of 1.5% per year up to 2010 and to an average of 2% per year from 2010 onwards.

1.2 Research question

The Options Document for Energy and Emissions 2010/2020 (hereafter referred to as the Options Document) describes measures for saving energy and emission reduction. Using the Options Document, two research questions were explored:

1. What are the possibilities for reducing the emission of greenhouse gases in the Netherlands for the year 2020?
2. What are the possibilities for increasing the rate of energy saving for the period 2010-2020?

The starting point for the first research question is the greenhouse gas emission level of 2020. This is 243 Mton CO_2 equivalent[1] according to the GE scenario in the Reference Projections for Energy and Emissions 2005-2020 (*Referentieramingen energie en emissies* 2005-2020 - Van Dril and Elzenga, 2005)[2]. Calculation are based on indicative targets for the greenhouse gases emission levels of 220, 200 and 180 Mton CO_2 eq. in 2020. The emission level of 220 Mton CO_2 eq. corresponds to the greenhouse gas emission in 2010 according to the GE scenario (Van Dril and Elzenga, 2005). This is therefore equal to a stabilisation of the emission level between 2010 and 2020. The emission level of 200 Mton CO_2 eq. corresponds approximately to a 6% reduction in emissions compared with the reference year 1990/1995[3]. This emission level corresponds to the Dutch 'Kyoto Target' for the year 2010 if applied nationally. The emission level of 180 Mton refers to an approximate 15% reduction in emissions compared with the green-

1 The unit 'kg CO_2 equivalent' enables emissions of carbon dioxide and the other five greenhouse gases in the Kyoto Protocol to be brought together as one, based on the contribution that each of these gases makes to climate change (weighted sum with global warming potential factors).

2 In the Reference Projections, an emission of 240 Mton is calculated for 2020. However, at the beginning of this report, it is stated that approximately 3 Mton should be added to this (both for 2010 and 2020). This report is based on these 3 Mton higher emissions.

3 The reference year for the official monitoring of greenhouse gases is 1990, with the exception of the F-gases for which the reference year is 1995.

house gas emissions in 1990/1995. Table 1.1 provides a summary of the development of emissions in the GE scenario and the indicative targets used in this study.

Table 1.1 *Summary of greenhouse gas development in the Reference Projections and the indicative targets that were examined in this study*

	Greenhouse gas emissions	
Emissions according to Reference Projections	Level compared with reference year [%]	GE (RR[b]) [Mton CO_2 eq.]
Emission in reference year (1990/1995)[a]	100	214
Emission in 2010	103	220
Emission in 2020	114	243
Indicative targets for 2020		
Stabilisation between 2010 and 2020	103	220
Reduction of 6% compared with reference year	94	approx 200
Reduction of 15% compared with reference year	85	approx 180

a The emission of greenhouse gases in the reference year is 213.75 Mton (Brandes et al., 2006).
b Reference Projections.

The following sub-questions were answered against the background of these indicative targets:
- Based on the Options Document, what is the technical potential for greenhouse gas emission reduction in 2020?
- What measures/categories of measures are important for the various reduction ambition levels?
- What are the costs and other characteristics of these measures/categories of measures?
- What sectors are important in greenhouse gas emission reduction?
- Based on what is known about the various categories of measures, what can be said about possible barriers to implementation?
- Are emission levels of indicative targets achievable?
- What is the effect of a structurally higher oil price on the potential and cost of emission reduction?

The same background scenarios were used for the research question about increasing the rate of energy saving. The following sub-questions were asked in order to answer this research question:
- What is the technical potential for energy saving in 2020 based on the Options Document?
- What is the average saving rate in the option packages for greenhouse gas emission reduction?
- What are the costs and other characteristics of these measures/categories of measures?
- What is the relationship between a high rate of energy saving and a reduction in the emission of greenhouse gases?
- Is a saving rate of 2% per year feasible?
- What is the effect of a structurally higher oil price on the potential and cost of a high rate of energy saving?

The analysis of possibilities for saving energy will be described in association with possible climate targets because energy saving is regarded as an important way of reducing CO_2 emissions.

1.3 General approach

The analyses described in this report were carried out with the Options Document. This Options Document includes information about potentials for emission reduction and reducing energy consumption for the target years of 2010 and 2020 against the background of the Global Economy scenario (GE) in the Reference Projections. Two modified 'background scenarios' were developed for these analyses, based on this GE scenario. A first modification concerned the incorporation of recent policy developments for stimulating sustainable energy, particularly offshore wind energy. A second variant derived from the GE scenario is based on a permanently higher oil price. The modifications compared with the GE scenario are described in Chapter 2.

Using the Options Document, option packages were put together against both background scenarios that satisfied the targets established for emission reduction and energy use at minimal national cost (see Paragraph 3.2 for a definition). The analysed targets for reduced greenhouse gas emissions are 220, 200 and 180 Mton CO_2 eq. In this respect, special attention was paid to the role of energy saving in these packages. Option packages were also put together on the basis of specific saving targets.

The possibilities for the Netherlands to meet the climate targets by means of emissions trading (such as the Kyoto mechanisms 'Joint Implementation' and 'Clean Development Mechanism') were not examined in this study.

1.4 Reading instructions

Chapter 2 provides a brief description of the background scenarios used. Chapter 3 deals with the Options Document, the instrument used for carrying out the analyses described. Chapter 4 describes the targets and preconditions used as a basis for putting together the various option packages. Chapter 5 shows the results of the analyses in terms of reduction potential and cost and examines the effect of a number of specific preconditions. Chapter 6 contains a critical appraisal of the results. The possibilities for policy instruments and areas of uncertainty are reviewed. Finally, Chapter 7 presents the conclusions regarding the feasibility of the targets for reducing greenhouse gas emissions and the rate of energy saving that were investigated.

2. Background scenarios

2.1 A description of the variants of the GE scenario used

For the analyses in this report, developments according to the ‘Global Economy’ (GE) scenario from the Reference Projections for energy and emissions 2005-2020 have been taken as the starting point. This is a scenario featuring high population growth and high economic growth. Moreover, the GE scenario was the background against which the options in the Options Document were described in the first place.

Based on the GE scenario mentioned above, two variants were developed for this analysis. The first variant includes the recent policy changes at the end of 2005 with regard to sustainable electricity. These concern the change in subsidies according to the Environmental Quality of Electricity Production Act (*Wet Milieukwaliteit elektriciteitproductie – MEP*) that terminated the open-ended nature of these regulations. As a result, the assumed generating capacity of offshore wind in 2020 is lower than the 6,000 MW on which the GE scenario was based.

The second variant also includes the update on the MEP legislation, but also assumes a structurally higher oil price from \$35 to \$40 per barrel from 2015 onwards. Linked to the higher oil price, the price of natural gas also rises while the price of coal remains fairly stable. This leads to a change in the energy carrier to be used, particularly in the energy sector, resulting in a change of emissions.

Both variants of the background scenario are indicated in this report as GE^{act} (reduced offshore wind power) and GE^{hi} (high oil price variant) respectively. The following paragraphs of this chapter describe the assumptions and effects for each variant of the scenario. Table 2.1 provides a schematic overview of the most important differences and similarities between GE in the Reference Projections and the variants derived from it.

Status of the scenario variants used

The scenario variants used in this analysis differ from the GE scenario deriving from the Reference Projections. They have been drawn up especially for these analyses and do not have the status of the GE and SE scenarios deriving from the Reference Projections, for example. These variants have been chosen to match the results to the current policy context as closely as possible. However, the variants are not described as comprehensively as in the Reference Projections.

The developed scenario variants were matched as closely as possible to the GE energy scenario and a high oil price variant of this that is being developed for the study *Welvaart en Leefomgeving* (Welfare and Environment, hereafter referred to as WLO). This assessment of future developments until 2040 will be published by the planning bureaus CPB, RPB and MNP in the middle of 2006. The WLO study will also include updated projections for the transport sector, which were not yet available for this study.

It is also important that in the high oil price variant (GE^{hi}), the pass-through of higher energy prices in accordance with the basic assumptions of the WLO has only been partially included for energy consumption. Changes in patterns of economic growth (volume and structure) resulting from the high oil prices, which may lead to a change in energy demand, cannot be included in the context of this analysis.

Table 2.1 *Schematic overview of a number of key figures in the variants used and in the Global Economy scenario in the Reference Projections*

	GE (RR)	GE^{act}	GE^{hi}
Average economic growth in 2002-2020	2.9%/year	Idem	Idem
Offshore wind energy (capacity in 2020)	6000 MW	2000 MW	2000 MW
Oil prices in 2020 [$/barrel]	25	25	38
Emissions in 2020 [Mton CO_2 eq.]	243	251	248

Figure 2.1 shows the developments in the trading prices of crude oil and natural gas. In both variants, the price of coal remains around 1.7 €/GJ.

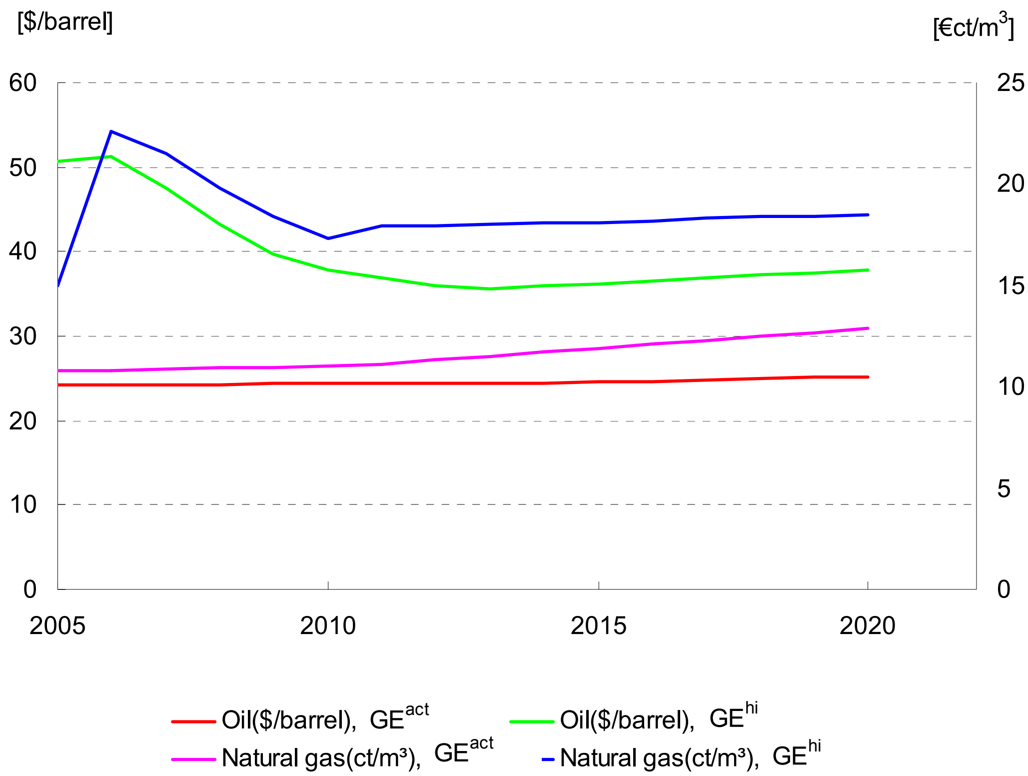

Figure 2.1 *Development of the prices of oil and natural gas in the scenario variants used*

2.2 Energy, emissions and savings in the scenario variants

This paragraph briefly describes the emissions and the energy consumption in the scenario variants and examines the most important changes with regard to the GE scenario of the Reference Projections.

Updated background scenario GE^{act}

The major difference with GE is that the MEP legislation loses its open-ended nature. This has two important consequences:

- Renewable generating capacity, and particularly offshore wind energy, is implemented more slowly than was predicted earlier in the Reference Projections. In 2020, 2,000 MW will be installed instead of the 6,000 MW predicted in the projections.
- Because electricity demand stays the same, additional generating capacity must offset the slower growth of wind capacity. Owing to the structure of the Dutch electricity generating industry, with a relative shortage of basic low cost generating capacity, this gap will mostly be filled with new coal-fired generating capacity.

As a result of this, primary energy consumption and emissions of CO_2, NO_x and SO_2 increase in comparison with the levels calculated in the Reference Projections. In 2020, the GE^{act} emissions are approximately 8 Mton higher than in the GE scenario of the Reference Projections (251 Mton instead of 243 Mton CO_2 equivalent).

GE, high oil price

The combination of a high oil price, the high gas price associated with this and a stable coal price leads to a number of partially opposing developments. These developments come on top of the increase in coal-fired generating capacity resulting from less wind power. Here is a summary of the most important developments:

- The higher price level of oil and natural gas has a direct effect on savings in the end-user sector. Saving measures become more attractive and the rate of saving increases, making the demand for natural gas and car fuel lower than in the Reference Projections. This development leads to a reduction in CO_2 emissions.
- In the electricity sector, the natural gas generating costs become higher. This leads to a shift from natural gas to coal and building new coal-fired generating capacity becomes more attractive. Because of the lower generating efficiency of coal based plants, fuel consumption and CO_2 emissions increase. The latter is further enhanced by the higher emission factor of coal. The Netherlands' net imports of electricity will also increase because foreign electricity, generated by coal-fired plants and nuclear energy will become more competitive.
- The higher generating costs cause a rise in the price of electricity but owing to a simultaneous shift to coal power, this rise remains relatively lower than the rise in the price of natural gas. This makes the ratio between electricity prices and the price of natural gas more unfavourable for combined heat and power (CHP). After all, in the case of combined heat and power, the majority of costs are associated with the consumption of natural gas and the majority of the profits with the production of electricity. This deteriorates the market position of CHP compared with the GE scenario in the Reference Projections (GE-RR), and the development of CHP is less in the case of GE-RR[4]. Compared with the projection, this results in lower savings, a higher primary consumption and higher CO_2 emissions.
- In the end-user sectors, the higher electricity prices lead to slightly higher savings on electricity, which somewhat tempers the tendency towards higher energy consumption and higher emissions in the generating sector.

All in all, these developments caused by a higher oil price result in slightly higher energy savings than in the GE scenario in accordance with the Reference Projections (with a low oil price development). Greenhouse gas emissions are 4 Mton higher than in the scenario with only updated policy. The extra importation of electricity contributes slightly less than 1 Mton to this latter difference.

Table 2.2 shows a few key figures for the energy system in the modified scenarios for 2020. Table 2.3 shows the total emissions of greenhouse gases and the primary energy consumption in the Reference Projections and the two variants. In both variants, greenhouse gas emissions are higher than in the Reference Projections.

[4] There is no question of an absolute reduction here. The production of electricity will also rise slightly in the case of high oil prices. There is stagnation in production between 2010 and 2020.

Table 2.2 *Key figures for the background scenarios for 2020*

		GE	GE^{act}	GE^{hi}
Final electricity demand	[PJ_e]	504	504	499
Final heat demand	[PJ_{th}]	1711	1712	1678
Production of electricity by CHP	[PJ_e]	128	128	109
Production of electricity by coal-fired plants	[PJ_e]	129	168	176

Table 2.3 *Development of greenhouse gas emissions and primary energy consumption in the variants used compared with the Global Economy scenario in the Reference Projections*

	Greenhouse gas emissions [Mt CO_2 eq.]		Primary energy consumption [PJ]	
	2010[a]	2020	2010	2020
GE	220	243	3434	3867
GE^{act} (policy update)	221	251	3449	3925
GE^{hi} (high oil price)	217	247	3407	3854

a Only physical emissions. Emissions cf. Kyoto do not or hardly change because the majority of the effects take place in the sectors that come under emission trading and the emission levels are steady.

The total of options does not change but the cost of potential does change

The oil price hardly changes the total possibility for saving energy or reducing emissions until 2020[5]. The extra potential added in the scenario variants resulting from the effect of the higher oil price is based on what is available as additional potential and vice versa. The total potential up to 2020 could change only if new options for emission reduction should arise through the influence of high energy prices, for example as the result of increased research efforts in that field. Such effects are not included in this analysis.[6]

5 Reducing the net importation of electricity results in a small change in the emission reduction potential.
6 In view of the relatively short period for research programmes up to 2020, little extra potential is to be expected.

3. Options Document for energy and emissions 2010/2020

3.1 Description

The Options Document for Energy and Emissions 2010/2020 consists of a large number of option descriptions and an analysis model that can put together packages based on the energy descriptions in order to achieve targets for CO_2, other greenhouse gases[7], NEC substances[8] and particulate matter. The option descriptions provide the reduction potential compared with the Global Economy scenario (GE) from the Reference Projections for energy and emissions 2005-2020, for the years 2010 and 2020. The Options Document comprises a comprehensive fact sheet for each option, including specifications of the effects on emissions and energy consumption, the various costs, the possible policy instruments and additional information regarding support and barriers. The method followed for the descriptions of options is described fully in the Options Document.

The analysis model developed for the Options Document can put together an option package that meets the target of one or more kinds of emission compared with a certain background scenario and taking account of preconditions specified by the user of the model, at minimal national cost. Conversely, the analysis model can put together option packages with the highest possible emission reductions on the basis of specified maximum costs and maximum cost-effectiveness. Such an approach makes it possible to explore the effect of a levy on one or more emissions.

Alternative background scenarios
The descriptions of the options in the Options Document are compared with the GE scenario from the Reference Projections but this does not mean that the Options Document cannot be used for analyses against other background scenarios. In fact, the analysis model makes it possible to scale options for other background scenarios and indicate whether there is more or less potential compared with a specific background scenario than with the Reference Projections. Due to the use of modified variants, this possibility is used in the analyses described. This means that the potential of some of the measures differs from the option descriptions in the Options Document.

Policy instruments
Primarily, the options in the Options Document describe the cost components and effects of (physical) measures and not the policy instruments needed for them. It is true that the fact sheets contain qualitative information about possible policy instruments but they provide no quantitative estimate of the effect of policy instruments on the application of options. The consequence of this is that it is not always known which part of the potential of an option can be actually implemented through policy and what the additional cost of the chosen instruments will be. This means that the option packages put together with the analysis model must always be carefully examined as to whether they can actually be implemented and with respect to the availability of policy instruments. This requires more detailed specific analysis and is partially the responsibility of the departments involved and politicians.

In the Options Document, a special place is given to a number of traffic options due to partially differing starting points in the option descriptions. A large number of the traffic options are

---

7 The other greenhouse gases are methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and SF_6.

8 The substances that come under the National Emission Ceilings Directive (NEC) are ammonia (NH_3), nitrogen oxides (NO_x), sulphur dioxide (SO_2) and the non-methane volatile organic compounds (NMVOC).

taken directly from the Traffic Emissions Options Document (*Optiedocument Verkeersemissies* – Van den Brink et al., 2004). In this document, the options are largely based on specific instruments and the effects and costs are also associated with that specific policy. The implications of this different approach to traffic options are briefly described in Paragraph 3.3.

3.2 Method of calculating environment costs

Costs and cost-effectiveness play a major role in drawing up the option packages. The costs employed in the Options Document are the National Costs and the End-User Costs in accordance with the Method of Calculating Environment Costs (*Methodiek Milieukosten* - VROM, 1994 and 1998). For the majority of the options, these costs are not directly included in the option descriptions but calculated from separately established cost components and the effects on energy consumption in combination with the national prices and end-user prices for the energy carriers involved.

National costs

The national cost is indicative of the costs and benefits that an option brings about for the Netherlands as a whole. In putting together option packages for emission reduction, minimising the national cost may be a first selection criterion from a national perspective. For this reason, these analyses focus on national costs first.

In the Options Document, investments are written off over 25 years (construction investments) or ten years (electro-mechanical investments). A discount rate of 4% is used for the national cost, based on the average real cost of capital for the government (interest on a ten-year government loan). For the cost of extra energy consumption and the benefits of energy saving, national prices for the various energy sources are employed. These national prices are based on the international trading prices for the energy sources involved. Table 4.2 on page 24 shows the national prices for GE^{act} and GE^{hi}. Subsidies and levies play no role in the national cost: these are money transfers within the Netherlands rather than costs for the Netherlands.

End-User Cost

The end-user costs are an indicator of the costs that individual players and sectors would experience and, up to a certain level, resemble the costs used in decision-making in the sectors. The backgrounds and calculation method are described in full in the Options Document.

The end-user costs use the same write-off period for investments as the national cost but the discount rate varies from sector to sector and depends on the average cost of capital for the sectors involved. The end-user energy prices also vary according to sector. Due to the limited role of end-user prices in this analysis, the discount rates and energy prices for end-user costs are not shown here.

In contrast to the national cost, subsidies and levies do play a role in the end-user prices. End-user prices for the sectors already include the effects of energy tax. In addition to this, measures can also benefit from existing specific subsidy schemes such as the Energy Investment Deduction (*Energie-investeringsaftrek* - *EIA*) and the MEP subsidies.

Appendix B contains a short, comparative analysis of the costs according to the Method of Calculating Environment Costs and the costs and other considerations that play a practical role in the sectors in decision-making regarding the adoption of measures.

3.3 Differing approach to traffic options

As stated in Paragraph 3.1, a large number of traffic options in the Options Document are taken directly from the Traffic Emissions Options Document. The consequence of this is that the traffic options differ in two respects from the other options:

- The traffic options are directly linked to a specific policy instrument.
- In the case of the traffic options, all the positive and negative effects of the option[9] are valued in monetary terms to the furthest possible extent. For example, benefits (e.g. for time gained) are attributed to options that (in addition to emission reduction) lead to less congestion and costs are attributed if people drive less (loss of mobility) because of a measure (such as in road pricing).

The approach based on policy instruments has a number of consequences. For example, part of the technical-economic potential is not covered. Only that part of the emission reduction potential for which specific policy was devised is included. To compensate for this disadvantage (for the present application) a number of options have been added to partially supplement the technical-economic potential. A second consequence is that careful attention must be paid to the overlap between options. This is provided for by means of exclusion rules in the analysis model.

The specific costs approach in the Traffic Emissions Options Document has been chosen because otherwise almost all measures that lead to a rise in traffic costs (such as increases in petrol duty or road tax) appear very cost-effective in the analysis. After all, less driving means less emissions and the fuel-costs saved lead to negative cost-effectiveness. This image suggests that limiting mobility results only in benefits, which conflicts with the fact that mobility is also useful for people. This extra social usefulness has also been expressed in financial terms as far as possible. This approach is also described as a possibility in the Method of Calculating Environment Costs (page 44 in (VROM, 1998)). It can also be said that in the case of most options in other sectors, such extra effects of loss or gain of usefulness either do not arise or arise to a far lesser degree. A consequence of this approach is also that the calculated total national cost of the packages of measures also includes, to a limited extent, costs and benefits that, strictly speaking, should not be included in the national cost according to the definition employed, e.g. the social value of mobility and the gain in time resulting from less congestion.

Briefly summarised, the technical potential for emission reduction and energy saving will be explored to a lesser degree in the case of traffic options than in the case of the other options. On the other hand, in the case of most traffic options, more clarity is provided about the possibilities for policy instruments (see Van den Brink et al., 2004, and Daniëls and Farla, 2006). In this analysis, allowing modified basic assumptions with regard to the cost of traffic options leads to a more balanced treatment of traffic options than when a strict interpretation of the method of calculating environment costs is followed.

9 With the exception of the effects of the emissions studied (CO_2, NEC substances and particulate matter).

4. Option packages: starting points

4.1 Targets

`The analysis model is used to put together option packages for the various indicative targets for greenhouse gases and energy consumption. Paragraph 1.2 explained why the indicative emission targets of 220, 200 and 180 Mton CO_2 equivalent are relevant. In addition to these emission levels, 20 Mton higher and lower emission levels have been calculated. Thus for total greenhouse gases, emission levels of 240, 220, 200, 180 and 160 Mton CO_2 eq. have been calculated for 2020.

Table 4.1 shows a summary of the different levels and associated emission reductions required with regard to GE, GE^{act} and GE^{hi}. In order to be able to assess the potential for energy saving, in addition to the greenhouse gas levels, there are calculations based on increasingly ambitious targets for reducing primary energy consumption with energy saving measures.

Table 4.1 *Overview of the emissions in the background scenarios, the emission levels studied and the required emission reductions*

Greenhouse gas emissions [Mton CO_2 eq.]	GE (RR)	GE^{act}	GE^{hi}
Emission in reference year (1990/1995)	214		
Emission in 2010	220		
Emission in 2020	243	251	247
Indicative targets	Emission level	Required emission reduction	
		GE^{act}	GE^{hi}
Stabilisation between 2010 and 2020	220	-31	-27
Reduction of -6% compared with reference year	200	-51	-47
Reduction of -15% compared with reference year	180	-71	-67

4.2 Energy prices

National energy prices

The price developments in the scenarios also determine the national energy prices used in calculating the national cost. Table 4.2 gives an overview of the national prices of the most important energy sources for GE^{act} and GE^{hi}. Only in the case of natural gas, oil and energy sources deriving from them are there differences between GE^{act} and GE^{hi}. The prices of other energy sources have been assumed to be the same in both variants.

A national electricity price does not exist, as the major part of Dutch electricity demand is generated in the Netherlands using other energy carriers. Saving on energy demand or alternative ways of generating energy thus only have an effect on the use of these alternative energy carriers and hardly on the import or export of electricity.

Table 4.2 *National energy prices employed*

National prices 2020 [€/GJ]	GE^{act}	GE^{hi}
Natural gas	4.1	5.8
Waste	-9.0	-9.0
Biofuel [a]	25.0	25.0
Biomass (high quality)	5.0	5.0
Biomass (medium quality)	2.5	2.5
Biomass (oil)[b]	9.0	9.0
Coal	1.7	1.7
Oil	4.3	5.3
Oil products	4.9	5.9

a Biofuel as transport fuel.

b Vegetable oil pressed from oil-bearing plants and used for generating electricity.

4.3 Preconditions

Prior to putting together the option packages, definite choices must be made about whether or not to include a number of option categories. This is particularly the case when certain relatively low cost solutions can *in theory* provide a large share of the required potential but technical obstacles and other barriers make this *a priori* very uncertain or even impossible. Preconditions can also reflect particular policy preferences. For example, it may be preferable to achieve an emission target not via only one or a few solutions but to spread the risks by including multiple sorts of measures alongside each other in a package.

Implementation from now on

In the case of all analyses, an implicit assumption is that all potential can actually be implemented within the preconditions stated. In the case of most measures, this means that implementation must start this year in order to achieve the full potential in 2020. If a start is made on implementing measures at a later date, the potential will decrease in most cases. However, the degree to which the potential decreases in relation to the year of implementation differs strongly.

No sustainability target

The analyses do not employ preconditions with regard to policy targets for specific solutions such as the deployment of renewable energy. An exception to this are the calculations that focus specifically on energy saving. For the analyses this means that the European targets for sustainable energy are not a precondition in the calculations, for example, and that the option packages do not need to achieve these targets.

Summary of preconditions

The preconditions in the analyses are based on physical and logistical limitations. Where relevant, a sensitivity analysis is used to show the consequences of alternative assumptions for effects and costs. Table 4.3 provides a summary of the preconditions employed. This table is followed by a short explanation of the preconditions.

Table 4.3 *Summary of the preconditions imposed for the analyses and the sensitivity analyses carried out*

Preconditions	Sensitivity analyses
No relocation of emissions abroad	Relocation of emissions abroad
Only options with clear domestic effects	N/a
Extra nuclear energy to a maximum of 2000 MW_e	No nuclear energy/to 4000 MW_e
CO_2 storage to a maximum of 16 Mton/yr in 2020	0 Mton in 2020
No intervention into consumer freedom of choice	Interventions allowed
Exclusion of options if realisation is expected to be very difficult and may, for example, encounter technical problems	No exclusions
Targets for air quality (NEC substances and particulate matter)	No targets/targets the same as 2010[a]

[a] The NEC targets for 2010 are as follows: NO_x 260 kton; SO_2 50 kton; NH_3 128 kton; NMVOC 185 kton. There is no emission target for particulate matter for 2010.

Relocation of emissions abroad

The effect of part of the options is that emissions in the Netherlands are reduced but, on balance, there is no reduction of greenhouse gases worldwide because of the relocation of activities abroad. An example of this is the reduction in activities with high emissions but only minor benefits for the economy. Because the consumption of the products of these sectors does not change, such a reduction in activities means, on balance, a relocation of emissions abroad. Because these measures do not contribute to a decrease in worldwide emissions, they have been excluded in putting together the option packages.

Only options with clear domestic effects

Some of the measures bring about the largest share of emission effects abroad. Obviously, there is a positive effect on worldwide greenhouse gas emissions but there is no substantial contribution to the Dutch targets (according to the agreements under the United Nations Framework Convention on Climate Change, UNFCCC). Such measures have been excluded from the option packages. Neither was a sensitivity analysis conducted because these options, by definition, have no effect on achieving domestic targets.

Possibilities for nuclear energy

Enlarging nuclear capacity in the Netherlands provides the possibility of reducing emissions. However, the feasibility of this expansion depends strongly on social acceptance, the possibility of facilitating the building of new capacity, and fitting this into the existing generation park. Due to the long preparation time needed (procedural and building time) and the fact that new nuclear capacity will mostly come instead of new coal-fired capacity in the first instance, the analyses are based on a maximum of 2000 MW_e of new nuclear capacity in 2020. This is the maximum capacity that can be fitted in instead of new coal-fired capacity. In sensitivity analyses, 0 MW and 4,000 MW of nuclear capacity have been calculated. The latter is conceivable only if, for example, the enforced accelerated reduction of existing coal and gas capacity becomes cost-effective due to much higher CO_2 prices in the short term, and that this is already clear before 2010.

Limited capacity for CO_2 storage

The capture and underground storage of CO_2 is a possible solution that is still faces a degree of uncertainty. The technology has yet to be proven on various points and it takes time to get the necessary storage capacity operational, such as for example exhausted gas fields. The basic assumptions are that in 2020 the Netherlands can have sufficient storage capacity operational to store approximately 16 Mton of CO_2 per year underground.[10]

Intervention in consumer freedom of choice
Some of the options concern measures regarding the purchase of energy-intensive equipment by consumers. Not purchasing such things as washing driers can result in a major reduction in energy consumption and therefore a reduction in CO_2 emission. In view of possible large problems regarding social acceptance of these measures, they have not been included in the option packages.

Excluding options that are difficult to achieve
For various reasons, some of the measures in the Options Document are still very uncertain. In a number of cases, there are still technical barriers to be overcome, or it is almost impossible to stimulate or enforce a measure through policy, or other problems make it almost impossible to introduce a measure. In almost all cases, this concerns potential that has more of a theoretical than a practical significance[11]. Such measures have therefore been excluded from the option packages in this analysis for the time being.

Targets for air quality (NEC substances and particulate matter)
In 2020, the Netherlands will also have to comply with targets for other emissions such as the NEC substances and particulate matter. For this reason, indicative targets for 2020 for the NEC substances and particulate matter were employed in carrying out the analyses. These targets have an influence on the composition of the packages for energy and climate targets due to the synergy and/or antagonistic effects between the environmental issues. The indicative targets used correspond to the medium ambition (B ambition) in the 'Clean air for Europe' (CAFE) programme of the European Commission (see also Folkert et al., 2005). These values are provisional. In the near future, adjustments to the forecasted emissions in 2020 and the possibilities for reduction may lead to modifications, after which the European Commission will come up with a proposal for individual targets for member states.

10 Applying CO_2 storage also means that, under the climate treaty, it must be possible to report this method of CO_2 emission reduction by deducting the amount of stored CO_2 from the national emission. The IPCC is working on directives that will be finalised in April 2006 (De Coninck and Bakker, 2005).

11 The options involved are technically still uncertain and may become available too late to make a contribution, and options that do not fit into the normal or even a lightly accelerated replacement rate for equipment. This involves CCF (based on a maximum of 5% of the technical potential) and the most extreme variants of a number of options.

Table 4.4 *NEC substances and particulate matter: emissions in the scenario variants, indicative targets employed and the required emission reduction derived from these targets in putting together the measures packages*

	Indicative targets	Emissions 2020			Required emission reduction		
		GE	GE^{act}	GE^{hi}	GE	GE^{act}	GE^{hi}
	[kton]	[kton]	[kton]	[kton]	[kton]	[kton]	[kton]
SO_2	43	80	83	83	37	40	40
NO_x	193	272	279	274	79	86	81
NMVOC	175 [a]	182	182	180	7	7	5
NH_3	104	147	147	147	43	43	43
PM_{10}	44	47	47	47	3	3	3
$PM_{2.5}$	22 [b]	-	-	-	-	-	-

a. The indicative target for NMVOC in accordance with the medium ambition of the CAFE programme is 153 kton. However, this is based on a reduction measure of 22 kton that was already implemented in the Netherlands. To correct this, calculations in this study were based on an indicative target of 175 (153 + 22) kton for NMVOC for 2020.

b. In the CAFE programme of the European Commission, the target for particulate matter is expressed for $PM_{2,5}$ instead of PM_{10} ($PM_{2.5}$ is a fraction of PM_{10} with a smaller average particle size. Because reduction measures for PM_{10} were used in the Options Document and the Reference Projections, the equivalent indicative target for PM_{10} is shown in this table.

5. Option packages: results

This chapter consists of four parts. Against the background of the GE^{act} scenario, Paragraph 5.1 provides a comprehensive overview of the potentials for and costs of achieving different emission levels for greenhouse gases. This paragraph also describes the option packages with which the levels will be achieved. Paragraph 5.2 discusses the role of energy saving in the option packages from Paragraph 5.1 and shows the options for and costs of achieving specific saving targets. Paragraph 5.3 describes the results of a sensitivity analysis of the preconditions (from Chapter 4) employed in the analyses. Finally, Paragraph 5.4 describes the effect of a higher oil price on the results. All results refer to GE^{act}, unless stated otherwise.

5.1 Domestic reduction of greenhouse gas emissions

Packages for the greenhouse gas emission targets

Option packages were put together using the analysis model for achieving the target levels for the emission of greenhouse gases of 220, 200 and 180 Mton CO_2 equivalent at the lowest possible national cost. The option packages have been compiled in such a way that they also satisfy the indicative targets for the NEC substances and particulate matter (see Table 4.4). The target levels described in the introduction are 220, 200 and 180 Mton CO_2 eq. For the benefit of the analysis and interpretation of the results, option packages for emission levels of 240 Mton and 160 Mton are also shown, but these are not indicative targets. The level of 240 is intended to show the measures that will be deployed without stringent targets. The level of 160 shows the maximum achievable target and also provides extra information about what is available in terms of more expensive (reserve) potential.

The term *target levels* in this report is exclusively reserved for the indicative targets of 220, 200, and 180 Mton CO_2 eq. If the text also refers to the levels of 240 and 160 Mton CO_2 eq., the terms *emission level(s)* or *level(s*) are used. Please note that in all cases this level functions as a maximum! The emissions may well be lower if sufficient cost-effective measures are available, or if extra emission reductions occur as a result of measures needed to achieve NEC targets.

Because it is difficult to get a clear overview with a presentation of the option packages at the level of separate measures, the level of detail is restricted to categories of measures or possible solutions, expanding on the underlying options where necessary. Table 5.1 shows the types of options that come under the various categories.

Table 5.1 *Category classification of options*

Categories	Examples/explanation
Other greenhouse gas options	Reducing emissions of other greenhouse gases such as F-gases, N_2O and CH_4, mainly in industry and agriculture.
NH_3 options	Options in livestock rearing focusing on reducing NH_3 emissions (sometimes also reducing the other greenhouse gas emissions).
Final saving	Insulating homes, more efficient central heating boilers, more efficient cars, more efficient household equipment and lighting. The characteristic of the saving is that the activity or function does not change while energy consumption falls.
Volume and structure effects	Less driving, less purchase and use of (household) equipment, lower growth in energy-intensive sectors. The characteristic of saving volume and structure effects is that the activity or function becomes less or changes in nature, leading to a decrease in energy consumption.
Nuclear energy	New nuclear power plants.
Generating efficiency	More efficient gas- and coal-fired power plants, accelerated replacement of old power plants.
Fuel substitution	Gas-fired power plants instead of coal-fired power plants.
CHP	More and/or advanced combined heat and power, particularly in industry, agriculture and services.
CO_2 storage processes	Underground storage of CO_2 released in industrial processes in fairly pure form.
CO_2 storage generation	Underground storage of CO_2 released by electricity generation in power plants and CHP that still has to be concentrated.
Renewable energy	Solar panels and wind turbines, biomass for electricity, transport fuel and gas.

Figure 5.1 shows the contribution of the various measures categories to reducing the emission of greenhouse gases for GE^{act}, for the various greenhouse gas emission levels. The packages shown achieve these emission levels at the lowest possible national cost.

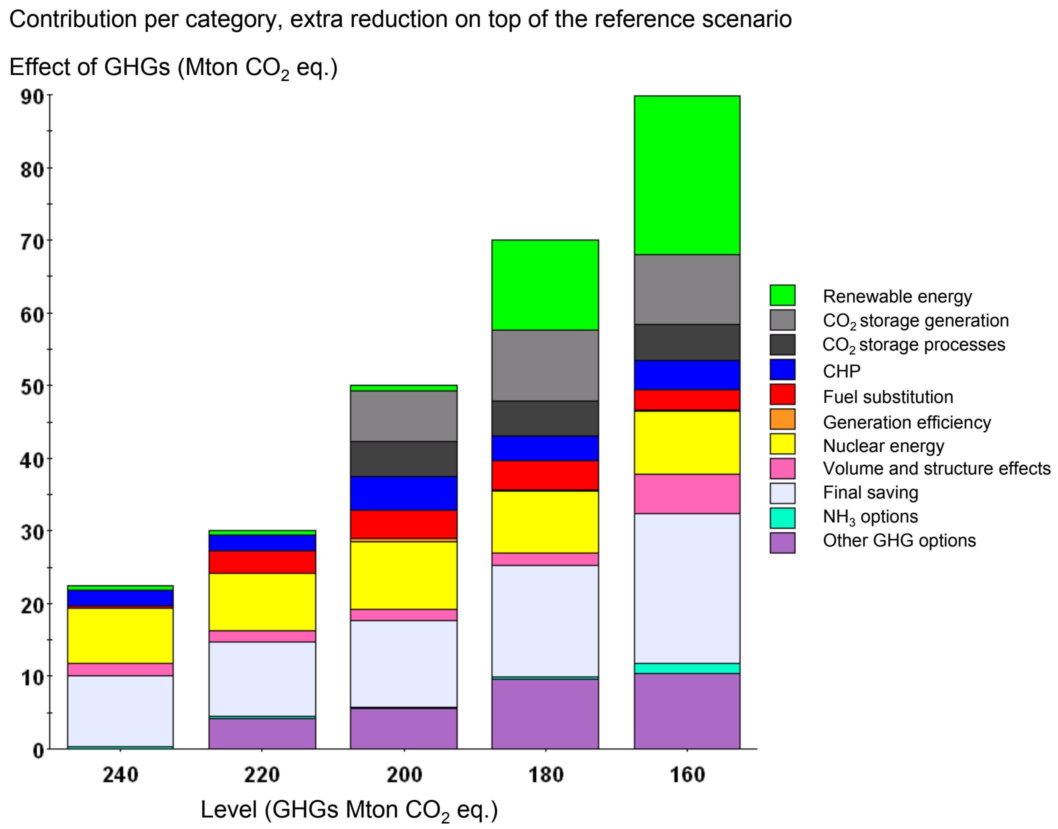

Figure 5.1 *Greenhouse gas emission reductions per category in the option packages for GE^{act} 2020*

At a level of 240 Mton CO_2 eq. the associated option package reduces emissions by 13 Mton CO_2 eq. more than is needed to achieve the emission level. The emissions realised are approximately 227 Mton CO_2 eq. (a reduction of almost 24 Mton compared with the emission in 2020). The analysis model used chooses to deploy extra options because this is needed in order to achieve the NEC targets or because the measures have negative national costs. From a target level of 220 Mton CO_2 eq. (approx. 30 Mton CO_2 eq. reduction compared with the emission in 2020) extra measures are needed to achieve the required reduction in greenhouse gas emissions.

Possible solutions/categories

- *Final saving and CHP*. Reduction at the lowest levels (240 and 220 Mton) approximately 10 and 2 Mton respectively. In the case of increasing targets, deployment in the option packages increases to approximately 21 and 4 Mton at the level of 160 Mton.
- *Nuclear energy*. Reduction at all levels between approximately 7 and 9 Mton[12]. Nuclear energy has low but positive national cost[13], and will be deployed to achieve the NEC targets at the highest emission level (240 Mton).
- *CO_2 capture and storage*. In industrial processes from a target level of 200 Mton with a constant contribution of 5 Mton. In the case of 200 Mton, also capture from electricity generation with a contribution of 7 Mton, rising to 10 Mton in the case of more ambitious targets.
- *Options for the other greenhouse gases*. Applied from a target level of 22 Mton; from 180 Mton onwards, options for ammonia reduction are also included due to the effects of

[12] The differences in reduction effect do not occur because the deployment of the option changes but because the capacity that is being superseded (proportion of natural gas and coal) has changed.

[13] The cost of nuclear energy includes the assumed cost of processing radioactive waste and dismantling the nuclear power stations 40 to 60 years after starting them.

the other GHG emissions. The total contribution rises to approximately 12 Mton in the case of a 160 Mton level.

- *Renewable energy.* Plays a modest role at the highest levels. From 180 Mton, the contribution is substantial with 12 Mton and rises to 22 Mton at the 160 Mton level.
- *Fuel substitution.* Plays a role from a target level of 220 Mton onward with a contribution that varies between 3 and 4 Mton.
- *Volume and structure effects*. Provide a contribution of almost 2 Mton from the highest levels, which is only higher at the 160 Mton level, namely 5 Mton. This mostly concerns measures in the transport sector and, at 160 Mton, also recycling of plastics.

Sectors

For policy making, it is relevant in which sectors measures must be applied and in which sectors these efforts result in a reduction of emissions. These are not always the same sectors: a reduction in the demand for electricity in households leads to lower emissions in the energy sector. If a greenhouse farmer decides to generate his own electricity using a CHP plant, this means an increase in CO_2 emissions in greenhouse farming and a reduction in emissions in the energy sector. This is why Figure 5.2 shows the reduction of emissions for each indicative target sector[14] both on the basis of the effort (left) and on that of the sector in which the effect becomes visible in terms of a reduction in emissions (right).

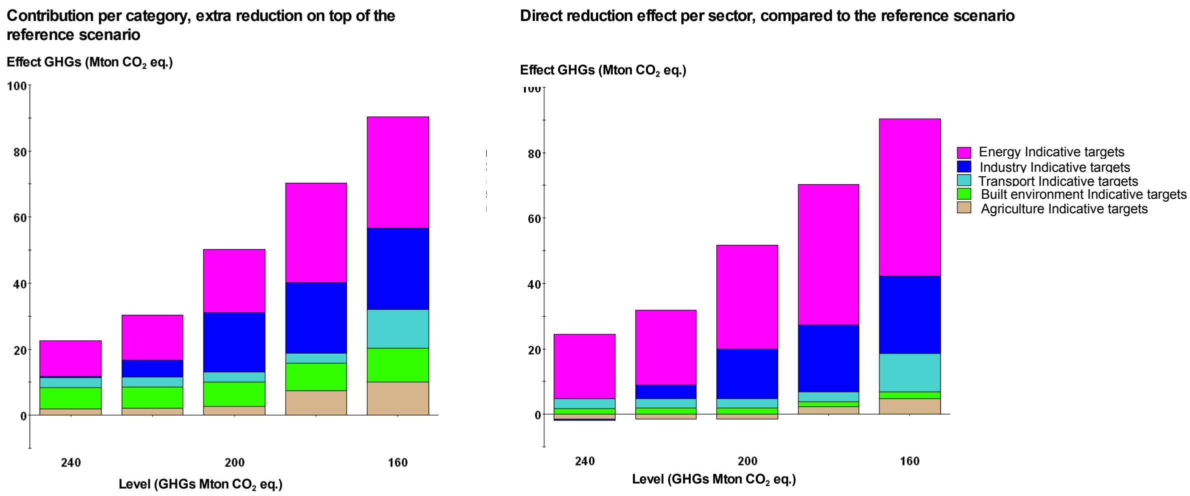

Figure 5.2 *Greenhouse gas emission reductions per sector in the option package for GE^{act}. The left figure shows the sector in which the measure is taken; the right figure shows where the actual emission reductions appear*

The following can be said about emission reduction per sector:

- *Energy sector*. Depending on the perspective, this sector has a very large contribution at all levels. Nuclear energy, part of CO_2 capture, fuel substitution and renewable energy all come under the energy sector in terms of effort and effect..
- *Industry*. Industry has a large role in both approaches if emissions have to be 200 Mton or less. The main points here are CO_2 storage, savings and reducing the emissions of other greenhouse gases.
- *Transport sector*. The options in the transport sector mostly consist of final saving and volume and structure effects. Emission reductions are almost entirely confined to the sector itself.
- *Built environment*. Savings on electricity consumption dominate the built environment. The contribution to the reduction of national emissions is substantial but direct emissions hardly decrease.

[14] In this figure the target value sector 'industry and energy' is split into two sub-sectors.

- *Agriculture.* In the case of low emission reductions, there is a rise in direct emissions from agriculture and horticulture due to the large role played by CHP. This leads to a reduction in the energy sector. In the case of higher emission reductions, there is a decrease in direct emissions through the contribution of savings and the Other GHG options.

Figure 5.2 shows a division over the sectors based only on technical-economic potentials. It is not possible to infer how reduction efforts should be divided over the sectors in practice, where not all the options will be equally easy to implement. This can mean that the sectoral division of the emission reduction of a policy package according to sectors may or must work out differently.

Cost curve
A cost curve for greenhouse gases shows which emission reduction (Mton CO_2 eq.) is possible at a certain price (€/ton CO_2 eq.). Figure 5.3 shows the national cost curve for a reduction to 160 Mton, close to the maximum feasible reduction potential. The first steep section of the curve, up to 10 Mton, comprises the options with negative costs on balance. This involves mostly traffic measures and energy saving behaviour changes in households. The second steep section starting from roughly 70 Mton comprises the options with relatively high costs. These include green gas, solar PV, reducing methane emissions and part of the (more expensive) energy saving options. In the centre section, measures such as nuclear energy, CO_2 capture, CHP and other savings play a major role, as do the options for the Other GHGs.

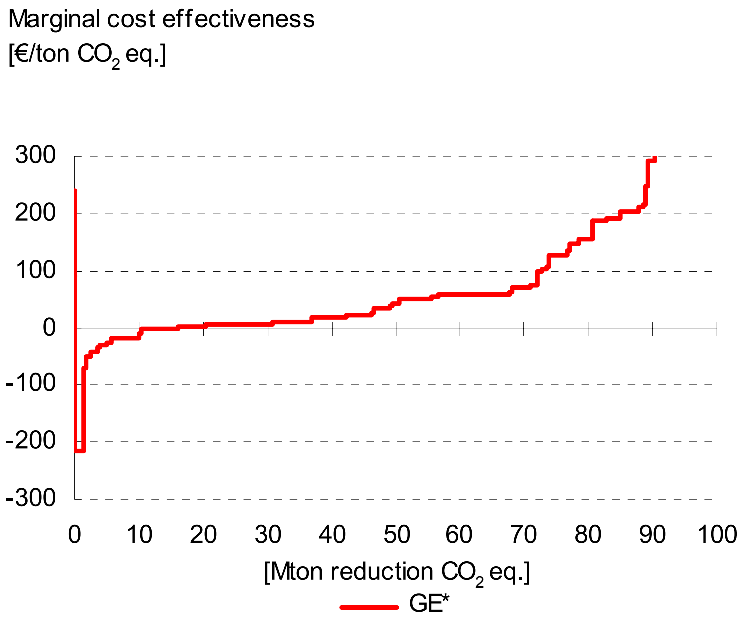

Figure 5.3 *Cost curve for greenhouse gas emission reduction of 90 Mton CO_2 eq.*

The cost curve shown could suggest that the Netherlands can achieve a reduction of approximately 15 Mton CO_2 eq without any additional costs. However, that conclusion cannot be drawn on the basis of this cost curve. The curve shows only the technical potentials and these take no account of the many problems that can occur in introducing the measures, as a result of which the effects may be lower. There are also measures that are attractive in terms of national cost but which are too expensive for the sectors concerned or involve too much risk. Moreover, policies for implementing this potential will also involve costs. How high these costs will be depends partly on the type of policy instrument that is selected.

Measures with negative costs

To make the significance of the cost curve clearer, and especially the potential of options with negative costs, Table 5.2 provides a number of examples of options with negative cost.

Table 5.2 *Overview of options with negative national cost*

	National cost [M€/yr]	Reduction [Mt CO_2 eq.]
Road pricing for cars, vans and motorbikes (C1.1)	-320	1.5
Electricity savings in buildings for trade, services and government	-45	2.3
Electricity savings through increasing efficiency of household electrical equipment	-39	0.9
Electricity savings on equipment in trade, services and government	-31	1.7
Economising on heating fuel in households	-28	0.4
Electricity saving through changed behaviour (saving effects) in households	-23	0.5
Improving refinery processes	-20	1.3
Other negative costs	-74	5.8
Total negative costs	-580	14

At € 320 million, more than half of the negative costs arise from the road pricing option. In fact, in the design as included in the Options Document, it is not an environmental measure but an option for improving traffic mobility. The negative national cost is the result of placing a financial value on the positive effects of traffic mobility, noise nuisance and safety. This measure has been on the political agenda for years but has been postponed on several occasions due to lack of social support.

Among the other measures with negative costs, saving on electricity consumption in the built environment is the most important measure. To some extent these measures require different (purchasing) behaviour in the sectors involved. An often occurring problem is that little information is available about the energy consumption of appliances. Even if this information is known, energy consumption usually plays a minor role in the decision to purchase. The reason for this is that, in comparison with other costs, energy costs do not play a significant role in the built environment.

In the case of behavioural measures, the trouble involved in saving energy often does not weigh up against the (financial) benefits to those concerned. As a consequence, there is usually no stimulus to save energy in offices. An obvious answer from the policy viewpoint is to employ standards for the energy consumption of equipment. The problem is that such standards can only be agreed upon in a European context.

Other potential

With regard to the rest of the reduction potential (with positive national cost) there are also all sorts of problems that play a role that do not always make it easy to achieve the available potential in practice and in time. Measures have to cope with problems of support, technical risks, a long preparation programme, high costs (national and/or for the sectors involved), limited sensitivity towards policy making, a lack of freedom and possibilities for the (Dutch) government to implement sufficiently strong policy, etc. Measures may also conflict with other objectives such as security of supply.

Table 5.3 shows the options that make the largest individual contribution in the cost curve and lists a number of problems that play a role in introduction.

Table 5.3 *Emission reduction and the cost of some major options in the case of the emission level of 160 Mton, and possible obstacles to implementation*

	Reduction [Mt CO_2 eq.]	National cost [M€/yr]	Cost-effectiveness [€/t CO_2 eq.]	Possible obstacles
Offshore wind energy	10.0	592	59	High costs
Building new nuclear power plant(s)	8.7	67	8	Support, little policy freedom, market risk
CO_2 capture, large-scale new CHP	5.9	117	20	Preparation time, support, high end-user costs
Using biofuel in transport	4.6	900	194	High costs
Nitrous oxide reduction in nitric acid factories	4.0	2	1	-
Fermenting manure in dairy farms	2.9	197	67	High costs
Reducing heat demand in industry, trading	2.9	135	46	High costs, support, policy freedom
Gas power plants instead of new coal-fired power plants	2.7	39	14	Security of supply, policy freedom
Other	48.6			
Total	90			

Phasing
In addition to the stated obstacles for certain options in Table 5.3, the phasing of measures also requires special attention. The final potential to be realised (and partially also the costs) depends strongly on the moment of introduction. For example, in order to replace a complete set of equipment with an average life span of 12 years by 2020 with more efficient cannot be realised. In such a case, every year that passes without making a start would mean of a loss of $1/12^{th}$ of the potential. This mechanism of potential loss plays a role in almost all measures that can be applied only or mainly at natural replacement times.

For some measures, the phasing aspect is even more important. The whole process from planning to production for a new nuclear power plant takes at least ten years. If there are still no firm plans for building a new nuclear power plant in 2010, the potential contribution will have dropped to zero in 2020. Also in the case of CO_2 storage, with the required construction of a large-scale infrastructure for transporting and storing CO_2, the effect of the starting year on the realisation (and therefore on emission reduction) in 2020 can be very drastic.

The cost of the targets
Table 5.4 provides a summary of the costs of the option packages. The table shows the total package costs and the collective negative costs, and shows the positive costs divided over the various emission themes. The negative costs are not ascribed to the emission themes.

The same comments apply to these costs as apply to the cost curve. If the entire potential of the options cannot be realised in practice, more expensive options will have to be deployed, resulting in much higher costs for the same target. The costs of implementing the required policy for realising these options are also not included. These costs can only be established when the relevant policy instrument is known.

From the table, it also appears that the cost of achieving the NEC targets drops as greenhouse gas targets are tightened. This is because an increasing share of the NEC targets will already have been achieved by measures that have to be deployed to achieve the greenhouse gas targets. This effect is at its strongest if there is much synergy between measures for NEC emission reduction and greenhouse gas emission reduction. This explains why the reduction of NO_x and particularly SO_2 is greater than that of NH_3.

Table 5.4 *Division of total national cost per greenhouse gas level according to emission theme*

National cost [million €/year]	Greenhouse gas emission level in 2020 [Mton CO_2 eq.]				
	240	*220*	*200*	*180*	160
Total cost of package	-65	*-46*	*283*	*1418*	4601
Options with net negative costs	-657	*-622*	*-581*	*-591*	-679
Options with net positive costs, per target[a] of which:	592	*576*	*864*	*2009*	5280
Greenhouse gases	0	*21*	*352*	*1551*	4919
NO_x	198	*199*	*182*	*148*	114
SO_2	74	*37*	*16*	*12*	11
NH_3	320	*318*	*313*	*298*	237

[a] All targets set for NMVOC and particulate matter will be achieved through the options deployed for greenhouse gases and acid emissions. For this reason, no costs are appointed to these two target substances in this table.

5.2 Possibilities for energy saving

This paragraph first describes the role of energy saving in the option packages in Paragraph 5.1. Next the rate of energy saving that is feasible is examined and the associated costs are identified. This is followed by an analysis of specific saving targets that are part of the packages aimed at reducing the emission of greenhouse gases. Here a distinction will be made between saving in accordance with the Energy Saving Monitoring Protocol (*Protocol Energiebesparing* –Boonekamp, 2001) and other measures that are often regarded as saving measures but which, according to the Protocol, are part of volume and structure effects. An explanation of the various savings terms is included in Appendix A. Of the categories of measures distinguished here, *final saving*, *CHP* and *generating efficiency* are part of saving according to the protocol. All *volume and structure effects* are in one category, with the exception of the special category *fuel substitution.* All the categories mentioned will be henceforth collectively referred to as *saving in the broad sense.*

The role of saving in the greenhouse gas option packages

A rise in the rate of saving to an average of 1.5% per year between 2005 and 2010 and 2% per year from 2010 means that in 2020 approximately 475 $PJ_{primary}$ will have to be saved on top of the background scenario. Figure 5.4 and Table 5.5 show the results. Based on these results, and in the case of a target level of 180 Mton, the saving rate is maximally 1.6% and saving in the broad sense 1.7%. Thus, a saving rate of 2% will not be achieved. In the case of a level of 160 Mton, saving in the broad sense amounts to just about 2%. This means that to achieve the targets for greenhouse gas emissions levels, other possible solutions based on cost-effectiveness are more attractive than the deployment of yet more real saving measures.

Table 5.5 *Energy saving from 2010 (in accordance with the Energy Saving Protocol and in the broad sense) in the option packages for the greenhouse gas levels studied*

		Greenhouse gas emission levels in 2020 [Mton CO_2 eq.]				
		240	*220*	*200*	*180*	160
Saving according to protocol	[PJ]	184	*194*	*246*	*297*	382
	[%/yr][a]	1.4	*1.4*	*1.5*	*1.6*	1.8
Saving in the broad sense	[PJ]	209	*240*	*298*	*349*	467
	[%/yr][a]	1.4	*1.5*	*1.6*	*1.7*	2.0

[a] The average saving rate (%/yr) between 2010 and 2020 is given. The presentation of the savings figures is associated with the phases in accordance with the parliamentary motion of Van der Ham/Spies. A run-up period to 2010 is assumed in which the saving rate increases from the level in the background scenario to the average level from 2010. If 1.7% is mentioned in the table, this means that between 2005 and 2010, an average saving rate of 1.35% will be achieved.

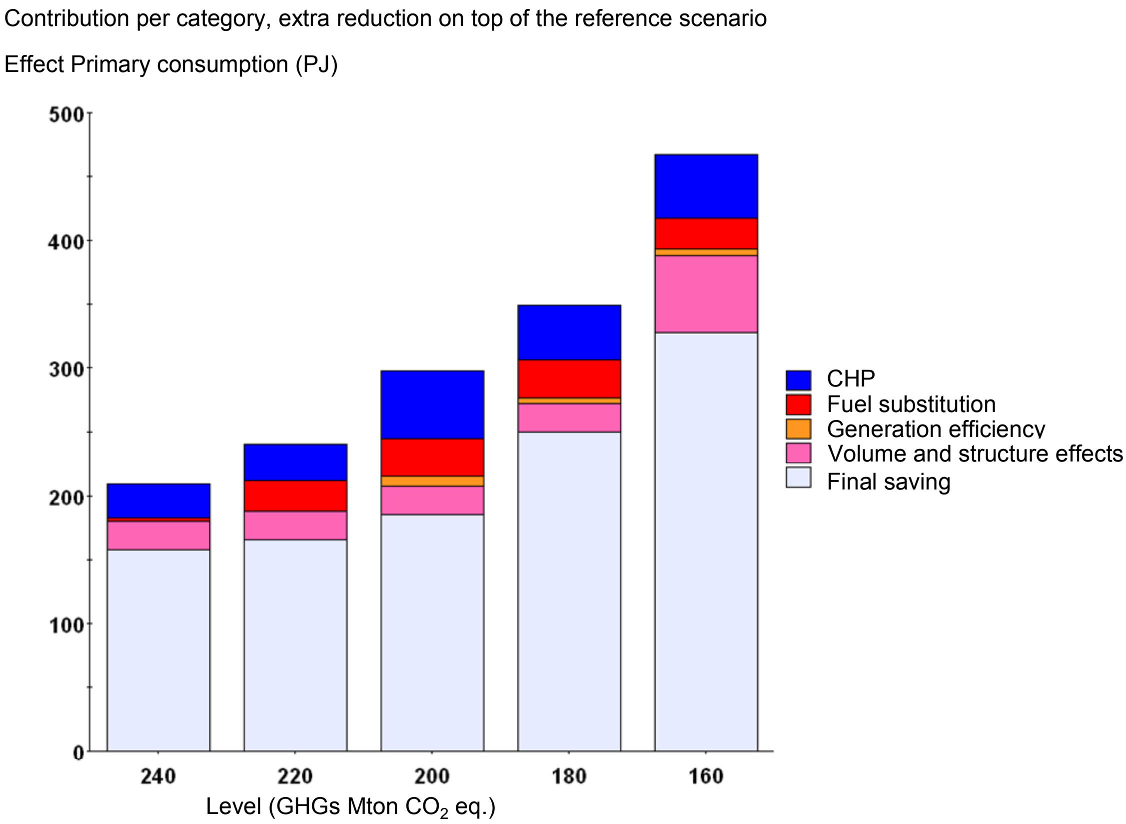

Figure 5.4 *Savings, volume and structure effects and fuel substitution in the GE[act] option packages*

Maximum achievable saving

An estimate of the maximum energy saving can be obtained by examining what reduction in energy consumption is possible by applying the energy saving options (according to the protocol in the broad sense) and Table 5.6 shows the saving. In this case, the maximum additional saving according to the protocol amounts to approximately 500 PJ or 2.1%, and with inclusion of volume and structure effects to 625 PJ or 2.3%. Based on these results, it is therefore possible to achieve a saving rate of 2% per year. Here too, one should add that this is theoretically possible on the basis of technical potentials and that in practice the possibilities will be much more limited and the costs will be higher. It also appears from the results that approximately 210 PJ can be saved even though this is not necessary for reaching the target. More detailed analysis shows that 190 PJ of this saving has negative national cost and that 20 PJ is saved in order to achieve the NEC targets. As in the case of the levels for greenhouse gas emissions, here too the levels shown are maximums, this time for primary energy consumption. Primary energy consumption must not exceed this level and may be lower.

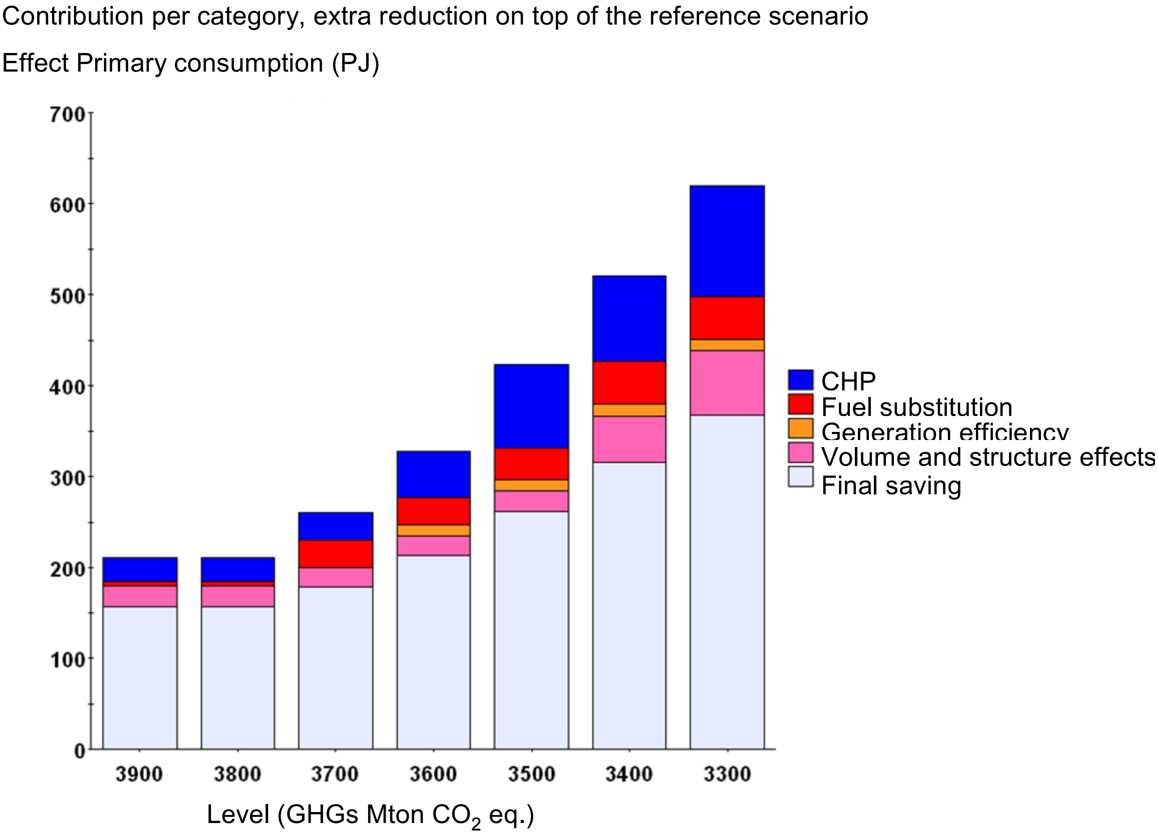

Figure 5.5 *Savings, volume and structure effects and fuel substitutions for decreasing levels of primary energy consumption in 2020*

Table 5.6 *Energy saving (in accordance with the Energy Saving Protocol and in the broad sense) for decreasing levels of primary energy consumption*

		Level of primary energy consumption in 2020 [PJ]						
		3900	3800	3700	3600	3500	3400	3300
Saving according to protocol	[PJ]	184	184	209	276	366	422	501
	[%/yr][a]	1.4	1.4	1.4	1.6	1.8	1.9	2.1
Saving in broad sense	[PJ]	209	209	263	327	426	526	626
	[%/yr][a]	1.4	1.4	1.6	1.7	1.9	2.1	2.3

[a] The average saving rate (%/yr) between 2010 and 2020 is given. Here too, the presentation of the savings figures is associated with the phases in accordance with the parliamentary motion of Van der Ham/Spies.

Table 5.7 shows the costs of the option packages for energy saving. Although the costs will be much higher in practice, the table still provides a first impression of the costs required to achieve a particular saving rate. Based on the table, it costs a minimum of half a billion euros a year to achieve a saving rate of 2% per year, in the broad sense. If the strict definition of the saving protocol is adhered to, these costs are even a minimum of € 2.5 billion per year. Revenues resulting from the energy consumption saved are already included.

Table 5.7 *Costs for option packages aiming at energy saving*

National cost [million €/yr]	Level of primary energy consumption in 2020 [PJ]						
	3900	3800	3700	3600	3500	3400	3300
Package costs	118	118	118	150	473	1476	4346
Options with net negative cost	-588	-588	-588	-588	-546	-633	-644
Options with net positive costs, per target of which:	706	706	706	738	1019	2109	4990
Saving	0	0	0	127	494	1586	4538
NO_x	349	349	349	258	191	188	84
SO_2	37	37	37	32	12	10	9
NH_3	320	320	320	321	321	324	359

Savings targets combined with greenhouse gas targets

The option packages in Paragraph 5.1 achieve the required targets for greenhouse gas emission reduction at the lowest possible (national) cost. However, the 2% saving target is in most cases not achieved. An additional precondition for an energy saving rate of 2%, on top of achieving the levels for greenhouse gas emissions, leads to higher costs. Table 5.8 shows the additional cost of a 2% saving target (in the broad sense) for greenhouse gas emission target levels of 200 and 180 Mton CO_2 eq.[15]

Table 5.8 *Costs for the greenhouse gas option packages with and without an additional energy saving requirement (2%/yr, in the broad sense, from 2010)*

Costs [million €/yr]	Target level for greenhouse gas emissions in 2020 [Mton CO_2 eq.]	
	200	180
GE^{act}	283	1418
GE^{act} (energy saving 2%/yr)	687	1636
Difference	404	218

In the case of a target level of 200 Mton, maintaining a 2% savings target will result in annual extra costs of € 400 million. In the case of 180 Mton, this drops to € 200 million; in the case of 160 Mton the saving achieved, even without a specific target, is already higher than with a target level of 200 Mton. Because there is less need for additional saving , the extra costs of achieving the saving targets also decrease.

5.3 Effects in the case of alternative basic assumptions

The preconditions set in advance have a great influence on the costs of achieving the emission targets. It was stated earlier that there are different perceptions regarding the feasibility of the various possible solutions. For this reason it is important to chart the possible effects in the case of alternative assumptions with regard to the limitations. Table 5.9 provides a summary of the change in the net national cost for the emission levels in 2020 in the case of alternative assumptions. The costs include measures for the NEC substances.

[15] It is not useful to show 220 and 160 Mton: because of the 2% target, the emission is already lower than 220 Mton and at 160 Mton the 2% target is already achieved (see Table 5.5).

Table 5.9 *Cost sensitivity of the option packages according to greenhouse gas emission level for the assumptions imposed*

National cost [million €/yr]	Greenhouse gas emission in 2020 [Mton CO_2 eq.]				
	240	*220*	*200*	*180*	160
Standard	-60	*-50*	*280*	*1420*	4600
Difference is costs (million €/yr) compared with standard option packages					
If emissions are relocated abroad	-150	*-170*	*-250*	*-740*	-2630
Nuclear energy to 4,000 MW_e	0	*0*	*-70*	*-300*	-770
No nuclear energy	160	*180*	*270*	*590*	2560
No CO_2 storage	0	*0*	*450*	*1810*	*
No nuclear energy and no CO_2 storage	160	*190*	*920*	*2860*	*
If there is intervention in consumer freedom of choice	-470	*-480*	*-530*	*-700*	-1000
Options that are difficult to achieve	0	*0*	*-10*	*-30*	-40
NEC targets for 2010	-540	*-500*	*-430*	*-360*	-230
No NEC targets	-620	*-580*	*-490*	*-410*	-240

* Level not feasible.

Salient is the impact of the preconditions for CO_2 storage and nuclear energy, particularly in the case of larger reductions. Without nuclear energy, and with the other preconditions unaltered, the national cost for achieving emission levels of 200 and 180 Mton CO_2 eq. is approximately € 270 and € 590 million euros per year higher. Without nuclear energy and CO_2 storage, the national cost rises by € 920 and € 2860 million. The reason for this lies in the fact that both possible solutions have big emission reduction potential at relatively low national cost. Excluding these options makes it necessary to include more expensive options in the package in the case of targets that remain the same. The impact of CO_2 storage and nuclear energy is all the more important because both require a long preparatory phase. Decision-making must take place early in order to enable emission reduction in 2020 with these options.

Figure 5.6 provides more insight into the effects of nuclear energy and CO_2 storage. The first thing to be noted is that a reduction of 20 Mton CO_2 equivalent of nuclear energy and CO_2 storage has hardly any impact on marginal cost-effectiveness. This image starts to diverge between 20 and 30 Mton. If nuclear energy is excluded, the marginal cost-effectiveness from 20 Mton reduction is an average of approximately 30 €/ton higher. Excluding CO_2 storage *and* nuclear energy has a more profound effect from lower reduction upwards. Between 25 to 50 Mton reduction, the average cost-effectiveness is approximately 40 €/ton higher and from 50 Mton reduction, this rises to 100 €/ton. The maximum feasible target is also affected strongly: without nuclear energy and CO_2 storage, approximately 20 Mton lower.

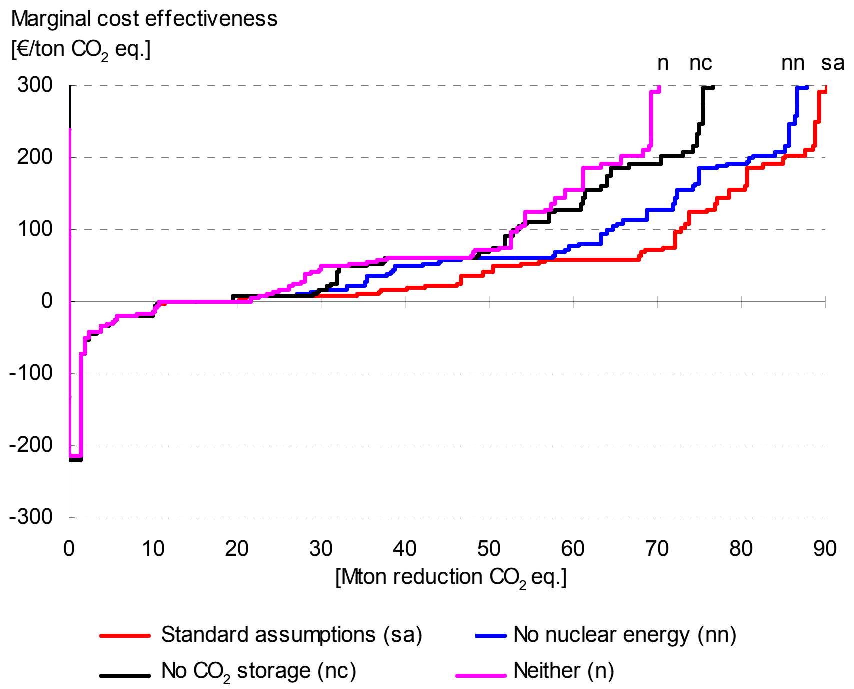

Figure 5.6 *Cost curves in GE^act with and without exclusion of the options CO_2 storage and nuclear energy*

5.4 Effects of higher oil prices

As described in Paragraph 2.2, higher oil prices lead to many changes that affect the emission reductions in the background scenario and therefore also the extra reductions that can be achieved by means of options. In principle, the total possible emission reduction remains the same. The minimum feasible emissions and the minimum energy consumption do not essentially differ from the situation with lower oil prices. However, the costs and the way in which the required emission reductions are achieved do not stay the same: options that save oil and gas will cost less; options that use extra energy will have higher costs.

Figure 5.7 shows the results for GE^{hi}. In GE^{hi}, the additional reduction for each emission level is approximately 4 Mton lower than in GE^{act} because the greenhouse gas emissions in 2020 in variant GE^{hi} are already lower than in GE^{act}. In broad terms, the composition of option packages is the same depending on the reduction itself, except for a number of small exceptions. The most visible change is that, at all levels, the share of CHP remains more modest because of the less favourable energy prices.

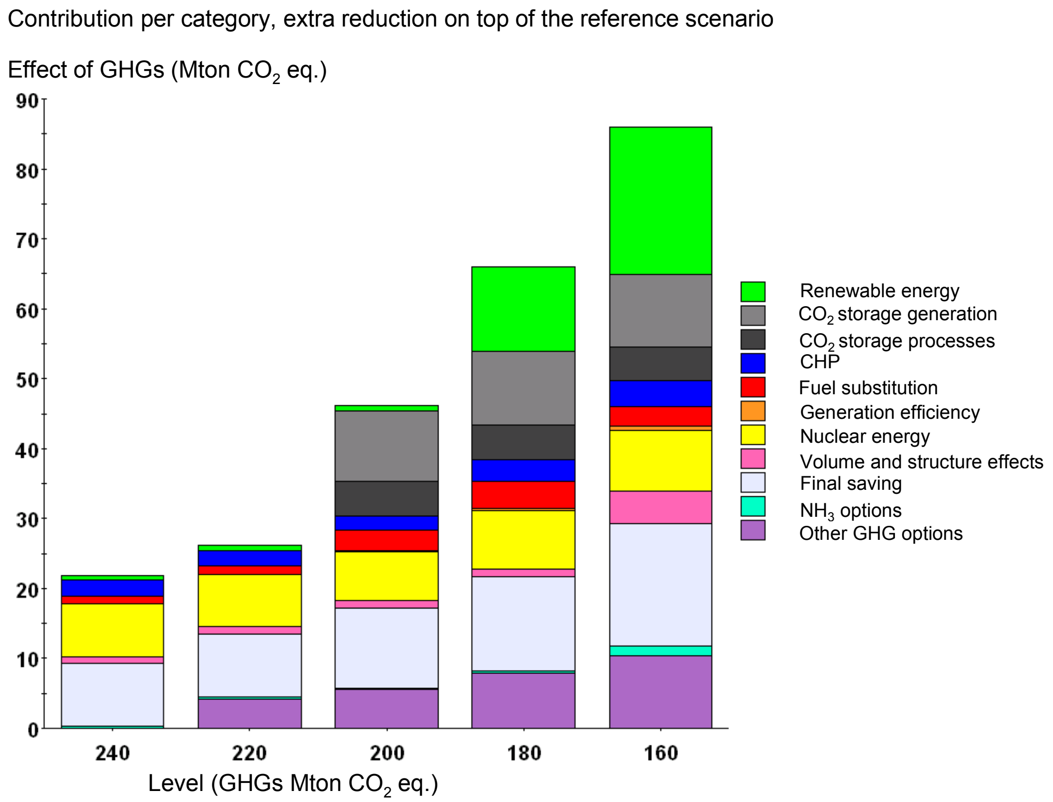

Figure 5.7 *Greenhouse gas emission reduction per category in the option packages for the high oil price background scenario (*GE^{hi}*)*

Costs for greenhouse gas targets

The most significant differences can be found in the cost of achieving the reductions. Figure 5.8 shows the marginal national cost-effectiveness curves for GE^{act} and GE^{hi}. For a good comparison, account should be taken of the fact that in GE^{hi} a 4 Mton reduction has already been achieved in the background scenario, which is not shown in the curve. Taken over the whole line, but particularly in the case of lower emission reductions, the marginal costs in GE^{hi} are slightly lower. In GE^{act}, the first 15 Mton CO_2 eq. can be achieved at negative marginal costs. In the case of GE^{hi}, this is 20 Mton CO_2 eq. For the lower emission reductions, the leading role for both background variants is played by energy saving and nuclear energy. Energy saving, in particular, benefits strongly from the higher fuel prices in GE^{hi}. In the case of larger reductions, the differences in the cost-effectiveness of measures are smaller in both variants. At these levels, CO_2 storage and fuel substitution play a major role and higher oil and gas prices lead to more disadvantages than advantages for these measures. Renewable energy, also largely represented at the higher cost levels, does benefit from the higher energy prices.

Table 5.10 *Cost sensitivity of the option packages according to greenhouse gas level for a high oil price*

National cost [million €/yr]	Greenhouse gas emissions in 2020 [Mton CO_2 eq.]				
	240	*220*	*200*	*180*	160
GE^{act}	-60	*-50*	*280*	*1420*	4600
GE^{hi}	-250	*-250*	*60*	*1030*	3690
Difference	-190	*-200*	*-220*	*-380*	-910

Table 5.10 shows the differences in total cost for the various levels. The costs are not completely comparable because the greenhouse gas emissions in 2020 in GE^{hi} are already 4 Mton lower than in the GE^{act} scenario, which also includes a slightly less than 1 Mton effect of more electricity imports. However, the overall picture can be explained on the basis of the deployment of different possible solutions. In the case of smaller reductions, the share of energy saving and nuclear energy is large, resulting in a difference of almost € 200 million from the lowest reductions upwards. This difference increases very slowly up to a target level of 200 Mton. The options that benefit from higher gas and oil prices and the options that suffer from these (CHP, CO_2 storage) approximately balance each other in terms of cost. From 180 Mton onwards, the difference increases again: here the extra reduction is achieved mostly through energy saving and renewable energy. At 160 Mton, the difference is more than € 900 million per year or an average of 10 €/ton CO_2 eq.

The role of saving
Figure 5.8 shows the energy saved (in PJ) in the greenhouse gas option packages for the situation with high oil prices (GE^{hi}). The additional saving is, on average, roughly 50 PJ lower than in GE^{act}. This partly results from the fact that more energy has already been saved in the background scenario GE^{hi}: the potential concerned has already been used. Another factor is that a larger share of the emission reductions is achieved with non-saving measures such as renewable energy. These possible solutions seem to benefit slightly more from the higher prices than many savings options. Finally, due to the higher electricity imports the saving potential in the Netherlands decreases slightly. The maximum saving rate is achieved at 160 Mton and is approximately 1.9% per year in the broad sense and 1.7% per year according to the protocol definitions.

Contribution per category, extra reduction on top of the reference scenario

Effect Primary consumption (PJ)

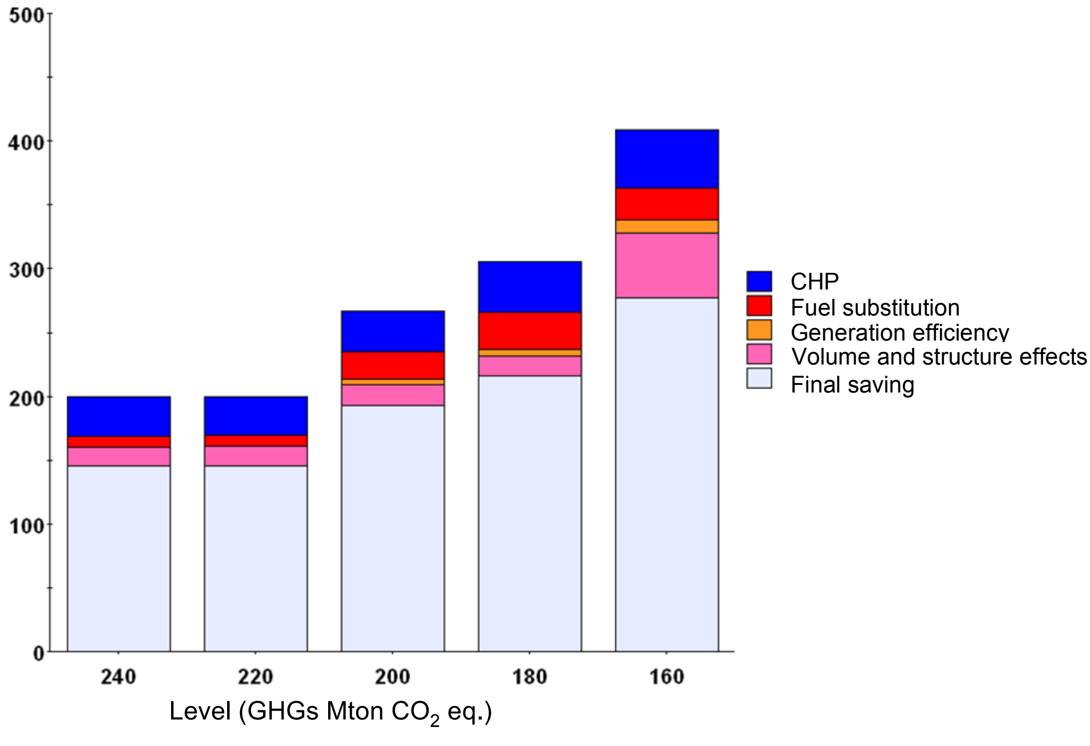

Figure 5.8 *Savings, volume and structure effects and fuel substitution in the case of falling greenhouse gas emissions in 2020 with regard to the high oil price scenario* GE^{hi}

6. Discussion

The purpose of this chapter is to comment on the results presented in Chapter 5 in order to arrive at conclusions relevant to policy-making. This involves interpreting the technical-economic potentials arising from the option packages and the possible significance of these potentials for the achievability of targets for 2020. For this purpose, the possible interpretation of results is examined first, indicating what this analysis may or may not mean in the debate about greenhouse gas emission reduction and energy saving. The second paragraph deals with uncertainties in the Options Document and uncertainties in the approach used in this analysis. The results of the sensitivity analysis are also discussed. Based on this, the robustness of the results will be indicated.

6.1 From option packages to implementation

Between options (technical potentials) and actual emission reductions (implementation) there is an entire trajectory that has not been part of the analyses carried out. This concerns the process of policy formulation and policy implementation. Because this process involves extra costs and because part of the potential effect is often lost in this process, it is essential to understand how the present analyses compare with the actual emission reductions to be achieved up to 2020 and the possible cost involved. This paragraph can only provide a rough sketch of this process. For an actual assessment of the degree of feasibility of emission reductions and energy saving, definite policy options must be confronted. The options in the Options Document lack a definite elaboration of policy options because the number of possibilities is almost infinite.

The options have been shaped in such a way that, viewed separately, they are theoretically feasible. This means that for each option a policy can be developed with which you can (almost) fully achieve the option, as long as this option is deployed in time. This does not always imply that the required policy is conceivable from the point of view of the current policy situation. It will also be easier to produce policy effectively, and in time, for one individual option than to implement a sizeable option package on time, which will achieve the potential from the option packages completely. Because of this, part of this potential cannot be achieved in practice, in the case of an option package that is based on technical potentials.

Figure 6.1 shows a schematic overview of the forces that play a role in progressing from technical potential to policy implementation, resulting in a certain use of potential. The main driving force is a 'sense of urgency', i.e. the perceived need to use the technical potential, which opposes support/barriers and costs (of the different options/option packages) in the consideration of policy. The process results in policy measures that are characterised by a certain 'intensity'[16] and timeliness. Both of these characteristics largely determine the degree to which the potential is used: the more intense the policy and the earlier it is introduced, the greater the utilised part of the potential will be. A higher sense of urgency makes quicker introduction and higher intensity more probable: in fact, the relative weight of the negative factors will be perceived as less important and will play a lesser role in decision-making. Conversely, in the case of a lower sense of urgency, it will be more difficult to implement a policy plan quickly while maintaining its effectiveness.

[16] The term 'intensity' is also used in describing the options in the Options Document in order to indicate that, in the case of increasing policy intensity, a larger (technical) potential can be employed. In the option descriptions, this is mostly associated with increased (specific) costs.

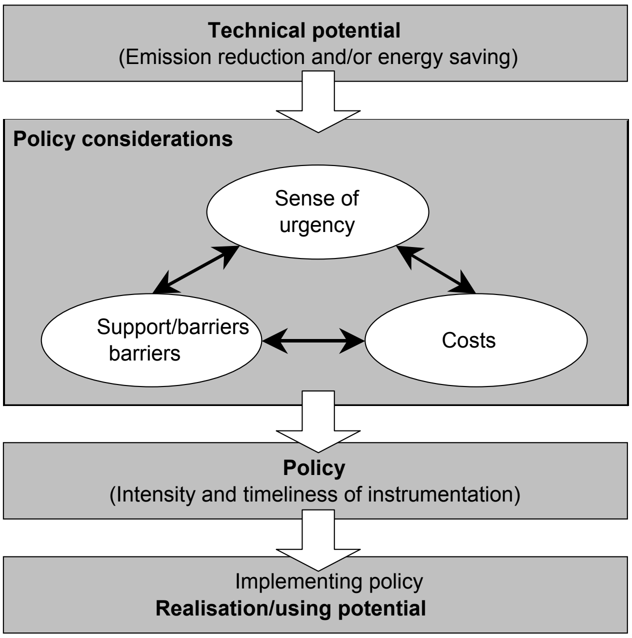

Figure 6.1 *Schematic overview of the major aspects of policy formulation and the mutual influence of these aspects (indicated with arrows)*

Timeliness and intensity

In certain cases, the descriptions of the options in the Options Document indicate the year in which a start should be made on implementation. For most options, the effect in 2020 can be achieved only if implementation is started early enough. Starting later means that either the effects will be reduced by a certain percentage or that no further reduction effect can be achieved with this option in 2020 as a whole. In the case of energy saving, for example, this means that every year's delay in implementing the policy will reduce the effects in 2020. In the case of nuclear energy and CO_2 storage, there will be no further reduction at all in 2020 if a late start is made. Because of the long preparatory and construction phases, a late start means that this option cannot be operational in 2020.

Sense of urgency

The sense of urgency, which is relevant here, is not restricted to the Netherlands. An internationally shared sense of urgency makes it easier to create international support and overcome barriers. It also enables making international agreements and preventing competitive relationships from being disturbed by unilateral national measures.

Support and barriers

Problems of support are to be expected particularly in the case of options that result in high costs or strongly restrict the freedom of movement of sectors and consumers. Here the design of policy plays an important role and determines the extent to which the discomfort is experienced by the sectors involved. But even if the sector involved is spared, the cost to society can rise to such a height that it is difficult to achieve the required social support. In extreme cases, the growth potential of the entire economy could be damaged. Problems of support are also to be expected in the case of measures that public opinion considers as dangerous or harmful. As the sense of urgency grows, problems of public support will lose importance: the objections attached to introducing a measure become less important than the objections attached to not introducing it. In many cases, there are (institutional) barriers to policy. Legal frameworks and international agreements may hinder the introduction of policy. For the Netherlands, for example, there are restrictions arising from European agreements and legislation. Here too, the hardness of these barriers is not absolute: as the sense of urgency becomes greater and there is broader consensus (also internationally), there are more possibilities for overcoming barriers.

Costs
The costs of options and policy are an important factor in decision-making. In the case of a greater sense of urgency, higher costs will be acceptable. In addition to the cost of the options themselves, the policy will also entail implementation costs associated with such issues as information, enforcement, administrative costs, assessing subsidy applications, etc. The implementation costs depend strongly on the policy instruments chosen, the character of an option and the intensity with which the policy is deployed. If very many separate players (e.g. consumers) have to be influenced, the costs will generally be much higher than if only a few players have to implement a measure.

Estimating the achievable potential
The above makes it clear how the sense of urgency, costs and barriers relate to each other. During policy formulation, the search is for policy packages that have sufficient support, given the sense of urgency and based on the choice of specific policy instruments and acceptable costs, and that fit in with the freedom of movement provided in the national and international (including European) context. For just about all options, this will lead to an achievable potential that is smaller or much smaller than the technical potential shown in this analysis. Furthermore, difficult policy formulation processes lead to delay, and therefore to further loss of potential.

Table 5.3, has already shown that there are various obstacles to the options with the largest emission reduction, which together account for almost half of the reduction potential. However, based on this present analysis, it is not possible to indicate what percentage of the technical potential for emission reduction will be ultimately achievable (in time) in 2020. This depends on the political debate, the possibilities for legislation at EU level and the development of support for certain options and certain policy instruments. For this reason, the achievability of certain targets for greenhouse gas emission reduction and energy saving is shown in Table 6.1 in relation to the percentage of the technical potential than can actually be implemented. This table clearly shows that in the case of a loss of only 20% of the potential, the highest targets for emission reduction and saving will already be very difficult to achieve.

Table 6.1 *Achievability of targets related to the achievability of technical potential in the Options Document (for the GE^{act} scenario)*

Percentage achievable of max. potential	Target level for greenhouse gas emissions [Mton CO_2 eq.]			Annual saving rate [%/yr; in the broad sense]		
	220	200	180	1.5	1.75	2.0
100%	✓	✓	✓	✓	✓	✓
80%	✓	✓	?	✓	✓	?
60%	✓	?	–	✓	?	–
40%	✓	–	–	?	–	–

✓ target can be achieved; ? target can just be/just not be achieved; – target cannot be achieved.

The graph in Figure 6.2 shows what it would mean if 20% or 40% of an option package were to be missing in the process from potential to use of potential. This figure is based on a proportional reduction in the realisation of all options in the option package. In practice, certain options will suffer a greater loss of potential utilisation than others but for the overall picture, the cost curves in Figure 6.2 give a fair impression of the consequences of not realising part of the technical potential.

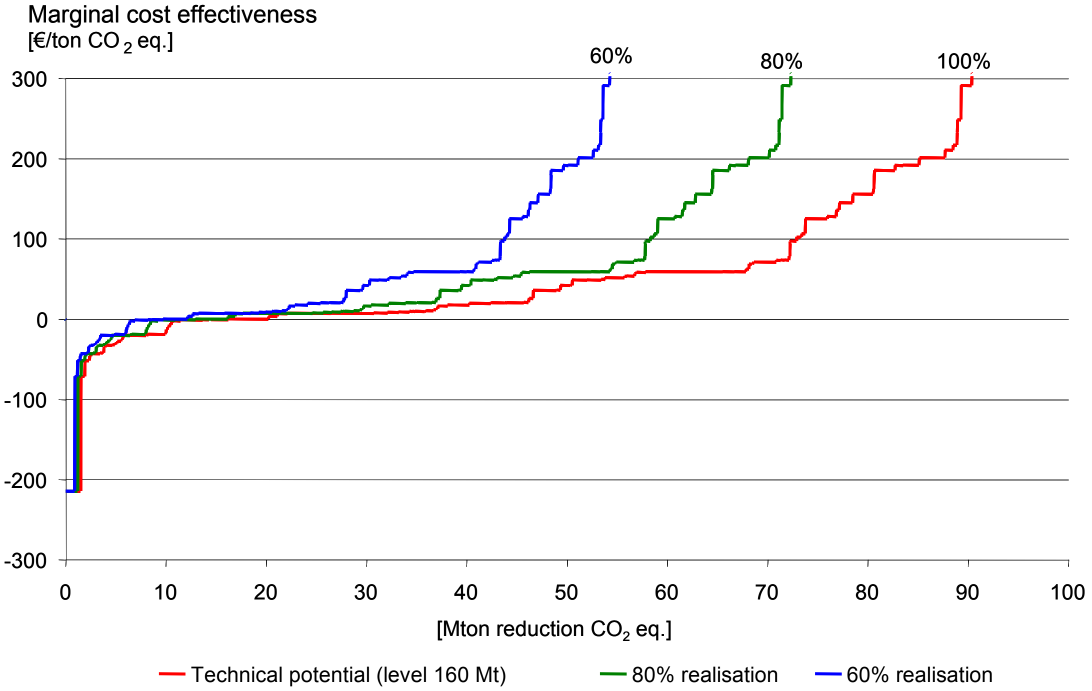

Figure 6.2 *Example of cost curves for technical potential and situations in which the achievable potential is 60% and 90% of the technical potential respectively (proportional loss over all options)*

A lower realisation level for the option packages also has effects on the costs of achieving the targets that are still achievable. Figure 6.2 shows what the cost curves look like for the technical potential and for situations in which respectively 80% and 60% of the technical potential is achievable. According to these figures, the marginal costs for achieving the emission level of 200 Mton CO_2 equivalent, for example, (a reduction of approx. 50 Mton) based on the technical potential, rise to 40 €/ton CO_2 eq., at 80% realisation to 70 €/ton CO_2 eq. and at 60% to 200 €/ton CO_2 eq. Similar to elsewhere in this study, this refers to the national cost-effectiveness. Implementation costs for instrumentation must still be added though.

An important question is therefore what a good assumption would be regarding the possible loss of potential in the process from technical potential to exploitation of potential. To get a picture of this, we can look at the implications of a high realisation of potential for the option packages presented and/or we can look back at the realisation of the policy in past years.

To illustrate this, Table 6.2 provides an overview of what a reduction to 180 Mton, i.e. with a potential realisation of at least 80%, would mean for a number of specific options.

Table 6.2 *Examples of implications for a target level of 180 in 2020*

Options required for achieving an emission level of 180 Mton CO_2 eq. in 2020	Examples of implications
New nuclear power plants (capacity: 1,600 MW_e)	- Definite plan before 2010. - Intervention if the sector cannot/does not want to bear the risk itself. - Completion of permit process and building within ten years.
5,500 MW_e offshore wind energy	- 5,500 MW_e extra compared with background scenario (GE^{act}). - Reverse recent changes in policy on sustainable energy.
Minimum of 12 Mton CO_2 capture	- Definite plans before about 2013. - Tuned to the exploitation of suitable gas fields so that storage capacity is available in time. - Permit process and construction of infrastructure for capture, transport and storage within 6 years (from 2013). - Via emissions trading: structural CO_2 price of at least 50 €/ton from 2011. Requires European harmonisation.
3 Mton reduction in industry via saving and CHP	- Via emissions trading: CO_2 price of at least 80 €/ton CO_2 eq. from about 2011. Requires European harmonisation.

Looking back on approximately 25 years of energy saving policy it is clear that, only at the beginning of the 1980s, the rate of energy saving in the Netherlands was estimated as clearly higher than 2%/yr[17] (Farla and Blok, 2000). This was a period of economic recession and very high energy prices. The saving rate for the period 1995-2000 has been established as 1.2%/yr (Boonekamp et al., 2004). In the years 1995-2002, this rate dropped to an average of 1%/yr. The saving policy at the beginning of the 1990s can be described as fairly intensive. In spite of this, a saving rate of much less than 2%/yr was achieved in that period.

Looking to the future, (see Paragraph 6.3, Table 6.2), a realisation of the saving potential in the Options Document of approximately 60% is expected for the measures proposed in the Energy Report 2005 and the PvdA Action Plan, including the saving (1%/yr) realised in the background scenario. Of the *additional* saving potential (i.e. on top of the saving in the background scenario) it is expected that 25-30% of the saving potential in the Options Document will be realised on the basis of both plans. These figures give an impression of the (possible) loss of potential in the policy process.

6.2 Uncertainties regarding the option packages

The uncertainties in this report comprise uncertainties in the Options Document and uncertainties resulting from the analysis. In the Options Document, there is a comprehensive examination of the uncertainties in the analysis tool and the option descriptions. Here, discussion of the uncertainties is limited mainly to those components that directly concern this analysis and to an evaluation of the solidity of the results. Additionally, there is a brief examination of the role of uncertainties in the data in the fact sheet regarding the robustness of results.

[17] The saving rates for the period 1980-1995, according to Farla and Blok (2000), were established before the Protocol for Monitoring Energy Saving was produced. The percentages are therefore not fully comparable.

Assumption sensitivity of the analyses
From the sensitivity analysis in Paragraph 5.3, it appears that *a priori* exclusion of certain categories of measures has an effect on the total costs of the option packages. Excluding options through which emissions are *de facto* relocated abroad and options that affect consumer choice leads to higher national cost at all emission levels. Satisfying emission standards for NEC substances also logically leads to higher national cost for the option packages.

The most important effect on costs and the possibility of achieving the emission targets comes from the assumptions regarding nuclear energy and CO_2 storage. Both options have great potential and can be deployed at relatively low national cost. Due to this, the assumptions regarding these options determine to a large extent the levels that can be achieved with the technical potential in the Options Document, and the national cost.

Background scenario and oil price sensitivity
The effect of the oil price in the background scenario appears to be relatively slight for the analyses in this report. The technical feasibility of targets does not depend, or hardly depends, on the oil prices, however the cost of achieving the targets is clearly associated with this. These changes in cost could also have a major effect on support.

The background scenarios used in this study derive from the Global Economy scenario in the Reference Projections for energy and emissions 2005-2020 (Van Dril and Elzenga, 2005), a scenario with relatively high economic growth. Associated with this high economic growth, the scenario also has a relatively high growth of emissions. In a scenario with lower emissions, the target levels could theoretically be achieved with less effort. On the other hand, the reduction potential in the options described could also decline. By basing analyses and policy on high-growth scenarios, the risk of disappointments regarding emission development is lower and it is assumed that a relatively robust policy development is possible.

Robustness of results
In spite of the many uncertainties, it is nevertheless possible to say which aspects of the results are robust and which less so. Important in this respect is that in the case of many options, deployment is not limited by the individual potentials in the first instance but by interaction (competition) with other options and limitations on a higher aggregation level (e.g. limiting CO_2 storage). For most categories of measures, small changes in the data of individual options will not quickly lead to large changes in the results but may lead to shifts in the deployment of individual measures. Therefore, uncertainties regarding the data for the options have a relatively limited impact on the more aggregated components of the results.

Consequently, the results with regard to categories of measures are fairly robust, particularly the order in which these occur in the case of increasing ambitions in the option packages. Similarly, the position of the different categories of measures in the cost curves is also fairly robust, and therefore, in general terms the shape of the cost curve too. This robustness is also confirmed by comparing the option packages for GE^{act} and GE^{hi}. In terms of size and direction, the shifts that occur because of this correspond well with what can be expected on the basis of the properties of the techniques involved.

The results at the level of individual options and precise cost levels are less robust. For example, with regard to cost, CO_2 capture in electricity generation occupies a robust middle position, which will not quickly change in spite of the uncertainties mentioned. Exactly which CO_2 capture options will be applied first is uncertain however[18]. Although it is true that potential for an individual option that is disappointing in practice may have a significant effect on the chances for this option, it will have much less effect on the practical results for the category of measure

18 For example, in the case of GE^{act} the model opts mainly for CO_2 capture in CHP and in GE^{ho} more for CO_2 capture in power stations. This difference is not a robust component of the results.

to which the option belongs. In most cases, a comparable measure in the same category can fill the gap. An exception is the nuclear energy category because this consists of only one option.

The results presented in this report are mostly more robust. Individual measures in which uncertainties play a more important role are of minor importance for most results.

6.3 Comparing energy saving in some policy documents

This paragraph explains the relationship between some recent policy documents and the options in the Options Document. The policy documents are the Energy Report 2005 (*Energierapport 2005* - EZ, 2005) and the PvdA Action Plan for Energy Saving (*PvdA Actieplan Energiebesparing* - PvdA, 2005). The aim is to clarify where and to what extent policy proposals overlap the options. The extent to which the plans appear suitable for implementation and how much saving can be expected will also be indicated.

The summary below shows the policy included in the documents that is extra to the GE scenario. The different documents are also compared. For each document, the overlap with options is indicated and how large this overlap is. The saving in 2020 compared with the GE scenario is given.

Table 6.3 *Summary of energy saving in some policy documents, estimate of the effectiveness of policy instruments and overlap with options. Saving per target value sector in* $PJ_{primary}$ *in the broad sense*

	Maximum saving according to Table 5.6	Optimum saving with reduction target of 180 Mton	Saving according to Energy Report	Current assessment of potential and policy instruments in Energy Report	Saving according to PvdA Action Plan for Energy Saving	Current assessment of potential and policy instruments in PvdA Action Plan
Built environment	206	124	128	91	210	72
Industry and energy	238	138	31	20	111	18
Transport	108	44	76	48	130	73
Agriculture	72	42	3	0	15	8
Generic						
Total	625	349	237	159	466	170
Energy saving in 2010-2020 in broad sense [%/year]	2.3	1.7	1.6	1.4	2.2	1.4
Idem, according to protocol [%/year]	2.1	1.6	1.5	1.3	2.0	1.4

The saving percentages given in Table 6.2 have been established on the basis of an equal rate over 2010-2020 and a constant rise from 2005 to this level in 2010. This enables comparison with the stated target of the Van der Ham/Spies parliamentary motion (see also the note to Table 5.5). However, with the Options Document, it cannot be stated whether the specific course of energy saving in time will correspond to this in this period.

Appendices C and D include summaries of the results at policy level. Table 6.3 shows energy saving in the broad sense, including the so-called volume and structure effects. This therefore includes, for example, options that:

- discourage the possession and use of electrical equipment through financial stimuli,
- discourage the use of cars through financial stimuli,
- limit speed on motorways,
- save through fuel substitution.

The effect of these deviations from the Energy Saving Protocol is included in the table, expressed in saving percentage. What is remarkable here is that neither plan provides options for electricity production companies.

Whether the plans are actually additional to the GE scenario has been investigated. The results aimed for in PJ saving are consistent with the target saving percentages over the period 2010-2020: the technical potential in the Energy Report corresponds to 1.5% per year; the potential in the PvdA Action Plan amounts to 2% per year. The measures stated in the PvdA Action Plan for the built environment have been established in a different way than the measures in the Options Document. In collaboration with the Ecofys agency, it has been established that a limited share of this measure potential is already part of the reference scenario (see also Appendix E).

The relationship between the stated measures and the options is not always clear. Appendices C and D contain a quantitative comparison of the stated measures with the individual options. The stated measures come largely within the scope of the options, with the following exceptions:

- The measure for saving electricity in commercial and industrial buildings in the PvdA plan has been estimated higher than is considered possible in the options: 95 $PJ_{primary}$ compared with 80 $PJ_{primary}$ (see also Appendix E).
- The energy saving for freight transport proposed in the PvdA Action Plan and the Energy Report is not covered by options. There are no saving options for freight transport in the Options Document.
- The option included in the PvdA plan for limiting the maximum speeds of cars in the car's design is not included in the Options Document.

As stated earlier, the options in the Options Document are technical-economic potentials and no assessment has yet been made of the policy instruments needed to achieve the stated results. However, the Energy Report and the PvdA Action Plan do state the policy instruments with which the results. However, the dimensions of these policy instruments have not yet been established. Based on the information available, a global estimate has been made of the rigour and feasibility of the instruments in the policy documents. Both the policy-technical feasibility (can the option be achieved with the stated instruments) and the social feasibility (is there sufficient support and are the implementation costs not too high) have been examined. It is important to note that the assessment of instruments is very global and is a random indication.

It may be concluded that the measures in the PvdA Action Plan correspond to measures in the Options Document with which the target saving of 2% per year, in accordance with the Energy Saving Protocol, can theoretically be achieved. The measures in the Energy Report correspond to a saving of 1.5% per year. However, if an up-to-date assessment of the instruments is taken into account, then the measures in both documents will not enable a saving rate of 1.5% per year. Nevertheless, in the case of further development of the policy instruments, a higher saving rate will be achieved.

7. Conclusions

7.1 Possibilities for the reduction in emissions of greenhouse gases

Approach

Based on the Options Document for Energy and Emissions 2010/2020 analyses were carried out to assess the potential for reducing greenhouse gas emissions in 2020. The Options Document describes the technical potential and the cost of options with which emission reductions can be achieved in the Netherlands. The analyses in this report have been carried out on the basis of these options. Possibilities for emission reduction by means of emissions trading systems such as 'Joint Implementation' and the 'Clean Development Mechanism' for example have not been included in this investigation.

For the benefit of this analysis, two variants have been developed of the Global Economy scenario in the Reference Projections for Energy and Emissions 2005-2020 (Van Dril and Elzenga, 2005). The first variant concerns the inclusion of policy changes with regard to the subsidising of sustainable electricity. A second variant was based on higher oil prices than were assumed in the Reference Projections.

In the updated scenario GE^{act}, at 251 Mton in 2020, the emission of greenhouse gases is 8 Mton higher than the 243 Mton in the GE scenario in the Reference Projections.

In order to sketch a realistic picture for these analyses in terms of policy, the total potential in the Options Document was restricted in advance by setting certain preconditions based on the achievability of certain possible solutions. For example, the contribution of CO_2 storage and nuclear energy was limited and there was no intervention in consumer freedom of choice. Additionally, based on the options deployed in 2020, strict(er) emission requirements for air-polluting substances such as NO_x, SO_2 and particulate matter are satisfied.

To assess the implications of possible climate targets for the Netherlands, an analysis model was used to put together option packages for increasing emission reduction targets, conditional on minimised national cost. Moreover, emission levels of 220, 200 and 180 Mton CO_2 equivalent were employed as indicative targets for 2020. The emission levels of 240 and 160 Mton CO_2 eq. were also assessed. A lower emission level cannot be achieved on the basis of the technical potential and the preconditions imposed in the Options Document.

It should be stressed that the results of this analysis relate to the Global Economy scenario used, a scenario with relatively high economic growth and high population growth, and therefore also high energy consumption and high emissions. The option packages presented have been put together on the basis of technical potentials with the minimising of national cost as a precondition. Other considerations such as the availability of policy instruments, support and sustainability aspects have not been used as preconditions in putting together these option packages.

Option packages

There is a maximum technical reduction potential of approximately 90 Mton CO_2 eq. in 2020. This will reduce greenhouse gas emissions in 2020 to 160 Mton CO_2 eq. This means that there is still some room for loss of potential with regard to the most ambitious target level of 180 Mton.

In the case of emission targets that require the lowest emission reduction, energy saving and nuclear energy play a major role. Energy saving concerns options with negative cost, resulting from saved energy costs. The nuclear energy option has low (positive) national cost. Apart from its CO_2 emission reduction effect, nuclear energy has been included in the option packages owing to the reduction of air-polluting emissions.

The option packages have been put together to achieve the indicative emission targets at the lowest possible national cost. In the total national cost, a major part is played by options with negative cost (through saved energy costs among others). For the indicative emission target of 220 Mton CO_2 eq., the total costs of the technical potential are even slightly negative on balance. For the option package for achieving the target of 180 Mton, the national cost is € 1,400 million per year.

Table 7.1 *Annual cost of achieving the indicative emission targets*

Indicative target 2020 [Mton CO_2 eq.]	Emission reduction needed in 2020 [Mton CO_2 eq.]	Annual cost of option packages 2020 [million €/year][a]		
			Of which measures with:	
		Balance	Negative costs	Positive costs[a]
220	31	-46	-622	576
200	51	283	-581	864
180	71	1418	-591	2009

[a] Including the costs of achieving the higher targets for NEC substances and particulate matter in 2020.

If they were implemented, the options with negative national cost-effectiveness would theoretically lead to cost savings on a national scale. This concerns measures that were not deployed in the background scenario. This is partly because it is difficult to implement these options (influencing behaviour, for example) and partly because support for these measures is limited (distance-related road pricing, for example).

In the case of higher emission targets, CHP, CO_2 storage and options for reducing other greenhouse gases play a role. This involves options with a national cost-effectiveness up to approximately 80 €/ton CO_2 eq. In the case of the highest emission reductions, expensive saving measures and renewable energy options are included in the option packages by the analysis model.

Various sensitivity analyses show that the national cost of emission reduction packages increases if nuclear energy is excluded or if CO_2 capture and storage are excluded. The national cost of the packages may be lower if consumer freedom or choice may be reduced or if extra nuclear energy is allowed.

The option packages have been put together in such a way that they will also satisfy tightened emission targets for the NEC substances (NO_x, SO_2, NH_3 and NMVOC) and particulate matter in 2020. If these targets are not included as conditions, the costs per year are approximately € 400 to a maximum of € 600 million lower.

In general it appears that various barriers can be identified that prevent the full technical reduction potential of an option from being used in practice. These barriers include lack of support for certain options, few policy options for implementing options, the (high) costs experienced by market parties, risks and long preparation times. These barriers occur in more or less the same extent over the entire range of cost-effectiveness. In the case of options with high national cost, the barrier of these high costs comes on top of this.

For the various emission targets, the sectors have been identified where measures will have to be taken. In this respect it appears that the energy and industry sector have a large share in the option packages. This share increases in the case of higher emission reduction requirements. In the case of savings on electricity and through CHP, measures will mostly be taken in other sectors than where the emission reduction takes place (namely the energy sector).

For each option described in the Options Document, the emission reduction described can be achieved if the required policy instruments are deployed efficiently and in time. However, it is clear that in practice, some of this timeliness and efficiency will sometimes have to be sacrificed in the interests of obtaining support. This will apply all the more if a policy package for higher emission reductions has to be produced. For this reason, based on the known barriers for the different categories of measures, it is clear that it will not be possible to achieve the full technical potential in the Options Document. In order to be able to achieve the indicative target of 180 Mton CO_2 eq. in domestic greenhouse gas emissions, a maximum of approximately 20% of the reduction potential may be lost in the implementation process. In order to be able to achieve an emission target of 200 Mton, a maximum of approximately 40% of the reduction potential may be lost. If part of the reduction potential is lost, this means in general that the average cost of the remaining potential increases.

7.2 Possibilities for increasing the rate of energy saving

In the option packages put together in order to achieve specific greenhouse gas emission levels in 2020 at minimum national cost, energy saving plays a major role. With the option package put together for arriving at the indicative target of 180 Mton CO_2 eq. in 2020, the saving rate is raised from an average of 1% per year to approximately 1.6% per year (average in the period 2010-2020, in accordance with the Energy Saving Monitoring Protocol). The most important saving measures concern final saving and extra combined heat and power. In the case of the package leading to domestic greenhouse emissions of 220 Mton in 2020, the rate of energy saving is raised to 1.4% per year.

In ordinary terms, in addition to saving according to the official monitoring methods, there are also measures that are not officially counted as saving. These are volume and structure effects, such as the reduction in energy consumption by less car mileage. If such measures and the saving effect of fuel substitution were to be considered as energy savings, the figures stated above for the target levels of 180 and 220 Mton would be raised to 1.7 and 1.5% respectively.

It is possible to raise the rate of energy saving extra to the energy saving in the option packages. Based on the maximum technical potential in the Options Document, an average saving rate (between 2010 and 2020) of approximately 2.1% per year would be possible. Including the energy saving structure and volume effects, this figure amount to be 2.3% per year. In this analysis, setting energy saving targets on top of the greenhouse gas emission targets leads to an increase in the total known national cost of approximately € 220 to 400 million per year for the indicative targets of 180 and 200 Mton respectively.

In order to achieve an energy saving target of 2% per year (in the broad sense), a maximum of approximately 20% of the reduction potential may be lost in the implementation process. In order to achieve a saving target of 1.75% per year (in the broad sense), a maximum of approximately 40% of the reduction potential may be lost.

The measures in the Energy Report 2005 and the PvdA Action Plan have been compared with the Options Document and the policy instruments were assessed. If an up-to-date estimate of the achievability of the measures is taken into account, then in neither of the plans will a saving rate of 1.5% per year be achieved. In theory, further elaboration of the policy instruments may still lead to a higher saving rate.

7.3 Effects of a higher oil price

To analyse the effects of a higher oil price, the background scenario was adjusted first. From this adjustment, it appears that extra final energy saving resulting from the higher energy price is largely counteracted by a reduction in CHP capacity and an increase in the use of coal to generate electricity. In net terms, the high oil price variant (GE^{hi}) results in greenhouse gas emissions in 2020 that are 4 Mton CO_2 eq. lower than in the updated GE^{act} scenario (with low oil price).

For achieving the three target levels for emission reduction, the national cost is lower than in the case of a low oil price (GE^{act}). In the high oil price variant, the national cost for the indicative targets of 220 and 180 Mton is approximately € 200 to 380 million per year lower. The lower costs of the high oil price variant are partially caused by the fact that the targets can be realised with a 4 Mton lower emission reduction. More important is that the cost-effectiveness of many measures improves as a result of the higher benefits of avoided energy consumption.

7.4 Additional comments

The analyses in this report show the possibilities on the Options Document for Energy and Emissions 2010/2020. The Options Document can be an important tool for assessing the possibilities for emission reductions and energy saving. However, it should be realised that this analysis is partial: it focuses mainly on the technical potential for emission reductions and energy saving and the minimal cost involved from a national perspective.

The analyses were carried out on the basis of (variants of) the Global Economy scenario in the Reference Projections, a scenario with relatively high economic growth and population growth and therefore also high energy consumption and high emissions. The results, particularly for the indicative target levels, must be viewed against the GE background.

In this analysis with the Options Document, various important aspects have received less emphasis. For example, the effect of measures on security of supply has not been a criterion in this analysis even though different options can score very differently in that respect. Other sustainability aspects of the options were also not involved when putting together the option packages. Policy instruments were not or were hardly discussed in this analysis, even though practical considerations regarding feasibility, support and the availability of policy instruments can lead to different choices than the calculated option packages at minimum national cost. In practice, this will often mean that part of the potential is lost.

The packages as put together in this study on the basis of national cost should not therefore be regarded as ‘optimum packages’. The government and politicians are responsible for taking other aspects into consideration that have been considered important but are not expressed in this approach as well. It is therefore recommended that follow-up studies be carried out as soon as the policy ambitions and the global solution possibilities are known, which deal more specifically with policy instruments and the actual achievability of the emission reduction potential.

References

Alsema, E. (2001): *ICARUS-4 Sector study for the refineries*. University of Utrecht. Internet: www.uce-uu.nl/icarus/.

Beer, J. de, and K Blok, (2003): *Energietransitie en opties voor energie-efficiency verbetering (Energy transition and options for energy efficiency improvement)*, EMAN03049 Ecofys 2003 commissioned by VROM-raad and Algemene Energieraad, Utrecht, December 2003 (in Dutch).

Boonekamp, P.G.M., A. Gijsen and H.H.J. Vreuls (2004): *Realised energy saving 1995-2002 according to the Protocol Monitoring Energy Saving*, ECN/MNP/SenterNovem, Report number ECN-C--04-085, Petten, October 2004.

Boonekamp, P.G.M., W. Tinbergen, H.H.J. Vreuls and B. Wesselink (2001): *Protocol Monitoring Energiebesparing (Protocol Monitoring Energy Saving)*, ECN/CBS/Novem/RIVM, Report number ECN-C--01-129, Petten, December 2001 (in Dutch).

Brandes, J.L., G.E.M. Alkemade, P.G. Ruyssenaars, H. Vreuls and P. Coenen (2006): *Greenhouse gas emissions in the Netherlands 1990-2004: National Inventory Report 2006*, EU report, Milieu- en Natuurplanbureau, Report number 500080001, Bilthoven, January 2006.

Brink, R.M.M. van den, A. Hoen, B. Kampman and B.H. Boon (2004): *Optiedocument Verkeersemissies: effecten van maatregelen op verzuring en klimaatverandering (Options Document Traffic Emissions: effects of measures on acidification and climate change)*, Milieu- en Natuurplanbureau/CE Delft, Report number 773002026, Bilthoven, 2004 (in Dutch).

Coninck, H.C. de and S.J.A. Bakker (2005): *CO_2 capture and storage; State-of-the-art in the climate negotiations*; ECN-C--05-104, Petten, 2005.

Daniëls, B.W. and J.C.M. Farla (2006): *Optiedocument energie en emissies 2010/2020 (Options Document Energy and Emissions 2010/2020)*, ECN/MNP, ECN-C--05-105/MNP-773001038, Petten/Bilthoven, February 2006.

Daniëls, B.W., Y.H.A. Boerakker and P. Kroon (2005): *Reservepakket 2010, Reservemaatregelen voor het halen van de Kyotodoelstelling 2008-2012 (Backup package: Backup policy measures for reaching the Kyoto target 2008-2012),* ECN-C--05-091; Petten, September 2005 (in Dutch).

Dril, A.W.N. van, and H.E. Elzenga (2005): *Referentieramingen energie en emissies 2005-2020 (Reference Projections Energy and Emissions 2005-2020)*, Energieonderzoek Centrum Nederland and Milieu- en Natuurplanbureau, ECN-C--05-018/MNP-773001031, Petten/Bilthoven, May 2004 (in Dutch).

Ecofys (2005): *Kosteneffectieve energiebesparing en klimaatbeheersing (cost effective energy saving and climate control)*, commissioned by 'Spaar het Klimaat' ('Save the Climate'), Utrecht, October 2005 (in Dutch).

EZ (2005): *Energierapport 2005, Nu voor later (Energy report 2005, now for the future)*, Ministry of Economic Affairs, The Hague, August 2005 (in Dutch).

Farla, J.C.M. and K. Blok (2000): *Energy Efficiency and Structural Change in the Netherlands, 1980-1995: Influence of Energy Efficiency, Dematerialisation and Economic Structure on National Energy Consumption*, Journal of Industrial Ecology, **4** (1), p. 93-117.

Folkert et al. (2005): *Consequences for the Netherlands of the EU thematic strategy on air pollution*, Milieu- en Natuurplanbureau, Report number 500034002, Bilthoven, 2005.

Harmelink, M. et.al. (2005): *Mogelijkheden voor versnelling van energiebesparing in Nederland (Options for accelerating energy saving in the Netherlands)*, Ecofys ECS050, Utrecht, 21 June 2005 (in Dutch).

MNP (2005): Geurs, K.T., R.M.M. van den Brink, *Milieu-effecten van 'Anders Betalen voor Mobiliteit' (Environmental effects of 'Paying differently for mobility')*, Report number 773002029/2005, Bilthoven, 2005 (in Dutch).

PvdA (2005): *PvdA Actieplan Energiebesparing (PvdA Environmental Action Plan*, www.diederiksamsom.nl (consulted on 1 November 2005), October 2005.

TK (2005): *Motie van de leden Van der Ham en Spies* (parliamentary document 28240, No. 27), adopted on 22 March 2005, Tweede Kamer, The Hague, March 2005 (in Dutch).

Verrips, A.S., H.J. de Vries, A.J. Seebregts, M.G. Lijesen (2005): *Windenergie op de Noordzee. Een maatschappelijke kosten-batenanalyse (Wind energy on the North Sea: a social cost-benefit analysis)*, Centraal Planbureau and Energieonderzoek Centrum Nederland, The Hague, September 2005 (in Dutch).

VROM (1994): *Methodiek Milieukosten (Methodology Environmental costs)*. Background document to environmental management publications series 1994/1, Ministry of Housing, Spatial Planning and the Environment, The Hague, 1994(in Dutch).

VROM (1998): *Kosten en baten in het milieubeleid - definities en berekeningsmethoden (costs and benefits in environmental policy: definitions and calculation methods)*, Environmental strategy publications series 1998/6, Ministry of Housing, Spatial Planning and the Environment, The Hague, 1998.

Appendix A Saving concepts

Energy saving may be defined in different ways. However, quantifying energy saving calls for a clear, unequivocal definition. In the past, there were various definitions in circulation which often led to confusion about what exactly was meant by a particular rate of energy saving. In order to end this confusion, in 2001 the Energy Saving Monitoring Protocol (Boonekamp et al., 2001) was developed as a standard for defining and calculating energy saving. Since the publication of the protocol, the rate of energy saving has been reported annually by ECN, CPB, SenterNovem and MNP (Boonekamp *et al*., 2004, among others) in accordance with this protocol. The Reference Projections for Energy and Emissions 2005-2020 (Van Dril and Elzenga, 2005) also specify the saving according to this standard. In this analysis, energy saving is also presented in accordance with this protocol.

Saving according to the protocol
The Protocol divides the development of energy consumption in volume, structure and saving effects. According to the protocol, saving is doing more with the same energy consumption or doing the same with less energy. In protocol terms, energy saving is the degree to which actual energy consumption is less than the reference energy consumption. The reference consumption is defined on the basis of physical indicators or activity levels[19] for the development of the sectors concerned. Saving according to the protocol comprises a number of categories of effects:

- Savings on final heat and electricity consumption (by means of more efficient equipment, for example)
- Combined heat and power in the end-user sectors
- Other increases of conversion efficiency in the end-user sectors by improved conversion efficiency per fuel
- Increasing the conversion efficiency in the energy companies by improved conversion efficiency per fuel

Structure and volume effects that bring about saving
In common parlance, a number of developments is also often regarded as energy saving but, according to the protocol, belong to volume and structure effects.

According to the protocol, saving by improving the conversion efficiency does not include fuel substitution. Although a switch from coal to gas power does lead to higher average efficiency, the protocol regards this as a structure effect because this does not lead to a change in efficiency within a particular fuel category.

Reducing an activity, which leads less fuel consumption, also does not count as a saving for the protocol. For example, reducing car mileage driven does not count as a saving but as a volume effect. Reducing energy consumption by reducing the size of certain energy-intensive sectors also comes under volume and structure effects in the protocol.

This does not detract from the fact that energy saving volume and structure effects can certainly be a target in policy focusing on reducing energy consumption. The Options Document includes a number of options of which the effects are expressed in energy saving volume and structure effects.

[19] For example, tons of manufactured steel, car mileage, number of homes or square metres of office area.

Appendix B Cost concepts

The relationship between the method of calculating environment costs and practice
As stated in Paragraph 3.2, the national cost is an indication of the cost for the Netherlands as a whole, while the end-user cost comes closer to the cost as sectors will experience it. In the option packages resulting from the analyses, it is noticeable that there is a great potential for measures with negative national cost. This concerns, by definition, measures that are not included in the background scenario in spite of their negative cost. This is not altogether surprising: the basic assumptions for the national cost differ strongly with regard to both energy prices and discount rates from the basic assumptions used by sectors themselves in evaluating the attractiveness of costs.

Factors that may lead to different decisions in practice
Additionally, there are still a few reasons why options with negative costs according to the end-user approach are not always implemented and are therefore not included in the background scenarios. These reasons are summarised briefly as follows:

- *Performance criteria.* It is known that, in practice, a number of sectors require higher returns on investments in energy saving measures than assumed in the applied method of calculating environment costs.
- *Split incentives*. In many situations, there are so-called ‘split incentives’. The person who decides on taking a measure is not the person who benefits from the favourable results. The decider often bears the costs. Split incentives occur particularly in renting living and working accommodation.
- *Decisions based on multiple criteria*. In the case of many decisions, energy saving and emission reductions are only one component in a variety of factors that play a part in the decision. An example is the purchase of electrical equipment, particularly brown goods, by households, where the energy consumption of the equipment to be bought plays a very minor role.
- *Lack of familiarity.* Particularly in sectors where energy does not play a major role as an expense, familiarity with energy saving measures is limited, even if these are profitable.
- *Information costs*. In a number of cases, a measure is cost-effective as such but the costs are increased dramatically by incurring costs in order to make the right choice. The result of this is often that, from the point of view of energy saving, a less than optimum choice is made and profitable potential is thus not used.
- *Risks*. The end-user approach is based on certain expectations with regard to energy prices and other developments that determine return on the investment. The sector may estimate this entirely differently. The position of a company may also be such that it cannot bear certain risks and therefore does not proceed to investments even though the expected return is positive.

Appendix C Measures in the Energy Report

Measures in Energy Report	PJ saving 2020 Related options in OD	Energy Report	Source	Assessed potential, estimated effectiveness and intensity of policy instruments	Current estimate [%]	PJ 2020 Realisation
White certificates	219	65	ECN 2005 Unused	System is still being developed, financial structures and financial stimulus needed, Energy Performance Building Directive (EPBD) is already assumed	75	49
Funds from Economic Structure Enhancing Fund (*FES – Fonds Economische Structuurversterking*) for built environment	A	4	Task setting on basis of CO_2 target	Not clear whether funds from Economic Structure Enhancing Fund lead to extra energy savings compared with the estimate for White Certificates	25	1
CO_2 tender for built environment	A	11	Reference Projection: 0-0.7 Mton	More than funds from Economic Structure Enhancing Fund focused on saving, extra benefit is limited	50	5
EU standards for equipment	71	48	ECN 2005 Unused; Ecofys 2005 “Acceleration”	Success depends particularly from industry’s approach in EU; no complete coverage of equipment expected	75	36
Industry innovation covenant	214	7	ECN 2005 Unused	Projection of 21 PJ already estimated 1/3	100	7
Electric motors and improved enforcement of Environmental Management Act	11	6	Ecofys 2005	Partially dependent on EU legislation	75	5
Continuing Emission Trading after 2012 (including effect on agricultures)	A	13	ECN estimate	Basic assumption of average CO_2 price to 2020 is uncertain	50	7
Funds from Economic Structure Enhancing Fund for industry	A	7	Task setting on basis of CO_2 target	Not clear whether funds from Economic Structure Enhancing Fund lead to energy saving	25	2
CO_2 tender for primary agriculture	74	0	LNV	Not clear whether this leads to energy saving	25	0
Funds from Economic Structure Enhancing Fund for agriculture	A	1	Task setting on basis of CO_2 target	Not clear whether funds from Economic Structure Enhancing Fund lead to energy saving	25	0
Traffic and transport measures:						
Speed 100>80km/hr (“Randstad”)	B	3	ECN Reserve package	Effect calculated by MNP, possible problem of support	75	2
Modifying Car and Motorcycle Tax	4	2	ECN estimate	Limited application	100	2
Extending the New Driving Force programme (*Het Nieuwe Rijden*)	4	8	ECN Reserve package	MNP estimate based on partial effectiveness	50	4
Extra speed limits for vans [D]	7	2	MNP, Options Document Traffic 2004	Due to limited enforcement and dropout, the intensity is not 100% estimated	50	1
European vehicle standards [E]	46	28	MNP, Options Document Traffic 2004	Intensity depends particularly on industry’s approach in EU	75	21
Labels for trucks	F	1	Estimate	Expecting some policy is justified	100	1
Funds from Economic Structure Enhancing Fund for transport	A	2	Task setting on basis of CO_2 target	Not clear whether funds from Economic Structure Enhancing Fund lead to energy saving	25	1
Extra package or road pricing	21	30	Balance approach in task setting	Instrumentation now seems to be largely in terms of distance-related road pricing	55	16
Total excluding Electricity Companies	671	237				159

[A] Funds from Economic Structure Enhancing Fund /CO2 measures can concern various options, also those that do not save energy.

B In the Options Document, the related measure for lowering the speed to 100 km/h in the whole of the Netherlands leads to a reduction of 11 PJ.

C The option 'Abolishing Car and Motorcycle Tax diesel supplement' in the Options Document provides potential for 2.8 PJ for 2020. The option CO_2 differentiation in Car and Motorcycle Tax has a potential of 4.2 PJ in 2020.

D The Options Document includes an option for equipping vans with speed limiters (effect in 2020 approx. 7 PJ).

E In the Energy Report, this standard concerns private cars and vans. Policy commitment for vans less than that of PvdA. Total result (standards and covenants) is estimated equally on balance.

F Not included.

Appendix D Measures in the PvdA Action Plan

PvdA results	PJ saving 2020 Related options in OD	PvdA plan	Source	Assessed potential, estimated effectiveness and intensity of policy instruments	Current estimate [%]	PJ 2020 Realisation
Gas in households	99	70	Ecofys 2005 Save the Climate foundation (*stichting Spaar het Klimaat*)	Policy instruments do not yet clearly provide the required financial structure and stimulus	50	35
Gas in industrial and commercial buildings	32	10	Ecofys 2005 "Acceleration" page 17	Policy instruments do not yet clearly provide the required financial structure and stimulus	50	5
Electricity in households	79	35	Ecofys 2005 "Acceleration" page 37	Intensity depends particularly on industry's approach in EU, no full coverage of equipment expected	50	18
Electricity in industrial and commercial buildings	80	95	Ecofys 2005 "Acceleration" page 18 and 24	Policy instruments do not yet clearly provide the required financial structure and stimulus, split incentives remain a problem, also potential is estimated highly	15	14
Industry	192	100	Ecofys Energy Transition 2003, H_2 (50% because of additionality)	Policy instruments are not fully indicated, potential is estimated highly	15	15
Refineries	33	11	Universiteit Utrecht 2001 *Icarus-4 Sector study for the refineries*	Policy instruments are not fully indicated	25	3
Horticulture	74	15	PvdA estimate of 150 to 135 PJ in 2020	Potential reasonable, policy instruments not fully indicated [C]	50	8
Transport [D]	102	130	Ecofys 2005 "Acceleration" page 48, corrected for overlaps	Derived from assumptions below	56	73
Of which:						
Tightening ACEA covenant for private cars	27	19	Ecofys 2005 "Acceleration" page 48	Intensity depends particularly on industry's approach in EU [E]	75	14
Covenant for vans	19	22	Ecofys 2005 "Acceleration" page 48	Intensity depends particularly on industry's approach in EU, potential is estimated highly	30	7
Covenant for trucks	[B]	40	Ecofys 2005 "Acceleration" page 48	Policy instruments are not fully indicated	15	6
Maximum speed 100 km/h	11	11	MNP, Options Document Traffic 2004	Intensity not 100% estimated owing to limited enforcement	75	8
Tax measures [A]	24	24	MNP, Options Document Traffic 2004	Calculated effect by MNP, possible problems in infrastructure and enforcement	75	19
Road pricing for light vehicles	21	20	MNP, Options Document Traffic 2004	Calculated effect by MNP, possible problem of support [F]	80	16
Limit top speed at car design	[B]	36	Source unknown	Support problematical	10	4
Total excluding Electricity companies	691	466				170

A Cocktail of duty, road tax and car and motorcycle tax in PvdA document: for the record. Based on 24 PJ potential in accordance with MNP source.

B Not included.

C The stated saving in horticulture is also included in the reference scenario for approx. 10% gain in ambient heat, in other words, strictly speaking sustainable.

D The figures include overlap between measures including overlap between tax measures and the tightening of the ACEA covenant (European Automobile Manufacturers Association).

[E] The current estimate here (75%) deviates from the current estimate for the comparable measure in the Energy Report 2005 (50% for European vehicle standardisation). The reason for this the different estimate of the effect in the PvdA plan and the Energy Report. The basic assumption used in the assessment was equal realisation in 2020.

[F] Percentage current estimate was applied to the potential estimate in the Options Document (see also Appendix assessment of the Energy Report).

Appendix E Comparison with Ecofys results

Brief summary of a document by Suzanne Joosen, Miriam Harmelink, Martin Mooij (Ecofys) and Marijke Menkveld (ECN Policy Studies).

In the recent discussions, differences arose in estimating the energy saving potentials by ECN and Ecofys. On 11 November, there was a meeting between Ecofys and ECN where an attempt was made to identify where these differences originate. This memo shows the results of this analysis of the differences.

The ECN Options Document works with varying intensity for each option. Table E.1 shows the savings in the highest intensity.

Table E.1 *Comparison of calculated savings between Ecofys and ECN*

No.	Ecofys option	Effect 2020 $PJ_{primary}$	ECN option	Effect 2020 $PJ_{primary}$
1	Energy saving in new homes	9	Better insulation in new homes	4
			Electric water pumps in new homes	7
2	Insulation in existing homes	123	Insulation in existing homes	61
3	Insulation in industrial and commercial buildings	7	Insulation in existing industrial and commercial buildings	29
			Insulation in new industrial and commercial buildings	3
4	More efficient boilers and water pumps	PM	More efficient boilers in homes	14
			(Electric water pumps in new homes)	(7)
			Solar boilers in existing homes	2.5
			Electric water pumps and heat/cold storage in industrial and commercial buildings	6
			Solar heating in industrial and commercial buildings	0.5
5	Reducing standby use	20	Saving electricity by changing behaviour	38
6	Energy saving for small electrical equipment	30		
			Saving electricity by more efficient equipment	41
7	Energy saving for large electrical equipment	PM		
8	Low-energy high-efficiency lighting for households	12-14		
9	Saving on lighting in industrial and commercial buildings	50	Saving building-linked electricity use in industrial and commercial buildings	50
10	Restricting electricity use outside office hours	25-30	Saving equipment-linked electricity use in industrial and commercial buildings	30

1. Energy saving in new homes

Ecofys uses 9 PJ and ECN 10 PJ. In short, the estimates largely correspond to each other.

2. Insulation in existing homes

Ecofys uses 123 PJ and ECN 61 PJ. The differences are caused by:

- The Ecofys figures are based on the number of homes in 2004, whereas the ECN figures are based on the situation in 2020. This means that in the ECN model, there are assumptions regarding demolition and autonomous application of insulation against the background of the

GE scenario. In the GE scenario, the saving through insulation in the period 2005-2020 is 13 PJ of gas in existing buildings.

- In its model, ECN uses different amounts of uninsulated surface area than Ecofys. However, the amounts of uninsulated surface area used by ECN and Ecofys do not result in large differences in the energy saving potential.
- The ECN calculations for the Reference Projections and the Options Document (GE scenario) include a climate correction with a falling number of heating degree days (as a result of climate change). Because of this, the demand for heat drops by 10% between 2000 and 2020 and thus saving through insulation will also drop by 10%. Ecofys does not take this into consideration but bases its calculations on the number of degree days and heating hours according to NEN 5128 (EPC). This leads to a difference of 6 PJ.
- Model differences in heat demand and the degree of saving. Analysis of these considerable differences (40 PJ) has not yet resulted in a clear picture and requires further study.
- ECN assumes that parts of buildings that are already insulated will not receive further insulation. Ecofys assumes that parts of buildings that were originally insulated to some extent will qualify for re-insulation. In the potential, this concerns particularly energy saving through roof insulation, approximately 3 PJ. ECN estimates that if they abandon this restriction, energy saving will be 50% higher than is projected now (approximately 90 PJ instead of 60 PJ).

3. Insulation in existing industrial and commercial buildings
Ecofys and ECN both state that data in this field are limited and that they have used saving percentages for existing homes in their calculations. ECN expects that the saving potential is between 3-30 PJ. Ecofys states that the 7 PJ concerns the potential that can be achieved by means of the white certificate system. These therefore correspond well to each other.

4 to 8. Electricity saving in households
At Ecofys, the option for reducing standby use is based on applying a technical measure. At ECN, this measure occurs in two options: both in terms of behaviour and technology. ECN uses 12 PJ for technical efficiency improvement for reducing standby use. This should be compared with Ecofys' 20 PJ. One reason why the ECN saving is lower is that it is based on the most commonly available equipment in order to apply this. Ecofys takes all equipment with standby use into consideration (however it does not use a separate option for saving by means of changing behaviour).

Ecofys assumes that the energy efficiency improvement achieved in the past for large equipment is also possible for small equipment. ECN has no specific option for saving with small equipment. ECN claims a possible saving of 5 PJ of electricity by low-energy high-efficiency lighting, which is a part of saving by more efficient equipment, but also saving by changing behaviour. This corresponds well with the 12 to 14 $PJ_{primary}$ of Ecofys.

9 and 10. Electricity saving in industrial and commercial buildings
On the whole, the Ecofys savings correspond to the ECN savings. Ecofys states that the savings calculations for restricting electricity use outside office hours are based on practical experience.