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Consequences for the Netherlands of the EU thematic strategy on air pollution

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Abstract

Consequences for the Netherlands of the EU thematic strategy on air pollution

Although air quality has greatly improved during the last decades, current levels of air pollution still have adverse effects on ecosystems and human health. Thousands or perhaps even tens of thousands of people may die prematurely every year as a result of air pollution in the Netherlands. In addition to this, the current EU air quality limit values for nitrogen dioxide (NO_2) and particulate matter (PM_{10}) are being exceeded in many locations in the Netherlands. Consequently, a large number of plans for spatial development are rejected because they do not conform to currently legislated limit values. This has serious economic and societal consequences.

In September 2005 the European Commission presented a thematic strategy on air pollution and a proposal for a new air quality directive for the abatement of air pollution in the European Union (EU). The measures come into effect after 2010 and are more far reaching than those recently proposed by the Dutch government which is directed to solving current problems. The measures proposed by the European Commission would greatly reduce air pollution while providing benefits to health that would be many times larger than the abatement costs. Attainment of the NO_2 limit value in the Netherlands is possible under the new measures, provided that a 5-year extension of the attainment date is acknowledged by the European Commission. However, this is not the case for the limit value for particulate matter (PM_{10}).The large-scale exceedances of PM_{10} will probably be avoided; however local exceedances will probably remain, and these may still have serious consequences for spatial planning. Extra national and, in particular, European-wide measures will be required to meet the limit value for PM_{10} in the Netherlands. The potential for achieving additional national abatement policy is, in fact, limited and expensive, while the foreign contribution to particulate air pollution is large.

If the air quality limit values are actually to be realized in the future, it is crucial that the EU source policy – which still has to be worked out – will at least meet the ambition level taken up in the thematic strategy. This is of special importance with respect to reducing air pollution originating from road traffic, because road traffic at bottlenecks makes a large contribution to the poor air quality. The most recent proposal (July 2005) of the European Commission for tightening EU emission standards for light-duty road traffic sets a comparable level for particulate matter but a lower ambition level for nitrogen oxide than the ambition level on which the strategy is based. This lower ambition level will, in the Netherlands, prevent timely attainment of the NO_2 limit value.

Keywords: Air pollution, Thematic Strategy, CAFE, EU, Particulate matter, Nitrogen dioxide

Rapport in het kort

Gevolgen voor Nederland van de EU thematische strategie voor luchtverontreiniging

De luchtkwaliteit is in de afgelopen decennia sterk verbeterd. Desondanks hebben de huidige niveaus van luchtverontreiniging een negatief effect op ecosystemen en de gezondheid van de mens. Mogelijk duizenden of misschien zelfs enkele tienduizenden mensen overlijden elk jaar vroegtijdig in Nederland door luchtverontreiniging. Daarnaast worden op veel lokaties in Nederland de huidige EU luchtkwaliteitsgrenswaarden voor stikstofdioxide (NO_2) en fijn stof (PM_{10}) overschreden. Een groot aantal plannen voor ruimtelijke ontwikkeling is door de Raad van State afgewezen omdat deze niet in overeenstemming waren met de wijze waarop de grenswaarden in Nederland zijn geïmplementeerd. Dit heeft serieuze economische en maatschappelijke gevolgen.

De Europese Commissie heeft een thematische strategie voor luchtverontreiniging en een voorstel voor een nieuwe luchtkwaliteitsrichtlijn uitgebracht in september 2005 om de luchtverontreiniging in de Europese Unie verder aan te pakken. Deze voorstellen worden effectief na 2010 en gaan veel verder dan de maatregelen van het kabinet uit het prinsjesdagpakket die op de huidige problemen is gericht. Met de voorgestelde maatregelen van de Commissie neemt de luchtverontreiniging fors af en ontstaan er baten voor de volksgezondheid die zijn vele malen groter dan de kosten. De grenswaarde voor stikstofdioxide is mogelijk haalbaar met de maatregelen mits de Europese Commissie Nederland 5 jaar uitstel van de ingangsdatum verleent. De grenswaarde voor fijn stof (PM_{10}) is echter waarschijnlijk niet haalbaar. Grootschalige overschrijdingen van de fijnstofgrenswaarde worden waarschijnlijk opgelost, maar lokale overschrijdingen blijven mogelijk. Deze overschrijdingen kunnen nog steeds een serieus effect hebben op plannen voor de ruimtelijke inrichting. Extra nationale en vooral maatregelen op Europese schaal zijn nodig om de grenswaarde voor PM_{10} in Nederland te realiseren. Het potentieel voor maatregelen in Nederland is namelijk klein en duur, terwijl de bijdrage uit het buitenland groot is.

Voor het werkelijk realiseren van de grenswaarden in de toekomst is het cruciaal dat het nog vorm te geven EU bronbeleid minstens even ambitieus is als in de thematische strategie. Dit is vooral van belang voor het terugdringen van de vervuiling van het wegverkeer omdat het verkeer op knelpunten sterk bijdraagt aan de slechte luchtkwaliteit. Het meest recente voorstel (juli 2005) van de Europese Commissie om de emissienormen voor licht wegverkeer aan te scherpen heeft voor fijn stof een vergelijkbare maar voor NO_x een lager ambitie niveau dan waarop de thematische strategie is gebaseerd. Realisatie van de grenswaarde voor stikstofdioxide zal met dit lagere ambitieniveau in Nederland niet op tijd mogelijk zijn.

Trefwoorden: Luchtverontreiniging, Thematische strategie, CAFE, EU, Fijn stof, Stikstofdioxide

Preface

The thematic strategy on air pollution and a proposal for the new air quality directive, both constructed in the Clean Air for Europe (CAFE) programme, were published by the European Commission on 21 September 2005. These documents contain proposals for new policy on air pollution in the European Union. The Dutch government asked the Netherlands Environmental Assessment Agency to assess the proposals and the data used in the CAFE programme with respect to consequences for the Netherlands. The result of this assessment is presented in this report. The Dutch government, at the Opening of Parliament in September 2005, has also presented a plan for combating air pollution. The assessment report of this plan will be presented together with this report as a twin package.

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Summary

The problem

Although air quality has greatly improved during the last decades, studies have indicated that short-term exposure to the air pollutants ozone and particulate matter can still be linked to the premature deaths of some thousands of people yearly in the Netherlands. The effects of long-term exposure to particulates, while very uncertain, have been estimated to be even more serious than those of short-term exposures, in that some ten thousands of people in the Netherlands may be dying up to 10 years prematurely. The biodiversity of Dutch ecosystems is also adversely affected by air pollution with nitrogen. Air pollution is a true transboundary problem in Europe. While one-half of the total air pollution in the Netherlands originates from sources abroad, the Netherlands itself exports a few times more air pollution than it imports. A common European policy on air pollution abatement would therefore provide the best means for combating air pollution overall. In response, the European Commission has formulated a thematic strategy on air pollution and a proposal for a new air quality directive within the framework of the Clean Air For Europe (CAFE) programme. The thematic strategy also presents a first proposal for the review of the NEC directive in which new agreements will be made with Member States for national emission ceilings for 2015 and 2020. In addition, at the Opening of Parliament in September 2005 the Dutch government presented a plan to combat air pollution.

The proposal of the European Commission

Because of the large health benefits to be obtained, the focus of the new EU policy is on particulate matter. The main elements of the strategy and the directive of the Commission are:

- Current air quality limit values for PM_{10} and NO_2 that remain unchanged.
- A new annual concentration cap for the finer fraction of particulate matter ($PM_{2.5}$) of 25µg/m^3 averaged per year that has to be attained by 2010 throughout the entire territory of each member state.
- A new interim reduction target value to reduce the yearly average urban $PM_{2.5}$ background level by 20% between 2010 and 2020. This target is not legally binding and will be reviewed when more monitoring data for $PM_{2.5}$ are available. The setting of different target values for the Member States and the legal status of these agreements will be addressed in this review.
- A proposal to tighten the emission ceilings in order to reduce the emission of sulfur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3), non-methane volatile organic compounds (NMVOC) and particulate matter $PM_{2.5}$ in 2020 in all Member States (see Table 1). This reduction will be realized with European Union (EU) and/or national source policies. The European standards for road traffic are crucial here because of their major impact on air pollution at all levels.
- A possibility for derogation of the limit values for particulate matter (PM_{10} and $PM_{2.5}$) and NO_2 by a maximum of 5 years beyond the attainment date if certain criteria are met. Any request for time extension should be accompanied by a plan to ensure compliance within the extended time period.
- A possibility to discount natural sources from air pollution levels for compliance purposes that can be determined with sufficient certainty. For the Netherlands, the contributions of sea salt and mineral dust from natural sources may be relevant in discounting these from particulate matter.

Table 1. EU proposal to reduce emission of air pollutants in 2020 with respect to 2000.

Substance	**Reduction, EU**	**Reduction, the Netherlands**
Sulphur dioxide (SO_2)	82%	40%
Nitrogen oxide (NO_x),	60%	50%
Volatile organic compounds (NMVOC)	51%	40%
Ammonia (NH_3)	27%	30%
Particulate matter ($PM_{2.5}$)	59%	20%

The Netherlands has one of the most eco-efficient economies in Europe

The Netherlands is densely populated, with one of the highest environmental pressures in the EU, but it has also one of the most eco-efficient economies of the EU. Therefore, the reductions set for the Netherlands in the proposal to tighten the emission ceilings are lower than the EU average (Table 1) since there is less abatement potential remaining. Regional concentrations of particulate matter and NO_2 in the Netherlands are among the highest in Europe, but the concentrations in Dutch cities are comparable to those of other large urbanized areas in Europe. For ambient ozone, the levels in the Netherlands are relatively low, but for the deposition of nitrogen and acid, the levels are among the highest in Europe.

What does this proposal to reduce pollution mean for air pollution in the Netherlands?

With current policy, the daily limit value for particulate matter (PM_{10}) will probably still be exceeded in the southern part of the Netherlands and cities until 2020. With the reduction in pollution as proposed in the thematic strategy, the concentration of particulate matter ($PM_{2.5}$ and PM_{10}) decreases (by an additional 5–10% in 2020). Consequently, the number of exceedances of the PM_{10} limit value will decrease by 50–80% in 2020, although especially exceedances will probably still occur in busy streets. Exceedances of the limit value for NO_2 will probably occur until 2020 with current policy. With the thematic strategy, the number of NO_2 exceedances will show an extra fall of 60–100% between 2015 and 2020. The remaining NO_2 exceedances can in principle be resolved with additional local policy from 2015 onwards. In addition to this, 5–20% of the ecosystems in the Netherlands will have extra protection against excess air pollution by nitrogen in 2020 with the ambition level in the thematic strategy.

Can the Netherlands meet the proposed requirements?

The exceedances of PM_{10} in 2005 and the limit value of NO_2 in 2010 are still probable with the proposed reduction of pollution in the thematic strategy. However, the derogation of 5 years may provide enough time to possibly resolve the NO_2 exceedances in 2015 with additional local measures. A crucial point is that the Commission does not loosen the ambition levels for the reduction of air pollution, especially for road traffic.

The most recent proposal (July 2005) of the European Commission for EU emission standards for light-duty road traffic sets a comparable level for particulate matter but a lower ambition level for nitrogen oxide than the standards on which the strategy is based. With this lower ambition level the limit value for NO_2 will probably not be attainable in 2015, but attainment will just be possible in 2020. The derogation time is probably not sufficient to resolve the exceedances of PM_{10} in 2010. The reduction of pollution in Europe with application of the thematic strategy is not enough to prevent local exceedances of the PM_{10} limit value in the Netherlands until 2020. An additional national abatement policy is not sufficient and very expensive, amounting to billions of euros.

The new 2010 concentration cap for $PM_{2.5}$ is stricter than the annual limit value for PM_{10}, but it is less strict than the PM_{10} daily limit value. Current information on $PM_{2.5}$ is very limited since only a few scattered measurements are available, and accurate assessments are therefore not possible. Preliminary assessments based on these limited data indicate that with the ambition level in the thematic strategy, the 2010 concentration cap is not probable until 2020. Exceedances are probably not widespread, but they do occur in busy streets in cities. The derogation time is not sufficient to resolve the exceedances of $PM_{2.5}$ in 2015. It is highly probable that the proposed interim reduction target of 20% for the average urban background level for $PM_{2.5}$ is unattainable with the ambition level in the thematic strategy; however, this target is not legally binding at the present time.

Sea salt has already been discounted from PM_{10} levels but not from the $PM_{2.5}$ levels. If, in addition to the proposed measures in the thematic strategy, sea salt is discounted from the $PM_{2.5}$ levels, attainment of the 2010 concentration cap might be possible in 2020. The proportion of mineral dust that is not anthropogenic and, therefore, discountable as a natural source from particulate matter is uncertain. The contribution of mineral dust to $PM_{2.5}$ is much smaller than its contribution to PM_{10}. Consequently, for PM_{10}, there is a potential for a large effect on attainment. However, a large part of the contribution of mineral dust to PM_{10} is probably not from a natural source. Although it is not likely that sea salt affects health, mineral dust probably does. Discounting natural sources does not improve air quality and means a weakening of the current limit values.

Road traffic has a major impact on poor air quality in the Netherlands. © Rob Folkert

Consequences for the Netherlands

The current situation in the Netherlands is that plans for spatial development are rejected if they are in conflict with air quality limit values, such as those for NO_2 and PM_{10}, which has serious economic and societal consequences. The attainment of NO_2 is possible with the policy in the thematic strategy but attainment for PM_{10} is not. For PM_{10}, large-scale exceedances will be resolved. However, local exceedances will probably persist until 2020, with possible serious economic and societal consequences. For $PM_{2.5}$, exceedances will probably occur; however, since the PM_{10} limit value is stricter, no new areas with exceedances are expected. The limit values can probably not be attained with national policy since additional abatement policy for particulate matter ($PM_{2.5}$ and PM_{10}) is very expensive, amounting to billions of euros, whereas the effect of abatement possibilities are limited and the foreign contribution to particulate air pollution is large.

The connection with national policy

The Dutch government presented a plan for combating air pollution at the Opening of Parliament in September 2005. This plan is directed to solving current problems, whereas the European policy only comes into effect in 2010. The thematic strategy will supplement the effect of this national policy by tightening source policy in all Member States and by providing cleaner vehicles through stricter emission standards all over Europe. With its own plan, the Dutch government is, in particular, accelerating the introduction of these cleaner vehicles. Additional measures are also being taken to reduce emissions, which too will contribute to the attainment of the future new emission ceilings that will be set by the EU. The plan of the Dutch government also contains local measures to combat exceedances of air quality limit values. The extra costs of source policy in the thematic strategy are approximately threefold the cost of the proposals in the current national plan.

Review of national emission ceilings and measures

The proposal in the thematic strategy to tighten the emission ceilings in order to reduce the emission of air pollution represents the first step in a review of the NEC directive, which is to be completed in 2006. Part of this reduction will be realized with EU policies, for example, further implementation of the Product and Solvent Directives, IPPC legislation and the EURO emission standards for mobile sources. Other reductions have to be achieved with national policy. However, no direct link was made in the thematic strategy between possible legislation and technical measures. Uncertainties should be taken into account when agreements are being made on new emission ceilings since uncertainties in emission projections are of the same order of magnitude as the policy task. These uncertainties may lead to a costly unattainable ceiling and/or ceilings that can be attained with current policy. Current knowledge on $PM_{2.5}$ emissions to provide the base upon which to build a national emission ceiling is very limited.

Costs and benefits

The proposal to tighten the emission ceilings in the thematic strategy will cost the Netherlands about 330 million euros per year. These additional costs have to be paid by agriculture (35%), industry (35%) and traffic (25%). The total abatement cost will increase by 10% in 2020. The benefits of the source policy in the thematic strategy for the Netherlands seem to be many factors larger than the costs, and almost all of the measures seem to be cost-effective. Benefits are dominated by the reduction in the health impacts from long-term exposure to particulate matter, although the magnitude of these benefits seems to vary depending on the underlying health study chosen as reference. Nevertheless, if the negative impact on health from short-term exposures to air pollution is taken into account, the mortality risk associated with this negative impact on health in the Netherlands is well above the Dutch limit values for environmental safety risks. Moreover, effects on ecosystems are not taken into account in the cost-benefit analysis since these benefits are not monetized.

The fraction of the particulates causing a specific health effect is unknown. Sea salt together with sulphate, ammonia and nitrate is most likely not a health hazard. As a precautionary measure, a reduction in the levels of particles from combustion sources would appear to be beneficial to health. Unfortunately, the abatement policy in the thematic strategy has not been optimized for this hypothesis. Different causal fractions lead to totally different abatement strategies for different sources at different costs. If the policy were to be optimized for primary particles as the causal fraction, costs to the Netherlands would decrease by approximately 65–85%. Measures to reduce secondary aerosol precursors (SO_2, NO_2, NH_3 and volatile organic compounds (NMVOC)) would then be unnecessary. However, a reduction in secondary aerosol precursors remains an important target for reducing the health risk from short-term exposure to ozone and the effects on ecosystems.

Reporting issues

Member States are obliged to submit reports on the levels of ambient air quality and exceedances of limit values to the European Commission. The current assessment methods of air quality in the EU result in assessments that are incomparable with respect to levels and exceedances between Member States. In the Netherlands, a combination of modelling and measurements is used, whereas many other Member States only use measurements. Moreover, the Netherlands uses a correction factor for the underestimation of particle measurements with the reference method, whereas many other Member States use different correction factors, while some do not use a correction factor at all. The detailed Dutch method of assessing air quality leads to relatively higher registered levels of air pollution and higher numbers of exceedances. While this inequity in assessment methodology seems to be improving, it is not yet resolved in the new air quality policy. However, reporting plans have not yet been worked out.

Differences in scientific data in CAFE

The cost for the Netherlands of the source policy as proposed in the thematic strategy should be regarded as a lower limit. The magnitude of the cost of the technical abatement measures reported by the EU is approximately in line with national figures, with the exception of the costs for NMVOC. Next, differences between national and EU scenario (CAFE Baseline) may lead to higher abatement costs for SO_2 and $NO_{x.}$

The current CAFE Baseline differs from national expectations showing a higher coal use and a higher proportion of diesel-powered vehicles, both of which lead to higher estimates for SO_2 and NO_x. These higher estimates have consequences for the position of the Netherlands with respect to negotiations for new emission ceilings, because a higher policy task will be calculated on the basis of the CAFE Baseline. However, the Commission is constructing a new CAFE Baseline, and the Netherlands has submitted a national scenario for presenting future developments specific to the Netherlands for the NEC review. Although there are differences in emissions between national expectations and the current CAFE Baseline, these differences are not significant with respect to the calculated environmental quality for the Netherlands.

The EMEP model, which is the basis for dispersion calculations in CAFE, overestimates the nitrate concentrations in the Netherlands and underestimates the NO_2 air concentrations. The model may therefore overestimate the importance of the long-range transport of oxidized nitrogen over the Netherlands. Although the overestimation of nitrate concentration is not so high in other areas, the EMEP/RAINS system can be expected to overestimate the reduction of $PM_{2.5}$ background concentrations in the Netherlands when EU reductions in NO_x emissions are applied. The system will also probably overestimate the efficiency of Dutch NO_x emission reductions. National measures to reduce NO_x Dutch emissions may thus prove more efficient than envisaged under the present CAFE calculations.

The Commission has not used scientific data to assess the attainment of the new $PM_{2.5}$ concentration cap for the Netherlands. The RAINS model does not address concentrations in street canyons or around industrial hot spots and thus cannot determine attainability of limit values.

1. Introduction

Although air quality has greatly improved during the last decades, there is still a strong association between air pollution and premature mortality, while biodiversity remains under pressure mainly from air pollution by nitrogen. Consequently, the European Commission is establishing a new air pollution policy within the framework of the ‘Clean Air for Europe’ (CAFE) programme in accordance with Sixth Environmental Action Programme. The objective of the air quality policy formulated by the European Commission in their action programme is to achieve levels of air quality that do not give rise to significant negative impacts on – and risks to – human health and the environment. Because of the large health effect from exposure to particulates, the focus has been on the abatement of particulates in CAFE. Within their action programme, the European Commission announced the construction of a thematic strategy on air pollution – as one of the seven thematic strategies. Thematic strategies propose actions for dealing with complex issues that require a broad and multi-dimensional approach. The European Commission initiated the CAFE programme of technical analysis and policy development as the means to support three important policy processes:

- The construction of a thematic strategy on air pollution;
- The review of the air quality directives;
- The review of the NEC (National Emissions Ceiling) directive.

The European Commission has published a thematic strategy on air pollution and a proposal for the new air quality directive in September, 2005 (EU, 2005a and 2005b). These plans will be discussed in the Council and Europarliament later this year. The proposed new limit values and revisions for air quality legislation are incorporated into the proposal for the new air quality directive. In the thematic strategy, the European Commission has proposed an ambition level to be considered with the revision of the NEC directive. The thematic strategy also represents the first step in a review of the NEC directive to be completed in 2006, in which new agreements will be made with Member States for national emission ceilings for 2015 and 2020.

The Dutch government asked the Netherlands Environmental Assessment Agency to assess the proposals and the data used in the CAFE programme. In this report, the environmental, economic and societal consequences of the new proposed legislation for the Netherlands have been assessed. This assessment has been made to support the position of the Netherlands during future negotiations and discussions of this new air pollution policy. Two key elements in the negotiations will be: (1) what are the costs of the proposals to the Netherlands and what are the environmental benefits for the same; (2) can the Netherlands meet the proposed demands. The Netherlands currently has problems attaining the national emission ceilings for 2010; additionally, the current EU limit values for PM_{10} and NO_2 are having serious consequences for spatial planning. Spatial plans are subject to appeal because of possible breaching of these limit values. Last the data on which the proposals have been based have been checked with national data.

This assessment includes a detailed calculation of Dutch air quality. Additionally, the data provided in assignment by the European Commission for the Netherlands have been compared with the national data to verify if the proposed targets are soundly based on accurate information. Benchmarks on air pollution have been made with other countries in order to compare the problems of the Netherlands with those of other member states. In Chapter 2, the CAFE Baseline and source policy of thematic strategy are discussed; in Chapter 3, air quality is assessed with respect to air quality standards in the thematic strategy; Chapter 4 consists of a discussion on the impacts of the air quality policy on health and ecosystems; Chapter 5 the costs and benefits of the proposed air pollution policy are presented; finally, in Chapter 6, implementation of new air quality policy is discussed.

2. CAFE Baseline and policy scenarios

The European Commission has constructed a strategy for combating air pollution within the Clean Air for Europe (CAFE) programme. To assess future air quality up to 2020, a European-wide scenario that includes additional climate measures has been constructed by the International Institute for Applied Systems Analysis (IIASA). Different policy runs with abatement measures have been constructed with RAINS (Regional Air Pollution Information and Simulation) to assess future air pollution policy ambition levels and to construct the ambition level of the thematic strategy. In this chapter we discuss both the CAFE Baseline scenario and compare it to national projections. We discuss the policy runs and the thematic strategy, including abatement measures and the costs involved. Lastly, we compare the eco-efficiency of the Netherlands with that of other member states.

2.1 CAFE Baseline and Dutch national scenarios

- *The CAFE Baseline scenario affects the Dutch position in negotiations for a new European air pollution policy because national expectations show a higher coal use and a higher proportion of diesel cars, thereby leading to higher abatement costs.*

- *The RAINS model itself appears to be intrinsically appropriate for calculating abatement scenarios for the Netherlands*

The CAFE Baseline scenario originally consisted of three different variants: (1) a European-wide scenario without climate policy; (2) a European-wide scenario with climate policy; (3) a national scenario submitted by a member state incorporated into the European-wide scenario with climate policy (Amann et al., 2005a). In the CAFE programme, the calculations and different policy runs have all been based on the European-wide scenario with climate policy. In this report the CAFE Baseline scenario refers to this scenario.

For the purposes of meeting both the criteria for international reporting and support of national policy, the Netherlands has constructed emission projections up to 2020 (Van Dril and Elzenga, 2005) based on two economic scenarios ‘Global Economy’ (GE) and ‘Strong Europe’. The activities and resulting emissions based on these projections are compared to those of the CAFE Baseline scenario and are presented in Tables 2.1 and 2.2, respectively.

Global Economy is the scenario which assumes international cooperation (free market), private responsibility, a minimum of governmental interference, a gross domestic product (GDP) growth of 2.8% per annum and a population growth of 0.6% per annum. The Netherlands has submitted the GE as the national scenario to advance and incorporate specific Dutch future developments in the NEC review. Strong Europe is the scenario which assumes international cooperation (for institutions), public responsibility, and active government participation, a GDP growth of 1.7% per annum and a population growth of 0.5% per annum. For both scenarios, the same climate measures are assumed, with a price of €11/tonne CO_2, and current legislation is assumed to be pursued until 2020 (i.e. exclusion of autonomous tightening of standards).

The GE scenario assumes a higher GDP growth rate than the CAFE Baseline, whereas the SE Scenario assumes a lower GDP growth rate than the CAFE Baseline. In the GE Scenario, energy use is higher than in both the CAFE Baseline and the SE Scenario. Compared to the CAFE Baseline scenario price of €20/tonne CO_2, both the GE and SE scenarios assume the lower price of €11/tonne (Table 2.1).

Table 2.1 Activities of the CAFE Baseline scenario versus the Dutch national scenarios Strong Europe (SE) and Global Economy (GE) for 2020. Sources: EC (2003) and Van Dril and Elzenga (2005).

2020	**CAFE**	**SE**	**GE**
Population (in millions)	17.4	17.6	17.9
GDP growth (%)	2.3	1.7	2.8
Energy use (PJ)	3440	3500	3780
CO_2 price (€/t)	20	11	11

Table 2.2. Activities of the CAFE Baseline versus the Dutch National Scenarios SE and GE for 2020. Sources: EC (2003) and Van Dril and Elzenga (2005).

	Coal use in power plants (PJ)		
	2000	2010	2020
CAFE	214	59	25
GE	212	245	320
SE	212	245	160
	Diesel use in passenger cars and for light-duty purposes (PJ)		
CAFE	87.5	96.1	97.3
GE	112.6	146.4	191
SE	112.6	146.4	191
	Dairy cows (x1000)		
CAFE	1504	1363	1333
GE	1504	1395	1725
SE	1504	1395	1461
	Other cattle (x1000)		
CAFE	2566	2466	2198
GE	2566	2110	1791
SE	2566	2062	2005

The main difference between the CAFE Baseline and the two national scenarios for sulphur dioxide (SO_2) is due to the lower use of coal assumed in the CAFE Baseline (Tables 2.2 and 2.3), which in turn results in lower power plant emissions. In 2020, this causes higher emissions in the national scenarios (9 SE and 20 kt GE). The lower emissions for NO_x in the CAFE Baseline result primarily from a lower proportion of diesel vehicles (17 kt in 2020) and an underestimation of emission factors from gas engines in the agricultural sector (10 kt in 2010). For total ammonia (NH_3) emissions, the GE and the CAFE Baseline scenarios show a good match. However, for the sector-level emissions from other cattle, the CAFE Baseline projections are higher, whereas in that for dairy cattle, the GE Scenario projections are higher due to higher animal numbers (Tables 2.2 and 2.3). The projection of animal numbers in 2020 is lower in the SE scenario than in the CAFE Baseline and, consequently, the emissions of ammonia are lower in the former (Table 2.3). For non-methane volatile organic compounds (NMVOC) emissions, the main difference between the scenarios originates from differences in the implementation of policy measures (Jimmink et al., 2004). The projected emissions of particulates (PM_{10}) shows a good match between the CAFE Baseline and GE scenarios, although a lower estimation of diesel cars in the former results in a lower projection of particulate emissions for road transport in 2020 (2 kt) compared to the GE and SE scenarios (Jimmink et al., 2004). Fewer animals and a lower activity at transfer points of goods lead to lower total emissions in the SE scenario.

Table 2.3. Projected Emissions of the CAFE Baseline versus the Dutch National Scenarios GE and SE and MTFR (Maximum Technical Teasible Reductions) for 2000, 2010 and 2020. Sources: Van Dril and Elzenga (2005); RAINSWEB (2005) and MNP (2005).

Emission	**(kilotonnes)**	**2000**	**2010**			**2020**			
Component	**Sector**		**CAFE**	**SE**	**GE**	**CAFE**	**SE**	**GE**	**MTFR**
SO_2	Industry, Energy and Refineries	63	40	60	60	45	57	73	36
	Consumers, Services, Trade and Commercial	2	1	2	2	1	2	2	1
	Transport	9	17	4	4	18	5	5	4
	Total	**75**	**59**	**66**	**66**	**64**	**64**	**80**	**41**
NO_x	Industry, Energy and Refineries	100	62	73	75	62	77	84	27
	Consumers, Services, Trade and Commercial	46	22	25	28	19	18	21	19
	Transport	268	198	185	185	159	167	167	120
	Total	**414**	**282**	**284**	**288**	**240**	**262**	**272**	**166**
NMVOC	Industry, Energy and Refineries	90	55	59	60	110	65	68	75
	Consumers, Services, Trade and Commercial	69	119	59	61	60	63	71	40
	Transport	111	35	55	55	32	43	43	29
	Total	**269**	**210**	**173**	**176**	**202**	**171**	**182**	**144**
NH_3	Agriculture	139	131	109	111	126	103	130	87
	Industry, Energy and Refineries	3	3	4	4	3	5	5	4
	Consumers, Services, Trade and Commercial	8	9	8	8	9	8	8	9
	Transport	3	2	3	3	1	3	3	1
	Total	**152**	**144**	**124**	**126**	**139**	**119**	**147**	**101**
PM_{10}	Industry, Energy and Refineries	13	11	11	12	12	12	14	8
	Consumers, Services, Trade and Commercial	8	10	8	9	10	8	10	7
	Transport	17	15	13	13	13	13	13	8
	Agriculture	10	13	9	10	13	7	11	9
	Total	**49**	**50**	**42**	**44**	**48**	**41**	**47**	**32**
$PM_{2,5}$[a]	Industry, Energy and Refineries	7	7	6	6	7	6	7	5
	Consumers, Services, Trade and Commercial	4	7	4	4	6	4	5	4
	Transport	15	12	11	11	9	10	10	8
	Agriculture	2	3	2	2	3	1	2	2
	Total	**28**	**27**	**22**	**23**	**26**	**21**	**23**	**19**

[a] *$PM_{2.5}$ emissions have been derived from PM_{10} emissions as an emission inventory for $PM_{2.5}$ is not available*

The CAFE Baseline scenario differs from the GE and SE scenarios by its assumptions of a higher use of coal, lower proportion of diesel cars and number of animals (fewer dairy cattle and more other cattle). These differences are responsible for the main differences in emission (Table 2.3). Other Member States also report a higher use of coal than the CAFE Baseline (Eurelectric, 2005). Other differences in emissions are caused by differences in emission factors, use of control technologies and the definitions of activities. The higher fishery emissions for SO_2 (about 20%) and NO_x (about 9%) in 2010 and 2020 are caused by RAINS assuming the use of a heavy fuel instead of medium distillates for fishery ships (Jimmink et al., 2004). The level of implementation of control measures in RAINS in general reflects current Dutch policy, but not with respect to non-methane volatile organic compounds (NMVOC). RAINS seems to beappropriate for calculating abatement scenarios. (Jimmink et al., 2004).

The differences between RAINS calculations and national assessments may lead to the diffrent application of abatement measures (see Section 2.2) and result in other abatement emission levels.

This is especially true for the low coal use projection, which conceals abatement problems and costs for SO_2 when compared with national expectations on coal-fired plants. Since the calculation of abatement levels at the lowest costs is dependent on the activity level and the level of control, a good reflection of Dutch policy and scenario assumptions is necessary. For this reason, the Netherlands has submitted the GE scenario as the national scenario for presenting future developments specific to the Netherlands. Moreover the European Commission will also review the CAFE Baseline for the NEC review.

The Netherlands cannot attain the national emission ceilings for SO_2 and NO_x in 2010 under current policy. For ammonia and NMVOC, the ceiling will be attained unless new insights show higher ammonia emissions for manure applications and higher NMVOC emissions from the road transport sector (Van Dril and Elzenga, 2005). In the national scenarios, the projected emissions stabilize or increase from 2010 to 2020 for all components but NO_x. Consequently, in 2020 compliance with the 2010 agreements is still not achieved (Table 2.3).

2.2 Thematic strategy, measures and costs

- *To achieve the objectives of the thematic strategy, SO_2 emissions in the Netherlands should be reduced by about 50% between 2000 and 2020, NO_x emissions by 45%, NMVOC emissions by 40%, NH_3 by 30% and $PM_{2.5}$ emissions by 40%.*

- *Applying the ambition level for source policy in the thematic strategy, the total abatement costs increase by 10% with respect to current policy for the Netherlands in 2020.*

- *Additional costs for the Netherlands amount to about €330 million annually by 2020. Costs of the measures are paid for by the agricultural and industrial sector (both €115 million) traffic pays 25% (€90 million) and the residential sector 5% (€10 million).*

- *The gap closure approach is the most cost-efficient one for $PM_{2.5}$ abatement in the Netherlands since other countries contribute to the reduction of transboundary air pollution in the Netherlands.*

- *Total cost of the strategy for the Netherlands should be regarded as a lower limit. The magnitude of the cost of the abatement measures reported by the EU is approximately in line with national figures, with the exception of the costs for NMVOC. Next differences between national and EU scenario data may lead to higher abatement cost for SO_2 and NO_x..*

- *Almost all of the technical measures the Netherlands is assumed to take are cost-effective.*

The CAFE Baseline scenario has been used to derive policy scenarios from. Consequently, these derived policy scenarios incorporate the same differences and problems as described in Section 2.1. For SO_2 and NO_x the levels for current policy are lower in CAFE than the national scenarios. The levels in the CAFE Baseline already require policy efforts with respect to the national scenarios. On the other hand for NMVOC the emission levels are higher than in the national scenarios.

In the CAFE Baseline, a great deal of international legislation is assumed, such as the Large Combustion Plants directive, the Product and Solvent Directives, IPPC legislation and the Auto/Oil EURO emission standards. For the ambition levels, additional legislation is assumed. All measures are generic ‘end-of-pipe’ techniques. For road traffic only one ambition level has been assumed instead of different levels for different costs (see also Section 6.3). Although highly cost-effective, additional measures on sea transport have been left out of the policy scenarios because of time limitations (Amann, 2005e). No volumetric measures or local measures are (yet) applicable within the model context of RAINS. Furthermore, the link between possible techniques and the development of supporting European legislation is missing.

Environmental target setting

In the CAFE Baseline scenario, three different approaches to setting environmental targets have been explored, and RAINS has been utilized to calculate different environmental targets for the least cost within the framework of these different preconditions. The three different approaches are:

1. European-wide targets
2. Uniform limit values
3. Gap closure

In the European-wide approach, an environmental target is chosen. This may be a reduction in environmental effects averaged over the EU-25 (for example, a percentage reduction of mortality from chronic exposure to particulate matter in the EU-25). This target is achieved European-wide by identifying those measures in the EU-25 that reach the environmental target for the least costs. The location at which the environmental improvement is achieved is thus not taken into account, and the optimization measures will be implemented for those regions for which the benefits will be the largest for all of the member states. While this approach maximizes the use of resources, it may compromise on (perceived) equity aspects, because environmental improvement is not equally distributed.

In the uniform limit value approach, a limit value for $PM_{2.5}$ has been chosen that may not be exceeded in the background anywhere in the EU25. This is achieved by applying cost-effective reductions that bring $PM_{2.5}$ concentrations in urban background air sheds below a certain limit everywhere in the EU-25. The RAINS model has included City-Delta modelling results to address $PM_{2.5}$ levels in an urban setting. This approach has been set to reflect roughly the setting of a limit value. However, RAINS is not capable of calculating concentrations in street canyons or around industrial hot spots and is thus not capable of calculating costs for setting limit values (Amann et al., 2005c). Furthermore, the EMEP model, on which the RAINS model rests its calculations of particulate matter dispersion, does not quantify contributions from natural resources and from secondary organic aerosols.

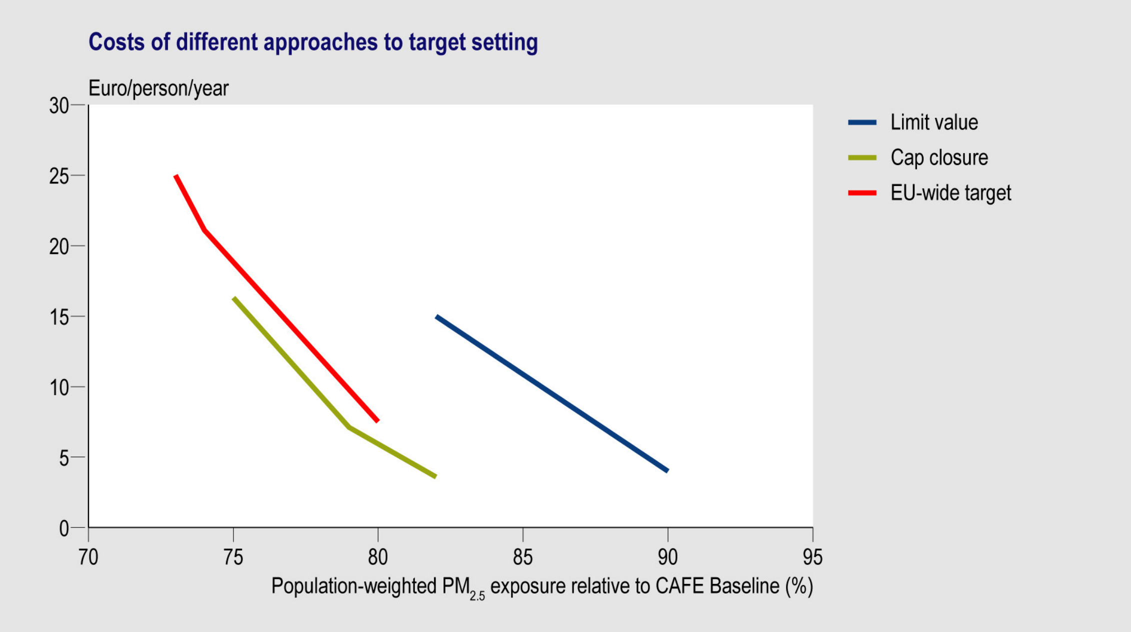


Figure 2.1 Costs for the three different approaches used in CAFE to abate $PM_{2.5}$ exposure in the Netherlands with respect to the baseline. Based upon Amann et al. (2005d).

The gap closure approach applies a uniform relative environmental improvement in every grid cell of RAINS in 2020 with respect to 2000. However, the uniform relative improvement in the gap between the current situation and environmental goals in 2020 is limited due to a few locations in the EU with typical situations. For example, the uniform gap closure is limited due to a large contribution from non-EU sources in Cyprus and the already relative clean air in Finland. In CAFE, the choice is made for a source-based 'gap closure' concept, which divides the scope for further improvement between the projected 'current legislation' case of the Baseline and the full application of all presently available control measures. In the source-based gap closure, a percentage of the maximum technical feasible reduction is applied for every member state.

On a European-wide scale, the different approaches do not differ greatly in cost and benefits (Amann et al., 2005d). However, on a national level, the approaches do differ. For the Netherlands, the limit value approach is an expensive approach and encompasses costs that are more than threefold higher for the same improvement with respect to exposure to $PM_{2.5}$ as the gap closure or an EU-wide approach (Figure 2.1). Since the Netherlands is in an area with the highest $PM_{2.5}$ concentration, the limit value approach leads to expensive measures for $PM_{2.5}$ concentration reduction. If a source-based gap closure approach is applied, all countries will reduce their emissions. This approach is the most favourable one for the Netherlands since all countries must participate in efforts leading to comparable measurements (the level playing field concept) and a lowering of the transboundary pollution in the Netherlands. Thus, other countries pay for reducing air pollution in the Netherlands, and vice versa (see Section 3.1.9). This approach is comparable to or slightly little more cost-effective than an EU-wide target approach (Figure 2.1).

Finally, an extensive analysis was carried out to determine the costs and the benefits of different levels of ambition for additional health and environmental protection. As mentioned earlier, these policy runs were based on a percentage improvement that lie between the baseline and the maximum technical feasible reduction for all countries ('country-wide source-based gap closure').

EU-wide objectives

The European Commission has ultimately chosen for a specific ambition level, which it sets out in its thematic strategy, a set of health and environmental objectives and emission reduction targets to be attained by 2020 (EU, 2005a).

The environmental objectives imply that the years of life lost due to $PM_{2.5}$ (concentration of $PM_{2.5}$) will be reduced by 75% and the health impacts attributable to ozone (concentration of ground level ozone) will be reduced by 60% of that which is technically feasible by 2020. In addition, the threat to the natural environment from both acidification and eutrophication will be reduced by 55% from what is technically possible by 2020.

The thematic strategy also sets EU-wide targets for reducing emissions between 2000 and 2020. SO_2 emissions will need to decrease by 82%, NO_x emissions by 60%, NMVOC emissions by 51%, NH_3 emissions by 27% and fine particulate matter $PM_{2.5}$ emissions by 59%.

Table 2.4. Environmental targets defined as a percentage improvement of that which is technically possible by 2020: current legislation (CLE) and MTFR are equal to. 0% and 100% improvement, respectively. Source:Amann et al. (2005e).

	CLE	**Thematic Strategy**	**MTFR**
Years of life lost due to $PM_{2.5}$ (EU-wide, million YOLLs)	0%	75%	100%
Acidification (country-wise gap closure on cumulative excess deposition)	0%	55%	100%
Eutrophication (country-wise gap closure on cumulative excess deposition)	0%	55%	100%
Ozone (country-wise gap closure on SOMO35 (see section 3.3)	0%	60%	100%

Consequences for the Netherlands

The thematic strategy proposes to reduce air pollution in EU between 2000 and 2020 with 82% for sulphur dioxide (SO_2), nitrogen oxides by 60% (NO_x), volatile organic compounds by 51% (NMVOC), ammonia by 27% (NH_3) and fine particulate matter ($PM_{2.5}$) by 59% (EU, 2005a). For the Netherlands the proposal means a reduction of SO_2 with about 40%, NO_x by 50%, NMVOC by 40% (NMVOC), ammonia by 30% (NH_3) and fine particulate matter ($PM_{2.5}$) by 20% (Table 2.5). Part of this reduction will be realized with current EU and national policies for example, by further implementation of Large Combustion Plants directive, national NOx-emission trading system, the Product and Solvent Directives, IPPC legislation and the EURO emission standards for mobile sources (Table 2.5). In CAFE three ambition levels have been defined (A, B and C) to reduce air pollution in EU-25 (Amann et al., 2005e; Table 2.5). The objectives presented in the strategy are based on these ambition levels. The ambition level in the thematic strategy matches the A ambition level for SO_2, the B ambition level for $PM_{2.5}$ and NH_3. The ambition level for NO_x is in between the A and B ambition level for the Netherlands.

Table 2.5 Emissions in 2000 and 2020 for current legislation (CLE) and according to the Thematic Strategy (TS) and the A, B and C ambition. Sources: Amann et al.(2005e and 2005f) for figures 2020 and MNP (2005) for figures 2000.

Emission (kt)	**2000**	**2020**				
		CLE	**TS**	**A ambition**	**B ambition**	**C ambition**
SO_2	75	64	45	45	43	42
NO_x	414	240	201	219	193	191
NMVOC	269	202	161	161	153	153
NH_3	152	139	105	110	104	103
$PM_{2.5}$	28	26	22	23	22	22

Costs of current emission control policies in the Netherlands are estimated at about €3300 million annually by 2020 for the Netherlands (Amann et al., 2005e), while additional costs have been estimated to be about €330 million annually by 2020 for the Netherlands. These additional costs represent a 10% increase over the costs of current policies.

Extra costs of the thematic strategy are borne by the agricultural and by the industrial sector (both 35% and €115 million), by the transportation sector (25%, €90 million), and by consumers (5%, €10 million).

Table 2.6 Control costs for current legislation (CLE) and additional costs for further emission reduction according to the Thematic Strategy (TS) and MTFR for the year 2020 for the Netherlands. Sources: RAINSWEB (2005) and Amann et al. (2005e and 2005f).

	Costs (M€/yr) CLE	**Costs (M€/yr) additional to CLE**	
		TS	**MTFR**[a]
SO_2	360	20	62
NO_x	285	82	714
NMVOC	42	10	415
NH_3	589	126	344
$PM_{2.5}$	118	8	363
Stationary sources sum	*1394*	*246*	*1844*
Traffic	*1947*	*82*	*82*
Total	3340	328	1926

[a] *Costs for MTFR match with figures in table 2.3 and are also based on RAINSWEB (2005). In Amann et al. (2005e) a different MTFR with cost of 897 M€ is reported.*

Technical measures to reduce air pollution in the Netherlands
The calculated reductions and cost involved for the Netherlands are based on technical measures for different components (Table 2.7). The RAINS model has calculated the most cost-effective measures in the Netherlands to achieve the targets as set by the European Commission (Table 2.4). According to National Emission Regulations (NeR) measure are cost-effective if they cost about 5 euro per kg or less. Cost and measures in RAINS as presented here will be checked in greater detail in October 2005 during the bilateral consultation with IIASA.

For SO_2, the most important cost-effective measures in the Netherlands to achieve thematic strategy ambition level by 2020 are further modifications in the refinery processes (7.5 kt). The cost-effectiveness of SO_2 measures is in line with Beck et al. (2004). All measures are cost-effective (Table 2.7). The cheapest and most important emission reductions according to RAINS is a switch to low sulphur fuels in sea fishery shipping (10.7 Kt, Table 2.7). However the figure of 10.7 kt is out of date; fishery ships already use low sulphur fuels in the Netherlands (Jimmink et al., 2004).

For NO_x, new EU emission standards for road traffic is an important measure for the Netherlands to achieve thematic strategy ambition level by 2020 according to RAINS (18 kt). Further technical measures to reduce emissions in industry, the energy sector and refineries (such as combustion modification and selective catalytic reduction techniques) are also important (about 21 kt). The magnitude of the cost-effectiveness is approximately in line with Beck et al. (2004) and all measures are cost-effective (Table 2.7). The cost of transport measures amount to about €5/kg NO_x (with important side effects on $PM_{2.5}$); for industry the cost is about €5/kg $NO_{x.}$ Road traffic measures reduce NO_x as well as $PM_{2.5}$, however, only costs for NO_x are considered in the cost curve NO_x (Figure 2.2.)

For fine particulate matter $PM_{2.5}$, thematic strategy ambition level may be achieved with new emission standards for road traffic (1.1 kt), highly efficient dedusting techniques in industry (1.0 kt) and various measures for households (1.2 kt, non-catalytic insertions in fireplaces and new stoves, ban on waste burning, filters in kitchens). Most measures are cost-effective with the exception of non-catalytic insert in fireplaces (Table 2.7). However, given the possible effect of primary particulates on health, the measures will be still be effective (see Chapters 4 and 6). The cost of these measures increases till about €10/kg (Figure 2.2).

Since agriculture is the major emitter of NH_3, almost all NH_3 measures apply to this sector. The most important of these are low ammonia emission applications of manure, the adaptation of animal housing (low emission stables) and low nitrogen-contained feed. In the Netherlands meanwhile extra measures have been taken for low ammonia emission application of manure with a potential of about 5-6 kt. The potential in RAINS (22 kt) for low ammonia emission applications of manure is rather high. This will be checked in greater detail in October 2005 during the bilateral consultation with IIASA.The cost-effectiveness for NH_3 measures is in line with Beck et al. (2004). Most measures are cost-effective, with the exception of the measures for fertilizer production and low nitrogen feed and stable adaptations for cows and pigs (table 2.7). The cost of these measures increases up to about €14/kg (Figure 2.2).

Most measures for NMVOC reduction involve good housekeeping measures and process adaptations in industry (Table 2.7). The measures presented in RAINS are relatively cheap and cost-effective, with only the use of solvent-improved paint being relatively expensive. However, compared with the cost-effectiveness measures presented in Beck et al. (2004), the cost projected in RAINS is lower by a factor of 10. This will be checked in greater detail in October 2005 during the bilateral consultation with IIASA.

Table 2.7 Cost-effective measures according to RAINS for realizing the thematic strategy objectives for the Netherlands. Source: RAINSWEB (2005).

	Emission reduction by 2020 compared to CLE (kt)					**Costs**	**Cost efficiency**
Sector: reduction measure	**SO_2**	**NO_x**	**$PM_{2.5}$**	**NH_3**	**NMVOC**	**(M€/yr)**	**(€/kg)**
Consumers: Low sulphur oil and coal	0.1					0.07	0.8
Transport: Low sulphur fuel in seagoing ships	10.7[1]					6.3	1
Refineries: Stage 3 control on process emissions from refineries	7.5					13.4	2
Industry: Flue gas desulphurization	0.2					0.4	2
Transport: Tightened EURO standards for road transport		18	1.1			82	5 (€/kgNO_x)
Industry/energy/refineries: combustion modification and selective and non-selective catalytic reduction techniques		21				82	4
Consumers: Ban on burning of residential waste			0.3			0.05	0.2
Industry: High-efficient dedusters industry, refineries and energy sector			1.0			1.0	1
Consumers: Filters kitchen households and on coal use			0.2			0.7	3
Consumers: Non-catalytic insert of fireplaces and new stoves			0.7			6.0	9
Agriculture: Low nitrogen application of animal manure				22		35.5	2
Agriculture poultry: Adaptation animal housing + low application of manure and low nitrogen feed				6		21.6	4
Industry: Fertilizer production				1.4		9.9	7
Agriculture cows and pigs: Low nitrogen feed + stable adaptation				4.3		59	14
Industry: Good housekeeping in industry					22	0.3	0.01
Industry: Leak detection and repair programme, Stage IV for steam cracking in chemical industry					4	0.6	0.2
Industry: Simulation of possible developments beyond the Product Directive in paint industry					5	0.8	0.2
Consumers: Catalytic inserts and new boilers or stoves in residential boilers					4.1	3.3	0.8
Industry/consumers: Various other measures					6	5	0.8
Total Thematic Strategy (kt)	19	39	3.3	34	41	328	
% transport	*56*	*46*	*34*			27	
% industry	*43*	*54*	*30*	*4*	*90*	35	
% consumers	*1*		*36*		*10*	3	
% agriculture				*96*		35	

[1] RAINS calculates higher emission reduction for sea fishery shipping than national estimates

The magnitude of the cost of the abatement measures reported by the EU is approximately in line with national figures, with the exception of the costs for NMVOC. Next to this the cost for abatement for SO_2 and NO_x are probably higher because of differences between the CAFE Baseline and national scenarios (see section 5.2). The total cost should therefore be regarded as a lower limit. The total costs based on national data are probably higher than calculated by RAINS.

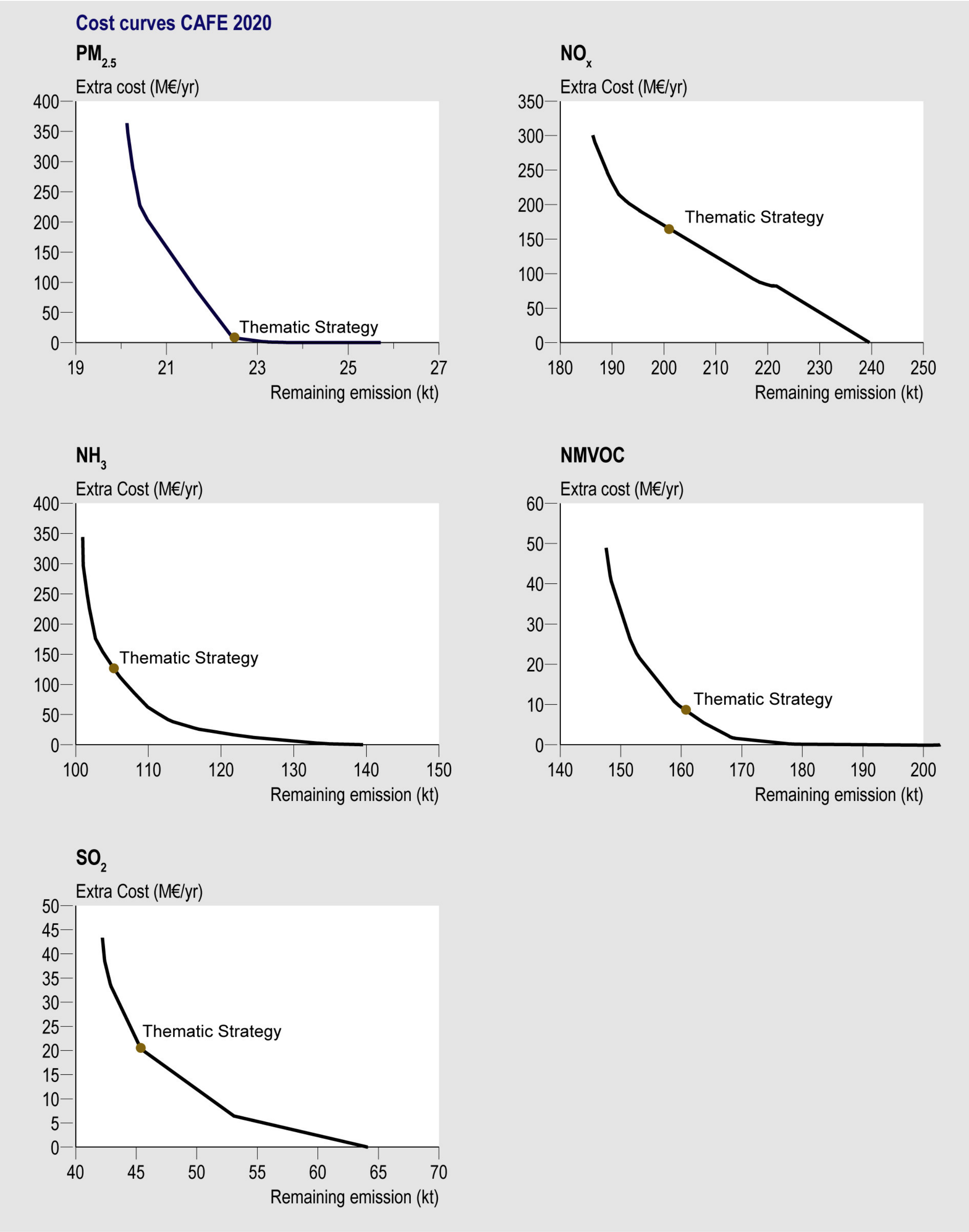


Figure 2.2 Cost curves for $PM_{2.5}$, SO_2, NO_x, NMVOC and NH_3 in RAINS for the CAFE Baseline in 2020 for the Netherlands. The formulated ambition level of the thematic strategy is indicated in the cost curves. The cost for mobile sources are all assigned to NO_x which is visible as a twist in the graph above. Source: RAINSWEB (2005).

2.3 Uncertainties in Dutch projections

- *There is an uncertainty of about 20% in the emission projections for 2010; these uncertainties will be larger in 2020.*

- *The uncertainty for particulate matter is unknown since the emission inventory is incomplete*

Uncertainties for the Dutch national scenarios have only been calculated for 2010. However, in 2020, the uncertainties in emission projections for the SE and GE scenario are at least as large as those for 2010. In 2010, the uncertainties amount to about 20% of the total emissions (Table 2.8).

Table 2.8 Emission projection in 2010 with lower and higher uncertainties deviations in the 2010 GE emission projections for the Netherlands.

Component/sector	**Emission projection (kt)**	**Uncertainty factor lower margin (kt)**	**Uncertainty higher margin (kt)**
SO_2	66.5	4.8	11.7
-Industry, energy and refineries	60.4	4.5	11.8
-Refineries	25.6	2.5	11.4
-Transport	4.2	1.0	1.0
NO_x	288.1	46.3	46.3
-Industry, energy and refineries	75.4	15.3	15.4
-Industry	67.3	15.0	15.0
-Transport	185.0	42.4	42.9
NH_3	126.0	26.9	24.7
-Agriculture	111.1	26.4	22.4
-Consumers	7.0	5.0	5.0
-Industry	4.0	4.9	4.9
PM_{10}	43.8	5.5	5.2
-Industry, energy and refineries	9.3	4.3	4.3
-Agriculture	10	0.8	0.5
-Transport	13.2	1.3	1.3
NMVOC	176.0	39.6	39.0
-Consumers	33.0	9.9	10.1
-Industry, energy and refineries	60.2	25.8	25.8
-Transport	55	23.8	24.6

For SO_2, the main uncertainties arise from refineries and power plants as the amount of fuel that will be used is uncertain. In the projections, it is assumed that a substantial reduction will be achieved because Shell has stated that its refineries will switch from oil to gas firing. However, there is a slim chance that this switch will not be made, which is the reason for the upper margin being larger than the lower one.

The main uncertainties for NO_x emissions result from the uncertainties surrounding emission factors in the transport sector. Test results are still not representative of real life situations. In the transport sector, the combustion temperature is very influential in determining the amount of NO_x emitted as are driving behaviours and the types of engines used. Because of the unpredictability of these factors, they cause large uncertainties. An additional considerable uncertainty for NO_x emissions arises from combustion emission factors in industry and power plants and the total amount of energy used.

The main uncertain factor for future NH_3 emissions, apart from an uncertainty in monitoring, is uncertainty concerning the efficiency of reducing NH_3 emission during the application of nitrogen onto grassland. The emission from low-emission machinery is very uncertain and is probably higher than previously assumed. Another uncertainty factor is the extent to which this technique will be applied to sandy soils. Finally, it also remains uncertain how the ratio of nitrogen excretion per animal will develop in the future.

For particulate matter emissions, only uncertainties for the known sources have been given. However, the emission projection is incomplete. Unknown sources that will determine the uncertainty in particulate emissions are missing from the projections for total emissions. Consequently, no estimate can be given for the uncertainty of the particulate emissions.

Uncertainties for NMVOC emissions are the highest in industry, energy and refineries and in transport. It was not possible to determine whether these uncertainties are mostly statistical monitoring uncertainties or scenario uncertainties.

No uncertainties (quantitative or qualitative) are presented for the CAFE Baseline scenario. However, given the results in Section 2.2, these seem to be at least larger than the uncertainties presented for the national scenarios.

2.4 Benchmarks

- *The Netherlands has one of the highest environmental pressures in the EU, but it also has one of the most eco-efficient economies of the EU.*

- *Comprehensive knowledge of particulate emission is currently lacking; moreover, data on particulate emission in RAINS seems to lack country-specific information.*

Compared to other Member States, the Netherlands is relatively densely populated and built up; it also has a lot of cattle. As a result, the Netherlands has a high emission of air pollutants per unit of surface area. This emission level is similar to those found in other densely populated areas in Europe, such as the Ruhr area in Germany, Northern Italy or London. However, when the emissions of many of these air pollutants are expressed per unit GDP or per number of inhabitants, the emission level in the Netherlands is relatively low compared with those of other Member States (Figure 2.4).

In the year 2000, emission factors for the Netherlands were lower than those in (almost) all of the other EU15 countries (Figure 2.3 and MNP (2005)). In the period 2000 to 2020, the decrease in emission factors for these other 14 countries is greater than in The Netherlands. An explanation for the difference in eco-efficiency is that the switch to natural gas had almost been completed by 2000 in the Netherlands, whereas in the other 14 Member States this transition proceeded at a later date. In addition to this, the Netherlands has applied more end-of-pipe technology than most of the other Member States. However, under current policy, other countries are catching up with the Netherlands.

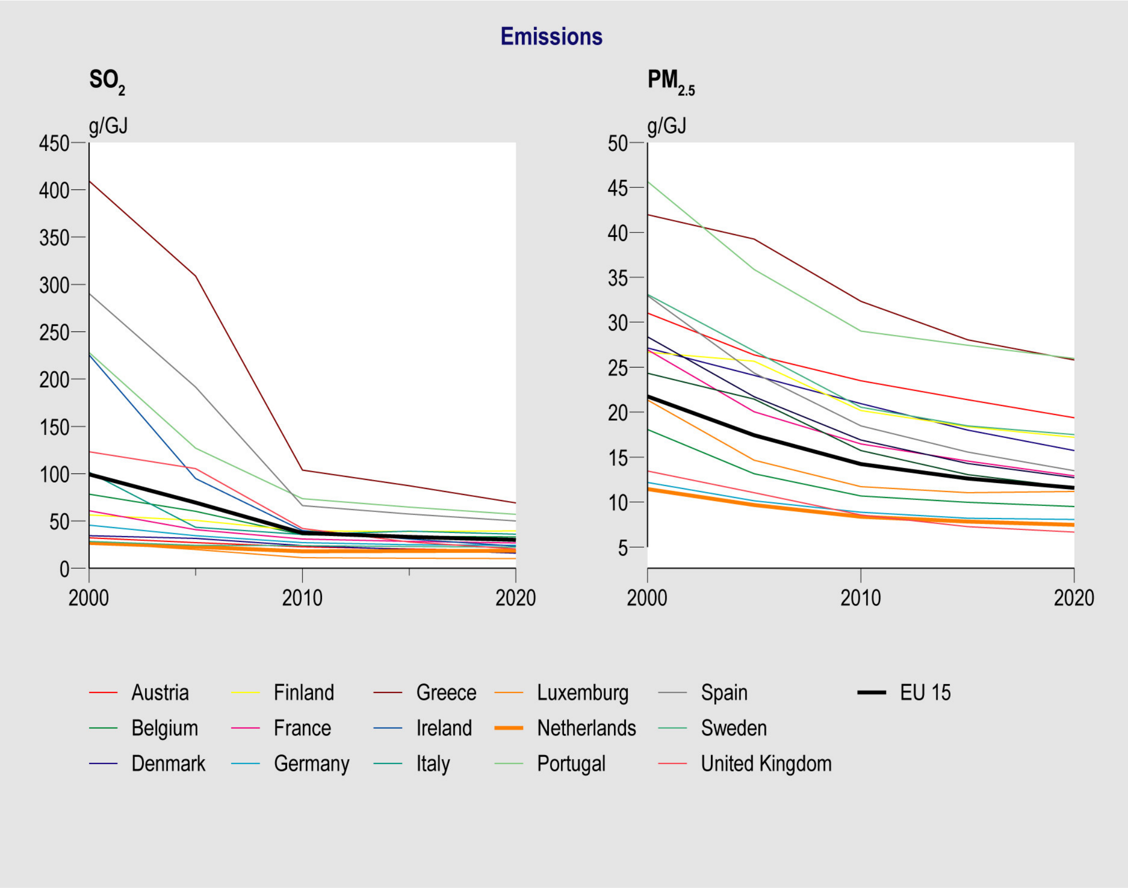


Figure 2.3 Emission of SO_2 and $PM_{2.5}$ in the EU15 per unit of energy use for 2000-2020 in the CAFE Baseline scenario. Source: RAINSWEB (2005).

PM_{10} per km^2 (2000)

NO_x per km^2 (2000)

PM_{10} per inhabitant (2000)

SO_2 per GDP (2000)

Figure 2.4 Emission levels per unit surface area GDP and per inhabitant for SO_2, PM_{10} and NO_x for 2000 for EU-15 countries. Source: RAINSWEB (2005).

$PM_{2.5}$ data in RAINS

In the EU25, the main contribution (40%) to total $PM_{2.5}$ emission comes from the domestic sector (stoves, fireplaces, barbeques, firework, smoking, space heating), with industrial processes and transport contributing approximately an additional 20%. Other sectors (power plants, waste burning, and agriculture) contribute 6%, 5%, and 3%, respectively (Table 2.9).

For stationary sources of $PM_{2.5}$ emissions, it is noticeable that the implied emission factor (2000) is equal in all countries except for Austria, Germany and the Netherlands; for example, stoves (RAINSWEB, 2005). The unabated emission factor is also the same for all countries (651 t/PJ), with the exception of Germany and Austria (67 and 149 t/PJ, respectively). For other components, such as

NO_x, the emission factors differ between each of the member states, but the absolute difference is less, as expected.

It is also remarkable that the emission factors in 2020 for residential and commercial fireplaces are exactly the same as in 2000. This is most likely due to the fact that there is currently no legislation for these sources. Germany has by far the lowest emission factor (77 versus 698) for uncontrolled fireplaces. For mobile sources, the emission factors are country- and time-specific, (partly) due to the use of a transport model in the context of RAINS that generates country-specific data.

Current knowledge on the emission of particulate matter in Europe is limited and, as a result, uncertainties are large (EEA, 2003). This is consequently reflected in the RAINS database. An additional factor is that many countries have not (yet) incorporated their specific emission factors into RAINS.

Table 2.9 Contribution of different sources to total $PM_{2.5}$ emission in the EU and in the Netherlands Source: Amann et al. (2005a).

Sector	**Contribution to total emission in 2020 (%)**	
	EU-25	**The Netherlands**
Domestic	43	23
Industrial processes	20	24
Transport	20	37
Power plants	6	0
Waste burning	4	2
Agriculture	3	9

3. Air quality in the future

In this chapter the developments in air quality in the Netherlands and Europe from 2000 up to 2020 are assessed for current policy, the policy ambition in the thematic strategy and Maximum Technical Feasible Reductions (MTFR). We assessed if the proposed air quality standards for particulate matter (PM_{10} and $PM_{2.5}$) and nitrogen dioxide (NO_2) will be attained in the Netherlands with the proposed policy in the thematic strategy. For this purpose, the air quality has been analysed at both the national and local scale. To determine the origin of this air pollution in the Netherlands, the contribution of different sectors in the Netherlands and abroad to the air pollution in the Netherlands has been calculated

Different scenarios have been used to calculate the air quality. We used the CAFE Baseline scenario and the national baseline scenarios Strong Europe (SE) and Global Economy (GE) to assess effects on air quality with current policy under different assumptions about future developments. The national scenarios also use the CAFE Baseline for the emission contribution from abroad. Differences between the CAFE Baseline and national scenarios were used to compare the results for air quality of these scenarios.

Policy effects of the thematic strategy have been assessed based on the CAFE Baseline for particulate matter and the GE national scenario for NO_2. For NO_2, we did not use the results derived from the CAFE Baseline because of the significant difference between the CAFE Baseline and the national scenario. However, there was no difference between the concentrations of particulate matter derived from the different baselines. We used two different variants for assessing the ambition levels for Euro standards for road transport (Euro5 light duty and EuroVI heavy duty) (see annex E and section 6.3). One variant uses the Euro standards as defined in the thematic strategy. The other differs with a recent proposal for lower Euro5 standards for light duty, as presented in the recent European Commission proposal for consultation (EU, 2005). The MTFR scenarios derived from the CAFE Baseline scenario have been used to calculate the potential of the maximum policy.

To compare if the air quality in the Netherlands differs from that in other member states, Dutch air quality levels have been compared with those in other member states. Results from the RAINS model have been used to compare air quality throughout Europe, whereas for the Netherlands, background concentrations were calculated with OPS and air quality in streets was calculated with the CAR model. Information on the models and methods can be found in Annex A.

In this chapter, air quality development is discussed first for particulate matter ($PM_{2.5}$ and PM_{10}), then forNO_2, ozone (O_3) and acid and nitrogen deposition.

3.1 $PM_{2.5}$ particulate matter

The thematic strategy and the proposal for an air quality directive contain two proposals to control the air quality for $PM_{2.5}$ (EU, 2005b):

- *A concentration cap for the annual average $PM_{2.5}$ concentration of 25 $\mu g/m^3$. This value has to be attained in 2010 (Van Giezen, 2005).*
- *An interim reduction target of 20% for the average urban background level for $PM_{2.5}$ concentrations, which is to be attained between 2010 and 2020.*

In addition, the European Commission introduces in its proposal for a new air quality directive a possibility to discount natural sources from air pollution levels for compliance purposes which can be determined with sufficient certainty. For the Netherlands, the discount of the contributions of sea salt and mineral dust from natural sources can be relevant in attaining the concentration cap for particulate matter concentrations.

The concentration cap for $PM_{2.5}$ is derived from the annual averaged limit value for PM_{10} of 40 µg/m^3 using a factor 0.6. The ratio of $PM_{2.5}/PM_{10}$ is about 0.75 (0.6–0.85) (Spoelstra et al., 2002; Denier van der Gon et al., 2003) in the Netherlands. The same rations are found across Europe, with the lower ratios observed for curbsites, where the highest concentrations occur. This suggests a large contribution of re-suspended road dust (Van Dingen et al., 2004). Consequently, the $PM_{2.5}$ concentration cap is stricter than the PM_{10} annual limit value and matches a yearly averaged PM_{10} concentration of about 33 µg/m^3. The daily limit value for PM_{10} is the strictest value since this limit value for PM_{10} matches an annual limit value of 31 µg/m^3 (Annex A).

3.1.1 Concentrations in Europe

- *Regional concentrations of anthropogenic $PM_{2.5}$ concentrations in the Netherlands and Belgium are at present, and will be in the future, the highest in Europe according to RAINS results.*

- *Concentrations in Dutch cities are comparable with concentrations found in other urban areas in Europe.*

- *The EMEP model, which is the basis for dispersion calculations in CAFE, overestimates the nitrate concentrations by about 3-4 µg/m^3 in the Netherlands; which leads to higher particulate matter concentrations.*

Regional areas
According to the RAINS model, the Netherlands, Belgium, the German Ruhr area, the Po area in Northern Italy and vast areas in Central Europe have the highest regional levels of anthropogenic $PM_{2.5}$ concentrations in Europe in 2000 (Figure 3.1). These areas have in common that they are densely populated and have relatively high emissions of primary particulate matter. This holds also for so-called precursor emissions – ammonia (NH_3), nitrogen oxides (NO_x) and sulphur dioxide (SO_2) – that contribute to the formation of secondary particulate matter. The high $PM_{2.5}$ concentrations in the Netherlands are specifically caused by the high concentration of secondary $PM_{2.5}$ particulate matter since the highest concentrations of primary $PM_{2.5}$ particulate matter occur in the Paris region, Belgium and the German Ruhr area (EMEP, 2004). In 2020, the highest concentrations of regional $PM_{2.5}$ will still occur in the Netherlands and Belgium, even if the MTFR scenario is applied over all of Europe. The EMEP model, which is the basis for dispersion calculations in CAFE, overestimates the nitrate concentrations by about 3-4 µg/m^3 in the Netherlands, which leads to higher particulate matter concentrations (Velders et al., 2005).

Urban areas
Calculations for 150 cities in 2000 show that $PM_{2.5}$ concentrations in cities in the Netherlands are at the same level (20–25 µg/m^3) as in cities in the Northern part of Italy, the German Ruhr area, Poland and Belgium and a few French and Spanish cities (Amann et al., 2004). For port cities, the estimates with city delta are too high since all particulate matter emissions from marine ships have been erroneously allocated to the ports, which directly affects the calculation for the two Dutch cities of Amsterdam and Rotterdam in city delta (Amann et al., 2004). In addition to this, RAINS cannot calculate concentrations in street canyons or around industrial hot spots and is thus not capable of determining the attainability of limit values (Amann et al., 2005c).

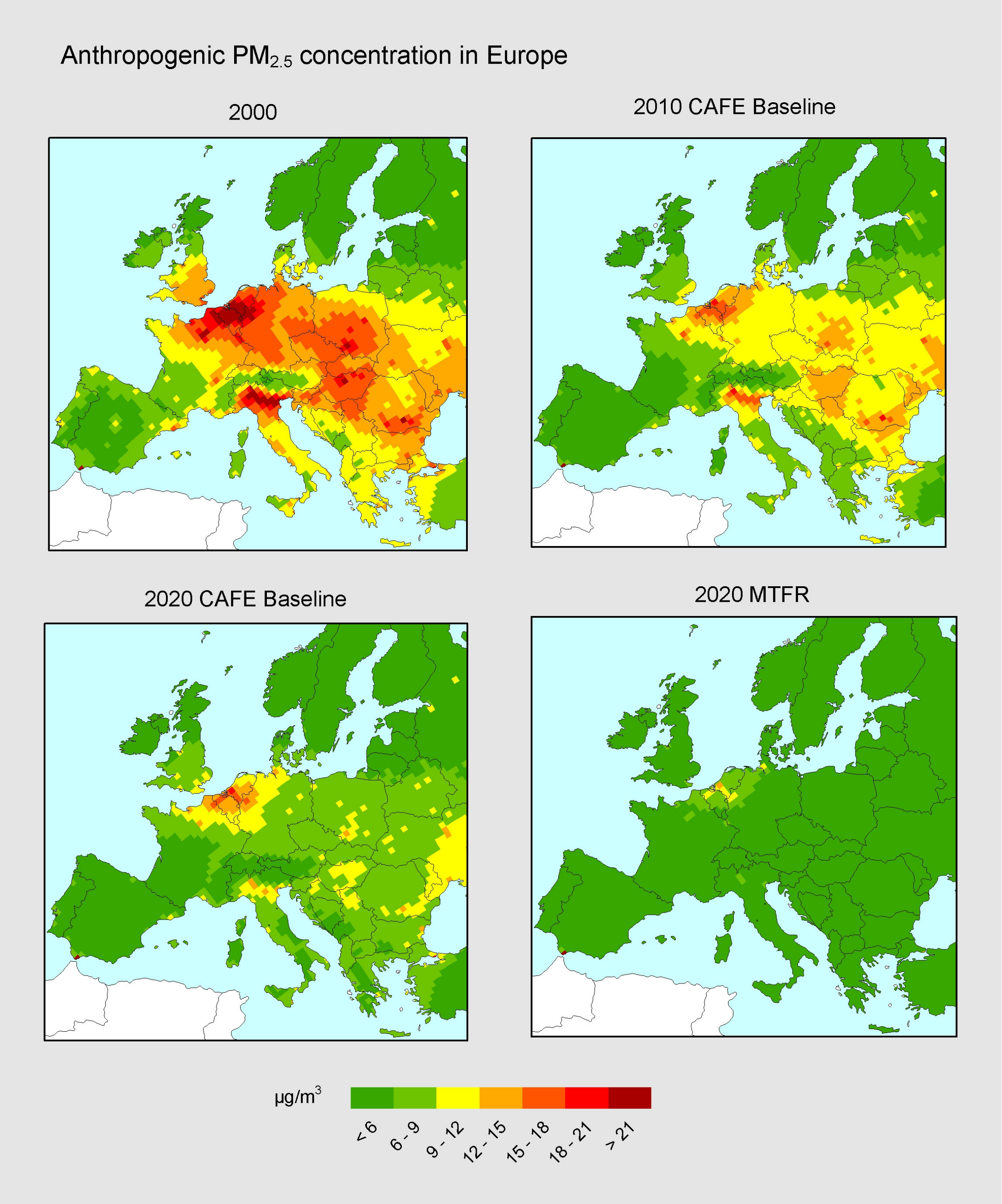


Figure 3.1 Anthropogenic regional annual mean $PM_{2.5}$ *concentrations* ($\mu g/m^3$) *calculated with the RAINS model for 2000, 2010 and 2020 under current policy and the Maximum Technical Feasible Reduction scenario (MTFR) using the meteorological conditions of 1997, except for 2010, for which the 1997, 1999, 2000 and 2003 meteorological conditions were averaged. Sources: Amann et al.(2004, 2005a).*

3.1.2 Concentrations in the Netherlands

- *With current policy, the concentration cap for $PM_{2.5}$ will be attained on a large scale, but will probably not be attained in 2010. Exceedances will occur in busy streets until 2020.*
- *Applying the ambition level in the thematic strategy, the concentration cap will possibly be attained in 2020 with additional local measures. Attainment in 2015 is not probable, even not if sea salt is discounted.*
- *The proposed interim reduction target of 20% for the average urban background level for $PM_{2.5}$ is very probably unattainable with the ambition level in the thematic strategy.*
- *The concentration cap for $PM_{2.5}$ is stricter than the annual limit value for PM_{10} but less strict than the PM_{10} daily limit value.*
- *The overestimation of RAINS/EMEP for nitrate concentrations will cause an overestimation of the reduction of $PM_{2.5}$ urban background concentrations when NO_x reductions are applied.*

Regional areas
The highest concentrations of anthropogenic $PM_{2.5}$ concentrations in the Netherlands occur in the urbanized western part and southern part of the country (Figure 3.2). The concentrations in Figure 3.4 are anthropogenic $PM_{2.5}$ concentrations and not total $PM_{2.5}$. Total $PM_{2.5}$ concentrations are 5–10 µg/m^3 higher due to an additional 'non-modelled' fraction of $PM_{2.5}$ (see 3.1.4). Total background concentrations range from about 13 to 22 µg/m^3 in 2015 and 2020 with current policy across the Netherlands. These concentrations are below the proposed concentration cap. With the ambition level in the thematic strategy, concentration levels will drop a further 5–10% to 12-20 µg/m^3 in 2020, and with the MTFR scenario, background concentrations will drop down to about 10–15 µg/m^3 in 2020.

The projected $PM_{2.5}$ emission levels based on the two national scenarios, Global Economy (GE) and Strong Europe (SE), and on the CAFE Baseline scenario differ significantly from each other (Chapter 2). However, the projected anthropogenic $PM_{2.5}$ concentrations based on these scenarios do not really differ (less than few percentages) (Figure 3.4). This is caused by the large transboundary contribution of 60-70% and that compared to total emissions the differences are relatively small.

The EMEP model, which is the basis for dispersion calculations in CAFE, overestimates nitrate concentrations by about 3-4 µg/m^3 in the Netherlands, which leads to higher particulate matter concentrations (Velders et al., 2005). The high nitrate concentration may overestimate the importance of long-range transport of NO_x over the Netherlands. Although in other areas the overestimation of nitrate concentration is not so high, it can be expected that the EMEP model overestimates the reduction of $PM_{2.5}$ background concentrations in the Netherlands when EU reductions in NO_x are applied.

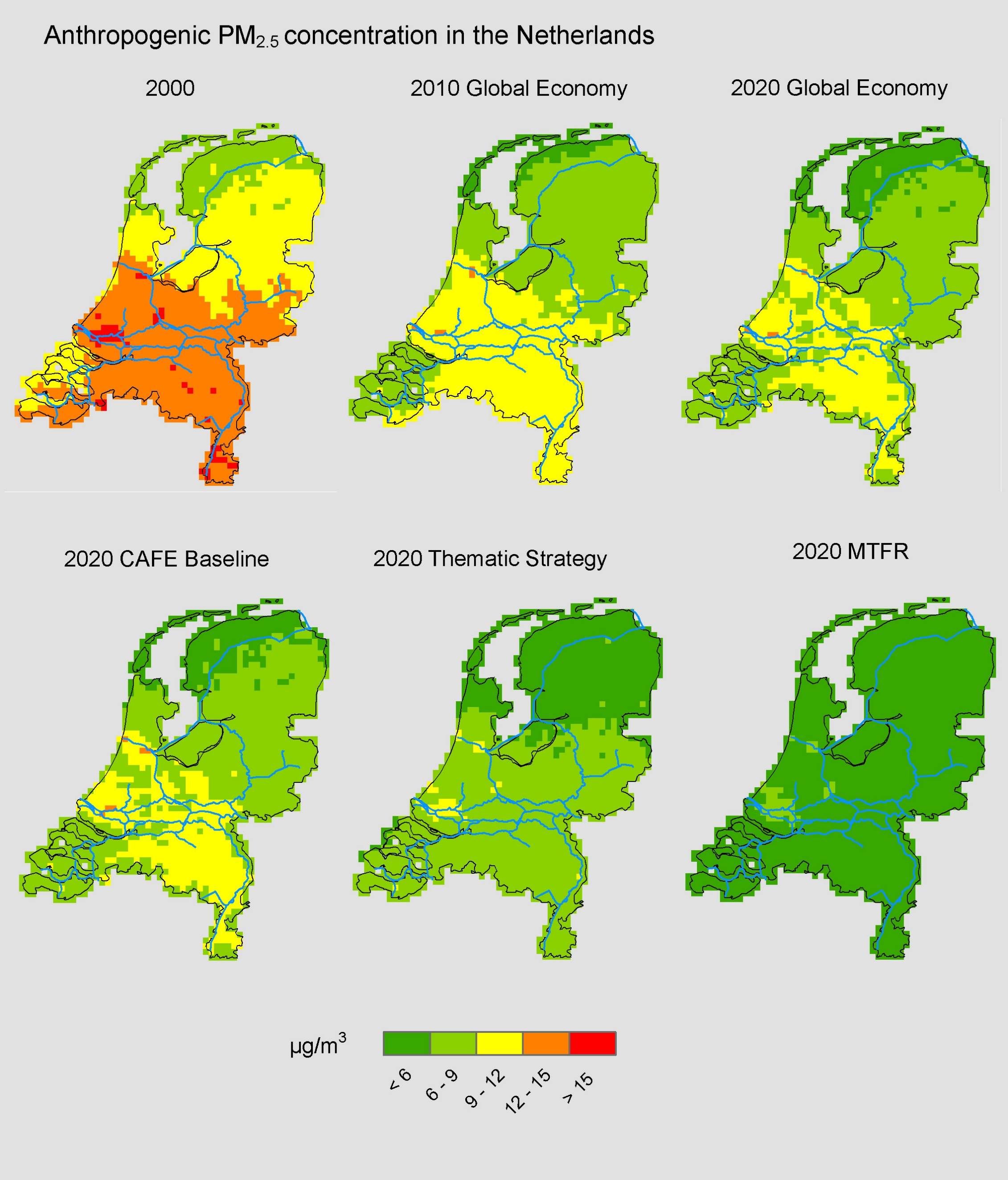


Figure 3.2 Annual average anthropogenic $PM_{2.5}$ concentrations ($\mu g/m^3$) for 2000, for current policy in GE for 2010 and 2020 and for current policy in CAFE Baseline, for policy ambition levels in the thematic strategy for 2020 and for MTFR for 2020 in the Netherlands. Concentrations are calculated with the OPS model based on long-term average meteorological condition.

Urban areas

With current policy, the total averaged $PM_{2.5}$ background concentration in Dutch agglomerations in 2010 and 2020 are estimated at 15–20 $\mu g/m^3$. With the ambition level in the thematic strategy, this drops down to about 14–19 $\mu g/m^3$ in 2020. The proposed interim reduction target of 20% for the average urban background level for $PM_{2.5}$ concentrations means a reduction of about 3–4 $\mu g/m^3$ between 2010 and 2020. With current policy, this average urban concentration decreases by 0.5 $\mu g/m^3$ between 2010 and 2020. With the ambition level in the thematic strategy, this concentration level drops by 2–3 µg/m^3 between 2010 and 2020 (Table 3.1), which is not enough to attain the proposed target. Only when the MTFR scenario is applied throughout Europe does the average urban concentration decrease by about 5 µg/m^3 between 2010 and 2020.

Table 3.1 Averaged anthropogenic $PM_{2.5}$ concentrations in agglomerations in the Netherlands in 2000, 2010 and 2020 for the different scenarios.

$PM_{2.5}^{a}$ (µg/m^3)	**2000**	**2010**	**2015**	**2020**		
Agglomeration		**GE**	**GE**	**GE**	**Thematic Strategy**	**MTFR**
Amsterdam/Haarlem	21.1 (19-24)	17.7 (15-20)	17.4 (15-20)	17.4 (15-20)	15.9 (13-18)	13.1 (11-16)
Utrecht	22.3 (20-25)	18.1 (16-21)	17.7 (15-20)	17.6 (15-20)	16.0 (14-19)	13.3 (11-16)
The Hague/Leiden	21.5 (19-24)	17.8 (15-20)	17.5 (15-20)	17.4 (15-20)	16.0 (14-19)	13.5 (11-16)
Rotterdam/Dordrecht	22.6 (20-25)	18.7 (16-21)	18.4 (16-21)	18.3 (16-21)	16.8 (14-19)	13.9 (12-17)
Eindhoven	22.3 (20-25)	18.0 (16-21)	17.5 (15-20)	17.3 (15-20)	15.9 (13-18)	13.0 (11-16)
Heerlen/Kerkrade	22.3 (20-25)	17.9 (15-20)	17.2 (15-20)	16.8 (14-19)	15.3 (13-18)	12.9 (10-15)
Average Agglomeration	21.8 (19-24)	17.9 (15-20)	17.6 (15-20)	17.5 (15-20)	16 (14-19)	13.3 (11-16)
Average Netherlands	19.4 (17-22)	16.0 (14-19)	15.6 (13-18)	15.4 (13-18)	14.2 (12-17)	12.1 (10-15)

[a] *A 'non-modelled' fraction of 7.5 (5–10) µg/m^3 is assumed.*

Streets

The information on $PM_{2.5}$ concentrations in the Netherlands is incomplete since there are only a limited number of measurement results and these are spatially and temporally inhomogeneous. However, the measurements that are available show concentrations of about 15–25 µg/m^3 (Annex B), which are below the concentration cap. The highest $PM_{2.5}$ concentrations are found in streets. Because of the large uncertainties and limited knowledge on $PM_{2.5}$ (see 3.1.4), the level of $PM_{2.5}$ exceedances of the cap in streets could not be accurately determined. First estimates indicate an additional traffic contribution in 2010 of up to 6 µg/m^3 along busy motorways and streets of major cities. In the agglomerations, a maximum background concentration of about 16–22 µg/m^3 is calculated for 2010 and 2020, when a non-modelled contribution of 5–10 µg/m^3 is assumed. This leads to a total maximum concentration in busy streets and along motorways of 20–28 µg/m^3 $PM_{2,5}$ in 2010. In 2015 and 2020, this traffic contribution is about 5 µg/m^3, leading to concentrations of 19–27 µg/m^3 $PM_{2,5}$ in streets. This range is around the proposed concentration cap, and exceedances of the cap will probably occur in busy streets in 2010, 2015 and 2020. When the ambition level in the thematic strategy for Euro standards for road traffic is applied, this traffic contribution could be reduced to 4 µg/m^3 in 2015 and 3 µg/m^3 in 2020 in streets (also when including the new Commission proposal (EU, 2005)). With the thematic strategy, the total concentration will drop to 18–26 in 2015 and 16–24 µg/m^3 in 2020 in streets, which makes it possible to attain the concentration cap in 2020. Possible exceedances will then be so specific that they probably can be resolved locally. When the MTFR scenario is applied, $PM_{2.5}$ concentrations will drop to 16–22 µg/m^3 in streets in 2020, and exceedances will probably be resolved.

Discount of natural sources

In its proposal for a new air quality directive, the European Commission introduces a possibility to discount contributions from natural sources to air pollution. Pollutant emissions to air from natural sources are capable of measurement but cannot be controlled. Therefore, where natural contributions to pollutants in ambient air can be determined with sufficient certainty, these can be subtracted when compliance with air quality limit values is assessed. In the Netherlands, this concerns sea salt and mineral dust, and the discounting of their contributions to air pollution from particulate matter can be relevant.

For PM_{10}, sea salt is already subtracted from the concentration levels, as indicated in the Order in Council for air quality (Bulletin of Acts, Orders and Decrees, 2005). Of the sea salt in PM_{10}, about 35% (25–50%) consists of the $PM_{2.5}$ fraction. This means a sea salt contribution to $PM_{2.5}$ of 1–2 µg/m^3, which is about 5–10% of the total background concentrations. If this amount of sea salt is discounted from the $PM_{2.5}$ levels, attainment of the cap is not probable in 2015, but it might be possible in 2020. Exceedances might still be possible but can then probably be resolved locally.

The contribution of mineral dust to $PM_{2.5}$ is much smaller and is about 20% of the PM_{10} crustal fraction. For $PM_{2.5,}$ a contribution of 0.5–1 µg/m^3 is expected. However, it is uncertain which part of this mineral dust is anthropogenic. For this reason, it is unknown how much of this fraction can be discounted. Since the man-made contribution can be rather large, there is not much perspective left for discount. The discount of natural sources means in practice a weakening of the limit value. When sea salt is discounted, the limit value matches a total annual mean limit value of about 26 µg/m^3 $PM_{2.5}$. This value corresponds to an exceedance of the yearly averaged PM_{10} concentration of about 35 µg/m^3.

3.1.3 Transboundary and sector contributions

- *The Netherlands is a net exporter of particulate matter.*
- *$PM_{2.5}$ is a transboundary problem, with about two-thirds of the anthropogenic pollution in the Netherlands coming from abroad.*
- *Major sources are industry, energy and refineries, (road) transport and agriculture.*

On average, about 70% of the anthropogenic $PM_{2.5}$ concentrations in the Netherlands originate, from foreign sources. In Heerlen, a city situated along the German-Dutch border in the southeastern part of the Netherlands, this foreign contribution amounts to 80%. In Amsterdam, it is limited to 50%. The major contributions of European sources to the anthropogenic $PM_{2.5}$ levels in the Netherlands come from industry, energy and refineries (40%), road transport (15–25%) and sea shipping (10–20%) in 2000–2020 (Table 3.2).

The largest domestic contributions to the $PM_{2.5}$ concentrations come from road transport (30–40%) and agriculture (20%). The contribution of road transport will decrease relatively quickly in the future. Sea shipping is the only sector for which the contribution is growing in absolute as well as in relative terms between 2000 and 2020.

Although the majority of the $PM_{2.5}$ air pollution in the Netherlands originates from sources abroad, the contribution of the Netherlands to $PM_{2.5}$ pollution in other countries is larger than the contribution of other countries to $PM_{2.5}$ pollution in the Netherlands (Table 3.4). The Netherlands is one the largest net exporters of $PM_{2.5}$ air pollution. However, almost all EU15 countries are net exporters of $PM_{2.5}$ air pollution as a large part of the pollution ends up over the sea and not over land. The sea has a very low emission level of $PM_{2.5}$ pollution per surface area at great distances off the coast, and hardly anyone, is exposed to particulate matter on the open sea. If the contributions of seas are neglected and only country-to-country contributions are considered, six EU15 countries are net exporters. The Netherlands and Belgium have the highest net export of $PM_{2.5}$ air pollution of these countries (Table 3.4).

Table 3.2 Sector contribution to the annual averaged anthropogenic $PM_{2.5}$ concentrations for the Netherlands for the year 2000 and for 2010 and 2020 for current policy (GE) scenario.

$PM_{2.5}^{a}$ ($\mu g/m^3$)		**Global Economy**	**Global Economy**
Sector	**2000**	**2010**	**2020**
Dutch sources			
Industry, energy and refineries	0.4	0.3	0.4
Road transport	1.5	0.9	0.9
Other transport	0.5	0.4	0.3
Agriculture	0.7	0.6	0.6
Consumers	0.4	0.4	0.5
Others	0.1	0.1	0.1
European sources			
Industry, energy and refineries	3.3	2.2	1.9
Road transport	1.9	1.0	0.7
Other transport	0.7	0.5	0.3
Agriculture	0.7	0.7	0.7
Consumers	0.8	0.6	0.5
Others	0.1	0.1	0.1
International shipping	0.9	0.8	1.0
Total	**12.2**	**8.6**	**8.0**

Tabel 3.3 Export/Import ratio for $PM_{2.5}$ calculated from the blame matrices of EMEP (2005). Export is here defined as the sum of the contributions of a country to the concentrations of $PM_{2.5}$ in all other countries (weighted by the area of the countries). Import is defined as the sum of all foreign contribution to the concentration in the country itself (weighted by the area of the country).

	Ratio Export/Import	
Country	**Excluding contribution to the seas**	**Including contribution to the seas**
Austria	0.9	1.3
Belgium	1.5	2.9
Denmark	1.0	2.4
Finland	0.5	0.8
France	0.6	1.7
Germany	1.1	2.1
Greece	0.4	1.8
Ireland	0.4	1.5
Italy	1.2	2.9
Luxembourg	1.2	1.5
Netherlands	1.5	3.2
Portugal	0.6	1.6
Spain	0.8	2.5
Sweden	0.3	0.7
UK	1.1	3.6

3.1.4 Uncertainties

The information on $PM_{2.5}$ concentrations in the Netherlands is incomplete since there are only a limited number of measurement results. Based on this limited number of measurements, a fraction of the ‘non-modelled’ $PM_{2.5}$ fraction has been estimated to be between 5 and 10 $\mu g/m^3$. Because of the limited data, no spatial estimate could be made. The non-modelled fraction contains ≤ 1 $\mu g/m^3$ $PM_{2.5}$ non-European hemispheric background, ≤ 2 $\mu g/m^3$ sea salt, some crustal material and a part which can be attributed to unknown or ill-defined sources. The assessment in this report has been based on this estimate for the non-modelled fraction. If future measurements show different levels, these will have an impact on the scenario calculations and, consequently, on the policy conclusions in this report.

An emission inventory for primary $PM_{2.5}$ emissions in the Netherlands is not available. Therefore, the inventory of $PM_{2.5}$ emissions has been derived with sector-specific scaling factors from the inventory of the PM_{10} emissions. Furthermore, the inventory of PM_{10} is not complete, and the uncertainties are unknown (Harmelen et al., 2005). The result is that the derived $PM_{2.5}$ emissions are more uncertain than the PM_{10} emissions.

3.2 PM_{10} particulate matter

The European Commission proposes to maintain the two current air quality standards for PM_{10}, but it will discard the stage II indicative limit values for 2010 (EU, 2005a). The current limit values are:

- The limit value for the 24-h averaged concentrations is 50 $\mu g/m^3$, not to be exceeded more than 35 days in a calendar year.
- The limit value for the annual average is 40 $\mu g/m^3$.

In addition to this, the European Commission introduces in the proposal for a new air quality directive a possibility to discount natural sources from air pollution levels for compliance purposes which can be determined with sufficient certainty. For the Netherlands, the discounting of the contributions of sea salt and mineral dust from natural sources can be relevant to compliance to particulate matter limit values. All calculations for PM_{10} in this report exclude sea salt concentrations according to the Bulletin of Acts, Orders and Decrees (2005).

3.2.1 Concentrations in the Netherlands

- *With current policy, the daily limit value for PM_{10} will probably still be exceeded in cities until 2020.*
- *With the ambition level in the thematic strategy, the PM_{10} exceedances will decrease by 50–80% extra in 2020, but exceedances will probably still occur in busy streets in 2020.*
- *Not all mineral dust is from anthropogenic sources. It is therefore not probable that the whole crustal fraction can be discounted as a natural source from PM_{10} . However, if, in addition to sea salt, this whole fraction is also discounted, this would have a large effect on attainment.*

Regional areas

PM_{10} concentrations show a gradient from south to north in the Netherlands, with the highest concentrations in the southern part of the country and in large cities (Figure 3.3). In 2000, exceedances of the limit value for the annual average in the background concentration were limited to some of the harbour areas in the Rotterdam and Amsterdam agglomerations. The more stringent limit value for the daily mean was exceeded in large parts of the Netherlands in 2000 (Figure 3.3). The PM_{10} concentrations in the Netherlands will decrease between 2000 and 2010 by 10–15% in the Baseline scenarios, and with a few percentages from 2010 to 2020. The exceedances of the annual limit value will disappear in the background concentration. The exceedances of the daily limit value will also decrease significantly with current policy, but will still occur in the southern part of the Netherlands until 2020. With the ambition level in the thematic strategy, the concentration will decrease still further by 5–10% (1–2 $\mu g/m^3$) with respect to current policy in 2020, and exceedances in the background concentration will largely disappear (Figure 3.3).

The differences between the national scenarios (GE and SE) and the CAFE Baseline scenario with respect to annual average PM_{10} concentration are negligible, primarily due to the diminishing effect of the large transboundary contribution and because of the small relative difference in total national emissions. However, on a local scale, the GE scenario leads to a 4 % higher concentration in Amsterdam and Hoek van Holland (Figure 3.3) because of the higher emissions around the transfer points of goods in this scenario.

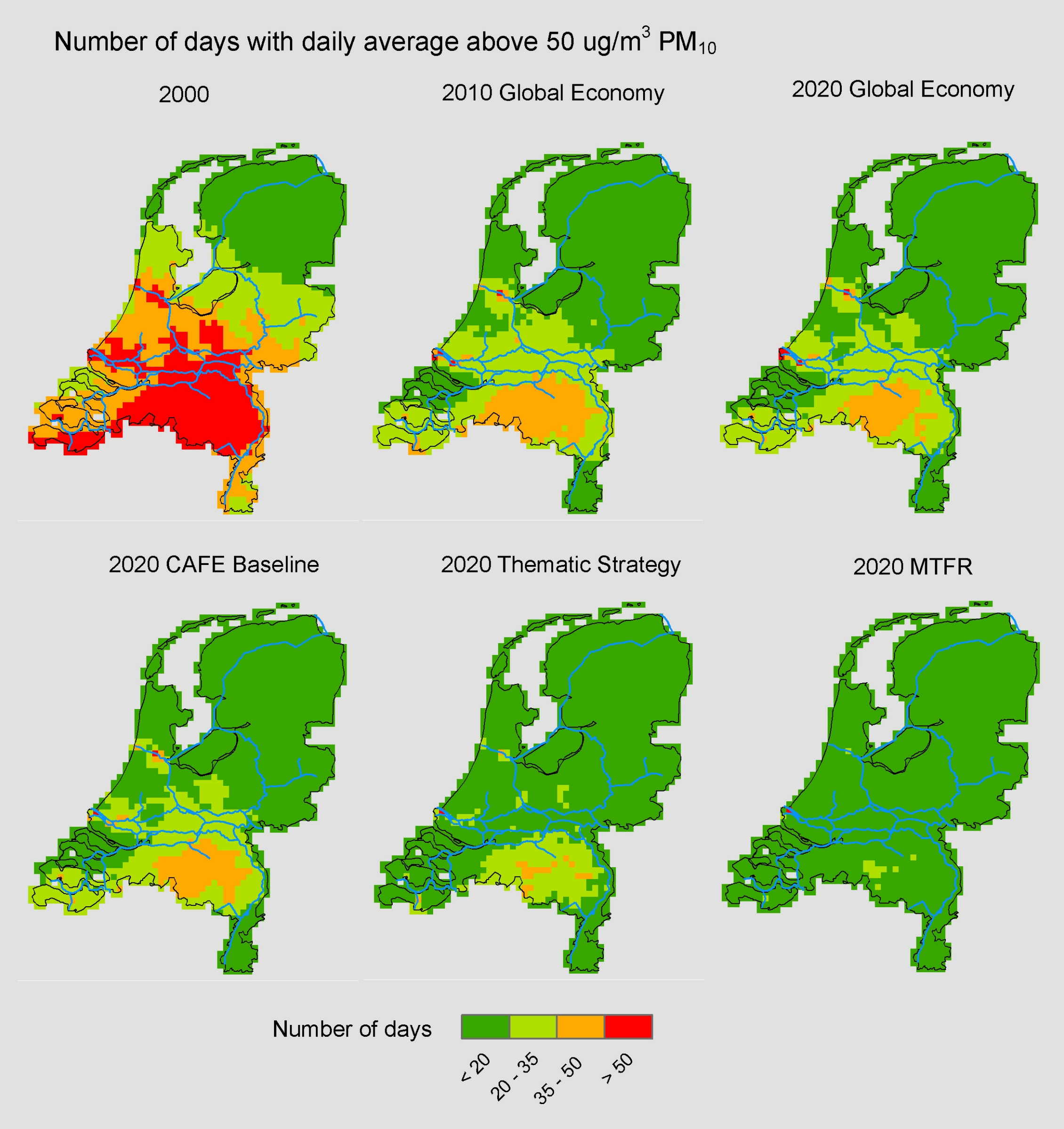


Figure 3.3. Number of days exceeding the daily value of 50 μg/m^3 PM_{10} for 2000, for current policy in GE for 2010 and 2020 and for current policy in the CAFE Baseline, in the thematic strategy and maximum technical feasible reductions (MTFR) for 2020 in the Netherlands. Orange and red indicate the locations where the daily limit value is exceeded. Concentrations are calculated with the OPS model based on long-term averaged meteorological conditions. Sea salt is discounted.

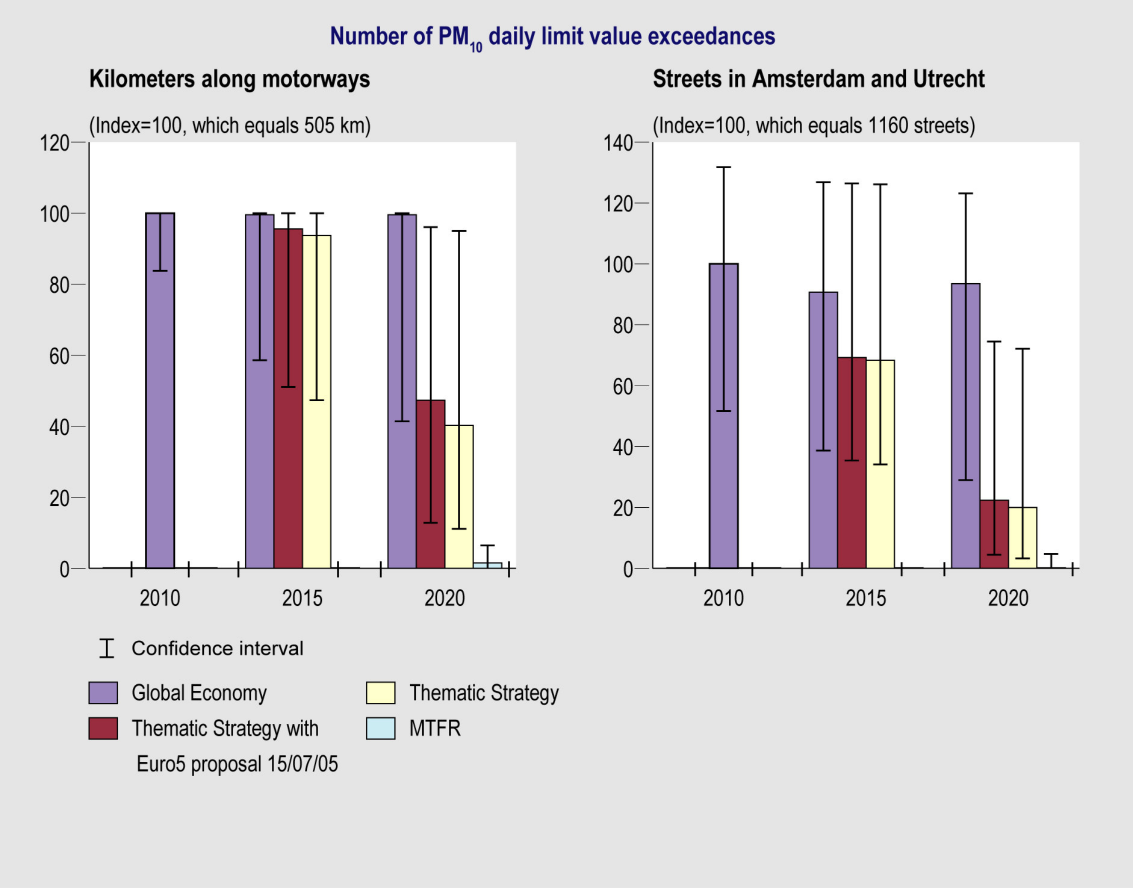


Figure 3.4. Number of exceedances of the PM_{10} daily limit value along motorways (km) and streets in Utrecht and Amsterdam with respect to current policy 2010 (GE), for thematic strategy, thematic strategy with euro 5 proposal15/07/05 in 2015 and 2020 and MTFR for 2020. Sea salt is discounted. The range indicated the confidence interval of 33-66%.

Urban areas and streets

The highest concentrations of PM_{10} occur along busy streets and motorways in urban areas. The local air quality has been calculated along a set of 164 hot spot stretches of motorways (505 km) and along a set of 1269 streets in Utrecht and Amsterdam (Annex A). Exceedance of the daily PM_{10} limit value probably remains up till 2020 with current policy. Exceedances of this limit value along motorways do not decrease in Figure 3.4 between 2010 and 2020 with current policy because concentrations for all of the examined stretches of motorway remain above the limit value. In streets, the decrease is about 20% between 2010 and 2020 with current policy (Figure 3.4). The thematic strategy has been based on new Euro standards for light duty (Euro5) and heavy duty (EuroVI). The ambition levels for Euro5 standards for particulate matter for road traffic do not differ greatly from the recent proposal of the European Commission for consultation and thus give about the same improvement (Figure 3.4). When the source policy in the thematic strategy is carried out, the exceedances will fall by an extra 5–25% in 2015 and 50–80% in 2020. However, exceedances probably still remain in busy streets in 2020. However, if maximum technical feasible reductions are applied, the exceedances are probably resolved in 2020 (Figure 3.4).

Discount of natural sources

The European Commission introduces in the proposal for a new air quality directive a possibility to discount contributions from natural sources to air pollution. Pollutant emissions to air from natural sources are capable of measurement but cannot be controlled. Therefore, where natural contributions to pollutants in ambient air can be determined with sufficient certainty, these can be subtracted when compliance with air quality limit values is assessed. For the Netherlands, the discounting of the contributions of sea salt and mineral dust from natural sources from particulate matter can be relevant.

For PM_{10}, sea salt is already subtracted from the concentration levels as indicated in Order in Council for air quality (Bulletin of Acts, Orders and Decrees, 2005). Sea salt has been taken into account in this assessment according to the Order in Council. For the daily limit value, 6 days can be discounted for sea salt.

The contribution of mineral dust to PM_{10} is about 3–5 $\mu g/m^3$ (Visser et al., 2001), which is much larger than its contribution to $PM_{2.5}$. However, it is uncertain just which part of this mineral dust is anthropogenic, and the exact level and spatial distribution is also unknown. For these reasons, it is unknown how much of this fraction can be discounted. Since the man-made contribution can be rather large, there is not much perspective left for discount. However if 3–5 $\mu g/m^3$ can be discounted, this will have large consequences on the attainment of the daily limit value for PM_{10}.

The discount of natural sources means in practice a weakening of the limit value. The daily limit value corresponds to the annual mean limit value of about 31 $\mu g/m^3$ PM_{10}. When sea salt is discounted, the daily limit value matches a total annual mean limit value of about 32 $\mu g/m^3$ PM_{10}. Although sea salt probably has no effect on health, mineral dust probably does (Brunekreef and Forsberg, 2005).

3.2.2 Transboundary and sector contributions

- *The Netherlands is a net exporter of particulate matter.*

- *PM_{10} is a transboundary problem, with about two-thirds of the anthropogenic pollution in the Netherlands coming from abroad.*

- *Major PM_{10} sources are industry, energy and refineries, (road) transport and agriculture.*

More than one-half (55%) of the total PM_{10} concentrations in the Netherlands originates from natural or unknown sources. Anthropogenic sources contribute 45% to the total PM_{10} concentrations, with 15% of the concentration coming from sources in the Netherlands. In Heerlen, a city situated along the German-Dutch border in the southeastern part of the Netherlands, the national contribution is 10%, whereas in Amsterdam it is 30%. Local road traffic contributes about 15% (average) to the local PM_{10} concentrations along motorways and 5–10% along streets. These figures remain constant over the years.

The major contributions of European sources to the anthropogenic PM_{10} levels in the Netherlands come from industry, energy and refineries (40%), road transport (15–20%,) sea shipping (10–20%) and agriculture (10%) in 2000-2020 (Table 3.4).

The largest domestic contributions to the PM_{10} concentrations come from road transport (30–35%), agriculture (25%) and consumers (10–15%). The contribution of road transport will decrease relatively quickly in the future. Sea shipping is the only sector whose contribution is growing in both absolute and relative terms from 2000 until 2020.

Although the majority of the particulate air pollution (PM_{10}) in the Netherlands originates from sources abroad, the Netherlands exports in deposition terms threefold more pollution than it imports (Figure 3.5), in the form of precursors of particulate matter and primary particulates (potential particulate matter). This means that the mass of air pollution from the Netherlands that deposits abroad is threefold larger than the mass of air pollution from abroad that deposits in the Netherlands. Deposition and the concentration of particulate matter in the air are positively correlated but cannot be considered to be the same thing. It is the concentration of particulate matter in the air which is the relevant factor with respect to health impacts. According to EMEP in terms of concentration the contribution of the Netherlands to $PM_{2.5}$ pollution in other countries is larger than the contribution of other countries to $PM_{2.5}$ pollution in the Netherlands (see Section 3.1.3).

Table 3.4 Sector contribution to the annual average PM_{10} concentrations for the Netherlands for the year 2000 and for 2010 and 2020 for current policy.

$PM_{2.5}$ ($\mu g/m^3$)		**Global Economy**	**Global Economy**
Sector	**2000**	**2010**	**2020**
Dutch sources			
Industry, energy and refineries	0.5	0.5	0.6
Road transport	1.7	1.1	1.1
Other transport	0.6	0.5	0.4
Agriculture	1.1	0.9	1.0
Consumers	0.5	0.5	0.5
Others	0.3	0.3	0.3
European sources			
Industry, energy and refineries	4.3	2.5	2.2
Road transport	2.2	1.3	0.9
Other transport	0.8	0.6	0.4
Agriculture	0.8	0.8	0.8
Consumers	0.8	0.6	0.5
Others	0.1	0.1	0.1
International shipping	1.0	0.9	1.2
Other			
Non-modelled	17.9	17.9	17.9
Total	**32.6**	**28.4**	**27.8**

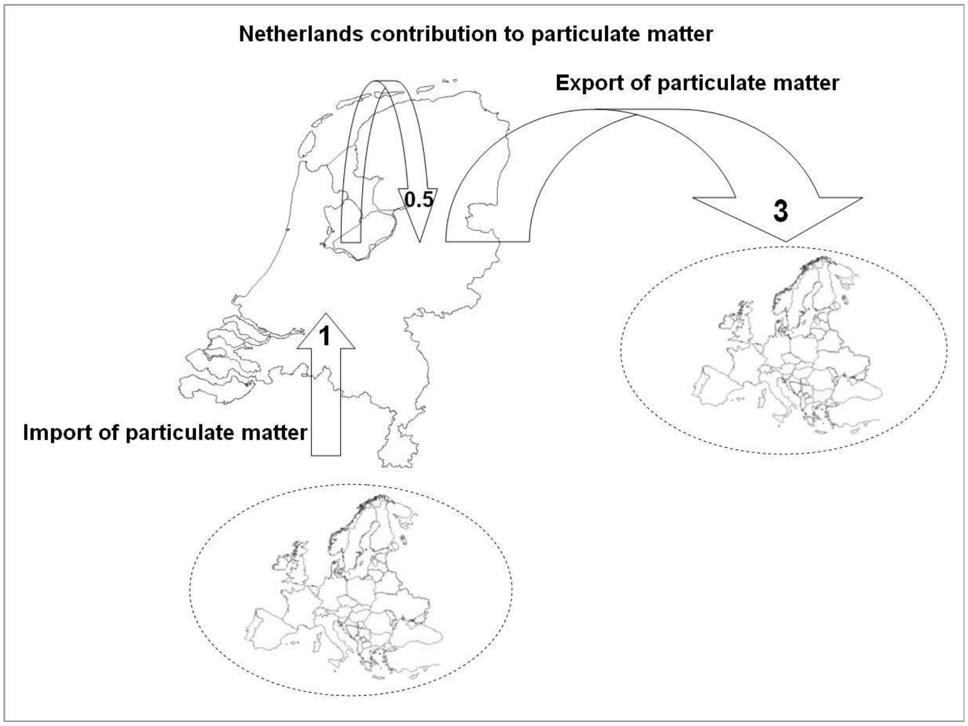


Figure 3.5 Import and export of mass of deposition of anthropogenic potential PM_{10} pollution in 2000 expressed in units of pollution imported. The ratios are based on deposition calculations with OPS.

3.2.3 Uncertainties

The Netherlands Environmental Assessment Agency uses extensive data on societal developments, emissions, measurements and meteorological and chemical knowledge to calculate concentrations in streets and motorways. Uncertainties in these parameters, in particular with respect to as background concentrations of particulate matter, emissions of particulate matter, local traffic intensity, local share of light and heavy duty, emission factors, model uncertainty, speed of traffic and local influence of trees and meteorology are taken into account (Matthijsen, 2005; Figure 3.4). The range calculated in Figure 3.4 indicates a confidence interval of 33-66%. It is improbable that any values fall outside of this range.New insights may lead to higher or lower emissions and, consequently, higher or lower concentrations of emissions. Deviations in important parameters are incorporated into the uncertainty ranges, as mentioned above. At the time of publication of this report, there are two important developments which may have a significant influence on the calculations.New forecasts indicate lower growth figures from 2010 up to 2020 for road transport of goods and inland shipping, lead to lower emissions in the Netherlands.

The annual average PM_{10} concentrations are underestimated by all models. Studies have shown that about one-half of the total measured PM_{10} concentrations is non-modelled. Visser et al. (2001) concluded that the non-modelled fraction consists of hemispheric background contribution, sea salt and some crustal material and unknown or ill-defined sources. For scenario calculations, this non-modelled fraction has been estimated on the basis of a long-term time-series measurement of PM_{10}. As a direct result of the first daughter directive, the Dutch monitoring air quality network had undergone some changes and adapted the measurement stations to meet the new requirements. The measurement results of this new monitoring network show lower concentrations for regional monitoring stations, as would be expected based on historical time series, emission trends and meteorological circumstances (RIVM is currently examining these new results).

Because of the link between measurements and scenario results, the outcome of this examination may impact on the scenario calculations and, consequently, on the policy conclusions in this report.

3.3 Nitrogen dioxide

In the thematic strategy, the European Commission proposes to maintain the limit values for NO_2. Two limit values were set for NO_2 in the first daughter directive (EU, 1999):

- The European limit value for the annual average concentration of NO_2 is 40 $\mu g/m^3$.
- For the short-term exposure to NO_2, the limit value is a hourly mean value of 200 $\mu g/m^3$ and may not be exceeded more than 18 times per year.

3.3.1 Concentrations in Europe

- *Regional NO_2 concentrations in the Netherlands are relatively high, but concentrations in cities in the Netherlands are comparable with those in other European cities.*

Regional concentrations of NO_2 are high in the Netherlands, Belgium, the German Ruhr area and in Northern Italy (Figure 3.6). Exceedances of the limit value occur all over Europe. The measured NO_2 concentrations in 2002 in cities in the Netherlands are comparable with those in cities in other parts of Europe.

3.3.2 Concentrations in the Netherlands

- *With current policy, exceedances of the NO_2 limit value will probably remain up to 2020. However, NO_2 concentration will decrease, and exceedances of the limit value will drop by 60–70% from 2010 up to 2020.*

- *With the ambition level in the thematic strategy, the exceedances will drop even more – by 60–80% in 2015 and 90–100% in 2020. Attainment of the limit value is then possible from 2015 onwards. Possible exceedances can be resolved with additional local policy.*

- *If the lower ambition level of the recent Commission proposal for Euro standards for passenger cars is implemented instead, attainment of the limit value is just possible from 2020 with additional local measures.*

Regional areas

The highest NO_2 concentrations are found in the urbanized western part of the Netherlands (Figure 3.7). The limit value for NO_2 is not exceeded in the background concentration at the present time (2004) and in the future, and NO_2 concentrations decrease with current policy (Figure 3.7). The NO_2 background concentration will decrease by 8% between 2010 and 2020 with current policy. With the ambition level in the thematic strategy, the background concentration will decrease by 20% between 2010 and 2020. Maximum technical feasible reduction reduces the background concentration by 30% between 2010 and 2020

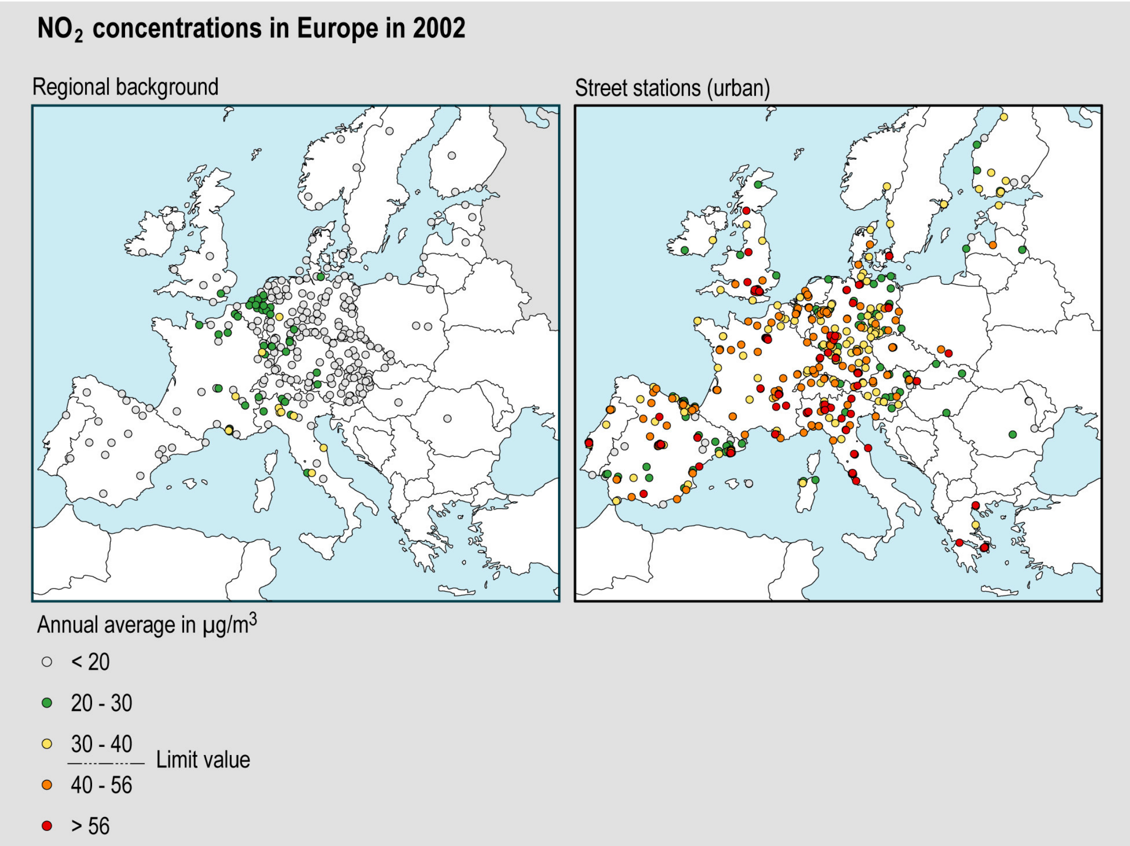


Figure 3.6 Annual mean nitrogen dioxide concentrations measured at rural and urban street locations in the European Union in 2002. Source: Airbase (2005).

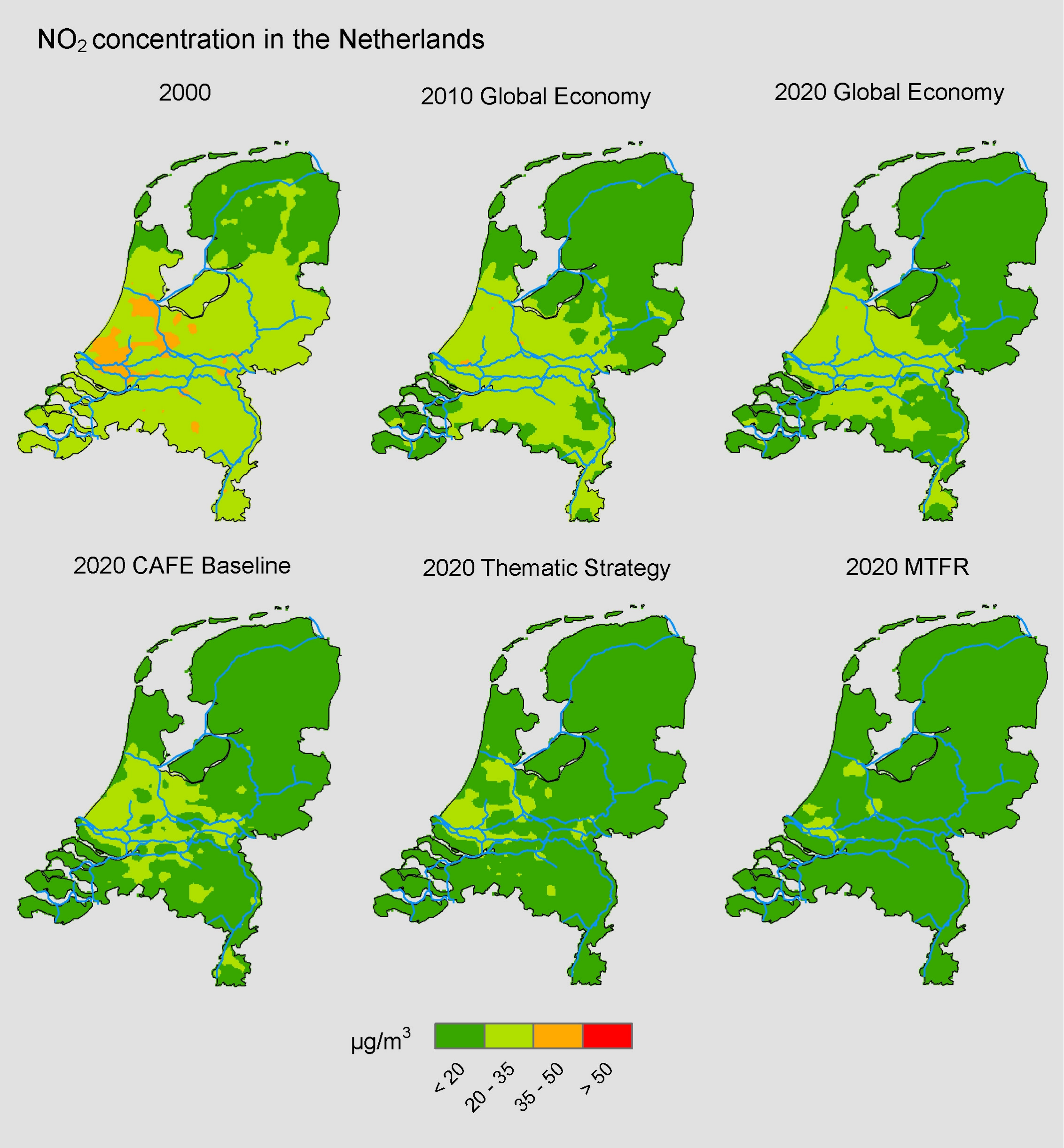


Figure 3.7. Annual averaged NO_2 concentrations for 2000, for current policy in the GE scenario for 2010 and 2020 and for current policy in the CAFE Baseline scenario, in the thematic strategy and maximum technical feasible reduction (MTFR) for 2020, in the Netherlands. Concentrations are calculated with the OPS model based on long-term averaged meteorological conditions.

The NO_2 concentration in the CAFE Baseline scenario is significantly lower (10%) than in the national scenarios (Figure 3.7). This is caused by the differences in the NO_x levels as described in Chapter 2. These differences have not affected the assessments in the CAFE Baseline scenario since no calculations have been made for NO_2 in CAFE. Because of these differences, we did not assess the effects of the thematic strategy based on the CAFE Baseline. For NO_2, we calculated the effects of the thematic strategy based on the national scenario Global Economy. The results of this scenario match the results based on the other national scenario, Strong Economy.

Streets

The highest concentrations of NO_2 occur along busy streets and motorways in urban areas. The local air quality has been calculated along a set of 164 hot spot stretches of motorways (505 km) and a set of 1269 streets in Utrecht and Amsterdam (Annex A). With current policy, there are probably still exceedances of the NO_2 limit value along motorways and in streets in cities, although the situation improves strongly (60–70%) from 2010 up to 2020 (Figure 3.8). The ambition level for Euro5 standards for NO_x in the recent proposal of the European Commission is much less ambitious (see Section 5.3) than the ambition level for the thematic strategy, and it therefore gives much less improvement (Figure 3.8). With the policy proposals in the thematic strategy, exceedances for NO_2 will decrease even more by 60–80% in 2015 and 90–100% in 2020. Attainment of the NO_2 limit value will then be possible from 2015 onwards, and possible exceedances can be resolved with local additional measures. However, when the thematic strategy with EuroVI but with the lower ambition level for Euro5 is carried out instead, attainment of the NO_2 limit value will then just be possible with additional local policy in 2020. Exceedances will just drop extra – 30% in 2015 and 60–80% in 2020 with these less ambitious standards (Figure 3.8).

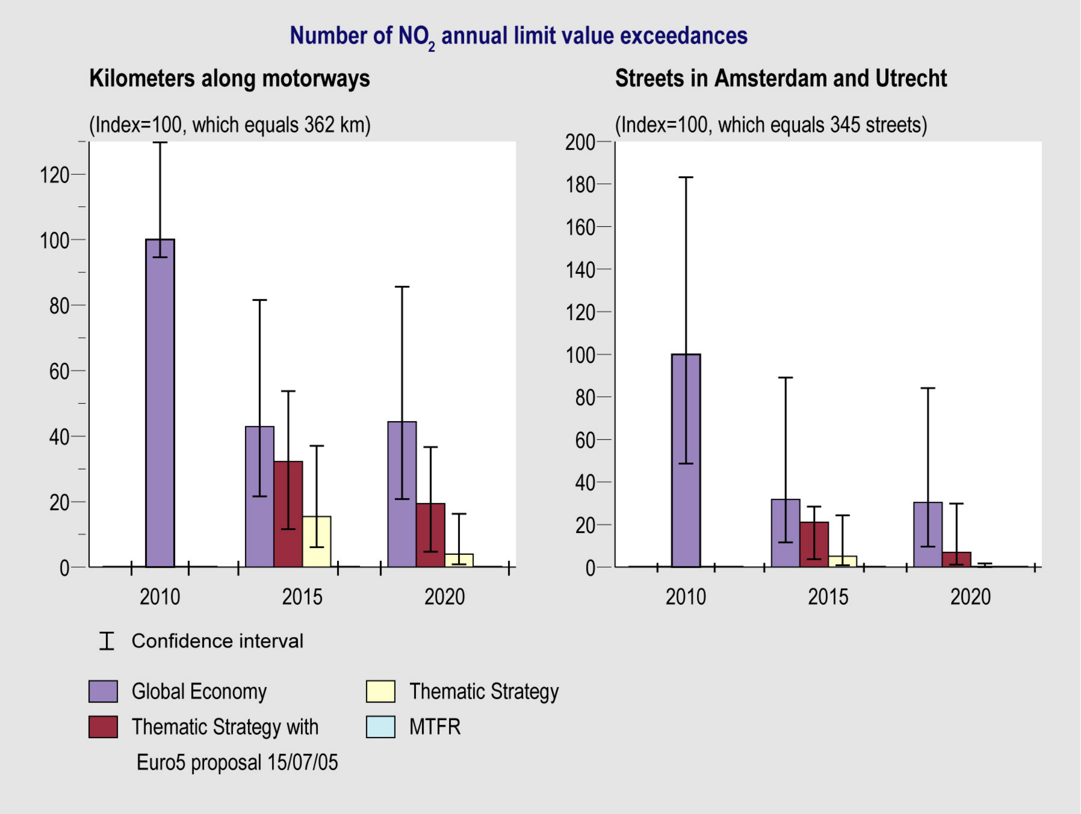


Figure 3.8. Number of exceedances of the the NO_2 limit value along motorways (km) and streets in Utrecht and Amsterdam with respect to current policy 2010 (GE), for the thematic strategy, thematic strategy with euro 5 proposal15/07/05 in 2015 and 2020 and MTFR in 2020. The range indicates the confidence interval of 33-66%.

3.3.3 Transboundary and sector contributions

- *Road traffic is the major source of NO_2 at all levels*

About 60% of the NO_2 concentration in the Netherlands is caused by national sources and 40% by sources abroad. Road traffic is the largest national (30–35%) and foreign (10–15%) source, and together these two sources contribute 40–50% to NO_2 levels in the Netherlands (Table 3.5).

The contribution of traffic to local NO_2 levels along motorways varies from an average of 35% to a maximum of about 55%. In the streets of major cities, these values are 15% and approximately 45%, respectively (Figure 3.9).

Table 3.5. Sector contribution to the annual average NO_x concentrations in the Netherlands in 2000 and in 2020.

Sector	**2000**	**2020 GE**
	(%)	**(%)**
Dutch sources		
Industry and Energy	5	7
Road traffic	34	29
Mobile machinery	7	5
Non-road traffic	4	7
Agriculture	1	1
Consumers	5	4
Others	4	3
European sources		
road traffic	17	10
other	24	35

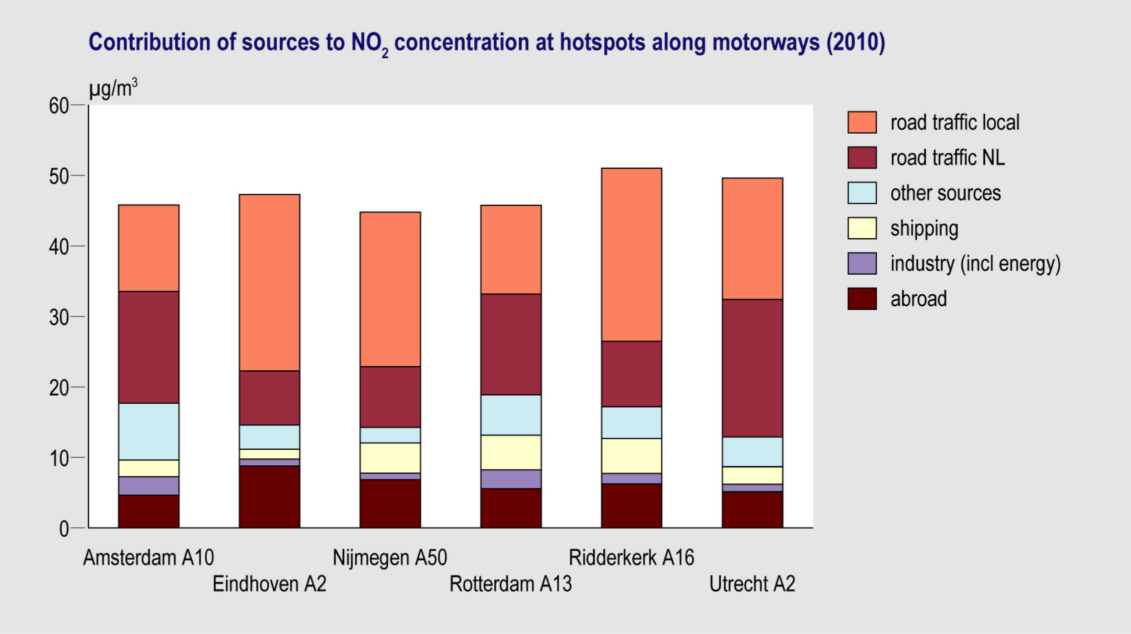


Figure 3.9 Contribution of sources to the NO_2 concentration along some motorways in agglomerations in the Netherlands in 2010.

3.3.4 Uncertainties

The Netherlands Environmental Assessment Agency uses extensive data on societal developments, emissions, measurements and meteorological and chemical knowledge to calculate concentrations in streets and motorways. Uncertainties in these parameters, in particular with respect to background concentrations of NO_2 and O_3, emissions of NO_2, local traffic intensity, local share of light and heavy duty traffic, emission factors, direct NO_2 emission, model uncertainty, speed of traffic, local influence of trees and meteorology are taken into account (Velders and Van de Kasteele (2005), Figure 3.8). The range calculated in Figure 3.8 indicates the confidence interval of 33-66%. It is improbable that any values fall outside.

In the calculations of exceedances in streets and motorways, uncertainties have been taken into account for deviations arising from new insights which may lead to higher or lower emissions and, consequently, higher or lower concentrations. Deviations in important parameters are incorporated into the uncertainty ranges as stated above and as presented in Figure 3.8. At the time of publication of this report, there are two important developments which may significantly influence the calculations.

There are indications that the direct emission of NO_2 is possibly higher than previously assumed. This may be a result of catalysts and technical changes in the combustion motors. A two- or threefold increase in this value has a substantial effect (1–5 $\mu g/m^3$) on the average NO_2 concentrations along motorways and streets. In addition, new forecasts indicate lower growth figures from 2010 up to 2020 for road transport of goods and inland shipping, leading to lower emissions in the Netherlands.

3.4 Ozone

In the thematic strategy and the proposal for a new air quality directive, the European Commission proposes to maintain the target values and long-term objectives for ozone (O_3) in ambient air. In the third daughter directive, two target values and long-term objectives have been set to protect human health and vegetation (EU, 2002).

Protection of human health:

- A target of 120 $\mu g/m^3$ as an 8-h average that may not be exceeded more than 25 days per year, as averaged over 3 years.
- A long-term objective of 120 $\mu g/m^3$ as an 8-h average.

Protection of vegetation during three summer months:

- A target value for the protection of vegetation AOT of 18,000 $\mu g/m^3$*h, as averaged over 5 years.
- A long-term objective of 6000 $\mu g/m^3$*h.

3.4.1 Concentrations in Europe

- *The highest ozone concentrations in Europe are found around the Mediterranean Sea. The levels in the Netherlands are relatively low.*

The highest O_3 levels in Europe are found around the Mediterranean Sea (Figure 3.10). Between 2000 and 2010, O_3 levels throughout Europe will decrease with current policy by 15–25% (Amann et al., 2005d). Between 2010 and 2020, the high levels in the Mediterranean region will further decrease by 5–10%. Levels are the lowest in the northern European countries, in which the decrease is slight. In the MTRF scenario, O_3 levels, especially around the Mediterranean area, decrease by 25–50% in comparison with the baseline scenarios (Figure 3.10)..

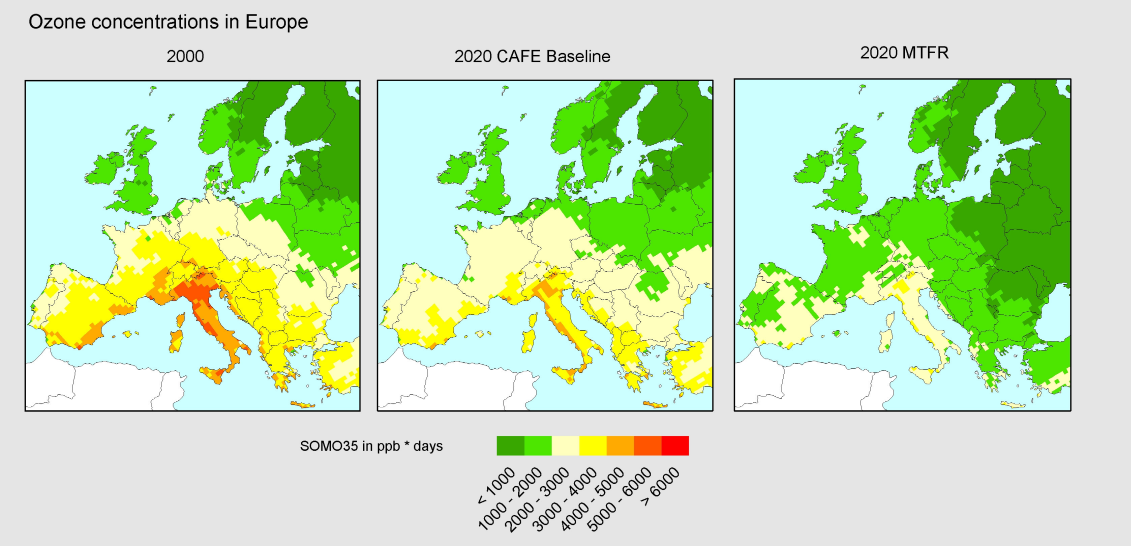


Figure 3.10 Ozone concentrations expressed as SOMO35 in 2000 and 2020 for CAFE Baseline and maximum technical feasible reductions. Calculations are based on results for the meteorological conditions of 1997. Sources: Amann et al. (2005b and 2005d).

3.4.2 Concentrations in the Netherlands

- *The target values for* O_3 *in 2010 are attainable in the Netherlands with current policy. The long-term objectives are unattainable up to 2020.*

The reduction in RAINS between 2000 and 2010 is in line with the European reduction of about 20–25% (Amann et al., 2005d). However, between 2010 and 2020, the reduction in the Netherlands just drops off a few percentages with current policy. The MTFR scenario causes the concentration to drop only a few percentages further (Figure 3.10). Based on the results from RAINS and Hammingh et al. (2002), the target values for 2010 for both the protection of human health and vegetation will be reached. However, based on the calculations of RAINS, the long-term objectives will not be reached in the greater part of the country, not even with the MTFR scenario (Annex A).

3.4.3 Uncertainties

The EMEP model slightly overestimates the O_3 concentrations for the Netherlands with just a few percent (EMEP, 2003; 2005).

O_3 levels are highly dependant on annual fluctuations in meteorological conditions. For example, when these O_3 indicators are calculated from observations made in 1997, 1999, 2000 and 2003, respectively, and compared, they differ approximately by a factor of 1.5–2.5. It is likely that differences in meteorological conditions are the dominant factor with respect to the measurement of O_3 levels, and that these greatly surpass the effects due to differences in emissions between the 4 years.

3.5 Acid and nitrogen deposition

In the thematic strategy, there are targets for improving exceedances of critical loads of nitrogen and acid deposition. In this section, we discuss the development of the deposition of nitrogen and acid. In 2010, the target value for acid deposition in the Netherlands is 2300 mol/(ha.y) and for nitrogen it is 1650 mol/(ha.yr), averaged over ecosystems.

In CAFE not maps of RAINS for deposition have been published. Therefore we used EMEP to examine the distribution of depositions in Europe (EMEP, 2004). The results of the EMEP model are used in RAINS. For the Netherlands we have used the OPS model.

3.5.1 Deposition in Europe

- *The nitrogen and acid deposition in the Netherlands is among the highest in Europe.*

The highest levels of nitrogen depositions occur in the Netherlands, Germany, Belgium, Ireland, France, Denmark and northern Italy (F*igure 3.11*). The main cause is the ammonia emissions (reduced nitrogen) from agriculture. The highest levels of sulphur deposition occur in Eastern Europe caused by the burning of sulphur-containing coal. The elevated levels in the Netherlands are caused by sea shipping.

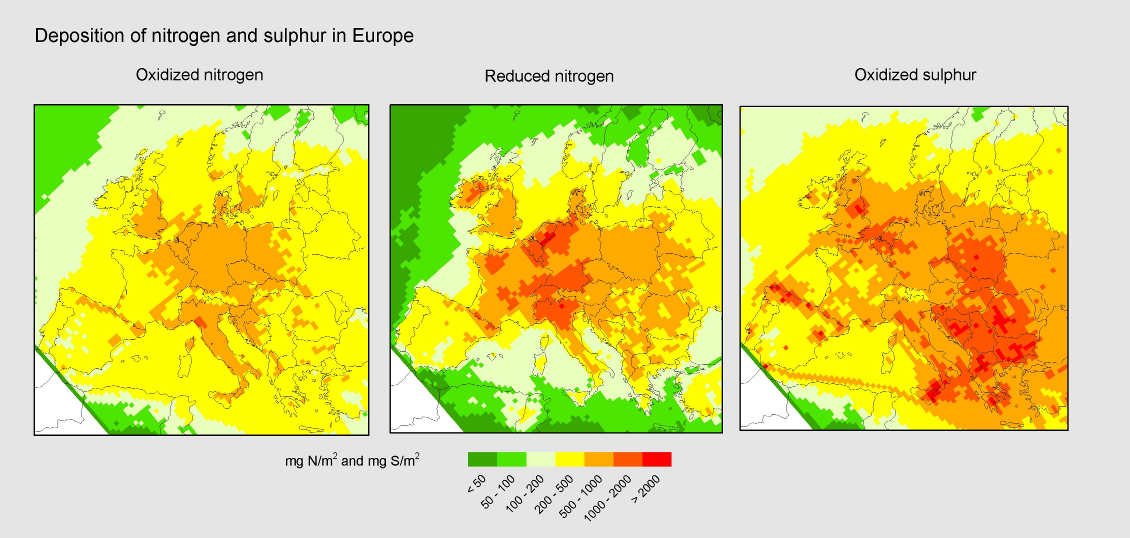


Figure 3.11 Deposition of oxidized nitrogen (NO_y*),reduced nitrogen (*NH_x*) and oxidized sulphur (*SO_y*) in Europe in 2002. Source: EMEP (2004).*

3.5.2 Deposition in the Netherlands

- *The national targets for deposition of acid are probably attainable in 2020 with the thematic strategy. The target for acid is possible from 2010 onwards with current policy.*

- *The EMEP/RAINS system probably overestimates the efficiency of Dutch* NO_x *emission reductions. National measures to reduce* NO_x *Dutch emissions may thus prove more efficient than envisaged under the present CAFE calculations.*

Nitrogen and acid deposition in the Netherlands will decrease with current policy by 20–25% from 2000 to 2010 and stabilize between 2010 and 2020 because NH_3 emissions stabilize in this period. With the ambition level in the thematic strategy, the deposition will decrease by 25% from 2010 until 2020. With the MTFR scenario, depositions are reduced by 30–35% between 2010 and 2020. Differences in deposition between the outcome of the CAFE scenario and the national scenarios are small (5%) (Figure 3.12).

The target value for acid will possible with current policy from 2010 onwards. The target for nitrogen will probably not be attained with current policy. With the thematic strategy both national target will probably be achieved in 2020. If the NH_3 gap is not taken account, the target values will already be met with current policy. This gap is not taken into account by RAINS in the scenarios.

The RAINS/EMEP model shows a good similarity with the results of the OPS model and to the measurements, but differences are found for oxidized nitrogen. The NO_x concentrations calculated by the EMEP model are about 50% lower than those calculated by the OPS model and are 40% lower than the measured concentrations (Velders et al., 2003). Consequently, the EMEP model underestimates the NO_2 concentration and the contribution of the emissions from NO_x in the Netherlands to the dry deposition of oxidized nitrogen in the Netherlands is 12% according to EMEP model and 36% following the OPS model. However, the total deposition of oxidized nitrogen is about the same for both models due to a higher wet deposition of oxidized nitrogen in the EMEP model. Since only a small fraction of the NO_x emission from domestic sources is deposited in the Netherlands, a more substantial part of the Dutch emissions is transported abroad than is shown by the calculations with the OPS model. The performance of the EMEP model in the Netherlands implies that the efficiency of Dutch NO_x emission reductions is probably underestimated by the RAINS/EMEP system. National measures to reduce NO_x Dutch emissions may thus prove more efficient than envisaged under the present EMEP/RAINS calculations.

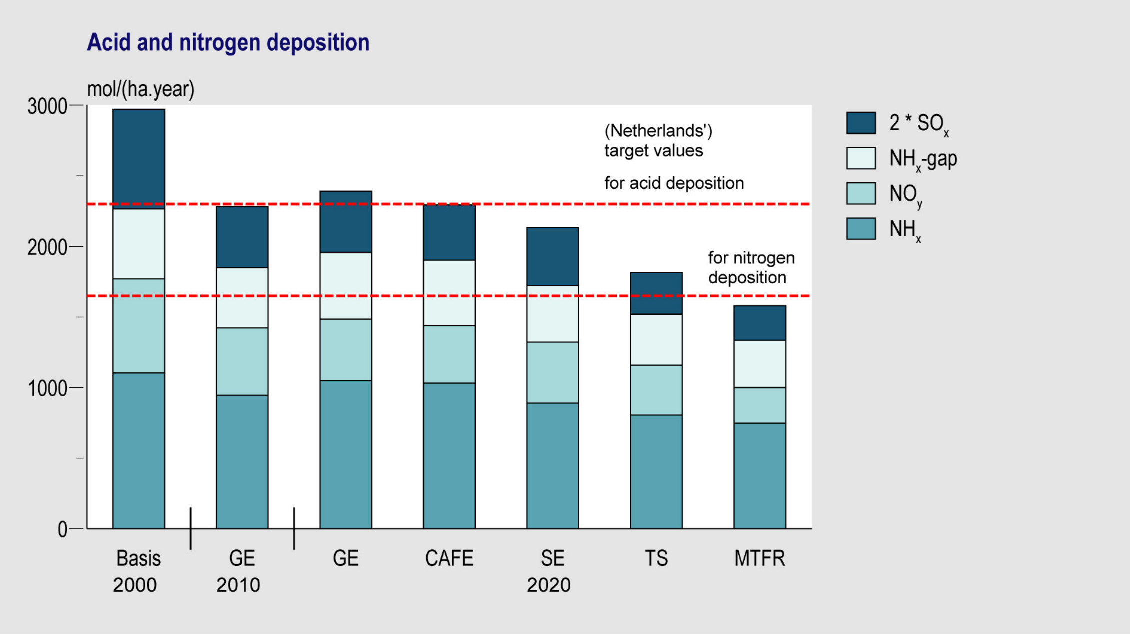
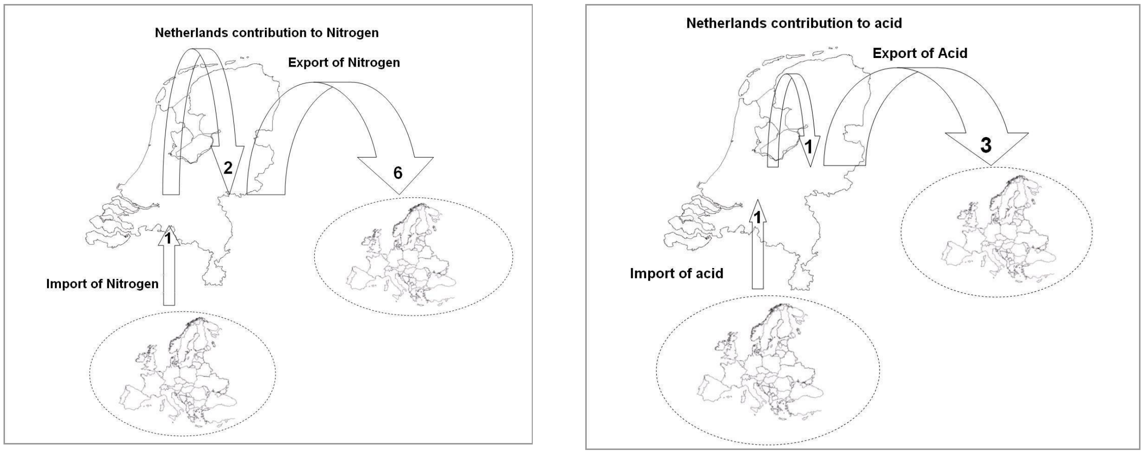


Figure 3.12 Average acid and nitrogen deposition in the Netherlands for different years and scenarios including the ‘NH_x gap’ correction. Calculated with OPS.

3.5.3 Transboundary contributions

A large part of the nitrogen and acid deposition in the Netherlands is from sources outside of the Netherlands (Figure 3.13). In 2000, this ‘import’ amounts to 40% of the nitrogen deposition and to 50% of the acid deposition. Nevertheless, the Netherlands is a net exporter of air pollution. The Netherlands exports about sixfold more nitrogen and threefold more acid than it imports (Figure 3.13). This means that the mass of air pollution with nitrogen and acid from the Netherlands that deposits abroad is respectively six- and threefold larger than that the mass of air pollution that deposits in the Netherlands from abroad.



Nitrogen Acid

Figure 3.13 Import and export of mass of deposition of nitrogen and acid in the Netherlands for 2000, expressed in unit of pollution imported. The ratios are based on deposition calculations with OPS.

3.5.4 Uncertainties

The largest uncertainty for acid and nitrogen deposition is caused by the NH_3 gap. Measured NH_3 concentrations leave 30% of the measured concentrations unaccounted for when calculated with dispersion models. This gap causes an underestimation of about 30% with respect to nitrogen emission in 2000. It is uncertain how this gap will develop in the future. The plausible causes for this NH_3 gap are probably a lower deposition velocity and higher emissions from the application of manure than currently assumed. These factors are currently being investigated in the ‘VELD’-project in order to resolve the gap (Smits et al., 2005).

4. Impacts in the future

In this chapter the impacts of air pollution on human health and ecosystems are discussed. The chapter is sub-divided into two main parts. The first part covers the effects of air pollution on health and includes a discussion of the effects of particulate matter and ozone in the Netherlands. These effects are calculated in CAFE by the RAINS model on the basis of World Health Organization (WHO) results. Next a presentation of alternative hypotheses for the causal fractions of particulate matter together with an assessment of the consequences of the respective policies is given. The second part of this chapter discusses the effects on ecosystems on the bases of critical loads as used in the CAFE programme.

4.1 Health impacts

4.1.1 Health impacts in Europe

- *Calculations with RAINS show that the current and future health impacts associated with air pollution are highest in the Netherlands and Belgium.*

Exposure to the air pollutants ozone and particulate matter is associated with health impacts. However, these health impacts are dominated by the effects attributed to chronic exposure to particulate matter (Amann et al., 2005e). The RAINS model calculates the life expectancy loss averaged for the general population in the Netherlands to be approximately 1 year in 2000 and about 8 months with current policy and 5 months for maximum technical feasible reductions (MTFR) in 2020 (Figure 4.1). The Netherlands and Belgium are densely populated, have a high density of husbandry and, therefore, are a hot spot for anthropogenic $PM_{2.5}$ in RAINS. Since RAINS links health effects to total anthropogenic $PM_{2.5}$ concentration (Figure 4.1), the Netherlands and Belgium consequently have the highest health impact from long-term exposure to $PM_{2.5}$ in Europe.

In CAFE the WHO made a systematic review of the health impact of ozone and particulate matter (WHO, 2003 and 2004b). The most important conclusions are:

- There is no threshold for particulates and ozone below which no adverse effects are expected.
- Current limit values do not preclude adverse health effects, and further reductions in air pollution will have significant health benefits, even in regions where levels are well below current limit values.
- Quantification of the contributions from different sources and of different particle components to health effects is currently not possible. However, particles from combustion sources seem to be particularly important for health.
- Many studies found that particulate matter ($PM_{2.5}$) have serious effects on health, but also that coarse particles (between PM_{10} and $PM_{2.5}$) have adverse health effects.
- The long-term effects of $PM_{2.5}$ clearly outweigh those of the short-term effects.

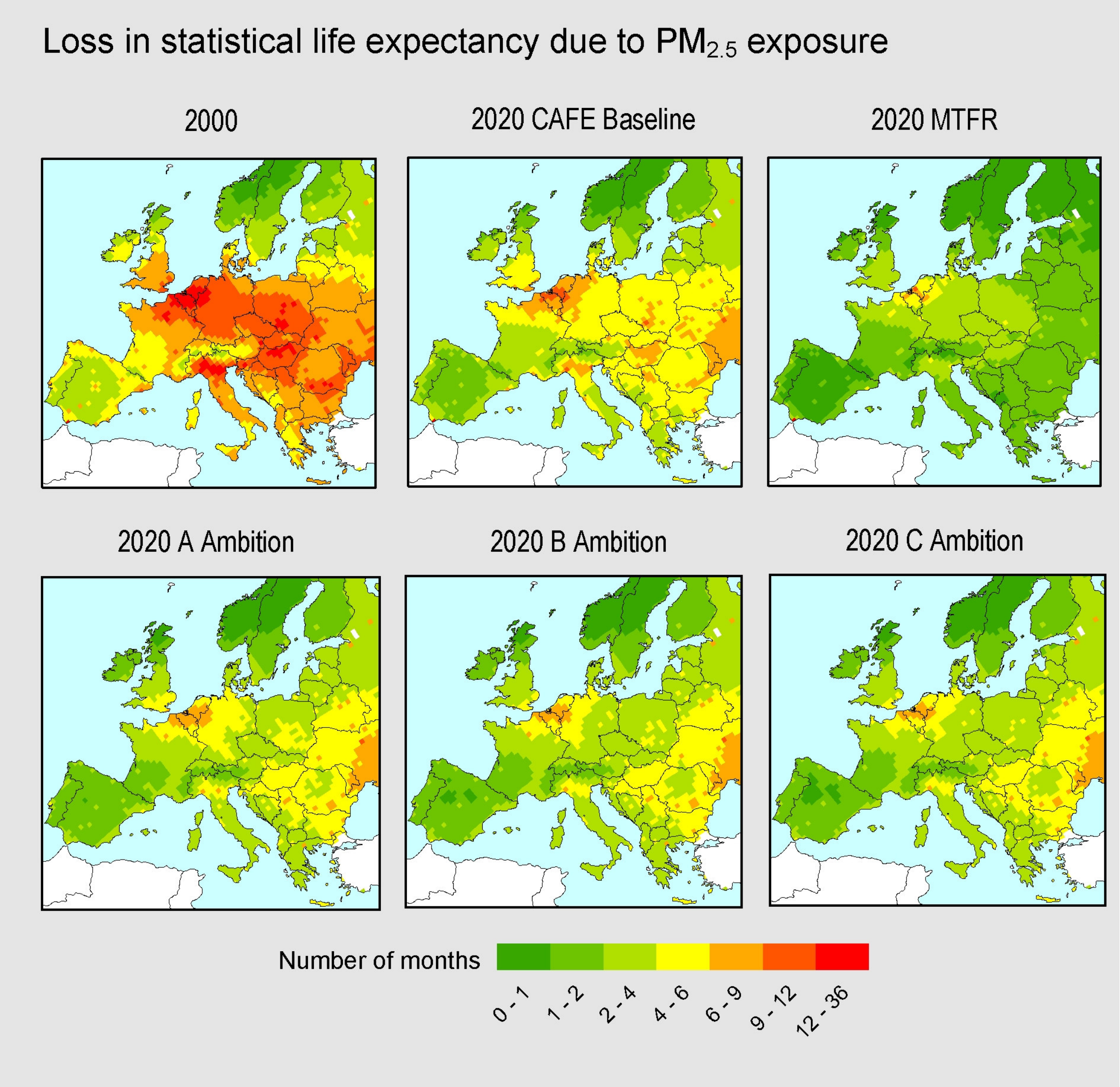


Figure 4.1. Loss in statistical life expectancy due to exposure to anthropogenic $PM_{2.5}$ for the year 2000, the baseline current legislation in 2020, A ambition, B ambition and C ambition and MTFR. The results are based on the meteorological conditions of 1997 and are averaged for the total population of Europe over 30 years of age. Source: Amann et al. (2005e).

4.1.2 Health impacts in the Netherlands

- *Based on Dutch studies it is estimated that at the present time a few thousand people die between a couple of days and a few months prematurely as a result of short-term exposure to air pollution in the Netherlands.*

- *Some tens of thousands of persons are estimated to die approximately 10 years prematurely as a result of long-term exposure to particulates if specific results from one American study are applied to the Netherlands. However, these results are very uncertain.*

Health impact assessments in the Netherlands have been made for acute effects associated with exposure to ozone and particulate matter based on Dutch data. The most recent estimate shows that a few thousand people die a couple of days to a few months prematurely in the Netherlands in 2003

(Fischer et al., 2005). Of these mortalities some 2,300-3,500 are attributed to particulate matter and 1,100-2,200 to ozone.

There is currently no quantified assessment of health effects associated with chronic exposure of particles based on Dutch or European data. Only studies in the USA have assessed such health effects from long-term exposure to particulate matter, however these results might not be directly and quantitatively applicable in the Dutch situation. Nevertheless, the results of these studies have been used in CAFE to assess the long-term effects of exposure to particulate matter. If specific results from one American study are applied ($PM_{2.5}$ from Pope et al. (2002) to the Netherlands, more than 10% of the Dutch population is assumed to die 10 years prematurely due to long-term exposure to ambient particulate matter in 2000. This corresponds to a loss in life expectancy of about 1 year when averaged over the whole Dutch population or to approximately 18,000 people dying a decade too soon (Knol and Staatsen, 2005). Two American studies show less or no effects; however, these studies are considered to be less representative. The uncertainties of the health impacts are therefore quite large. The knowledge base of these estimates is small and, consequently, the range associated with chronic exposure is large (see Section 4.3).

Table 4.1. Overview of impacts on health for the total population of the Netherlands for different policy ambition levels for $PM_{2.5}$ and ground level ozone. Source: Amann et al. (2005e).

	2000	**2010 National Emissions Ceilings (NEC)**	**2020 Current policy**	**2020 A ambition**	**2020 B ambition**	**2020 C ambition**	**2020 MTFR**
Loss in statistical life expectancy through exposure to anthropogenic $PM_{2.5}$ (months)	11.8	8.6	8.3	6.6	6.1	5.9	5.7
Premature deaths attributable to exposure of ozone (cut-off 35 ppb)	416	n.a.	369	353	345	340	336

Although epidemiological studies have found associations between health and NO_2 values around the current limit value (WHO, 2004a), there generally is serious doubt about whether exposure to NO_2 itself is the cause. It is believed that in these situations ambient NO_2 should be seen as an indicator of traffic-related air pollution. This mixture is associated with health effects, as also suggested by the results of Krämer et al. (1999).

4.1.3 Differences in calculating health impacts

- *In CAFE the health impact associated with acute exposure to particulate matter are not estimated, despite the fact that these effects have been replicated more often.*

In CAFE, only mortality associated with chronic exposure to particulate matter has been calculated. The RAINS calculations of loss of life are based on an American study carried out by Pope et al. (2002), while the Dutch study is based on a combination of an American study carried out by Dockery et al. (1993) and the one by Pope et al. (2002) (Knol and Staatsen, 2005). Since the CAFE and Dutch impact analyses are based to a certain extent on the same studies, it is not strange that both assessments deliver quantitatively very similar health impacts.

Because of the overestimation of ambient anthropogenic particulate matter concentrations in RAINS, the estimated improvement of the health impact by abatement measures in the Netherlands will be lower than that calculated with RAINS. RAINS attributes all of the health effects to anthropogenic $PM_{2.5}$, whereas Knol and Staatsen (2005) attribute the health effects to the total PM_{10} concentration. The Dutch calculations indicate that estimated total PM_{10} levels – and the health impacts that are implicitly assumed to be associated with them – decrease in 2010 and 2020 (MTFR) by 12% and 35%, respectively, compared to 2000 (Section 4.5). These values are significantly lower than the relative 27% and 52% that RAINS calculates (Table 4.1) for the same periods. However, as it is unknown which fraction of the particles causes the health effects, both approaches may be valid, or partially valid, or some totally different scenario may turn out to be more cost-effective if one of the alternative hypotheses for the causal fraction(s) eventually receives more scientific support (Section 4.5).

4.1.4 Uncertainties in health impact assessments

- *Quantitative chronic health estimates might outweigh the impact of acute effects; however, current estimates are very uncertain.*

- *The impact of the more often replicated effects of acute exposure is on its own already well above current Dutch limit values for environmental safety risks (a yearly risk of one death per million inhabitants).*

- *The current health impact of long-term health effects of particulate matter based on American studies seems to be the same order of magnitude as that of such life style factors as smoking, unhealthy diet or insufficient physical exercise.*

In contrast to the respiratory effects that appear from exposure to ozone, the biological mechanisms, the exact sources and the causal fraction(s) responsible for the effects of exposure to particulate matter are as yet unknown. The extent of the health impact on a population and the levels above which mortality risks arise cannot be accurately quantified at the present time. This applies to ozone as well as to particulate matter. The relation between short-term changes in air pollution and health effects in a population has been found in several studies, whereas to date there have only been five studies on long-term effects – with partly contradicting results.

Acute effects

There are currently more than a hundred time-series studies on the acute effects of exposure to particulate matter being conducted on most of the continents. These have established an association between air pollution and mortality and/or morbidity in quite different populations (as measured by their gross domestic product (GDP) or purchasing power parity (PPP)) and for very diverse exposures to quite different mixtures of PM. In the Netherlands, short-term exposure to PM_{10} is associated with 2,300-3,500 premature deaths per year, with the shortening of life varying from 1 day or a few days to up to a few months.

The Dutch limit value for the mortality risks caused by environmental safety is one death per million inhabitants per year. In a country with 16 million inhabitants and an estimated few thousand premature deaths per year associated with acute exposure to air pollution, this limit value seems to be exceeded.

Chronic effects

The scientific basis for chronic effects of particulates is small, and there are currently only four studies available for health impact analysis with results of the full cohort. The composition of these four American cohorts is mixed: some cohort studies involve the general population, such as the six cities study by Dockery et al., (1993) and the American Cancer Society (ACS)-cohort by Pope et al. (2002), while other studies are limited to specific groups, such as the Seventh Day Adventists (Abbey et al., 1999) or retired US army personnel with high blood pressure (Lipfert et al., 2001). Despite a number of limitations, the Pope study used in CAFE is the largest cohort study published in the scientific literature. Consequently, assessments of the health impacts of particulates are often based on this study. However, two other studies show either no effect or only an effect on men, introducing questions on the strength and direction of the relationship between particulate matter and long-term health effect.

In this report a number of uncertainties surrounding the ACS-cohort and some objections against the direct use of values from Pope et al. (2002) for quantitative estimates in Europe are presented. There concerns revolve around the following points:

- The smoking status in the cohort is only assessed once – at the beginning of the study – while smoking habits in the USA have changed considerably since that time; such changes in smoking habits most likely have a social economic status (SES)-related component as well and might confound the observed frequencies of health effects in the population of the ACS;
- No individual-based exposure is assessed in the ACS-cohort; instead, city average exposures are used as a proxy for this individual exposure assessment;
- A higher SES seems to mitigate the health impact of particulate matter in the ACS-cohort, which may point to an as yet unaddressed confounding or smoking-related influence (compare with first bullet);
- The application of American results indiscriminately to Europe neglects the existing differences in air pollution mix and sources as well as the population health status; for example, the use of a different proxy (sulphate) from the same cohort as a measure for the air pollution mixture leads to a negligible health risk in the Netherlands;
- The quantitative effect of air pollution (RR) concerning heart problems or lung cancer changes during the follow-up periods in the ACS-cohort.

These concerns are not absolute. However, if valid, they may quantitatively influence the estimated health impact of long-term exposure to PM. In addition to these points, it should not be ignored that the use or negation of a chosen threshold value or the subtraction or not of a concentration background from the ambient or modelled concentrations also influences quite considerably the extent of the calculated health effects that are attributable to PM. Chronic health impact assessments assume that ambient particulate matter is the only cause of death instead of being one of the (many) factors influencing mortality. In addition, PM-associated mortality has been applied universally to whole populations of adults of over 30 years of age instead of being associated to those people having a higher health risk. It is more readily conceivable that people with a weaker health status run a somewhat higher risk. These implicit assumptions in the previous estimates of the health impact probably lead to an overestimate of the number of life years lost as a result of exposure to PM. The health impact from long-term exposure to particulate matter (some 10-15% of the population) from the ACS cohort ends up having an effect on the total population of the same order of magnitude as life style factors such as smoking, unhealthy food intake, insufficient physical exercise etc.

The differences in the estimates and uncertainties of the health impacts are for a large part dependent on the intrinsic parameters of the studies carried out, as we showed above. However, they also depend on the different hypotheses that are possible to explain the observed results of these epidemiological and toxicological studies. These different hypotheses will now be explored in somewhat more depth, as they present a way of dealing with a number of the uncertainties that have been presented.

4.1.5 Different hypotheses for particulate matter

- *The causal fraction of particulate matter is not yet known. Sea salt does not seem to be a problem like nitrate, ammonium and sulphate. From a precautionary point of view, measures on primary particles from combustion sources might be specifically beneficial for health.*

- *The abatement policy in CAFE is not optimised for primary particles from combustion sources such as RAINS concentrates on the total anthropogenic fraction, which mainly compromises fewer health-relevant particulate fractions.*

- *Different causal fractions (hypotheses) lead to totally diverging abatement strategies for dissimilar sources and eventually to quite distinct costs.*

The abatement measures need to affect the causal fraction of particulate matter in order to be effective; if this causal fraction does not change, there can be no decrease in the associated health effects in the population. In CAFE, the WHO made a systematic review of all currently available information on air pollution and health effects (see 4.1 and WHO (2004a)). The conclusions drawn by the WHO indicate that a quantification of the contributions from different sources and from different particle components to health effects is currently not possible. A similar conclusion was drawn from two different studies carried out in the Netherlands that examined specific locations and sources (Hoek et al., 2002; Fischer et al., 2005). Sea salt is probably not a problem, and the secondary inorganic aerosols are not the most logical target for abatement measures when mortality effects in the general population are the prime target of environmental policy (Schlesinger and Cassee, 2003). However, primary particles from combustion sources in particular seem to have an important impact on health.

In this section, various hypotheses on the causal fraction are set out. A number of different hypotheses are elaborated on to some extent. The numbers 1 to 5 attributed to the hypothetical theories will be used later in this report when the different abatement scenarios are linked to policy options and an assessment is made of the robustness of these options. Hypothesis 1 is for inhalable particles (PM_{10}) that people can get into their airways and lungs by breathing ambient air. Hypotheses 2 to 5 are for the descending range of particle diameters down to the ultra-fine particles (hypothesis 5) that are more than two orders of magnitude smaller than inhalable PM.

1. In the first hypothesis, the health effects are deemed to be caused by the total amount of PM_{10}. This hypothesis has been the basis for the current EU limit values for PM_{10} and for the previous round of air quality criteria of the US-Environmental Protection Agency (EPA). In this hypothesis, any decrease in ambient PM_{10} levels, whether man-made or natural, will lead to a similar proportional reduction in health effects and health risks in the population. (1.B) This theory can also be applied to the $PM_{2.5}$ fraction. Implicitly this last hypothesis forms a basis for the discussions on the current round of air quality criteria of the US-EPA. For PM_{10}, the average transport distance is a few hundred kilometers, with an atmospheric residence time in the order of 1 day
2. In the second hypothesis, the health effects are only caused by the anthropogenic fraction of PM. This theory can also be applied to the $PM_{2.5}$ fraction. For 2.B This hypothesis has been used in CAFE with RAINS. For 2.B the causal fraction is now restricted to the anthropogenic $PM_{2.5}$ fraction. For $PM_{2.5}$, the average transport distance is close to 1000 km, with a residence time in the order of days.
3. In the third hypothesis, the health effects are only caused by the primary fraction of PM, and not by the secondary inorganic aerosols (Schlesinger and Cassee, 2003). (3.B) This theory could also be applied to the $PM_{2.5}$ fraction, leading to similar residence times and transport distances as with hypothesis 2.
4. In the fourth hypothesis, the primary anthropogenic particulate matter from combustion sources is regarded to be the causal fraction (Buringh and Opperhuizen, 2002). This fraction

is sometimes measured as BS (Black Smoke) or the EC/OC (Elemental Carbon/Organic Carbon) fraction. This primary combustion fraction has a rather small size cut-off – around 1 µm aerodynamic diameter – and the average transport distance is well over 1000 km. This fraction has the longest residence time in the ambient atmosphere of the various fractions reported here.

5. In the fifth hypothesis the ultra-fine particles, or PM$_{0.1}$ are seem as the causal fraction of the health effects; these can also be expressed as the total numbers of particles (Seaton et al., 1995). The average transport distance of these ultra-fine particles is rather limited due to coagulation and other atmospheric processes and is restricted to some tens of kilometres. Their residence time generally is only a few hours. This fraction is a local phenomenon, whereas all of the other fractions are transboundary.

The current state of environmental science is such that any of these five hypotheses (as well as quite a number of other hypotheses not mentioned) may be (partly) valid). As such, the consequences of these rival hypotheses should be evaluated separately as they may lead to a quite different package of abatement policies when they are optimised for results and costs on a European or national scale. Our analysis has been restricted to these five, but in principle many more hypotheses can be set forward. For example, in the literature there have been suggestions that the health effects are caused more specifically by transition metals (Frampton et al., 1999) or by other natural fractions as such endotoxins (Becker et al., 2003). A personal communication (Cassee, 2005) of the most recent American Toxicological Society (ATS) meeting indicates that differences in health effects attributed to diesel cars and those with gasoline engines may be less divergent than previously believed: traffic-related transition metals such as Cu and Zn were mentioned as possible suspect components of the causal fraction.

The different theories also have consequences for fractions that have not been explicitly discussed. When hypothesis 4 is compared to Hypothesis 1, it is assumed that the fraction of secondary inorganic aerosols (SIA), which is composed of ammonium sulphate and ammonium nitrate, as well as the ambient sea salt and the natural crustal and plant airborne material are not causal for the observed health effects.

Table 4.2. Concentration contribution (in µg/m^3) of the 'causal' fraction in PM$_{10}$ and PM$_{2.5}$ in 2020 averaged over the Netherlands and the difference in the health impact (HI) by applying Maximum Technical Feasible Reduction (MTFR) when the given fraction is responsible for all health effects. See Annex D.

	CAFE	**MTFR**	**HI**
PM$_{10}$			
Hyp 1. Total PM$_{10}$	27.6	21.3	-23%
Hyp 2. Anthropogenic PM$_{10}$	9.7	6.3	-35%
Hyp 3 Primary anthropogenic PM$_{10}$	4.2	2.7	-34%
Hyp 4. Primary combustion PM$_{10}$	1.5	1.1	-29%
PM$_{2.5}$			
Hyp 1.B Total PM$_{2.5}$[a]	17.9	14.6	-18%
Hyp 2.B Anthropogenic PM$_{2.}$	9.2	4.6	-50%
Hyp 3.B Primary anthropogenic PM$_{2.5}$	3.5	1.5	-58%
Hyp 4.B Primary combustion PM$_{2.5}$	1.2	0.7	-41%
Ultra-fines PM$_{0.1}$			
Hyp 5. Estimated ultra-fine	0.7-0.8	0.4-0.6	-20-40%

[a] Assuming a contribution of 10 µg/m^3 from unknown and natural sources.

For the calculation of the effects of different policies, the effect of the maximum technical feasible reduction with respect to the CAFE Baseline in 2020 is assessed. In these calculations, all health effects associated with particulate matter are attributed by the causal fraction given in the hypotheses. Any abatement policy leading to a change in the level of this fraction leads to a proportional similar change in its health impact. Different policies have been compared with each other in this manner. The calculation of the different fractions in each hypothesis is given in Annex D.

According to Hypothesis 1, all particulate matter is responsible for the associated health effects for PM_{10} and $PM_{2.5}$. Here an improvement of about 20% is expected by applying maximum technical feasible reductions in 2020 (Table 4.2). Abatement in this assumption will have to concentrate on all anthropogenic sources. The largest part of the particulate matter is the non-modelled fraction, which is partly natural and partly unknown. However, natural and unknown sources cannot be abated.

In Hypothesis 2, only the anthropogenic fraction is deemed responsible for the health effects by PM_{10} and $PM_{2.5}$. An improvement of about 35% and 50% is expected by applying maximum technical feasible reductions in 2020 (Table 4.2). Abatement measures will have to concentrate on all anthropogenic sources. In fact, this is precisely what has been done in CAFE.

If according to Hypothesis 3 the primary anthropogenic fraction is causing all the health impacts for PM_{10} and $PM_{2.5}$, an improvement of about 35% and 60% is expected by applying maximum technical feasible reductions in 2020 (Table 4.2). The most import gain can be found in abatement measures of the sector agriculture for PM_{10}, which contributes 19% (Table 4.2). The second most important contribution comes from the sector transport in the Netherlands, which has a mass contribution of 16%. The abatement cost will be much lower as the sources and components to be abated are already largely reduced since the abatement of secondary precursors (SO_2, NO_x, NH_3) is not necessary to increase health effects any more.

If, as assumed in the fourth hypothesis, the primary anthropogenic combustion is responsible for all health effects for PM_{10} and $PM_{2.5}$, an improvement of about 30% and 40%, respectively, is expected by applying maximum technical feasible reductions in 2020 (Table 4.2). The most important contribution to the concentration comes from the Netherlands' transport sector – 38% – followed by the contributions from the European transport sector – 18% – and consumer sector – 14%. Abatement policy and costs will have to focus on these sectors, and the cost will consequently be reduced to only these sources.

In the fifth hypothesis, the ultra-fines comprise the causal fraction. For the ultra-fines, an improvement of about 22-44% is expected by applying maximum technical feasible reductions in 2020 (Table 4.2). Since the residence time of ultra-fines is small, local and national emissions determine the concentration. The most important contribution on a mass basis of the ultra-fines to the concentrations comes from Netherlands' transport sector – 64% – followed by the contribution from consumers – 24%. Abatement policy and costs will be directed to these sources, and no transboundary contribution will have to be resolved. There is a difference by a a factor of two in effect if the ultra-fines are derived from PM_{10} or $PM_{2.5}$. This is caused by the substantial uncertainty in deriving a small amount of ultra-fine particles.

This more detailed analysis of these five different hypotheses reveals that quite different abatement policies have to be considered for each of them. However, the control of primary particles from combustion sources and especially from the transport sector seems to be an effective measure under all five hypotheses. This conclusion is also in line with that of the WHO in that particles from combustion sources seem to be particularly important for health risks.

4.2 Ecosystem impacts

4.2.1 Impacts within a European context

- *Risks for the adverse effects of both nitrogen and acid deposition on ecosystems are high in the Netherlands as well as in neighbouring countries (Germany, France, Belgium).*

- *The update of the European critical load database in 2005 will reduce the differences in percentage area between the Netherlands and Germany in exceedance of critical loads.*

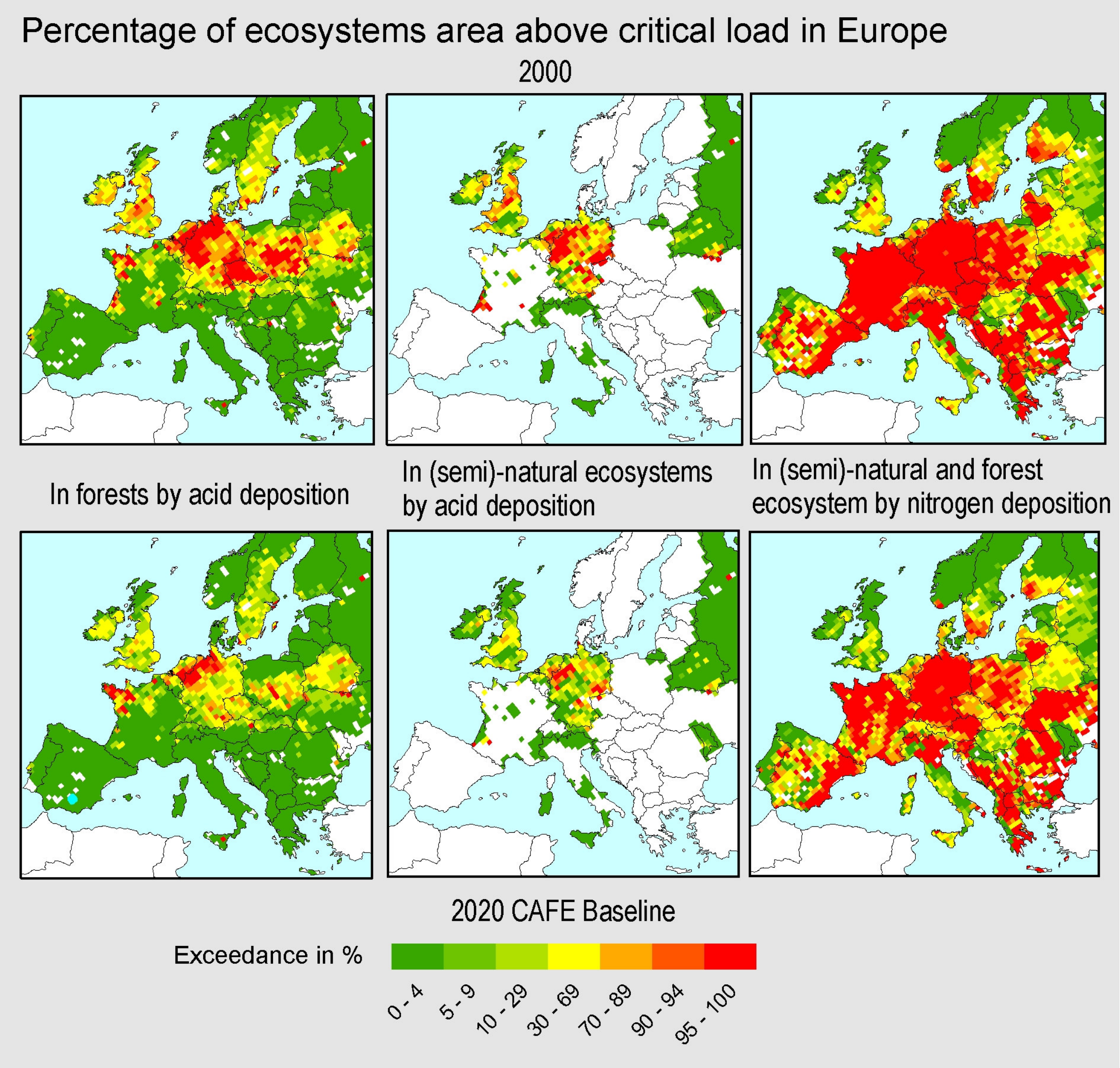


Figure 4.2 Percentage of area in which the critical loads for forest and (semi)-natural ecosystems are exceeded for acid and nitrogen deposition in 2000 and 2020 for the CAFE Baseline. Source: Amann et al. (2005e).

Deposition levels of nitrogen and sulphur are relatively high in the Netherlands and its surrounding countries (Section 3.5). Figure 4.2 shows the change between 2000 and 2020 in percentages of forests and semi-natural ecosystems at risk of acidification and eutrophication. The percentage of ecosystem area with exceeded critical loads in the Netherlands is higher than the average percentage of ecosystem area with exceeded critical loads in the EU with respect to both acidification and eutrophication.

Compared to its direct neighbours, the problem in the Netherlands seems somewhat smaller. This difference is mainly due to fact that the Dutch critical load database (see textbox) contains not only critical loads of very sensitive ecosystems but also contains those of the less sensitive ecosystems. Ecosystems on wet clay and peat soils in the western part of the Netherlands, which are less common in neighbouring countries, are not very sensitive to eutrophication and/or acidification. However, the deposition levels in the Netherlands have been, and sometimes still are, at levels to cause all of the adverse effects in these less sensitive ecosystems.

With the updated European critical load database of 2005, the differences between Germany and the Netherlands will be somewhat smaller, as indicated in Figure 4.2 (see section 4.6.3): the critical loads of Germany have somewhat increased, whereas in some of the 50×50 grids the Dutch critical loads have decreased (CCE, 2005).

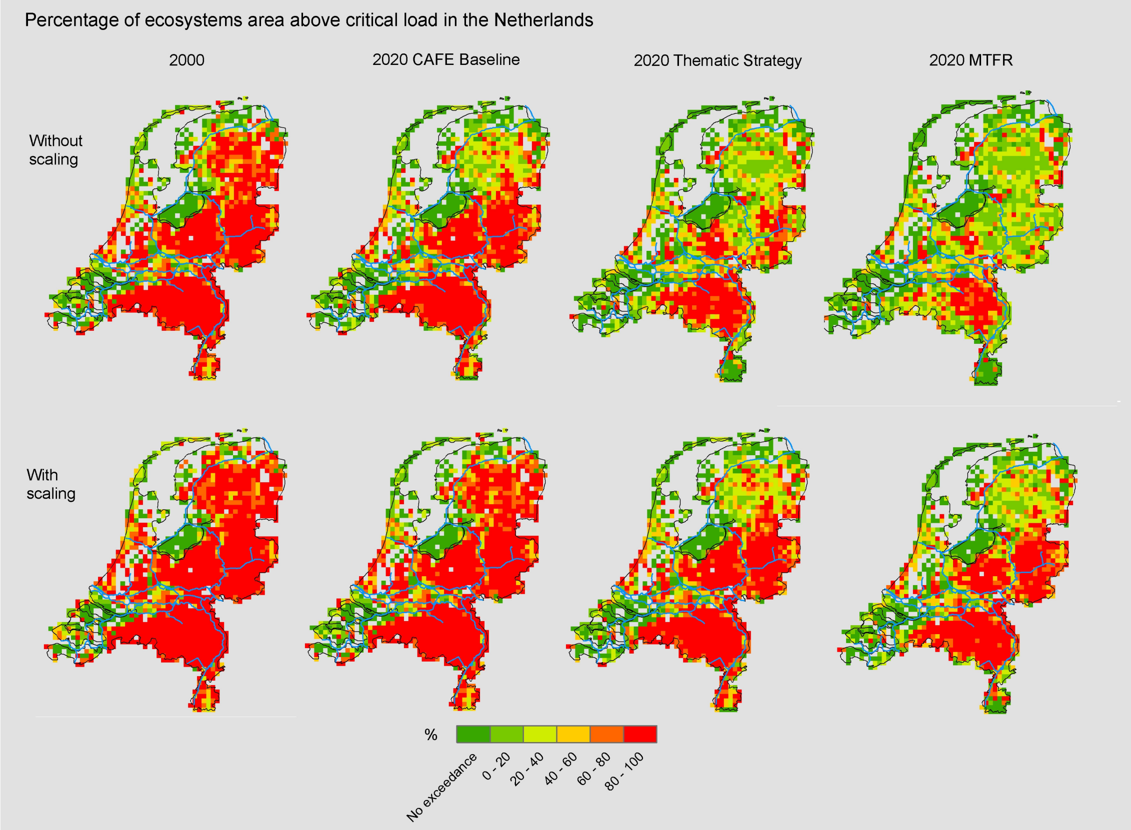


Figure 4.3 Percentage of area in which the critical nitrogen loads are exceeded for (semi)-natural ecosystems (including forest ecosystems) for excess nitrogen deposition: for the year 2000 and 2020 for current legislation (GE), thematic strategy and MTFR. With and without scaling for NH_3.

4.2.2 Ecosystem impacts in the Netherlands

- *In 2000, the critical loads are exceeded in 75–85% of ecosystem area in the Netherlands. In 2020 with current policy, 65–75% of the ecosystem area receives excess deposition, mainly caused by the maintained high level of ammonia (NH_3) emissions.*

- *With thematic strategy, the areas with excess deposition decrease to 45–70% in 2020.*

- *The reduction in NH_3 levels as the means of reducing the deposition of nitrogen is becoming increasingly important with respect in the protection of Dutch ecosystems.*

High levels of deposition of sulfur and nitrogen compounds can result in the acidification of soils, and groundwater quality and, consequently, soil quality, tree growth and biodiversity may be negatively affected (Albers et al., 2001). The deposition of nitrogen may also influence tree vitality and biodiversity as a result of eutrophication. The critical loads (see textbox) needed to protect these entire ecosystem functions are often exceeded in the Netherlands. Exceedance of critical loads by current or future loads indicates risks for adverse effects. However, in the Netherlands, exceedances of critical loads have been so high that adverse effects are already being detected in soil and groundwater conditions and changes in the composition of species of (semi-) natural ecosystems (MNP, 2004).

The proportion of Dutch ecosystem areas that are unprotected from acidification and eutrophication hase decreased since the 1980s by about 5% and 7%, respectively, due to a decrease in the deposition of sulfur and nitrogen compounds. While many of the precursor emissions are declining over time in the baseline emission scenario, the protection of ecosystems from acidification is expected to improve only gradually, mainly due to the continuing high level of NH_3 emissions, which also cause risks for eutrophication. In 2000, the critical nitrogen loads for 75–85% of the ecosystems in the Netherlands are exceeded. With current policy, the exceedances decrease to 65–75% in 2020, with the pollution reduction levels in the thematic strategy, to 45–70% and with maximum technical feasible reductions, the exceedances decrease to 30–60% (Figure 4.3). The range in these calculations is determined by calculations with and without scaling for the NH_3 gap (see Section 3.4).

Figure 4.3 shows the percentage ecosystem area in which critical loads of nitrogen deposition are exceeded. Exceedance is high in the eastern part of the Netherlands. Protection of less sensitive ecosystems on clay and peat soil in the western part of the Netherlands and along Dutch rivers is higher.

4.2.3 Differences in calculating the impact on ecosystems

- *Maps of exceedances of critical loads calculated for CAFE and national air-pollution policy in the Netherlands are based on the same critical load database. However, the higher resolution of the national deposition data produces more exceedances than the coarse EMEP data.*

- *The exceedances of critical nitrogen loads in CAFE are lower than in the national data.*

The exceedances of critical loads for eutrophication mapped in Figure 4.2 are based on the European critical load database, while the higher resolution exceedances mapped in Figure 4.3 are based on Dutch critical loads data that are embedded in the European critical loads database.

Critical loads: an indicator for describing risks to ecosystems

Critical loads are defined as 'a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge' (Nilsson and Grennfelt, 1988). Exceedances of critical loads by current or future nitrogen loads indicate risks for adverse effects. The International Cooperative Programme on the Modelling and Mapping of Critical Levels and Loads and Air pollution Effects, Risks and Trends (ICP M&M; www.icpmapping.org) and the Coordination Center for Effects (CCE; www.mnp.nl/cce) have developed methods to derive critical loads for protecting ecosystem services.

In the Netherlands, drinking water production, (commercial) wood production and nature conservation, all different ecosystem services, are threatened by acidifying and/or eutrophying atmospheric deposition. The objective of the Ministry of Housing, Spatial Planning and the Environment and of the Ministry of Agriculture, Nature Management and Fisheries is to protect these different ecosystem services. In the recent evaluation of the Dutch acid rain abatement strategies, critical loads were derived for the protection of:

1. Drinking water; by protecting ground water against contamination by nitrates (NO_x) (critical nitrogen load) and aluminium (Al) (critical acid load);
2. Forests (soils); by protecting forests against nutrient imbalance due to elevated foliar nitrogen contents (critical nitrogen load) and against risk of root damage due to elevated aluminum concentration or soil-quality deterioration by requiring no changes in pH (or base saturation) and/or readily available Al (critical acid load);
3. Biodiversity; by protecting plant composition in terrestrial ecosystems and small heath land lakes against eutrophication (critical nitrogen load) and acidification (critical acid load).

The calculated exceedances of critical loads indicate the risks for adverse effects on the ecosystem services. The methodologies used to derive the critical loads are described in the CCE Status Reports (www.mnp.nl/cce), and the Critical Loads Database 2004 is described in Hettelingh et al. (2004).

The UNECE Convention on Long-Range Transboundary Air Pollution (LRTAP) and the EU Programme Clean Air For Europe (CAFE) use critical loads from the European critical load database. This database, which contains several national critical load databases, is kept updated with improved knowledge by the CCE under the LRTAP-Convention. The European database of critical loads includes national data submitted by 25 National Focal Centres, including the Netherlands. The Dutch critical loads have been derived in 2001 in a study on the Dutch acid rain abatement strategies (Albers et al., 2001). The Dutch database has been updated in 2004 and recently in 2005 following the European guidelines established under the LRTAP-Convention and documented in the Mapping Manual (www.icpmapping.org). The recent Dutch updates are documented in CCE reports (Hettelingh et al*., 2004;* Posch et al., 2005) The European critical loads database contains about 1.4 million data points distributed over 50×50 km^2 grid cells covering pan-Europe. Dutch critical loads are assessed within 250×250 m^2 grid cells, the dominant ecosystem in each of which is reflected in the European database. In the update of 2005, critical loads could not be calculated for some individual grid cells containing natural ecosystems (especially some types of wet natural grasslands). These grid cells were left out of the database sent to the CCE (Posch et al., 2005).), whereas in earlier updates empirical critical loads were assigned to grid cells were no critical load could be calculated. This does not influence overall calculated exceedances on the European 50×50-km grid scale or on the 5×5-km grid scale because the total area and omitted ecosystems are relatively small with respect to surface area. However, on the higher resolution Dutch exceedance maps, these differences are visible in the western and northern parts of the Netherlands.

The calculated exceedances depend not only on the critical loads used but also on the deposition data used. European maps are calculated with a spatial resolution of 50×50-km grids. National applications, as depicted in Figure 4.3, are based on data of a higher resolution (5×5-km grids). Total deposition levels calculated with the EMEP model match well with national data (Velders et al., 2004).

In CAFE grid-average nitrogen deposition is used without NH_3 scaling. The exceedances of critical nitrogen loads in CAFE based on EMEP information are 61% in 2020 for current policy and about 27% for MTFR as calculated for 1997 meteorology (Amann et al., 2005e). The national figures are 65–75% and 45–70%, respectively, for long-term meteorology. The national figures are a little higher when compared to the lower limit that does not include NH_3 scaling. These differences may be caused by differences in resolution and meteorology. This has to be checked in greater detail.

4.2.4 Uncertainties

- *The largest uncertainties stem from deposition differences caused by the correction for differences between measured and modeled NH_3 levels.*

The computed risk of acidification and eutrophication has increased since 2001. For acidification, this increase can be attributed to both the updated critical load database and EMEP computed depositions using the EMEP Unified Model. However, the increase in the computed risk of eutrophication is largely due to deposition results generated with the Unified Model (Hettelingh et al., 2004). EMEP produces now ecosystem-specific deposition instead of grid-average deposition. Grid-average deposition is lower than ecosystem-specific deposition for forests.

There are, however, also uncertainties in the way by which ecosystem impacts are assessed. The critical load approach focuses on the preservation of biogeochemical steady states. The critical load approach needs to be combined with dynamic model assessments if information on time delays of recovery or damage is required in response to changes of exceedances. Moreover, the critical load approach does not yet capture the biology of impacts. The severity of the impacts of atmospheric deposition can thus depend on a number of factors: (1) the duration and total amount of increased deposition; (2) the chemical and physical form of the deposition; (3) the intrinsic sensitivity of the plant and animal species present; (4) the abiotic conditions in the soil and or water; (5) past and present land use or management (Bobbink et al., 2002). The influence of uncertainty in the deposition data is thought to have a larger effect on the European exceedances than on the uncertainty in the critical loads (CCE, 2005). Critical loads for a specific ecosystem on a specific site can be difficult to determine due to uncertain and large spatial and temporal variations in these factors (Van Dobben et al., 2004).

Another large uncertainty is caused by the correction for the ‘ammonia gap’. This causes an increase of about 30% in nitrogen deposition (see Section 3.4).

5. Costs and benefits of proposed measures

Important aspects of the thematic strategy on air pollution are the cost effectiveness and the costs versus benefits of the new air quality policy. IOM and AEA Technology have established a methodology to assess current and future health impacts and the benefits of new air quality policy (costs of applying abatement techniques originate from the RAINS database). The analyses have used data from the RAINS model for assessments of benefits. In this chapter, the costs and benefits to the Netherlands are compared with those of other countries, and the costs for the Netherlands are discussed on the basis of CAFE results, including uncertainties in the outcomes of the cost-benefit analysis. The benefits have been calculated for the A, B and C ambition in CAFE (see Chapter 2). The thematic strategy lies in between the A and B ambition and is judge as such in this chapter.

5.1 Costs and benefits in Europe

- *The net benefits for the Netherlands for the proposed ambition level in the thematic strategy are relatively high in Europe.*

The cost-benefit analysis (CBA) looks at the following receptors:

- Health (mortality and morbidity from particulate matter and ozone (O_3))
- Materials (buildings)
- Crops
- Ecosystems (not monetized)

Although the economic costs of the effects of O_3 on health and materials –i.e. crops – are included in the analyses, the benefits from abatement policy in monetary terms are dominated by far by the health benefits from reduced long-term exposure to particulate matter. These benefits stem mainly from an improvement in the chronic effects on mortality (expressed as numbers of people affected and years of life lost) and, to a lesser extent, to an improvement in morbidity effects from particulate matter (AEA, 2005). The situation in the Netherlands is no exception. In CAFE, the net benefits of an air pollution policy for the Netherlands are relatively high compared to those for other Member States for the three different ambition levels defined within CAFE (Figure 5.1; Watkiss, 2005). The proposed ambition level in the thematic strategy lies between the A and B ambition as set out in CAFE. The net benefit of these ambition levels is positive for most countries, with the exception of Cyprus, Finland and Ireland.

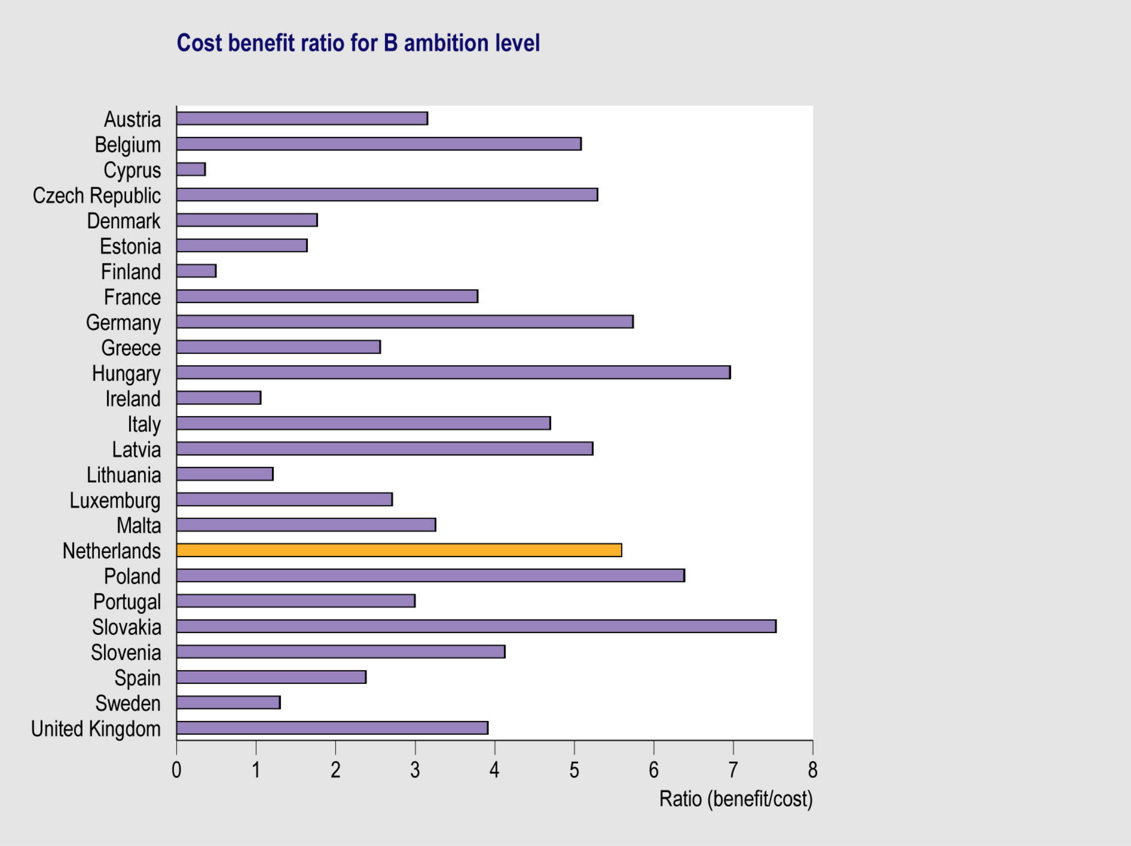


Figure 5.1 Cost ratio (benefits/cost) for the B ambition level using a low estimate for benefits. Source: Watkiss (2005).

5.2 Costs and benefits in the Netherlands

- *The benefits of the ambition level in the thematic strategy are factors larger than the costs for the Netherlands under the assumptions in CAFE.*

- *The benefits for the Netherlands are factors greater for all ambition levels in CAFE except for the maximum technical feasible reductions (MTFR) with the use of lower estimates.*

- *Net benefits depend heavily on the particular assumption made for the health impact theory of a particular causal fraction.*

- *Effects on ecosystems are ignored in the cost-benefit analysis (CBA) since they cannot be quantified in monetary terms.*

- *If only the primary anthropogenic fraction is associated with health effects, abatement costs will drop by 65–85%.*

The CBA in CAFE shows net benefits for the Netherlands for the A, B and C ambition levels, but not for the step from ambition C to maximum technical feasible reductions (MTFR) (Table 5.1). All of these results are based on lower benefit estimates; if the higher estimates are taken, even the step from ambition C to MTFR is cost-effective (Holland et al., 2005). It is worth noting in Table 5.1 that the step from ambition B to C is more cost effective than the step from current policy to the A ambition. The former step is more effective because the Netherlands rarely has to take any measure – and thus costs – from ambition B to C because the reduction in concentration of air-borne particulates in the Netherlands is caused by the measures taken abroad.

Because the CBA is driven by the benefits to health resulting from the abatement policy on particulates, the uncertainty of this analysis is determined by the uncertainty of causality of different particulate matter components (Chapter 4). Different hypotheses on particulate matter components with respect to the causal fraction lead to different abatement strategies (Chapter 4) and, consequently, to different abatement costs. In CAFE, it is assumed that all fractions of the anthropogenic particles are equally responsible for the associated health effects. However, if only the primary anthropogenic fraction is causally linked with effects on health, only a policy on the primary particles would be needed to affect health benefits from reduced air pollution. The need for taking measures to reduce the precursor emissions of secondary inorganic aerosols would then be unnecessary from the health perspective. As a result, abatement costs would drop by 65–85%. The achieved benefits would be at least be the same as when all fractions are equally responsible since the concentration of primary $PM_{2.5}$ decreases faster than total anthropogenic particulate concentration in the Netherlands in the assessed ambition levels. Calculations with RAINS also show a large reduction in costs when the assumption is made that only primary particles are linked with health effects (Amann et al., 2005e). Costs drop even further when only the primary combustion particles or ultra-particulate matter are taken to be the causal fraction associated with health effects (see Section 4.1) since the sources and amount of emissions to be abated decrease still further.

A reduction in secondary aerosol precursors remains important policy for reducing the health risks from short-term exposure to O_3 and the effects on ecosystems. Because the benefits from an abatement policy in monetary terms are driven by the health benefits resulting from reduced long-term exposure to particulate matter, the effects on the ecosystem are neglected if optimization is applied for the different causal fractions of particulate matter. Effects on the ecosystem are not monetized and are difficult to express in terms of money. A policy on ammonia (NH_3), nitrogen oxides (NO_x) and sulphur dioxide (SO_2) is particularly important for ecosystems.

Table 5.1 Additional costs and benefits in the Netherlands in 2020 for each step in abatement ambition level in CAFE. Sources: Amann et al. (2005e) and CAFE-CBA (2005).

Total	**Additional Costs RAINS (M€/yr)**	**Additional benefit Low estimate (M€/yr)**		**Cost/Benefit Ratio**
Step in ambition level		VOLY	VSL	
C → MTFR	521	338	545	1-1.5
B ambition → C	31	238	385	0.1
A ambition → B	239	528	854	0.3-0.5
Baseline →A ambition	188	2192	3553	0.1

5.3 Uncertainties

- *The benefits of the cost benefit analysis depend heavily on the particular study chosen as the basis for the quantitative assessment.*

The costs for abatement technologies in RAINS for the Netherlands seem to be in the same order of magnitude as national data except for non-methane volatile organic compounds (NMVOC), for which the costs are lower than national data (see Chapter 2). However, small differences in cost effectiveness might still cause large differences in the total cost. The costs will be checked in greater detail in October 2005 during the bilateral consultation with IIASA.

The benefits in the cost-benefit analysis in CAFE stem mainly from an improvement in the chronic effects on mortality and, to a lesser extent, to an improvement in morbidity effects from particulate matter (AEA, 2005).

For chronic health effects, the CBA utilizes U.S. data on the effect of air pollution on chronic mortality since there are no European data on this topic. In CAFE, the cohort study of Pope et al. (2002) is used. Despite a number of limitations, the Pope study used in CAFE is the largest cohort study published in the scientific literature. Consequently, assessments of the health impacts of particulates are often based on this study. However, two other studies show either no effect or only an effect on men, introducing questions on the strength and direction of the relationship between particulate matter and long-term health effect. This indicates that for the benefit analysis the particular study that is chosen to be the basis for the quantitative assessment may make a large difference with respect to any assessment of the health effects associated with long-term exposure to PM. These health impact uncertainties are discussed in Section 4.1. Of other great importance for determining benefits is the valuation of the monetized life shortening due to chronic exposure. Two methods are used in CAFE: Value of a Statistical Life (VSL) and Value Of a Life-Year-lost (VOLY). With respect to the empirical basis for monetary valuation, the VSL metric is much stronger than the VOLY method (AEA, 2005a). In CAFE, an estimate has also been made for both VSL and VOLY, and these have been used as the metric for effects of chronic exposure on mortality. These values differ by about a factor of two (AEA, 2005a).

For morbidity, a complicating issue is that a cross-European region morbidity assessment is hampered by the lack of region-specific relative risk factors and reliable information on baseline disease prevalences. Therefore, health impact assessments on morbidity endpoints can only be carried out using large simplification factors. The adopted methodology generalizes to a large extent and applies specific values to all of Europe.

6. Implementation of new air quality policy

The thematic strategy on air pollution proposes a number of different measures to improve air quality: (1) the better regulation of air quality through the streamlining and revision of existing air quality legislation; (2) the review of the National Emissions Ceilings (NEC) directive; (3) the modification of the emission standards for vehicles, ships and (industrial) installations; (4) the integration of air quality concerns into other sectors. In this chapter we discuss the consequences of implementation of the proposed new air pollution legislation for the Netherlands.

6.1 Air quality legislation

With the proposed revision of the air quality directives the legislation will be streamlined. The core of new air quality legislation is that current limit values will remain unchanged while new limit values for finer particulate matter ($PM_{2.5}$) are foreseen. Within the framework of existing limit values, those for nitrate dioxide (NO_2) and PM_{10} are the most relevant since these are currently being exceeded, and this situation is expected to continue with current policy. The other pollutants regulated in daughter directives show no or only very limited exceedances of limit values. Ozone (O_3) still poses a risk to human health; however, the 2010 target value for O_3 is not exceeded in the Netherlands and, importantly, the exceedance of a target value does not have legal consequences while exceedances of limit values do.

Exceedance of a limit value means that the protection level against air pollution is not that which was agreed upon at the time these targets were set. There are also economical consequences for exceedances of limit values. With the implementation of the first daughter directive, the Netherlands linked spatial planning with the attainability of (future) air quality limit values. These limit values apply everywhere in the outdoor air excluding work places. Since the implementation of this directive in 2001, different interest groups have appealed several of the spatial plans proposed by national and local authorities, based on possible breaching of air quality limit values for NO_2 or PM_{10}. In a substantial number of these cases, the appeal was upheld by the courts on the grounds of exceedance of air quality limit values, thus leading to rejection of the specific plan. These spatial plans involved plans for the construction and/or modification of roadways, zoning plans that re-allocated land for the development of business activities or the construction of housing accommodations as well as permits for new industrial activities.

Important elements in the thematic strategy for the attainment of old and new limit values in the revision of the air quality legislation are:

- Applicability of limit values. The limit values for the protection of human health apply everywhere; the limit values for the protection of vegetation only apply in appropriate areas with vegetation outside built-up areas.

- Discounting the contribution of natural sources for compliance purposes. Member States can discount the contribution of natural sources if they can objectively quantify and demonstrate contributions from natural sources

- A possibility of derogating from the attainment date of the limit values for particulate matter (PM_{10} and $PM_{2.5}$) and NO_2 by a maximum of 5 years. Any time extension should be accompanied by a plan to ensure compliance within the extended time period.

- Assessment of air quality. A requirement to provide digital maps of air pollution in Member States has been proposed in the thematic strategy. No requirement has been proposed to resolve non-equivalence of particulate measurements in the EU.

Applicability and derogation are relevant for all limit values being exceeded and are discussed below. The discount of air pollution from natural sources is particularly relevant for particulate matter since mineral dust and sea salt contribute significantly to the fine particle concentration. The contributions of natural sources to air pollution are discussed in Chapter 3.

6.1.1 Applicability and assessment of limit values

- *The assessment methods of air quality currently applied in the EU result in levels and degrees of exceedances that are incomparable. New proposals improve this situation but may not eliminate it entirely. The detailed Dutch method of assessing air quality leads to relatively more exceedances.*

Applicability

Under the current abatement policy in the Netherlands, plans for spatial development are rejected if they are in conflict with air quality limit values, such as those for NO_2 and PM_{10}. Relative to the Netherlands, in other EU countries the number of court appeals against spatial plans on the basis of breaches of the air quality limit values has been relatively limited to date. The main reasons for this difference are twofold: (1) the Netherlands' limit values are considered to be absolute limit values that apply everywhere, while in other countries (Belgium, France, UK), the need to meet a limit value is weighted with other interests when decisions are made on the granting of permits; (2) in some countries (Germany, Austria), limit values only apply in practice to areas where the population can be exposed to pollution (Koelemeijer et al., 2005).

In the revision of the air quality directives in 2005/2006, the Commission will specify more clearly just where the environmental objectives (limit and target values) apply. The limit values for the protection of vegetation will only apply to appropriate areas outside of built-up areas, whereas the limit values for health remain valid everywhere. While such an application is easy to check for compliance, it is not cost-effective with respect to solving the health problems. It would be more effective to concentrate on attaining limit values that would protect human health at locations where the exposure of a population would be for a significantly long period of time in comparison to the average period of the limit value. The proposal of the Commission means a continuation of the current legal problems concerning spatial plans for infrastructure in areas where the population is not exposed.

Assessment of air quality

Member States of the EU are required to assess their air quality and report the assessment to the European Commission. The assessment consists of measurements possibly completed with model calculations. While there are criteria for the number and location of measurement points, model calculations are not mandatory, and Member States can decide whether or not to use additional model calculations to assess air quality. The Netherlands uses high-resolution model calculations to assess exceedances of air quality, whereas many other Member States only use measurements to assess their air quality (Koelemeijer et al., 2005). The use of high-resolution models automatically leads to the detection of more exceedances. The new air quality directive and strategy propose the mandatory use of digital maps of air quality in member states. The application of digital maps may partly resolve current inequities in assessing air pollution as Member States would have to assess their air quality by means of a defined resolution system throughout their entire territory. However, the system for reporting has not yet been worked out. Requirements for digital maps and equivalences for measurements are yet unknown factors. The current unequal situation may just persist.

In the first daughter directive, a reference method (gravimetry) is prescribed for the sampling and measurement of PM_{10}. Member States are allowed to use other methods, but they should demonstrate equivalence with the reference method, and systematic deviations should be corrected with a correction factor. A country-based overview of the sampling and measurement instruments currently in use and the correction factors is given in Buijsman and De Leeuw (2004). The deviations depend on the composition of the particulate matter and can differ in time and space, but as long as the measurement method not is calibrated, a correction factor of 1.3 is advised (EC Working Group on Particulate Matter, 2002). However, two different reports show that not all these countries use this recommendation (CAFE Working Group on Particulate Matter, 2004; Buijsman and De Leeuw, 2004) and that different countries use different correction factors. It is unlikely that these differences are determined by the different situations in which the measurements are performed (Buijsman and De Leeuw, 2004). For example, France uses a correction factor of 1 for TEOM (tapered element oscillating microbalance) measurements, whereas in Belgium, a correction factor of 1.47 is used (Buijsman and De Leeuw, 2005). In the Netherlands, a uniform correction factor of 1.33 is used (Van der Meulen et al., 1990; Van Putten, 2002). The system for reporting and measurements has not yet been worked out. Requirements for equivalence measurements are yet unknown factors.

6.1.2 Attainment and derogation of limit values

- *The daily limit value for PM_{10} is probably not attainable until 2020 and a derogation of 5 years will not be sufficient.*

- *Serious economic and societal consequences of the rejection of spatial plans because of exceedances of the particulate matter limit value will probably be resolved on a large scale, but local exceedances with the potential for rejection of spatial plans will persist up tol 2020.*

- *The PM_{10} limit value will determine the scale of exceedances for the different particulate matter limit values.*

- *The Netherlands can prossibly resolve the exceedance for NO_2 in 2015 on its own if – in particular – the new standards for road traffic are in line with the ambition level in the thematic strategy. A derogation of 5 years might then possibly be sufficient.*

- *The new limit value for $PM_{2.5}$ is probably not attainable in 2010 and 2015. Attainment will be possible in 2020. A derogation of 5 years will most likely not be sufficient.*

- *The proposed interim reduction target of 20% for the average urban background level for $PM_{2.5}$ is probably unattainable for the Netherlands.*

Derogation
If a member state cannot meet certain limit values or concentration caps, the period for compliance can be extended by a maximum of 5 years if at the very least the following criteria are met (EU, 2005b):

- Establishment of a plan or a programme for the zone or agglomeration to which the postponement would apply and the communication of that plan or programme to the European Commission;

- Establishment – and communication to the European Commission – of an air pollution abatement programme for the period of the postponement which incorporates at least information on the status of implementation of related directives concerning air pollution and demonstrates that conformity with the limit values or concentration caps will be achieved before the new deadline;

- The concentration for the pollutant may not exceed the maximum margin of tolerance.

The proposal for the new air quality directive does not prescribe the exact criteria these plans and programmes have to meet, as these still have to be worked out in more detail and assessed per situation. Derogation would relieve the legal problems of exceedances for PM_{10} and NO_2 for the Netherlands, but, without addition policy, compliance with the NEC directive will be a problem for the Netherlands (Van Dril and Elzenga, 2005) and may become a problem in meeting the criteria for derogation.

Particulate matter – PM_{10}

With the policy and proposed reduction of pollution as stated in the thematic strategy, the exceedances of PM_{10} in 2005 are probably not resolved (Chapter 3). The derogation time of 5 years is not sufficient time to resolve the exceedances of PM_{10} in 2010 since the policy of the strategy only becomes effective after 2010. The reduction of pollution in Europe with the exceedances in the thematic strategy is not enough to prevent local exceedances of the PM_{10} limit value in the Netherlands up to 2020. With the use of Maximum Technical Feasible Reductions (MTFR), the exceedances can probably be resolved if they are applied throughout all of Europe and not just in the Netherlands alone (Chapter 3). Additional measures are also very expensive (> 1 billion euros per $\mu g/m^3$), amounting to billions of euros (Table 6.1). Since the PM_{10} limit value is probably not attainable until 2020 and since it is the most strict of all limit values, it is this limit value which will determine the scale of rejection of spatial plans based on the breaching of fine particle limit values. Serious economic and societal consequences on a large scale will probably disappear, but potential rejections of spatial plans on a local scale will persist up to 2020.

Sea salt has already been discounted from PM_{10} levels, but it is uncertain which amount of mineral dust can be discounted as a natural source. It is highly improbable that all mineral dust will be discounted, but if this were so, there is a potential for a large effect on attainment (see Chapter 3).

National measures

As stated above, the Netherlands cannot solve the problems of PM_{10} air pollution on it's own. However, the Netherlands can effectively reduce the exceedances with national and local measures. The Dutch government has presented a plan to combat air pollution at the Opening of Parliament in September 2005. The measures contained in this plan involve the:

- Subsidizing of vehicles with new Euro standards (Euro4/5 heavy duty and Euro5 light duty);
- Subsidizing of dust filters for old and new vehicles;
- Promotion of environmentally friendly local transport, freight transport and shipping;
- Development of clean fuels and the limiting of fiscal advantages for business passenger cars (limiting the fiscally advantageous grey license plate);
- Application of source measures to reduce emissions from particulate matter in industry and agriculture;
- Application of local measures to the infrastructure and financial support for cities for local measures.

Table 6.1 PM_{10} concentrations averaged over the Netherlands in 2000 and 2020 for different policy ambition levels calculated for CAFE Baseline scenario based on OPS. Cost figures are from RAINS (Amann et al., 2005e) and RAINSWEB (2005).

	2000	**2020**		
		GE	**Thematic Strategy**	**Maximum Technical Feasible Reduction (MTFR)**
PM_{10} (total) ($\mu g/m^3$)	32.6	27.8	26.3	24.2
PM_{10} anthropogenic (NL) ($\mu g/m^3$)	4.7	3.8	3.3	2.4
Incremental additional cost NL with respect to baseline and TS (M€)			330	1600
Additional NL cost In M€ / $\mu g/m^3$ with respect to baseline and TS of NL concentrations attribution			660	1800

This plan is aimed at current problems and effectively reduces exceedances. In particular, the Netherlands is accelerating the introduction of cleaner vehicles with new European standards with this plan. Additional measures reduce emissions, which will also contribute to the attainment of future new emission ceilings that will be set by the EU. Moreover, this plan contains local measures to combat exceedances of air quality limit values (Hammingh et al., 2005).

Nitrogen dioxide (NO_2)

The exceedances of the NO_2 limit value in 2010 are probably not solved with the proposed reduction of pollution in the thematic strategy. However, the derogation of 5 years will provide enough time to possible solve the NO_2 exceedances in 2015 with additional local measures (Chapter 3). It is very crucial here that the European Commission does not loosen the ambitions in the reduction of air pollution, especially for road traffic. However, the last proposal of the Commission for consultation of Euro5 standards for light-duty road traffic is much less ambitious for NO_x than the standards used for the thematic strategy in CAFE (see section 5.2). These latest standards will make the limit value for NO_2 will be possibly just attainable by 2020 (see Chapter 3).

National measures

In principle, the Netherlands can solve its own problems with respect to NO_2 with additional national and local measures, at least if the EU tightens up the standards enough for road traffic. Included in the plan that the Dutch government presented at the Opening of Parliament in September 2005 are important measures pertaining to road traffic for the abatement of NO_2:

- The subsidizing of vehicles with new Euro standards (Euro4/5 heavy duty and Euro5 light duty).
- The promotion of environmentally friendly local transport, freight transport and shipping.
- The limiting of fiscal advantages for business passenger cars (limiting the fiscally advantageous grey license plate (if you want it translated).
- Application of local measures to the infrastructure of and financial support for local measures in cities.

With this effective plan the Netherlands places special emphasis on accelerating the introduction of cleaner vehicles with new European standards. Moreover, the plan contains local measures for combating exceedances of air quality limit values that are crucial in reducing the last exceedances (Hammingh et al., 2005).

Particulate Matter $PM_{2.5}$

The new 2010 concentration cap for $PM_{2.5}$ is stricter than the annual limit value for PM_{10} but less strict than the PM_{10} daily limit value. The PM_{10} limit value will determine the scale of economic and societal consequences associated with the rejection of spatial plans due to the breaching of fine particle limit values. It is not expected that $PM_{2.5}$ will lead to additional areas of exceedances. Information on $PM_{2.5}$ is very limited: only a few scattered measurements are available and, consequently, accurate assessments are not possible. Preliminary assessments indicate that with the ambition level in the thematic strategy the 2010 concentration cap is not probable up to 2020. Exceedances are not widespread, but they do occur in busy streets in cities. The derogation time is not sufficient to resolve the exceedances of $PM_{2.5}$ in 2015. If, in addition to the derogation time, sea salt is discounted from the $PM_{2.5}$ levels, attainment of the concentration is possibly by 2020. Additional measures for $PM_{2.5}$ (>1 billion per µg/m^3) are very expensive, amounting to billions of euros (Table 6.2), and the potential benefits to the Netherlands are small, with just an additional 0.8 µg/m^3 when the Netherlands would implement maximum technical feasible reductions on top of the thematic strategy (Table 6.2)

The proposed interim reduction target of 20% for the average urban background level for $PM_{2.5}$ is unattainable with the ambition level in the thematic strategy, but is not yet legally binding.

Table 6.2 Anthropogenic $PM_{2.5}$ concentrations averaged over the Netherlands in 2000 and 2020 for different policy ambition levels calculated for the CAFE Baseline scenario based on OPS. Cost figures are from RAINS (Amann et al., 2005e) and RAINSWEB (2005).

	2000	**2020**		
		GE	**Thematic Strategy**	**Maximum Technical Feasible Reduction (MTFR)**
$PM_{2.5}$ (total) (µg/m^3)	11.9	7.8	6.7	4.6
$PM_{2.5}$ anthropogenic (NL) (µg/m^3)	3.6	2.6	2.4	1.6
Incremental additional cost NL with respect to baseline and TS (M€)			330	1600
Additional NL cost In M€ / µg/m^3 with respect to baseline and TS of NL concentrations attribution			1400	2000

6.2 Revision of the NEC directive

- *Uncertainties should be taken into account when agreements are being made on new emission ceilings since uncertainties in emission projections are of the same order of magnitude as the policy task. Uncertainties may lead to a costly unattainable ceiling and/or to ceilings that can be attained with current policy.*

- *The current knowledge base for $PM_{2.5}$ is limited for setting an emission ceiling. Emission inventories for particulate matter are very uncertain.*

As already stated in Chapter 2, the CAFE Baseline differs from the national projections, thereby leading to different outcomes with respect to the Dutch position in negotiations for the review of the NEC directive. Differences in coal use and the proportions of diesel-powered vehicles lead to lower estimates of SO_2 and NO_x emissions in the CAFE Baseline. For the national scenario, the emissions in 2020 of SO_2 and NO_x are 0–16 and 22–32 kt higher, respectively. For the Netherlands, this means that the CAFE Baseline as used for RAINS already represents a reduction task of about 0–16 and 22–32 kt for these components. Costs will be higher with the national scenario because the costs increase sharply in the cost curves, as presented in Chapter 2 for the chosen ambition levels. This may lead to ambition levels that cannot be attained without high costs. On the other hand, emissions for non-methane volatile organic compounds (NMVOC) are higher, leading to a lower estimation of cost in CAFE.

Since the uncertainty in the emission projection of the national scenario is over 20% in 2020 (see Chapter 2), the magnitude of the policy task is about the same as that of the uncertainty factor. This may result in agreed national emission ceilings that are unattainable or to ceilings that can be achieved with current policy, which may lead to unattainable air quality limit values. It is therefore important to take uncertainties in emission projections into account.

The policy proposed by the Commission is to include $PM_{2.5}$ in the NEC review. However, at the present time the $PM_{2.5}$ knowledge base is limited for setting an emission ceiling because there is no emission inventory for $PM_{2.5}$. Current $PM_{2.5}$ figures are derived from PM_{10} data, but the emission inventory for PM_{10} is currently incomplete, thereby most likely leading to the underestimation of emission levels. Consequently, the uncertainties for $PM_{2.5}$ emissions are also probably underestimated, and the uncertainties are very large. Costs for abatement are, however, very high. The cost curves in Chapter 2 show that additional costs for abatement easily amount up to billions of euros as the cost curve rises beyond thematic strategy ambition levels. On the other hand, since the uncertainty is very large, it is also possible that an agreed-upon ceiling may be achieved with current policy.

6.3 EU measures

- *The European Commission proposal for new EU standards for light-duty vehicles for consultation is much less ambitious for NO_x (fourfold) but has an ambition level for PM_{10} about the same as used in CAFE.*

- *In CAFE, the assumed new EU standards for heavy-duty vehicles are not very ambitious, but for light duty they are.*

- *New emission standards for road traffic are crucial to reduce air pollution at hot spots.*

- *There is no direct link between the ambition level in the strategy and EU source policy*

In CAFE, a link has been made with other EU measures. The European Commission has launched a proposal on tighter emission limits for passenger cars (EU, 2005) that is not directly linked to the ambition level in the thematic strategy. A link has been made in CAFE between the tightening-up of EU standards for road traffic and the abatement policy for road traffic (Amann et al., 2005e). For road traffic, the ambition in CAFE is fixed at different ambition levels, A, B and C, because only one ambition level has been assumed instead of having different levels for different costs. The fixed ambition level of transport shifts the burden to industry if higher ambition levels are chosen for abatement. Moreover, additional abatement measures for sea transport have been left out. For other technical measures, no direct link or proposal in CAFE had been made between possible legislation and technical measures such as the IPPC (Integrated Pollution Prevention Control) and LCP (Large Combustion Plants) directives (see Chapter 2). Integration with other (environmental) policy has only been defined for climate policy within the CAFE Baseline. In this section we will discuss EU standards for traffic and additional climate policy as assumed for CAFE.

New EU standards for road traffic

Tighter emission limits for road traffic are crucial in reducing exposure to air pollution. Firstly emission reductions for road traffic are many times more effective than emission reduction in other sectors to reduce concentration of PM_{10} and NO_2 at hot spots (Beck et al., 2004 and Hammingh et al., 2005). Secondly, road traffic is the major source for NO_2 and PM_{10} at hot spots (see Chapter 3).

In July 2005, the European Commission launched a proposal for new emission limits for consultation with respect to light-duty vehicles (see Table 1; EU (2005)). These standards are much less ambitious for NO_x (almost fourfold) and about the same ambition level for PM_{10} (Table 6.3). The new standards will reduce NO_x by 20% (gasoline) and 25% (diesel) and PM_{10} by 80% (diesel) with respect to the previous standards. The reduction of NO_x is much less than the reduction in emission standards as used in CAFE as a basis for the thematic strategy.

Assumptions have been made in CAFE about new EU standards for both light- and heavy-duty road vehicles because the European Commission proposal for light-duty vehicles had not yet been published. These assumptions have been adopted from Ricardo (Amann et al., 2005e). These standards are very ambitious for light-duty vehicles but not for heavy duty vehicles (Table 6.3). In 2020, the new standards from Ricardo lead to a 40% reduction in NO_x and a 35% reduction in PM_{10} with respect to the road transport sector in the Netherlands.

If EuroVI emission standards for heavy-duty vehicles and Euro5 emission standards for light-duty vehicles were to be reduced as much as technically feasible (heavy-duty vehicles: Riemersma et al., 2005; light-duty vehicles: Rijkeboer et al., 2003), NO_x and PM_{10} emissions from the road traffic sector in the Netherlands in 2020 would be reduced by 60% and 30%, respectively,.

Table 6.3 Different ambition levels and proposals for Euro5 light-duty and EuroVI heavy-duty standards. Source: Amann et al. (2005e) and EU (2005).

	Euro5 light duty (compared to Euro4)				**EuroVI heavy duty** (compared to EuroV)	
	Gasoline		Diesel		Diesel	
	NO_x	PM_{10}	NO_x	PM_{10}	NO_x	PM_{10}
Commission proposal for consultation	-25%	-	-20%	-80%	-	-
CAFE as basis for Thematic Strategy	-	-	-75%	-92%	-30%	-50%
MTFR	-90%	-	-70%	-80%	-90%	-90%

Interaction with climate policy

Additional climate measures have been assumed in the CAFE Baseline. The effects on air pollutants are, however, small. The market price for CO_2 is assumed to increase linearly from €12 to €20 in the 2010 to 2020 period. This leads to a CO_2 stabilization in the EU25 in 2020 relative to 2000. As a result of this assumed climate policy, total energy use decreases by 1% in the Netherlands. The effect of this assumed climate change on air pollution emissions is a slight decrease in NO_x emission (1%) and an increase in SO_2 emission due to an increase in heavy fuel usage (5%). There are no significant effects on other pollutants. If the market price is increased to €90 in 2020, the emission of NO_x decreases by 5% and SO_2 by 3% with respect to the baseline as a result of this climate policy (Amann et al., 2005b). Since the CAFE Baseline makes less use of coal than the national scenarios, the results will be different depending on the climate policy chosen (i.e. trade, CO_2 storage, energy savings, etc).

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Annex A. Modeling methods

$PM_{2.5}$ and PM_{10} Modelling with RAINS, OPS and CAR

Air quality results at the European, national, city and street levels are taken from RAINS, the Dutch OPS-model, City Delta (Amann et al., 2004) and the CAR-model (Eerens et al. 1993). For the calculation of concentrations along motorways, a data set consisting of 164 of the most polluted stretches is used (total length of highways: approximately 500 km). The concentrations in streets are represented by 1269 streets in Amsterdam and Utrecht (1269 streets). This data set provides insight into the effects of policy measures in cities, but does not give a complete picture of local exceedances in the Netherlands. Moreover, Rotterdam which is expected to have high concentrations is missing in this data set.

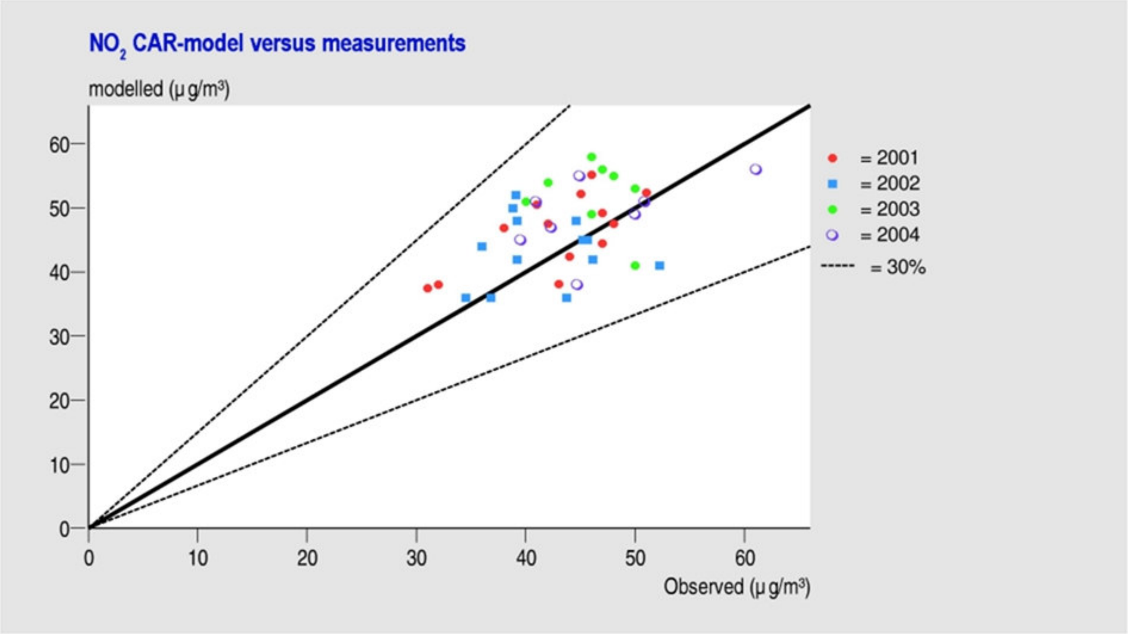
Empirical Dutch relation between annual average PM_{10} concentration and the number of days with a daily average PM_{10} concentration above 50 µg/m^3.

Number of days > 50 = 5.37 × PM_{10} yearly average – 132

NO_2 modelling with OPS and CAR

In this section the results of the OPS-model are discussed. There are no results available for NO_2 in the CAFE Baseline (Amann et al., 2004 and 2005a). In the OPS-runs, long-term average meteorological conditions (1990–1999) are used to model NO_x concentrations. An empirical relation between NO_x and NO_2 and O_3 is used to convert NO_x fields into NO_2 fields. The results of the OPS-runs are restricted to the situation in the Netherlands.

For local situations with heavy traffic, the CAR model is used to calculate concentrations. CAR is a simple model, but its accuracy complies with the EU requirement of 30% (NO_2) and 50% (PM_{10}). Figure A shows the results of the CAR model and observations of NO_2 and PM_{10} concentrations at traffic stations in 2001-2004.



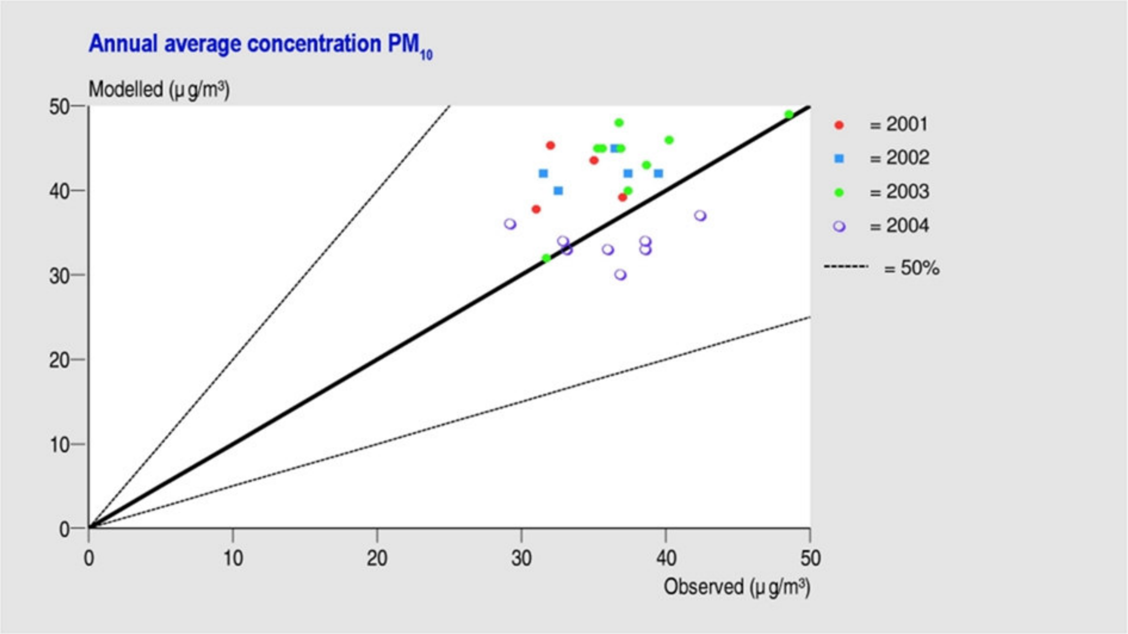


Figure A. Observed (horizontal) versus modelled (vertical) nitrogen dioxide and PM_{10} concentrations at traffic sites in 2001-2004. The dotted lines represent a 30% (NO_2) and 50% (PM_{10}) deviation from the 1:1 line. Nitrogen dioxide concentrations modelled with CAR are approximately 3% higher than observered values since the model applies a height of 1.5 m, while sampling takes place at 3.5 m.

Ozone modelling with RAINS

Ozone is described using indicators for its effects on human health, on forests and vegetation. The effects on human health are described by the sum of the excess of the daily maximum concentration (8-h means) over a threshold of 35 ppb (SOMO35). The European standard for human health protection is the number of days in a year with the daily maximum concentration (8-h means) above 120 µg/m³ (referred to as EX120). The indicator describing the effects of ozone in forests is the accumulated excess ozone over a threshold of 40 ppb (80 µg/m^3) during six summer months (AOT40F). The 'F' in AOT40F is to distinguish this parameter from the European standard, AOT40, which has been incorporated into Dutch legislation and which describes the effects of ozone on vegetation during three summer months (see Annex C).

EU standards for the number of days with concentrations above 120 µg/m^3 (referred to as ex120) are implemented in the Dutch legislation but not modelled here. Translations are presented in table A1. The CAFE-baseline study with RAINS presents ozone levels in 2000, 2010 and 2020 (Amann et al., 2005a). To simulate long-term meteorological conditions for each year the averages is calculated of four runs with meteorological conditions of respectively 1997, 1999, 2000 and 2003. A scenario with Maximum Technical Feasible Reductions is described for 2020 (Amann et al., 2004). In this case calculations are done with meteorology for 1997. Halfway between those scenarios is a third scenario with a B ambition level (Amann et al., 2005e).

SOMO35 and EX120, AOT40F and AOT40

Table A1. Observed and modelled values for ozone indicators SOMO35 and EX120. Target values for 2010 are 1800 ppb×days for SOMO35 and 25 days per year for EX120; both as floating three year averages.

	Meteorological conditions	Emissions	SOMO35	EX120
			ppb×days	*days/year*
Observed				
	1997	1997	600–1,500 [a]	1–20
	1999	1999	1,100–1,800 [a]	7-23
	2000	2000	500–1,300 [a]	4-16
	2003	2003	1,400–2,500 [a]	5-34
	1997, 1999, 2000 and 2003	Average of 4 years	1,000–1,700 [a]	5-25
Modelled				
	1997, 1999, 2000 and 2003	2000 CLE	1,500–2,500	17-36 [b]
		2010 CLE	800–2,000	3-26 [b]
		2020 CLE	800–2,000	3-26 [b]
	1997	2020 CLE	800–2,200	3-30 [b]
	1997	2020 D23 medium	800–2,100	3-28 [b]
	1997	2020 MTFR	800–1,600	3-19 [b]

[a] Value corresponding to the standard for EX120, derived from the correlation between averages of observations in 1997, 1999, 2000 and 2003

[b] Value corresponding to SOMO35, derived from the correlation between the averages of observations in 1997, 1999, 2000 and 2003

Table A2. Observed and modelled values for AOT40F and AOT40. Limit values for 2010 are 18 ppm×hours for AOT40F and 18,000 (µg/m3)×hours for AOT40; both as floating five year averages.

	Meteorological conditions	Emissions	AOT40F	AOT40
			ppm×hours	*(µg/m^3)×hours*
Observed				
	1997	1997	3-9 [a]	2,700–7,500
	1999	1999	4-11 [a]	6,500–13,000
	2000	2000	3-6 [a]	4,700–10,000
	2003	2003	5-16 [a]	5,300–15,300
	1997, 1999, 2000 and 2003	Average of 4 years	4-11 [a]	5,600–10,000
Modelled				
	1997, 1999, 2000 and 2003	2000 CLE	7-20	7,800-20,000 [b]
		2010 CLE	3-15	4,000-15,000 [b]
		2020 CLE	4-12	5,000–13,000 [b]
	1997	2020 CLE	5-12	6,000–13,000 [b]
	1997	2020 MTFR	4-10	5,000–11,000 [b]

[a] Value corresponding to the standard for EX120, derived from the correlation between averages of observations in 1997, 1999, 2000 and 2003

[b] Value corresponding to SOMO35, derived from the correlation between averages of observations in 1997, 1999, 2000 and 2003

Annex B. Available measurements of $PM_{2.5}$ in the Netherlands

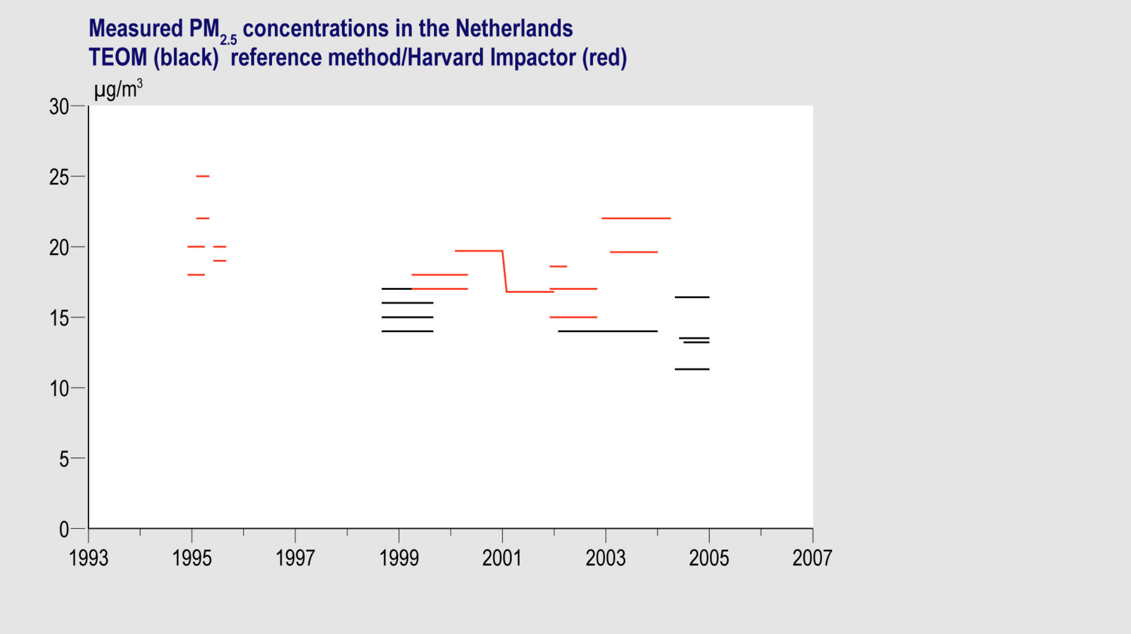


Figure B. Overview of available $PM_{2.5}$ *measurements in the Netherlands 1995-2004. The red lines show averages of measurements conducted according the reference method or with a Harvard Impactor. The black lines show the averages of measurements performed with TEOM equipment (Tapered Element Oscillation Microbalance).*

Annex C. Definitions of ozone indicators

A sequence of 1-h mean concentrations of ozone ($C_{p,t}^{1h}$) for location *p* and time *t* observed during a year can be used to calculate ozone indicator AOT40F:

> the accumulated excess ozone over a threshold of 40 ppb (=80 µg/m³) during daytime (8–20 h) in the summer half-year (April – September), to protect forests
>
> $$AOT40F = \sum_{April}^{September} \sum_{8<t\leq 20} (C_{p,t}^{1h} - 40)\text{, in ppm·hours;}$$

and the standard AOT40:

> the accumulated excess ozone over a threshold of 40 ppb (=80 µg/m³) during daytime (8–20 h) and the months may, June and July, to protect vegetation
>
> $$AOT40 = \sum_{may}^{july} \sum_{8<h\leq 20} (C_{p,t}^{1h} - 80)\text{, in µg/m³·hour.}$$

The sequence of daily maximum 8-h mean concentrations can be derived form the 1-h mean concentrations:

$$C_{p,t}^{8h} = \tfrac{1}{8} \sum_{t-7}^{t} C_{p,t}^{1h} \ .$$

Next, the sequence of daily maximum 8-h mean concentrations:

$$\hat{C}_{p,day}^{8h} = \max_{1\leq t\leq 24} (C_{p,t}^{8h}) \ .$$

The sequence of daily maximum 8-h mean concentrations is input for the ozone indicator SOMO35:

> the sum of excess of daily maximum 8-h means over the cut-off of 35 ppb (=70 µg/m³) calculated for all days in a year, to protect human health
>
> $$\mathrm{SOMO35} = \sum_{day=1}^{365} \max((\hat{C}_{p,day}^{8h} - 35), 0)\text{, in ppb·days;}$$

and the standard EX120:

> the number of days with the daily maximum concentration above 120 µg/m³, calculated for all days in a year, to protect human health
>
> $$EX120 = \sum_{day=1}^{365} n_{day}\text{ , in days}$$
>
> where n_{day} is given by:
>
> $$if\,(\hat{C}_{p,day}^{8h} > 70) then (n_{day} = 1) else (n_{day} = 0)\,.$$

Annex D. Details health calculations

In order to visualise the health impact of the different hypotheses, we have to define how much of the causal fraction of the particulate matter in the Netherlands, which is specific for the hypothesis in question, is influenced by the different packages of abatement measures.

- For Hypothesis 1, we simply take the modelled total aerosol in the Netherlands.
- For Hypothesis 2, it also is quite simple: we also take the modelled total aerosol but subtract the constant but not modelled part of 17.89 µg/m^3 of the PM_{10} and 10 µg/m^3 of the $PM_{2.5}$ in the Dutch aerosol.
- For Hypothesis 3, we subtract all secondary inorganic aerosol (SIA: ammonium, sulphate and nitrate) from the previous levels of Hypothesis 2.
- The calculation for Hypothesis 4 is somewhat more complicated as we have to make an estimate of the proportion of the PARTICULATE MATTER that originates from combustion sources. For this, the fraction for 2003 from the Dutch emission registry has been assessed that belongs to either combustion emissions or process emissions. The fraction of combustion from the total emissions is then used to multiply the concentrations from the different sectors of the models to find the eventual fraction of combustion-related concentration contribution from those sectors of industry in future years and under the different packages of abatement measures. The fractions used for this calculation are presented in Table D.
- The calculation for Hypothesis 5 is less complicated as the influence of foreign sources is less for these ultra-fine aerosols. Therefore, the contribution from these sources is put as zero, and to account for the fact that also from the primary combustion a small fraction might be larger than 0.1 µm in diameter, the previously found fraction of local Dutch combustion emissions is multiplied by 0.9.

Table D. Fraction from different sectors used to calculate the contribution of primary combustion aerosols

Netherlands:	**Fraction (%)**
Industry and refineries	26.8
Energy	78.2
Transport	87.4
Consumers	51.8
Utility and construction	3.8
Agriculture	1.1
Other countries:	
Industry	2.6
Energy and refineries	94.9
Transport	87.4
Consumers, utility and construction	28.5
Agriculture	1.1
Others	0

Annex E. Reductions for different euro standards road traffic

Emission for different ambition levels for EU emissions standards for road traffic with respect to GE.

Emission reductions in GE (kt)						
Road traffic	**Euro5 EC proposal (2010) and EuroVI CAFE (2011/2012)**			**Euro5 CAFE (2010) and Euro VI CAFE (2011/2012)**		
NO_x	**2010**	**2015**	**2020**	**2010**	**2015**	**2020**
Light Duty	0.0	-4.2	-6.8	0.0	-15.7	-25.1
Heavy Duty	0.0	-5.2	-10.7	0.0	-5.2	-10.7
Total	0.0	-9.5	-17.5	0.0	-20.9	-35.9
PM_{10}						
Light Duty	0.0	-1.5	-2.5	0.0	-1.8	-3.0
Heavy Duty	0.0	-0.1	-0.2	0.0	-0.1	-0.2
Total	0.0	-1.7	-2.8	0.0	-1.9	-3.2