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Attainment of EU NO_2 standards in the Netherlands

Implementation of the 1st EU daughter directive

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Samenvatting

Onder gemiddelde meteorologische omstandigheden zal de luchtkwaliteit voor NO_2 in Nederland met bestaand beleid en uitvoering van het Gothenburg-protocol sterk verbeteren, maar nog niet voldoen aan de nieuwe EU-norm in 2010. Overschrijding van de norm vindt voornamelijk plaats bij woningen langs snelwegen in stedelijk gebied. Om alsnog te voldoen aan de grenswaarde zal mogelijk lokaal voor miljarden euro aan infrastructurele maatregelen (sloop huizen, tunnels, luifels) genomen moeten worden. Ook bij uitvoering van het Nationaal Milieubeleidsplan 4 (NMP4) en het BOR (Bereikbaarheids Offensief Randstad) verkeersbeleid wordt de norm nog overschreden in 2010. Wel daalt het aantal overschrijdingen fors (factor 15). De kosten om vervolgens alsnog met aanpassingen aan de lokale infrastructuur aan de grenswaarde te voldoen bedragen dan nog enkele tientallen miljoenen euro. Pas als er na de uitvoering van NMP4 in 2010 in Europees verband maximaal emissiereductie- en verkeersbeleid wordt ingezet, dan vindt er in en na 2015 geen overschrijding bij woningen meer plaats.

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Summary

General
The first EU daughter directive was implemented in Dutch legislation on 19 July 2001. Consequently, the Netherlands is required to comply with the new standard for NO_2 in 2010. A number of recent studies indicate that the standard at that time will still be exceeded, especially near motorways in urban areas. In order to attain the limit value it may be necessary to implement local infrastructural modifications costing billions of euro (demolition of houses, construction of trenched motorways and tunnels, placing of pitched barriers).

This study has been conducted to examine whether it would be possible to attain the standard outside dwellings located alongside motorways through additional abatement policy and what the consequences would be if the attainment date were to be postponed. Also looked into were the major sources of NO_x in cities; the effects of NO_2 on health in relation to the EU standard; the impact on ambient air quality in the Netherlands of more stringent policy implemented by other EU Member States; and the situation in other Member States.

Exceedences from 2010 to 2020 near dwellings located along motorways
Under average meteorological conditions, the air quality for NO_2 in the Netherlands under current policy and with implementation of the Gothenburg protocol will improve considerably, but will not comply with the new EU standard in 2010. The standard will still be exceeded in 2010 near about 2100 dwellings located along motorways. Even if the Fourth National Environmental Policy Plan (NEPP4) is implemented, the standard will still be exceeded in 2010, although the number of dwellings where the standard is exceeded will drop considerably to about 350. If, in addition to the NEPP4, the separate policy on transport (BOR) for the heavily populated western part of the country called the Randstad is also implemented, the number of dwellings subject to exceedence will drop further to around 140. Only if the emission reductions and policy on traffic are **maximally** enforced across Europe in 2010 after implementation of the NEPP4 policy, will there be no more exceedences near dwellings in 2015 and beyond.

Cost of potential modifications to local infrastructure
If the NEPP4 is implemented, the cost of local infrastructural measures that may be required in order of meeting the limit value will drop from a few billion euro to 60-90 million euro. If the BOR is also implemented, the cost will drop to 20-30 million euro. The cost of implementing NO_x policy from the NEPP4 is, at around 78 million euro a year, by orders of magnitude lower than the costs that would be needed for modifications to local infrastructure.

Uncertainties in the calculation
In 2010 we are talking about the tip of the iceberg as far as exceedences are concerned. A slight variation of 10% in the concentration can cause the ‘iceberg of exceedences’ to either emerge above the water level or sink beneath it. As a result of such a 10% variation in the concentration, the distance from the motorway at which the standard is still exceeded can vary by a factor of 3-4.5, the number of houses within this zone by a factor of 7-22 and the cost to prevent exceenedences by a factor of 2-20. This variation occurs systematically and is caused by favourable or adverse meteorology; it may also occur by chance, however, due to uncertainties in calculations. With an uncertainty of 10-15% in the calculations of concentration it is therefore impossible to give an accurate estimate of the number of dwellings affected in 2010. If maximum emission reduction policy is implemented in 2015

and 2020, the uncertainty about exceedences drops sharply. In that case, the concentrations drop to such a level that –to continue the metaphor- the huge iceberg of exceedences near dwellings virtually disappears beneath the waves.

Health effects and EU NO_2 standards
Long-term exposure to NO_2, and to traffic-related particulate air pollution, for which NO_2 is taken as an indicator, can be expected to result in effects on health as well above as below the annual average EU NO_2 standard. It is understood for NO_2 (and the associated air pollution) that long-term multi-year chronic exposure is more important than short-term exposure. Thus, for the development of policy measures the long-term trend in concentrations probably carries more weight than the concentration in any isolated year, which may turn out to be relatively higher as a result of very unfavourable meteorological conditions.

NO_x sources in urban areas
Emissions from households and from the trade, services and government sectors (largely space heating) are, after traffic, the principal source of NO_x in urban areas. Reductions in these sectors would result in an even further substantial reduction in urban concentrations.

Effect of additional policy in EU Member States in 2010
Any additional emission reduction policy of other EU Member States would have little or no impact on the problem areas in the Netherlands in 2010. On the other hand the implementation of additional far-reaching policy after 2010 would require a European-wide approach.

Feasibility of meeting the NO_2 standard in other EU Member States
Urban air quality in relation to NO_2 in the Netherlands is better than the EU average, now as well as in 2010. It is therefore to be expected that, compared to the Netherlands, the feasibility of meeting the standard for nitrogen dioxide will be even more of a problem for other (southern) EU Member States.

1. Introduction

Oxides of nitrogen (NO_x) are emitted into the air mainly in combustion processes. Road and other traffic, which accounted for two-thirds of the emissions in 2000 (RIVM, 2001a), are the principal source of NO_x. About 95% of NO_x is released as nitrogen monoxide (NO) and about 5% as nitrogen dioxide (NO_2). After emission, some of the NO is converted into NO_2. The concentrations that occur in the Netherlands are determined by the large-scale, European background concentrations and increases caused by local emissions. The risk of high concentrations is greatest near motorways in urban areas.

Adverse effects of NO_2 on humans and ecosystems occur on brief exposure to high levels and on chronic exposure to low levels. In order to protect the population from the health effects of NO_2, standards were set in the first daughter directive (EU, 1999).

This first EU daughter directive (EU, 1999) was implemented in Dutch legislation by means of an Order in Council (Bulletin of Acts, Orders and Decrees, 2001) on 19 July 2001. The NO_2 standard for the annual average is 40 $\mu g/m^3$. For brief exposure the hourly-average standard is 200 $\mu g/m^3$. This standard may be exceeded 18 times a year. No exceedences of the standard are expected in 2010. Problems could occur with regard to attaining the annual average standard for NO_2 in 2010.

Studies carried out by Metz et al. (2000) and Van Velze et al. (2000) show that the EU annual average NO_2 limit value will still be exceeded in 2010, particularly along busy motorways in urban areas. In order of meeting the limit value, it will be necessary to implement measures costing billions. Countries like the United Kingdom, Germany, Austria and Belgium have indicated that they also expect difficulties in attaining this standard (VMM, 2001).

The study carried out by Metz et al. (2000) is based on the MV5-EC2010 scenario. This scenario contains policy for which the regulations or funding had been finalised before 1 January-2000. The NO_x emissions in this scenario are virtually consistent with the emission target to which the Netherlands had at that time committed itself under the Gothenburg protocol. The study then looked at the extent to which infrastructural measures would be needed, following supplementary traffic measures to comply with the standard.

The Netherlands has suggested at EU level the possibility of introducing phasing for attainment of the NO_2 limit value (e.g. shifting the deadline from 2010 to 2015). The Directorate-General for Environmental Protection (DGM) requested the RIVM to examine the extent to which the NO_2 standard would be met along motorways in the Netherlands after 2010 (2015 or 2020) if complementary NO_x emission policy without implementation of any drastic infrastructure changes is implemented. Questions were also asked about the major sources of NO_x in cities for purposes of complementary policy, the health effects of NO_2 in relation to the EU standard, the impact on the Netherlands of more stringent emission policy pursued by other EU Member States, and the existing problems in other Member States.

This report first of all discusses the health effects of NO_2 in relation to EU standards and gives an overview of EU directives (Chapter 2). It then reports on the method of research (Chapter 3), the feasibility of meeting the NO_2 standard in the Netherlands, the cost of modifications in the local infrastructure (Chapter 4) and the situation in other Member States (Chapter 5). Finally, Chapter 6 presents the discussion and conclusions.

2. Health effects and the EU NO_2 standard

With the adoption of the Air Quality Framework Directive (EU, 1996) EU air quality policy was given a new boost. The European Commission was obliged to present the European Parliament and the Council of Ministers with proposals for so-called daughter directives for 13 substances by the year 2000.

The line set out in the framework directive starts with substantiation. Recommendations made by the WHO (Air Quality Guidelines) and UN-ECE are re-assessed by experts from the Member States and supplemented with information on emissions and sources of the appropriate components, measurement and assessment techniques and cost/benefit analyses. All this is published as a so-called ‘position paper’. On the basis of this information the Commission then puts forward a proposal for a directive.

When establishing limit values, the possible harmful effects on health form only one of the considerations. The first daughter directive sets standards for *inter alia* NO_2, for which the recommendations of the WHO were adopted. The directive contains an evaluation clause that states that the standards for nitrogen dioxide must be evaluated in 2003 if new scientific information has become available on health effects and on the feasibility of the standards.

This chapter looks at the health effects of NO_2 in relation to the standard from the first daughter directive. It also briefly discusses how, when and which European directives will be drawn up.

2.1 Standards for NO_2 in relation to health effects

Acute inhalation of NO_2 can result in tissue damage in bronchial tubes and lungs, in a pulmonary function decrement, in an increase in respiratory complaints and in an increased reaction to allergens. Epidemiological studies show that there is a positive link between weekly average NO_2 exposure and infections in the bronchial tubes of children. The long-term exposure of laboratory animals to NO_2 shows that irreversible changes can occur in the structure and function of the lungs, that the effectivity of the immune system can decline and that pulmonary emphysema can arise.

The WHO-recommended values for NO_2 (WHO, 2000) are 200 and 40 $\mu g/m^3$ for protection against acute and long-term effects, respectively. The EU has adopted these recommended values in hourly average and annual average limit values. A number of epidemiological time-series analyses also carried out in the Netherlands and mainly targeting health effects associated with PM_{10}, show that effects such as increased (premature) mortality and respiratory illness are also associated with NO_2 concentrations in ambient air. However, there is serious doubt about whether NO_2 itself is the cause. It is assumed that in these situations NO_2 should be seen as an indicator of the mix of particulate air pollution mainly related to traffic emissions. The precise contribution of traffic emissions to health effects is not yet quantifiable.

Based on these observations and assumptions, expectations are that long-term exposure to NO_2 and to traffic-related particulate air pollution associated with NO_2 can give rise to effects on health in accordance with a more-or-less continuum in the exposure/effect relationship. This means that effects will increase with higher annual average concentrations of NO_2, but also that effects do occur below the annual average limit value for NO_2 of 40 $\mu g/m^3$. The annual average concentration is the result of periods with higher and with lower concentrations. The contribution to health risks made by peaks in the concentrations of shorter and longer duration is difficult to indicate. In scientific risk evaluations for air pollutants the emphasis is, considering the current relatively 'modest' NO_2 concentration levels, on the impact of long-term chronic exposure in particular. The longer period of time over which the concentrations are averaged is to a certain extent arbitrary. It is understood that for NO_2 (and the associated air pollution) the health effects will depend more on the long-term chronic exposure than on the exposure for a single year. Thus, for the development of policy measures the long-term trend in concentrations probably weighs heavier than an isolated year, for which the concentration may turn out to be relatively higher than on average as a result of very unfavourable meteorological conditions.

Meeting the limit value, calculated as an average over several years, could offset this variation caused by meteorology. The analysis of trends in ambient air quality levels and of NO_2 emissions can then demonstrate the effectiveness of the abatement policy.

2.2 EU daughter directives

After the Council of Ministers and the European Parliament have approved the Commission's proposed directive, amended or otherwise, the directive is published in the official journal of the European Communities. The Member States then have a specific period within which to transpose the directive into their national legislation.

The first daughter directive (NO_2, SO_2, PM_{10} and lead) was published on 29 June 1999 and came into force 20 days later. The Member States then had until 19 July 2001 to implement the decision in their legislation. On 19 July 2001 the first daughter directive came into force in the Netherlands via an Order in Council (Bulletin of Acts, Orders and Decrees, 2001).

The second daughter directive for CO/benzene was published on 13 December 2000 (EU, 2000) and has to be implemented in national legislation by 13 December 2002.

The third daughter directive dealing with ozone has been published in February 2002. It should be implemented in national legislation eighteen months later.

In the summer of 2002 the European Commission is expected to put forward a proposal for a fourth daughter directive containing proposals for heavy metals (nickel, cadmium, arsenic and mercury) and polycyclic aromatic hydrocarbons (PAHs, including benzo(a)pyrene).

First daughter directive

The first daughter directive sets binding standards for the concentrations of sulphur dioxide (SO_2), lead, nitrogen dioxide (NO_2) and particulate matter (suspended particulates; PM_{10}) in ambient air, as well as dates by which these standards must be attained. In the event of new scientific understanding concerning effects on health and the feasibility of meeting the standards, the directive contains an evaluation clause stating that the standards for particulate matter and nitrogen dioxide must be evaluated in 2003[1].

Background to EU directives

The Commission has set things in motion for all 13 of the substances referred to in the framework directive. On completion of these, it intends to embark on a new, more integrated course in the CAFE (Clean Air for Europe) programme, in which the daughter directives will be evaluated. At present (July 2001), the position is as follows:

1.	Framework directive agreed	27 September 1996
2.	EoI (Exchange of Information) decision agreed	27 January 1997
3.	European Publication 1st daughter directive (SO_2, NO_2/NO_x, PM10 and Lead)	29 June 1999
4.	European publication 2nd daughter directive (Benzene and CO)	13 December 2000
5.	Notification of CAFE programme by European Commission to Council of Ministers and European Parliament	May 2001
6.	Implementation of 1st daughter directive via Dutch Order in Council	19 July 2001
7.	European Publication of 3rd daughter directive	February 2002
8.	Proposal for daughter directive on heavy metals and PAH	Summer 2002?

In situations for which it is to be expected that standards will be not be attained by the date set, contingency plans must be prepared. The first year for mapping out and reporting on the air quality required under the directive is 2001. On the basis of this data it will be necessary to designate the areas for which action plans need to be developed under these regulations. Any plans must then be in place by 2003 and be implemented in the years that follow. The data from this first round of planning (including the accompanying cost) will become available at the same time that the evaluation of the 1st daughter directive is planned.

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[1] Article 10 reads: *No later than 31 December 2003 the Commission shall submit to the European Parliament and the Council a report based on the experience acquired in the application of this Directive and, in particular, on the results of the most recent scientific research concerning the effects on human health and ecosystems of exposure to sulphur dioxide, nitrogen dioxide and oxides of nitrogen, different fractions of particulate matter and lead, and on technological developments including the progress achieved in methods of measuring and otherwise assessing concentrations of particulate matter in ambient air and the deposition of particulate matter and lead on surfaces… Furthermore the Commission will examine the annual limit value for the protection of human health for nitrogen dioxide and will make a proposal confirming or modifying that value.*

Consequently, this data may play an important role in the evaluation of the directive by the European Commission. In addition, the results of the evaluation in 2003/2004 may contribute to the decision-making on implementation of the prepared action plans.

3. Description of performance of additional research

To be able to answer the question on the extent to which the NO_2 standard could also be attained along motorways in the Netherlands after 2010 (2015 or 2020) with complementary policy on NO_x emissions, additional research was conducted. The starting point was the problem areas (for 2010 along motorways in urban areas) taken from the study carried out by the Centre for Energy Conservation and Clean Technology (CE) (Metz et al., 2000).

Use was made of data from existing research and measurements to estimate NO_2 in the present situation and to obtain a general picture of the air quality in 2000-2020 and an overview of the situation in other Member States. First of all, a brief outline is given of the CE study, followed by the structure of and basic data (emission and emission factors, traffic intensities and road links (stretches of road), dwellings and cost of local modifications) taken from the supplementary RIVM study.

3.1 Earlier CE study

The Ministry of Housing, Spatial Planning and the Environment (VROM) commissioned CE to examine options for attaining the NO_2 limit value in very busy traffic situations in order to obtain a more accurate picture of the problems. A study was made of the air quality along the Dutch motorway network in 2010.

In order to map out the problem areas along motorways, CE compiled an inventory of the potential problem areas in the motorway network in 2010, to which end it divided the entire network of roads in the Netherlands into over 4000 stretches. The expected emission factors and traffic intensity, as well as the background concentrations in 2010 were established for each road link (for scenario EC 2010 (CPB, 1997)).

From these 4000 road links a selection was made of 500 where problems could be expected, the selection being made on the basis of traffic intensity (more than 100,000 vehicles per working day). From the other road links a selection was made for control purposes on the basis of background concentration and traffic intensity. From this it emerged that the selection criterion of 100,000 vehicles per day gave a reasonably complete picture of the roads with problems in 2010.

Using a method of calculation based on tables compiled by the Netherlands Organisation for Applied Scientific Research (TNO), the distance from the road axis over which the annual average concentration of NO_2 was expected to be exceeded was established for the 500 road links. On 148 road links the exceedence distance was found to be 25 metres or more from the road axis. On 41 road links the exceedence measured 75 metres or more. These 41 road links cover a total of almost 100 km of motorway.

The method of calculation used is less elaborate and also less reliable than calculations made using a dispersion model. For this reason, 25 road links were computed using the TNO dispersion model. This showed that for the majority of the roads the exceedence distances from the two methods of calculation were fairly consistent or very consistent.

Employing land-use data, CE estimated the built-up area along the 148 road links. From the analyses it emerges that 78 road links run past the 'built environment'. Counts made with the aid of visual observations revealed that in the case of 25 road links dwellings were located in the exceedence zone. The number of dwellings involved is about 4000 to 5000.

A rough estimate was made of the cost of taking remedial action. In addition to traffic measures, the following options were included: placing pitched barriers along the road, building trenched roads, building tunnels or demolishing houses in the exceedence zone. The most extreme remediation alternative was the complete elimination of exceedence zones throughout the Netherlands. This proved to be an extremely expensive option (about 15 billion euro), because it would involve building many tunnels. With a more selective use of pitched barriers and tunnels where the 'built environment' or, more specifically, only dwellings are affected, less extremely expensive alternatives present themselves. Depending on the choices made, the cost of these more selective options varies from about 0.7 to 3.0 billion euro.

3.2 RIVM method and basic data

Using emission scenario 2010 MV5-EC (RIVM, 2000b) and new scenarios for 2010 and 2020 with additional measures/targets for NO_x, calculations were made of the NO_x background concentration using SIGMA (Vissenberg et al., 2000). Then, with the aid of the CAR model (Eerens et al., 1993) and suitable vehicle emission factors and vehicle intensities, the 25 road links from the CE study (where there is an exceedence in residential areas) were recomputed.

Compared with MV5, this study showed conversion of revised spatial emission distributions for NO_2 to be used for denitrification in the soil, aircraft LTO, agricultural machinery (mobile and other), special vehicles and the trade, services and government sector. NO_x was converted into NO_2 in accordance with Eerens et al. (2001). Background concentrations were calculated on a grid of 5 x 5 km. CE used a finer grid of 1x1 km. The different spatial distribution in particular causes the background concentrations to differ from the data used by the CE.

Road links close to inhabited areas were taken as the departure point because the objective of the European standard is protection of the population. Also, the RIVM calculations were made with favourable and adverse meteorology, in which the concentration is assumed to be about 10% higher or lower than average. The reason for this was to gain an impression of the sensitivity of the system, but also to comply with the requirements of the European directive, which assumes that the standard - averaged over a year - should be met from 2010, but draws no distinction between favourable and adverse years.

New exceedence distances were established from the calculations. The number of affected dwellings was determined on the basis of these distances and with the aid of GIS. This allows a picture to be obtained of the problem areas, resolved or unresolved, when additional policy targeting sources are implemented.

The basic data used are discussed below.

3.2.1 Emission scenarios for NO_x emissions

NO_x emission scenarios for the Netherlands

The CE study was performed on the basis of the MV5-EC2010 scenario. This scenario contains policy for which the regulations or funding had been finalised on 1 January 2000 (see Chapter 1). In order to be able to assess the impact of additional policy targeting sources, a scenario was designed on the basis of information from RIVM (2001). This incorporated additional policy compared to the European Coordination (EC) scenario (CPB, 1997) from the Fifth National Environmental Outlook (RIVM, 2000b) for 2010 and 2020 (table 3.1, Annex 1).

For 2010 a reconstruction was made of the NEPP4 emission objective (231 kt NO_x). Based on the NEPP4 emission objective per sector and the MV5 figures, the emission reductions required per sector were examined. A check was also made of the measures that apply (based on the DGM-NEPP4 working document 'evaluation of acidification targets' (VROM, 2000). These are incentives for clean engines for inland shipping, other traffic measures (all categories), tightening up of degree on emission stocks of heating installations (BEES) and National emission Regulations (NeR) in light industry (total capacity < 20 MW_{th}) and lowering emission ceilings in heavy industry. They also include cleaner, gas-fired installations in the trade, services and government (TSG) sector, and in the agriculture and the consumer sector (table 3.1).

Table 3.1 NO_x scenarios of supplementary policy 2010 & 2020

NO_x 2010 reconstruction of NEPP4 emission objective	Emission (kt)
Current policy EC MV5 (incl. EURO-5 trucks)	272
Less:	
Inland shipping: clean engine incentives (about 90 million)	5
Traffic, miscellaneous measures	5
Measures for industry: non-NOx emission-trade sectors (tightening up BEES and NeR requirements) and NOx emission-trade sectors (ceiling lower than 57 ktonne)	10
TSG and construction: various technologies	6
Agriculture: various technologies	6
Consumers: various technologies	8
Leaves in 2010	231
NO_x 2020 maximum reduction policy	
Current policy EC MV5 (incl. EURO-5 trucks)	260
Less:	
Standard for inland shipping (same as Euro-5 trucks from 2010) & 50% retrofit in ships built before 2010	24
Standard for sea shipping (same as Euro-5 trucks from 2010)	10
Euro-5 cars and vans	12
Standard for mobile equipment (same as Euro-5 trucks from 2010)	6
SCR/ULN burners stationary sources (50%)	35
Leaves in 2020	173

For 2020, the emission levels conceivable for that year were examined on the basis of the available technology. Foreseeable administrative obstacles and the remaining implementation period were explicitly taken into account. Technology with a far-reaching impact (fuel cells, behavioural changes, innovations, maximum use of SCR/ULN burners (Selective Catalytic Reduction/Ultra Low NOx)) was not included. The measures involve the introduction of SCR for new engines for inland ships with 50% retrofit, Euro-5 standards for cars, vans and mobile equipment and SCR/ULN burners for stationary sources (50%) (see table 3.1). The scenario drawn up for 2020 ties in with 2010 concerning measures and is technically feasible if a powerful extra policy boost is given. Virtually all the technical measures proposed for 2020 require a European approach.

Besides uncertainties in the EC scenario itself, the reduction scenario is surrounded by additional uncertainties about the measures. A rough estimate was made of their impact. Attainment of the targets for 2010 and 2020 also require concrete action to be commenced soon (policy measures and funding). Further, if economic growth increases (GC 2020 works out to 10 kt higher) and technical developments and/or policy are disappointing, emissions could work out higher.

To give an indication of the concentration between 2010 and 2020, a linear interpolation of the emissions was made for '2015'. Only for inland shipping was it assumed that the level of emissions in 2015 would be the same as the 2020 level on account of a standard incorporating a retrofit requirement. Within the uncertainties surrounding the scenarios, this can be taken as a rough indication for 2015.

According to estimates, the cost of attaining the NO_x target in 2010 is about 78 million euro a year (VROM, 2001).

Emission scenarios for NO_x outside the Netherlands

Within the EU a directive was being prepared (COM, 1999) which also incorporated emission ceilings for all the Member States for 2010. This was designated the NEC (National Emission Ceilings) directive. The Commission's 1999 NEC proposals propose considerably greater reductions than the 1999 Gothenburg agreements of the UN-ECE (Gothenburg protocol (Annex 9)).

The emission targets set in the Gothenburg protocol appear feasible with current policy. The Commission's NEC proposal (238 kt NO_x for the Netherlands) on the other hand is comparable as regards effort to what the Netherlands would have to do to attain the NEPP4 targets. However, with the consent of the European Parliament, the European Environment Council has lowered the emission ceilings to just below the level of the Gothenburg protocol (see Annex 9).

In this study, both the original proposal of the European Commission and the proposal accepted by the Council of Ministers have been computed. The idea behind this is that the Commission's NEC scenario maps out the situation if the entire EU were to do roughly the same as regards NO_x policy (effort comparable to NEPP4). Calculations using the Commission's NEC proposal show the situation with the Netherlands being the only country to implement additional policy (NEPP4) and the rest of the EU doing nothing extra.

For countries outside the EU the emission ceilings for 2010 from the Gothenburg protocol were used as reference.

For 2015 and 2020 the Gothenburg scenario was scaled for the EU15 using the reduction the Netherlands has in 2015 and 2020 compared to Gothenburg, the idea behind this being that the EU will be pursuing roughly the same policy as that of the Netherlands, because virtually all the technological measures considered require a European approach.

For 2015 and 2020 the non-EU15 countries were likewise scaled to the Gothenburg scenario using the reduction the Netherlands has in 2015 and 2020 compared to Gothenburg. The idea is that the present principal non-EU countries (Poland, Czech Republic, Hungary, etc.) will probably have joined the EU and will implement European environmental policy.

Table 3.2 Description of the computed scenarios

Alternative	Description		
	Netherlands	EU	Other countries
2010 MV5-EC	Current policy as assumed in MV5	Gothenburg 2010	Gothenburg 2010
2010 NEPP4 NEC Commission	Reconstruction NEPP4	NEC Commission	Gothenburg 2010
2010 NEPP4 NEC Council	Reconstruction NEPP4	NEC Council	Gothenburg 2010
2015 NEPP4	Interpolation 2010 NEPP4-2020 NEPP4	Gothenburg 2010 scaled to NL reduction vis-à-vis Gothenburg	Gothenburg 2010 scaled to NL reduction vis-à-vis Gothenburg
2020 NEPP4	2020 maximum additional policy	Gothenburg 2010 scaled to NL reduction vis-à-vis Gothenburg	Gothenburg 2010 scaled to NL reduction vis-à-vis Gothenburg

3.2.2 Road traffic emission factors

The emission factors for the NEPP4/Additional policy scenario were derived from the emission factors of the MV5-EC scenario. The emission factors were scaled to the amount of reduction that occurred in the relevant traffic category. At the same time, it should be noted that the NO_x reduction for road traffic could quite conceivably be mainly a result of emission reductions at high speeds. The highest emissions occur at higher speeds, so that is where the greatest reduction can be achieved. In this event, the emission factors below represent an overestimate. The emission factors for 2015 have been construed through interpolation.

It was assumed in the calculations that freight and passenger traffic move at an average of 80 and 100 km/hr, respectively, as the selected road links are all located near urban areas. This is on average 10 km/hr lower than the speeds employed by CE.

Table 3.3 NO_x emission factors (g/km)

Type of traffic	**2010 EC-MV5**			**2015 EC interpolation**			**2020 EC-MV5**		
	80 km/hr	100 km/hr	120 km/hr	80 km/hr	100 km/hr	120 km/hr	80 km/hr	100 km/hr	120 km/hr
Passenger	0.22	0.27	0.35	0.19	0.23	0.30	0.15	0.18	0.24
Freight	3.68	3.75	-	3.02	3.08	-	2.36	2.41	-
	2010 NEPP4			**2015 NEPP4 interpolation**			**2020 NEPP4 max. policy**		
	80 km/hr	100 km/hr	120 km/hr	80 km/hr	100 km/hr	120 km/hr	80 km/hr	100 km/hr	120 km/hr
Passenger	0.21	0.26	0.34	0.14	0.17	0.22	0.07	0.08	0.10
Freight	3.44	3.50		2.90	2.96		2.36	2.41	-

3.2.3 Traffic intensities and road links

A brief analysis of the traffic intensities versus the number of dwellings within 75metresalong the motorway shows these 25 road links (Figure 3.1 and Annex 2) to include the principal problem areas along motorways in the Netherlands.

Data from the LMS were used for the traffic data per road link in 2010 and 2020; the two scenarios used for these years spanned the margin of the expected average weekday intensity. The margin is covered by a reference scenario (current policy) and a scenario with volume-of-traffic measures as it is quite possible that a scenario containing many technical measures for NOx will probably have measures relating to traffic volume as well. For this reason, the following scenarios were selected (AVV, 2000):

- 2010 reference, without (BOR)
- 2010 BOR alternative
- 2020 reference
- 2020 NVVP mix

The BOR (traffic policy for the Randstad) scenario includes additional public transport projects, and a rush-hour charge has been introduced in the network of trunk roads. This results in a lower intensity than in the reference situation despite expansion of the road network capacity in the BOR. In the national traffic and transport plan (NVVP) mix a large number of policy options (far-reaching or additional) have been implemented compared with the reference (pay lanes, variation of fixed car expenses, congestion levy, expansion of road capacity and improvements in public transport). Consequently, intensity is lower than in the reference (Annex 1).

The reference traffic intensity figures for 2010 from CE and the LMS figures differ here for three road links (A12-3, A9-9, A10-14). According to the supplier (RAND Europe), the CE scenarios and the figures used here are different. The CE intensities for A12-3 and A9-9 are 30% and for A10-14 10% higher.

3.2.4 Models for concentration calculations

For the calculation of background concentrations use was made of SIGMA (Vissenberg et al., 2001), which is based on calculations made with OPS. To calculate concentrations along motorways, use was made of the CAR model. The OPS and the CAR model are described briefly below.

OPS
The Operational Priority Substances (OPS) model is a model for the atmospheric transport of chemicals. The input data it requires are data on emissions, stack heights, thermal content (if any) and meteorological data. The model can calculate period-averaged concentrations and depositions on a national or smaller scale. A detailed description of the model can be found in Van Jaarsveld (1989) and Van Jaarsveld (1995).

The uncertainty in the concentrations calculated by the model is 15% for a specific year, and 10% for the long term. Validation against individual sources was only possible to a limited extent due to a lack of data.

CAR
The acronym CAR stands for Calculation of Air pollution by Road traffic. The model assumes that concentrations at the edge of the road are composed of: 1. regional background concentration; 2. contribution made by the city and 3. traffic emissions in the street. The regional background is determined from measurements from LML regional stations. The urban contribution is calculated from the virtual diameter of the city and an average concentration increase (compared with the regional background per kilometre of buildings). In this study the background (regional and urban) was calculated using SIGMA. Background concentrations were used on a scale of 5 x 5 km. The traffic emissions were calculated from the number and type of vehicle per 24-hour period, their average speed and emission factors. For the motorway calculations in this study the CAR model was modified and calibrated against CE calculations (based on the TNO traffic model and the TNO book of tables).

Calculations on individual road links have an uncertainty of about 20% for annual average concentrations. You can find more information about the CAR model in Eerens et al. (1993).

3.2.5 Establishing residential area exposure

Using the ACN (Address Coordinates Netherlands) database for 2000 and housing data from dBMailer (source RIVM-CIM), the number of dwellings that were inside the CE exceedence zone in 2000 was established for 2010 (Metz et al., 2000). Contrary to CE, the dwellings within a radius of 25m of the road axis were also included. In contrast to CE, the exceedence distance was determined for each side of the road and was not kept the same for both sides. The differences per road link between the CE and RIVM method are in a number of cases considerable. The total number of dwellings falls in the same order of magnitude for both methods, though. RIVM's total estimate works out slightly lower (5%).

Table 3.4 Recount of the number of dwellings within exceedence zones (differs for each side) using GIS according to Metz et al. (2000)

Road link		Province	Number of dwellings CE	Number of dwellings RIVM
A13-5	Rotterdam Airport-Kleinpolderplein	South Holland	1200	1366
A10-15	Geuzenveld-Haarlem	North Holland	800	594
A10-14	Osdorp-Geuzenveld	North Holland	750	984
A16-11	Dordrecht-'s-Gravendeel	South Holland	300	301
A20-6	Centrum-Krooswijk	South Holland	250	41
A16-5	Feyenoord-v. Zoelenlaan	South Holland	150	17
A10-13	Osdorp-Sloten	North Holland	120	195
A20-10	Kethelplein-Schiedam	South Holland	100	3
A16-2	Prins Alexander-Kralingen	South Holland	100	38
A16-10	Zwijndrecht-Dordrecht	South Holland	90	157
A9-9	Jct Badhoevedorp-Badhoevdorp	North Holland	70	110
A12-3	Voorburg-Bezuidenhout	South Holland	50	49
A16-8	A15 (Jct. Ridderkerk)-Hendrik-Ido-Ambacht	South Holland	50	8
A16-4	Centrum-Feyenoord	South Holland	50	21
A16-9	Hendrik-Ido-Ambacht-Zwijndrecht	South Holland	40	36
A16-7	Jct Ridderkerk-A15 (Jct Ridderkerk)	South Holland	40	50
A4-2	Sloten-Jct Badhoevedorp	North Holland	30	4
A27-4	De Bilt-Bilthoven	Utrecht	30	0
A2-11	Nieuwgein Zuid-Vianen	Utrecht	30	0
A50-4	Jct Valburg-Jct Ewijk	Gelderland	30	9
A20-7	Kleinpolderplein-Centrum	South Holland	50	130
A15-7	Charlois-Vaanplein	South Holland	20	1
A15-8	Vaanplein- jct Ridderkerk	South Holland	15	0
A10-16	Haarlem-Havens West	North Holland	10	7
A16-3	Kralingen Centrum	South Holland	10	10
TOTAL			4385	4131

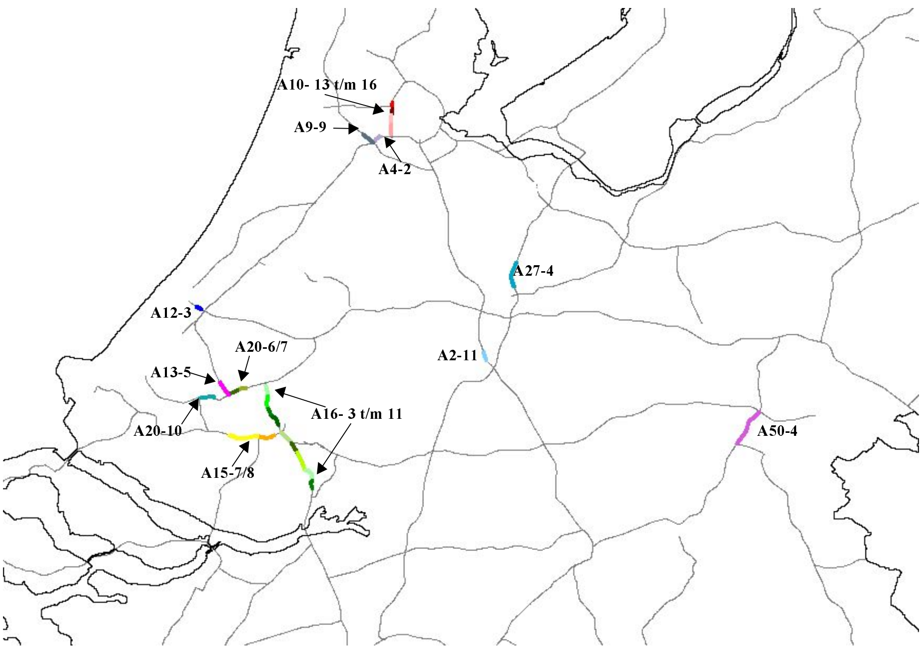

Figure 3.1 The 25 road links studied in the Dutch motorway network

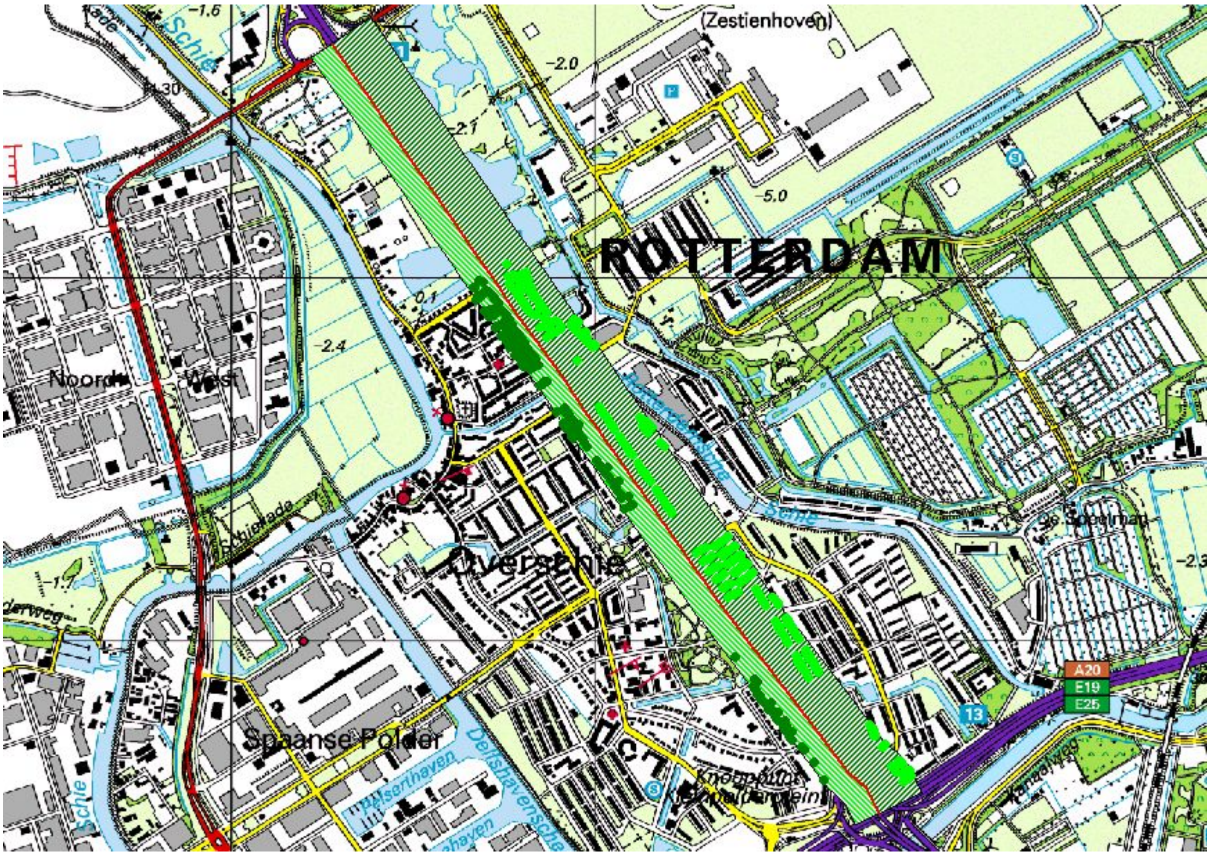

Figure 3.2 Dwellings in Rotterdam Overschie (A13-5) affected beyond the annual average EU standard (shaded) in 2010. Concentrations according to Metz et al. (2000)

3.2.6 Establishing cost of local modifications for problem areas

The CE study looked in detail at local measures taken near motorways to solve the air quality problem areas. The measures include trenched roads, pitched barriers, traffic measures and tunnels. From this analysis a number of alternatives were drawn up for solving the problem areas along all the road links, and on road links with buildings and dwellings. In order to calculate the cost, a rough average estimate was made of the cost per measure per road link (table 3.5). For the demolition of a dwelling the costs of an average owner-occupied property (€ 174,300) were multiplied by the demolition costs (€ 4,500). The CE study did not examine whether the owner-occupied properties in the exceedence zones were average properties. No costs were assumed in the CE study for traffic measures (speed restrictions, alternative routes).

Table 3.5 Alternatives to modifications near motorways plus associated cost (price level 2000)

Alternative	Measure per (exceedence distance)	Direct costs per unit (euro)
Alternative G: Demolition	Tearing down dwellings (>25m)	178,800
Alternative E: Combined package	Traffic measures (< 30m)	-
	Pitched barriers on each side of road (30-65m)	10.7 million
	Tunnel per road link (> 65m)	138 million

Source: Metz et al. (2000)

For an indication of costs and cost reduction if complementary policy is implemented, two packages of CE measures were computed. These packages (alternatives E and G) cover the costs mapped out by CE (0.7-3 billion euro) for solutions to problem areas in residential environments. The first package consists of demolishing all the dwellings within the exceedence zone. The second consists of removing the exceedence zone in three stages:

- For road links with an exceedence of up to 30 metres, traffic measures will be implemented.
- Along roads with an exceedence of 30 to 65 metres, pitched barriers will be placed along the stretch of the road where there are dwellings. Traffic measures will also be implemented along these road links.
- For the road links with an exceedence of more than 65 metres, a tunnel will be built along the stretch of the road where dwellings are located.

Finally, a combination of alternative E and G was considered (optimum). In this alternative the cheapest solution from alternative E or G was used to tackle the exceedence.

The CE calculations of the cost and the RIVM calculations differ slightly, because in the RIVM calculation consideration is given to the need for a pitched barrier for each side of the road, and the number of dwellings was established differently (5% fewer dwellings). Neither did the RIVM calculations consider a combination of pitched barriers and demolition; however, they did consider an optimum situation involving demolition, pitched barriers and tunnels. A computation of the CE reference (cost 0.7-3.0 billion euro) in the RIVM manner produces virtually the same cost, though (0.7-2.5 billion euro).

4. Air quality for NO_2 in the Netherlands

The NO_2 standard for the annual average is 40 μg/m^3. For brief exposure, the hourly average standard is 200 μg/m^3. This standard may be exceeded 18 times a year. In addition to limit values, the 1st daughter directive and the Dutch Air Quality Decree has plan thresholds (limit value plus margin of tolerance). These are thresholds for the air quality level above which it is mandatory to draw up plans. The aim of these plans is compliance with the limit values by 2010 at the latest. The level of the plan thresholds for NO_2 in 2001 is 45% higher than the limit values and will be tightened up 5% each year. In 2010 the level of the plan thresholds will equal the limit values.

This chapter indicates what the air quality is at present (section 4.1). It then gives an indication of the expected change in air quality for the reference and complementary policy scenario for 2000-2020 (section 4.2). This is followed by a discussion of the contribution made by NO_x sources in Amsterdam and Rotterdam (section 4.3), how the problem areas along motorways in urban areas will develop (section 4.4) and, finally, the cost of resolving remaining problem areas (section 4.5).

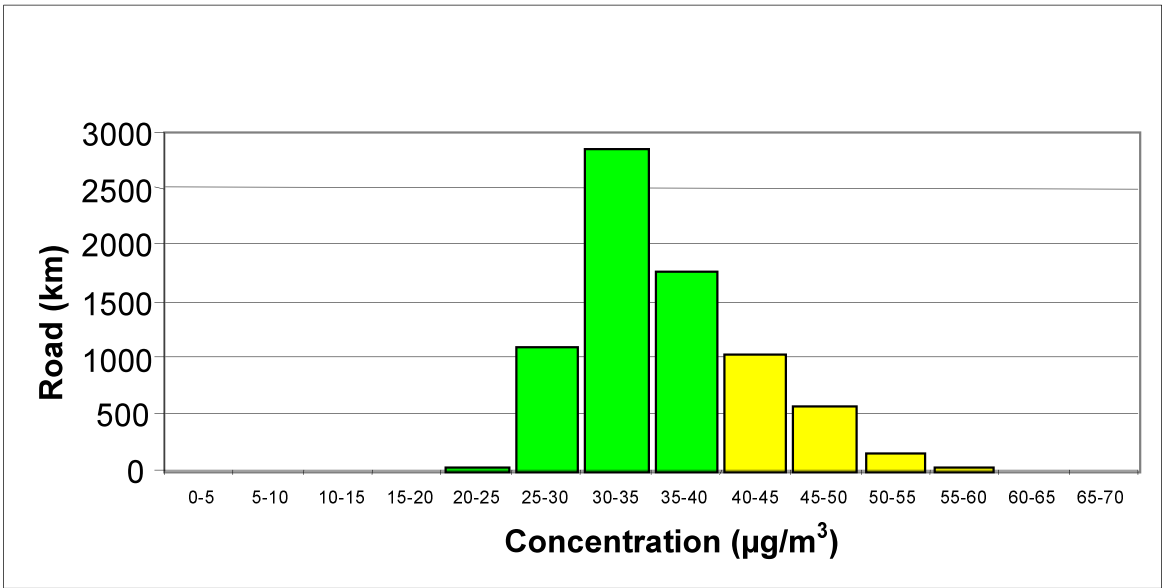

Figure 4.1 Annual average nitrogen dioxide concentrations along busy traffic routes (in km) in the Netherlands in 2000. Green: below the EU standard for 2010 (40μg/m^3); Yellow: exceedence of the EU standard for 2010 (RIVM, 2001a)

4.1 Air quality for NO_2 in 2000

The annual mean concentration, averaged for the Netherlands, was 21 μg/m^3 in 2000. Figure 4.2 shows the annual average concentration across the Netherlands. The highest concentrations occurred in the Randstad and the lowest in the northeast. Exceedences of the 40 μg/m^3 level occurred in the urban background of Amsterdam and Rotterdam.

Local emissions (mainly from traffic) can give rise to a higher concentration in several locations, though. Figure 4.1 shows a calculation for 2000 in which the number of kilometres of road is set against the calculated concentration. Along about 1700 kilometres of road an exceedence of the 40 μg/m^3 standard was calculated. Located in this exceedence zone are around 150,000 dwellings inhabited by about 400,000 people.

The expected concentrations for 2001 will - if the meteorological conditions are similar - be roughly consistent with the most recent concentration distribution (figure 4.1) calculated for 2000. These data show that the limit value plus margin of tolerance (together in total 58 μg/m^3 for 2001) will be exceeded along busy roads with an aggregate length of 10 km. About 1000 dwellings inhabited by about 3000 people are located along these roads.

It should be noted here that 2000 was a favourable year in terms of meteorological conditions. Allowing for potentially adverse meteorological conditions and uncertainties in the road-length calculations, exceedence of the plan threshold is possible along 10 to 200 km of road in 2001.

Using LML measurements, a connection was made between an hourly average that is exceeded 18 times a year and an associated annual average concentration. From this connection an annual average of 60-75 μg/m^3 was found to roughly correspond with (is as strict as) the hourly average standard of 200 μg/m^3, which may be exceeded 18 times a year (Annex 10). An annual average of 40 μg/m^3 has a corresponding hourly value of 120-140 μg/m^3, which may be exceeded 18 times a year or a 200 μg/m^3 hourly standard, which may be exceeded about 0-1 times a year. This means that the annual average standard for NO_2 is stricter than the hourly average standard. If the annual average is not exceeded, the hourly average value will not be exceeded either.

Emerging from the above-mentioned is that concentrations on a limited scale, which exceed the annual average of the plan threshold (above 58 μg/m^3). This means that exceedence of the hourly average standard is still possible. Exceedence of this standard is most likely in locations where the direct NO_2 emissions are relatively high, e.g. in large cities at locations where there is a lot of slow-moving traffic (diesel and other) with cold engines[2] (i.e. not close to motorways).

The plan threshold for the hourly average is not exceeded in 2000. No exceedences of the hourly average standard are expected for 2010.

4.2 Changes (2000-2020) in air quality for NO_2

The air quality for NO_2 improves considerably from 2000-2010 as a result of emission reductions in and outside the Netherlands in the reference scenario for 2010 MV5-EC (figure 4.2). In 2010 MV5-EC the annual average EU standard in the urban background of the Rotterdam agglomeration and in the vicinity of Nijmegen (sand dredges) is still exceeded, however.

[2] The NO_2 fraction in the NO_x emission from cold engines is higher than from hot engines.

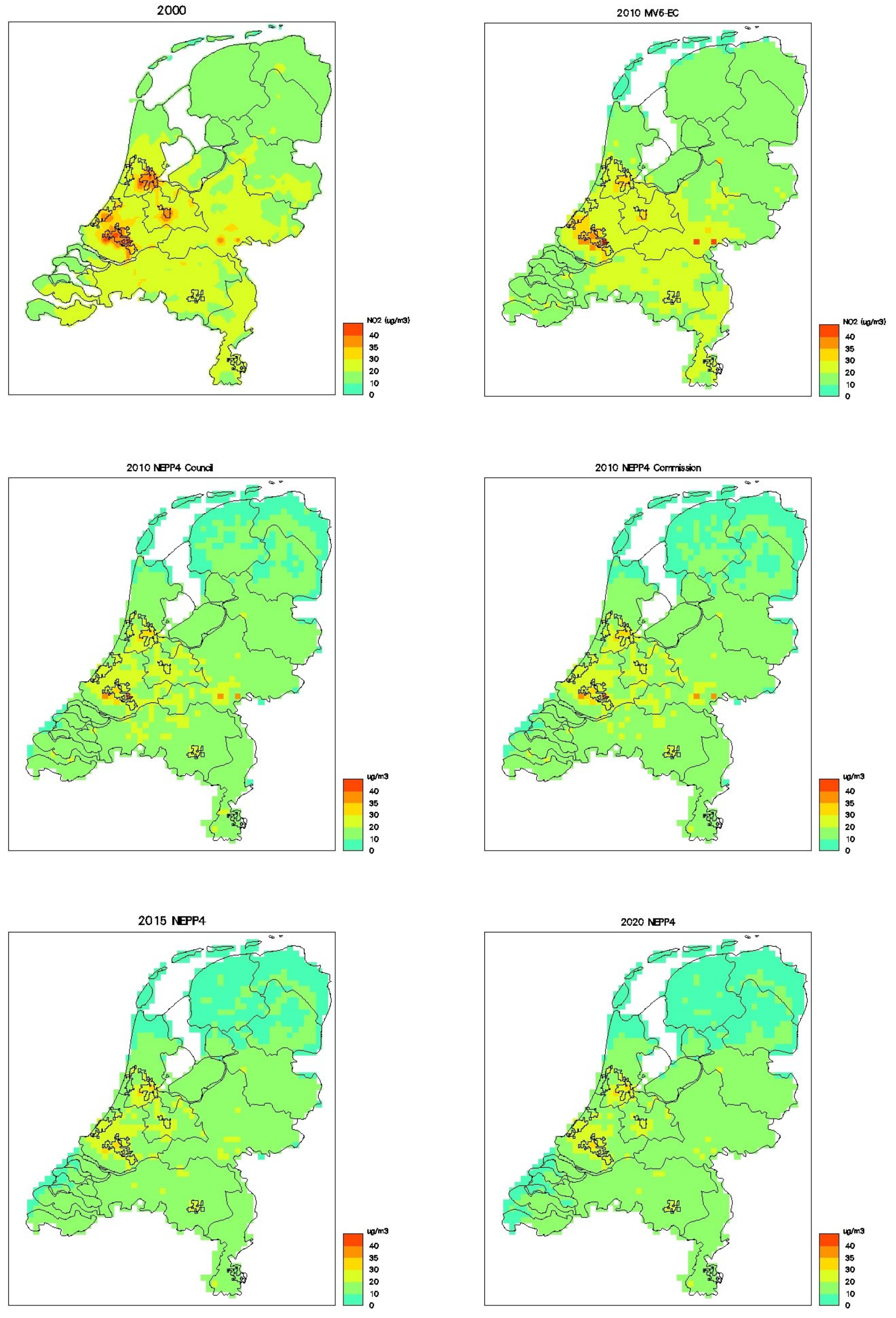

Figure 4.2 Annual average NO_2 concentration across the Netherlands for 2000 and the different scenarios: 2010 MV5-EC; 2010 NEPP4 Council and Commission, and 2015 NEPP4 and 2020 NEPP4 under average meteorological conditions

In all the emission alternatives in which additional policy is implemented (NEPP4 2010) a drop in the annual average NO_2 concentration compared with the reference (2010 MV5-EC) is calculated. The alternatives NEPP4 Council and Commission are virtually the same. In both Council and Commission no exceedence occurs in the urban background of Rotterdam or the surroundings of Nijmegen with average meteorological conditions.

Only under meteorological conditions adverse to air quality are exceedences of the EU standard also expected for NEPP4 2010 in the Rotterdam agglomeration and in the vicinity of Nijmegen (sand dredges).

The alternatives with maximum emission policy for 2015 and 2020 show no more exceedences (figure 4.2), not even when allowance is made for adverse meteorological conditions and for a scale level of a few square kilometres. The concentrates were calculated for average meteorological conditions on a grid of 5 x 5 km^2. Because the standard has to apply to adverse meteorological years as well and to surface areas of a few square kilometres, allowance was made for this. In an adverse meteorological year the concentration is about 10% higher; when a grid of 5 x 5 km^2 is scaled up to 1 x 1 km^2 concentration is also about 10% higher in a local grid cell.

However, the calculations do not take into account any local increase along busy trunk roads and motorways in urban areas. Section 4.4 shows how the situation changes at the local level along busy motorways in urban areas.

4.3 Changes (2010-2020) in motorway problem areas

The 25 road links selected by CE because there were dwellings located within the exceedence zone (annual average > 40 $\mu g/m^3$) are recomputed in this section for reference and complementary policy scenarios (table 4.1). The NEPP4 scenario combined with the Council proposal was disregarded as it produced virtually the same as the NEPP4 combined with the Commission proposal (see section 4.2). Exceedence distances were calculated from 25 up to and including 250 m. The uncertainty on an individual road link as the result of a possible chance error is great. For this reason the results shown were aggregated as far as possible.

Table 4.1 Computational procedure for motorway scenarios

Name of scenario	Traffic intensity[1]	NO_x background[1]	Vehicle emission factor[1]
2010refMV5EC	Reference 2010	EC2010 (MV5)	EC2010 MV5
2010refnepp4nec	Reference 2010	NEPP4 Commission	NEPP4
2010bornepp4nec	Bor 2010	NEPP4 Commission	NEPP4
2015nepp4	(Bor 2010+ NVVP2020)/2	NEPP4-2015	NEPP4-2015
2020nepp4	NVVP-mix 2020	NEPP4-2020	NEPP4-2020

[1]See section 1.3.2

The exceedence distances for CE are higher than the reference scenario (2010refMV5EC) for average meteorological conditions (table 4.2) mainly because CE used higher emission factors. In the CE calculations traffic speeds are on average 10km/hr faster than in the RIVM calculations. Consequently, the CE emission factors are 15% higher for cars and 2% higher for trucks. The RIVM background concentrations, however, are on average slightly higher than the ones used by CE (see Chapter 3). As a result, the RIVM exceedence distances are higher on a number of road links, but, on average, the scale dips towards lower values.

The exceedence distance clearly decreases in the alternatives in which policy increases (figure 4.3). The downward trend in the background concentration and the emission factors for road traffic (2010refMV5EC>2010refnepp4>2010bornepp4nec>2015nepp4>2020nepp4) can be clearly seen in a decrease in the exceedence distance. In the reference, the exceedence distance on 10 road links was greater than 75 metres under average conditions. When the NEPP4 is implemented, nowhere is there an exceedence distance of more than 50 metres under average conditions. In 2015 and 2020 with maximum reduction policy there is an exceedence distance of more than 35 metres on two and zero road links, respectively, under average meteorological conditions.

Table 4.2 Exceedence distance (in metres) per road link for different scenarios, the highest exceedence distance (from the road axis) per road link for an average meteorological year

	CE	2010refMV5ec	2010refnepp4 nec	2010bornepp4 nec	2015nepp4	2020nepp4
A16-7	159	63	39	34	25	<25
A20-7	145	99	40	37	27	<25
A13 –5	130	73	37	<25	<25	<25
A16-5	126	78	48	41	31	<25
A15-7	124	84	50	48	38	35
A16-3	120	80	47	42	31	<25
A20-6	115	81	38	35	26	<25
A16-4	108	65	43	39	29	<25
A16-8	106	59	41	38	30	<25
A10-15	100	124	44	39	29	<25
A15-8	100	58	40	38	31	27
A16-9	100	70	46	40	32	26
A10-14	97	87	40	32	<25	<25
A10-16	92	80	38	32	<25	<25
A16-2	90	53	36	33	<25	<25
A16-10	89	91	50	43	25	<25
A10-13	83	42	31	27	<25	<25
A16-11	80	99	47	39	<25	<25
A4-2	79	40	29	<25	<25	<25
A20-10	74	70	37	30	<25	<25
A50-4	73	39	34	31	27	<25
A2-11	60	48	37	39	37	<25
A27-4	54	56	31	29	<25	<25
A12-3	50	29	<25	<25	<25	<25
A9-9	36	56	34	26	<25	<25

Under meteorologically adverse conditions the NO_2 concentration is assumed to be about 10% higher and under favourable conditions about 10% lower. Figure 4.3 and Annex 5 show that as a result, the exceedence distances alter substantially compared with average meteorology. The increase in adverse years is on average a factor of 3 for alternatives in 2010 and 2015. In 2020 there are almost no exceedences under average conditions, with the result that the increase compared with the average is large. The decrease under favourable conditions is a factor of about 3-4.5 in 2010. In 2015 and 2020 there are a few or no more exceedences, respectively.

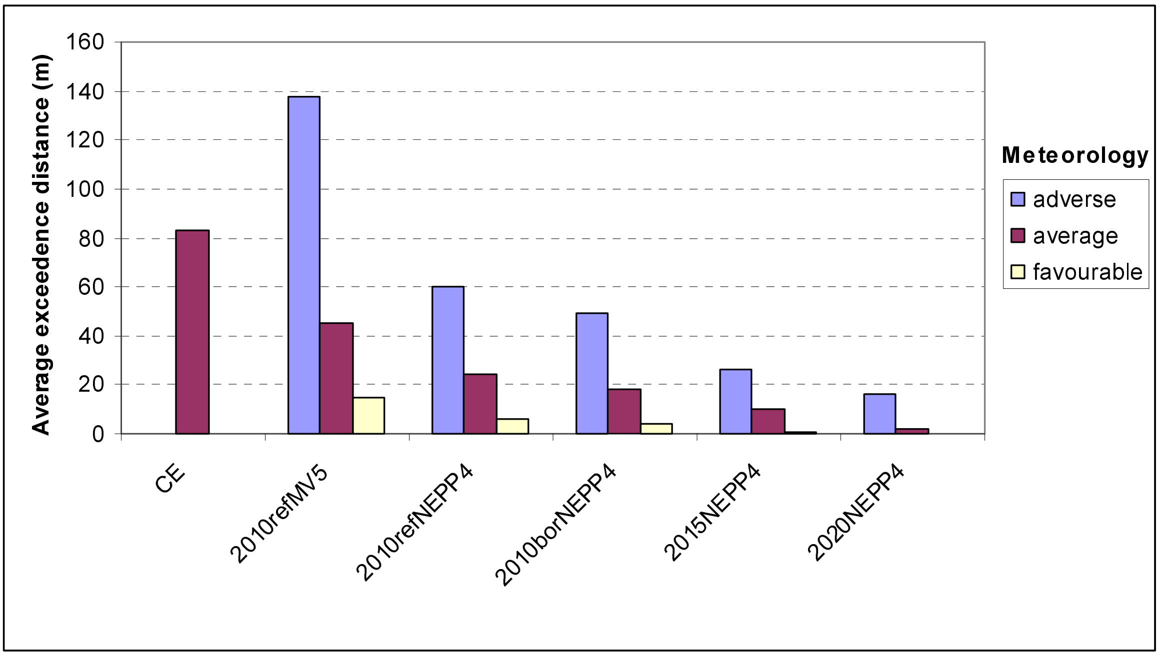

Figure 4.3 Average exceedence distance on 25 road links (50 sides) for different scenarios and meteorological conditions

Table 4.3 shows the number of houses within the exceedence distances for average, favourable and adverse meteorological conditions. Annex 6 shows the number of dwellings per road link.

In an average meteorological year the number of dwellings above the standard can be estimated at about 2100 (along 14 road links) for the reference situation in 2010 (2010refMV5EC). Of these dwellings, about half are located in the Rotterdam agglomeration (ring road, A16, A13) and the other half in the Amsterdam agglomeration (A10 west). The number of dwellings declines considerably, however, in the alternatives involving additional policy. When the NEPP4 is implemented, the number of exposed dwellings falls by a factor of 6 to around 350 (along 8 road links) in an average year. If, in addition to the NEPP4, the special traffic policy for the Randstad is implemented, the number of dwellings drops by half again to about 150 (along 4 road links). With a maximum reduction policy, there will be no dwellings in an exceedence zone under average conditions in 2015.

Table 4.3. Number of dwellings within the exceedence distance in the various alternatives

	CE	2010refMV5ec	2010refnepp4nec	2010bornepp4nec	2015nepp4	2020nepp4
Average meteorology[2]	4400	2070	350	140	0	0
Adverse meteorology	-	>14000[1]	2950	1660	130	40
Favourable meteorology	-	160	20	0	0	0

[1] In a number of cases the exceedence distance is > 250m. The number of dwellings was determined at 250m.

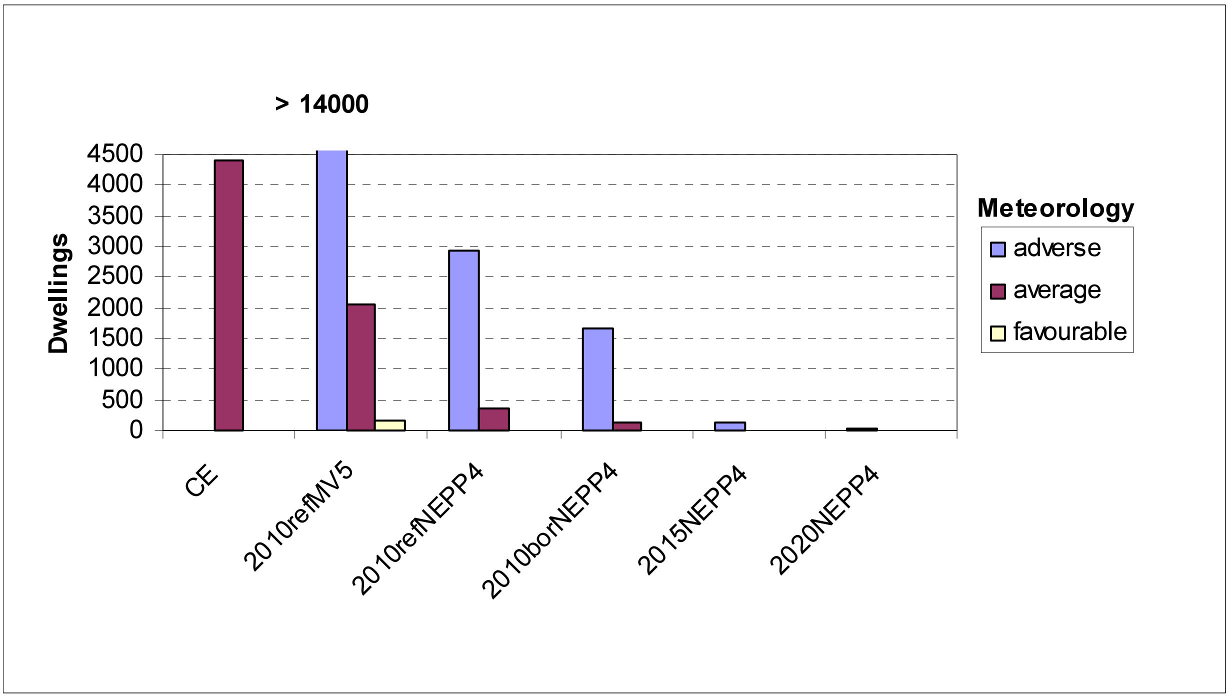

Figure 4.5 Number of dwellings in exceedence zones in different scenarios under different meteorological conditions

In an adverse meteorological year the calculations show more than 14,000 dwellings within an exceedence zone along 24 road links (45 km of motorway). For NEPP4 the number of dwellings affected in an adverse year is about 2900 (along 17 road links). If, in addition to the NEPP4, the special traffic policy for the Randstad (BOR) is implemented, the number of dwellings falls to around 1700 along 12 road links. With a maximum reduction policy, exceedence occurs - under adverse conditions - near about 130 dwellings along 7 road links in 2015. If a maximum reduction policy is continued, only about 40 dwellings along 4 road links will be exposed to concentrations in excess of the standard in 2020.

For favourable meteorological conditions the problem areas can be resolved in 2010 through the implementation of the NEPP and BOR. Implementation of the NEPP4 only will leave about 20 houses still located in exceedence zones, and if no policy is implemented about 160 dwellings will be in exceedence zones. After 2010, there will be no more problem areas under favourable conditions if maximum reduction policy is continued.

From figure 4.5 it appears that there is a strong quadratic connection (with a regression coefficient of 0.99) between the average exceedence distance over 25 road links and the total number of dwellings in the exceedence zone. It proves possible to approximate the connection between the average exceedence distance and the number of dwellings with a second degree polynomial. A 10% concentration increase which in 2010 produces an exceedence distance that is three times as great means nine times as many dwellings in the exceedence zone. A 10% reduction in concentrations, which in 2010 produces an exceedence distance that is smaller by a factor of 3-4.5 times, means 9-20 times fewer dwellings in the exceedence zone

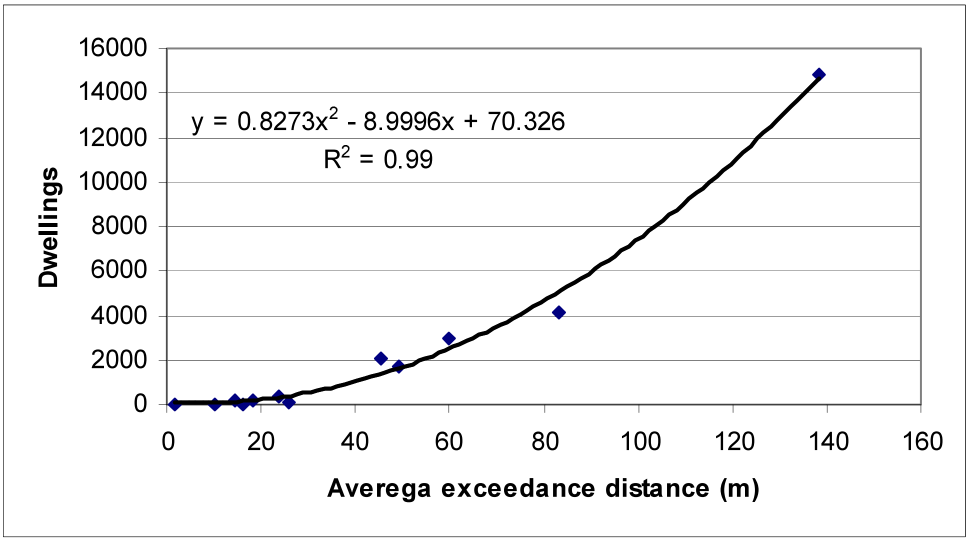

Figure 4.5 Connection between average exceedence distance over 25 road links and the number of dwellings in the exceedence zone

4.4 Cost of tackling remaining problem areas

Local measures can be taken to resolve the problem areas along motorways. These measures include demolishing houses, placing pitched barriers, traffic measures and the construction of tunnels. The cost calculations are based on the CE calculations (Metz et al., 2000). Section 3.2.6 explained how the cost of these measures was estimated. This section indicates the various costs per scenario for resolving the problem areas at the local level.

Table 4.4 Cost (in billions of euro) to avoid exceedence in the case of average (av), adverse (adv) and favourable (fav) meteorology for the different alternatives

Cost (billions of euro)	**2010REFMV5 EC**			**CE**	**2010REFNEPP4 NEC**			**2010BOR NEPP4NEC**		**2015NEPP4**		**2020NEPP4**	
Meteo	*av*	*adv*	*fav*	*av*	*av*	*adv*	*fav*	*av*	*adv*	*av*	*adv*	*av*	*adv*
Alternative G: Demolish	0.4	2.6	0.03	0.8	0.06	0.5	0.003	0.02	0.3	0	0.02	0	0.01
Alternative E: Combined package	1.7	3.2	0.04	3.0	0.09	2.1	0	0.03	1.5	0	0.07	0	0.02
Optimum	0.4	1.5	0.03	0.7[1]	0.06	0.5	0	0.02	0.3	0	0.02	0	0.01

1 Combination of pitched barriers and demolition; tunnels are not an option.

Table 4.4 shows the cost of modifications near motorways to ensure that no dwellings are affected in excess of the standard. The cost range for average circumstances in the reference situation (MV5) for 2010 is estimated at 0.4 to 1.7 billion euro. The calculations show a substantial reduction in cost for the alternatives involving additional policy. When the NEPP4 is implemented, the cost falls by a factor of 9-19 to 60-90 million euro under average conditions. The implementation of BOR (the special traffic policy for the Randstad) on top of the NEPP4 produces an additional reduction in the modification costs of about 40-60 million. After 2015 there are no exceedences in residential areas under average conditions, so there are no costs for modifications either.

Under adverse meteorological conditions the cost of modifications for the reference situation, at 1.5-3.2 billion euro, is a factor of 2-4 higher. With the NEPP4 the cost in respect of average conditions, at 0.5-2.1 billion euro, is a factor of 9-23 higher. In 2015 and 2020 there is no exceedence under average conditions and no cost, but under adverse conditions 20-70 and 10-20 million euro, respectively, are needed for local modifications.

Under favourable meteorological conditions 30-40 million euro is required for modifications in the reference situation. Implementation of the NEPP4 reduces this sum to 3 million euro. If the BOR is then implemented as well, there are no more problem areas and no more costs.

The above calculations show the sensitivity to small changes in the concentration. While the cost with 2010 MV5-EC for average meteorological conditions is around 0.4-1.7 billion, the cost with adverse meteorology (concentration 10% higher) is at 1.5-3.2 billion substantially higher (a factor of 2-40). With favourable meteorology (concentration 10% lower) the cost, at 30-40 million euro (a factor of 10-40), is substantially lower.

On the two road links, A20-6 and A20-7, for scenario 2010refMV5EC, where the background under adverse meteorological conditions exceeds the standard, infrastructural modifications will only bring about a reduction in the concentration. To drop below the standard will, under these conditions, require emission reduction policy on a larger scale, as contained in the scenarios involving complementary policy.

Also, calculating with average costs produces an additional error, because the situations considered could systematically depart from the average. In addition, there may be direct costs attached to traffic measures (alternative routes).

It should be noted, therefore, that the costs are indicative; due to the uncertainties in exceedence calculations may also differ considerably.

4.5 Contribution of NO_x sources to urban concentrations

The relative share of the urban concentration and the background concentration (in the countryside outside the city) was calculated for the various NO_x sources in Amsterdam and Rotterdam. For this purpose the contributions to the NO_x concentration were calculated at a point in the city and a point outside the city. The urban share was determined by deducting the source contributions outside the city from the contributions in the city. This was done for 1999, reference scenario 2010 MV5-EC and the scenarios involving additional policy: 2010 NEPP4, 2015 NEPP4 and 2020 NEPP4 (table 4.5).

The differences between the urban and the background contributions of Amsterdam and Rotterdam were small for all the scenarios, although in Rotterdam, the harbour, and in Amsterdam, Schiphol airport, are seen to make a higher contribution to both the background and the urban concentration. Because the agricultural concentration outside urban areas is higher than in urban areas, this sector was assigned a ‘negative’ value in the calculations for the urban contribution.

In all the scenarios road traffic was the chief source of NO_x in urban areas, contributing around 55-70%. The ‘other traffic’ category largely comprises mobile equipment (e.g. earth moving equipment, cranes, pile drivers, forklift trucks). Although these are placed under the heading of road traffic, officially they are not. Their emissions are linked to the population density and so mainly occur in urban areas. Due to a sizeable reduction in road traffic in 2020, the relative share of road traffic in the urban concentration declines towards 2020. households and the trade, services and government sector (largely space heating) are, after traffic, the principal source of NO_x in urban areas. Their relative share increases from 20 to about 40% of the urban contribution in the scenarios due to the fact that these emissions increase slightly from 2010 to 2020 in these scenarios (Annex 1). Together, traffic, households and the trade, services and government sector are good for about 80% of urban emissions.

Table 4.5 Relative contribution of NOx sources to the urban and background concentration for NO_x. Annual average NO_2 concentration in the background and in the city is in parentheses

Background	1999		2010 mv5-ec2010		2010 NEPP4[1]		2015 NEPP4		2020 NEPP4	
	A'dam	R'dam	A'dam	R'dam	A'dam	R'dam	A'dam	R'dam	A'dam	R'dam
NO_2 concentration ($\mu g/m^3$)	(24)	(29)	(18)	(22)	(15)	(19)	(14)	(17)	(13)	(16)
Percentage (%)										
Road traffic total	50	43	34	30	39	34	39	35	37	34
Light road traffic	28	23	13	10	14	10	10	8	6	5
Heavy road traffic	17	16	16	14	17	16	18	18	19	18
Other traffic[2]	5	5	6	6	8	8	10	10	12	11
Foreign countries	20	21	19	19	19	18	19	19	16	16
Agriculture[3]	10	14	15	20	15	20	15	21	15	21
Households + TSG	8	7	10	8	6	5	9	8	15	13
Shipping	6	9	10	15	11	16	6	9	6	9
Industry & Energy	6	5	7	6	7	6	7	6	7	6
Aviation	1	0	3	1	3	1	4	1	5	1
Other	0	0	1	0	1	0	1	0	1	0

Δ Urban contribution	1999		2010 MV5-EC		2010 NEPP4[1]		2015 NEPP4		2020 NEPP4	
	A'dam	R'dam	A'dam	R'dam	A'dam	R'dam	A'dam	R'dam	A'dam	R'dam
NO_2 concentration in the city ($\mu g/m^3$)	(42)	(43)	(35)	(36)	(30)	(32)	(30)	(31)	(31)	(31)
Percentage (%)										
Road traffic total	66	69	55	55	71	70	64	65	54	56
Light road traffic	23	27	10	12	12	15	8	11	4	5
Heavy road traffic	16	19	15	18	17	22	16	20	14	19
Other traffic[2]	28	23	30	25	41	33	40	33	36	32
Households + CSP	27	22	36	30	20	17	29	24	38	34
Industry & Energy	5	7	5	8	5	9	5	8	4	7
Shipping	1	4	2	7	2	9	1	6	1	5
Aviation	1	0	2	0	2	1	3	1	3	1
Agriculture[3]	-2	-3	-2	-2	-3	-6	-3	-5	-2	-4
Other	2	1	2	2	2	2	2	2	2	1

[1] *2010 NEPP4 Commission; the concentration is 1-2% higher with the Council alternative*
[2] *Mainly mobile equipment*
[3] *Including denitrification in agricultural and other soils*

Road traffic is the principal source of background concentrations for all the scenarios (35-50%) and together with foreign countries (15-20%), agriculture (10-20%), households and CSP (about 10%) and shipping (5-15%) is good for 90% of the NO_x emission contribution. In the scenarios with extra policy in and outside the Netherlands the relative foreign contribution to the background concentration for Amsterdam and Rotterdam declines (about 5%). Thanks to the substantial reductions in the shipping sector, its relative contribution also declines in the background. The relative contribution of trade, services and government and households (space heating) increases towards 2020 because emissions increase slightly.

If the NEPP4 is implemented in 2010, the urban contribution in particular declines when compared to the reference. After that, the urban contribution stabilises in Rotterdam and shows a slight increase in Amsterdam up to and including 2020. The reason for this increase is that, alongside the substantial reduction in most sectors, there is a slight increase in household emissions and those of the trade, services and government sector (space heating) and to a lesser extent emissions from air traffic from 2010 NEPP to 2020 NEPP4.

5. Air quality for NO_2 in other Member States

Other countries of the EU such as the United Kingdom, Germany, Belgium and Austria have indicated that they will have difficulty attaining the NO_2 limit values (VMM, 2001). Germany has no idea as yet of the scale of problem areas that will occur. For example, in North Rhine-Westphalia (the Ruhr) no study has yet been made of possible exceedences of the standard along motorways. The Germans do not consider it possible to give a detailed picture of the cost yet. They say it will only be possible as regulations are implemented, in particular after the first plans have been made.

In the United Kingdom the national target is attainment of the NO_2 standard of 40 µg/m^3 as annual average as early as 2005 (instead of 2010). Local authorities are expected to deal with any problem areas. Attainment of this standard is, however, expected to be difficult (at least in 2005). Problems are also still expected in big cities like London in 2010.

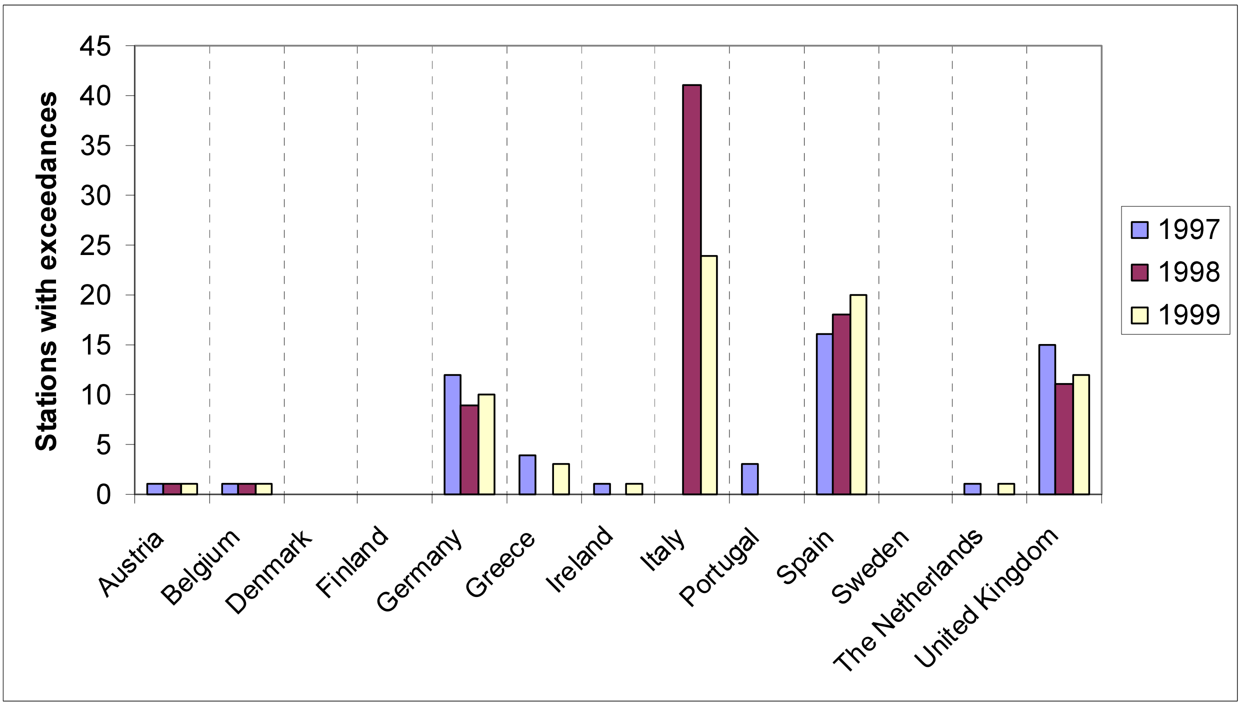

Figure 5.1 Exceedences of annual average NO_2 of 60 µg/m^3 in the EU. (Data on France and Luxembourg not available; lack of data on Italy for 1997 and on Greece for 1998) Source: RIVM/Airbase

5.1 Air quality situation for NO_2 in 1999

The data for 1997-1999 were checked in the EEA's air quality database. The measurements are very location-dependent and do not cover all exceedences. Also, there is no data on France and Luxembourg, and data is missing for 1997 on Spain and Italy and for 1998-1999 on Greece. However, the figure and table do give an indication of exceedences in other countries compared with the Netherlands.

In 1998, 156 stations had a level in excess of the 40 µg/m^3, 38 of which were street stations. For 2010, the stations that already measure an annual average in excess of 50 and 60 µg/m^3 are of importance. Figure 5.1 and table 5.1 give an overview of 70 exceedences of 60 µg/m_3 as registered by monitoring networks in Europe. In Italy and Spain especially, 60 µg/m_3 is exceeded at many measuring points (traffic stations). The number of exceedences observed in Germany and Great Britain were also many times greater than in the Netherlands.

Table 5.1 Exceedences of annual average of 60 µg/m^3 per type of station in monitoring networks in Europe in 1999

Country	Type of station	Number of stations with exceedences	Average exceedence concentration (µg/m^3)
Belgium	Traffic	1	74.7
Germany	Background	1	64.4
	Traffic	7	67.8
	Unknown	2	69.2
Greece	Traffic	3	70.5
Great Britain	Background	2	64.8
	Traffic	10	73.1
Ireland	Traffic	1	70.0
Italy	Background	2	70.7
	Industry	2	67.6
	Traffic	20	73.5
Netherlands	Traffic	1	62.9
Austria	Traffic	1	61.4
Poland	Traffic	1	71.1
Spain	Background	1	62.8
	Industry	1	65.6
	Traffic	18	71.8

No data available on France and Luxembourg.
Source: RIVM/Airbase

5.2 Changes (2000-2010) in air quality for NO_2

In recent years various studies have been conducted into the air quality situation within the European Union. All these studies have shown that if additional measures are not taken at many locations in Europe, exceedence of the NO_2 standard can be expected in 2010 (figure 5.2).

Very recent additional calculations (not yet reported), based on the PEEP study (Annex 7), show that in the agglomerations around Paris, Barcelona, Milan and Rome exceedence of the annual average will occur over a large area. The standard will be exceeded in many other big

European cities (including Amsterdam) says the report, but in these cases it will be confined to very busy streets.

From these studies particularly big cities in the southern Member States are shown to expect poorer air quality for NO_2 than the Netherlands. Urban air quality in relation to NO_2 in the Netherlands is already better than the EU average now and will continue to be so in 2010.

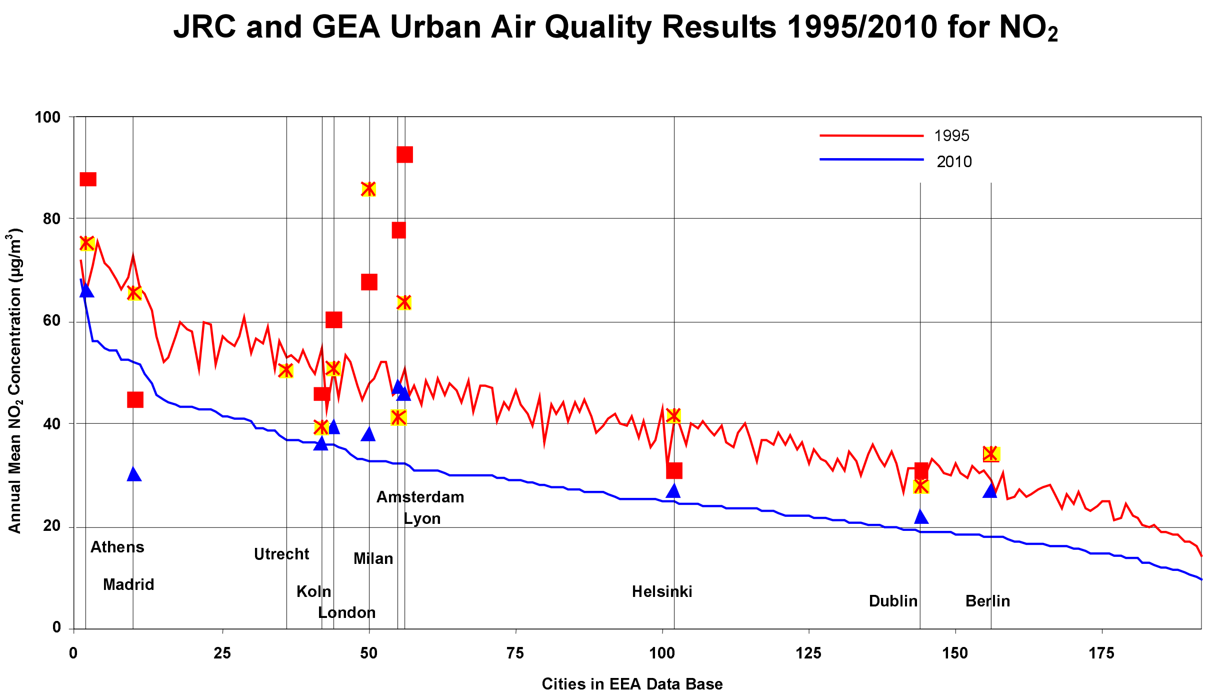

Figure 5.2 Annual mean urban NO_2 concentrations in various EU cities using the Air Quality Assessment Model (UAQAM) (red line (1995) and blue line (2010) and results of Joint Research Centre (JRC) (red squares (1995) and blue triangles (2010). The asterixes indicate the measured values (1992-1996). Source: De Leeuw et al. (2001)

At the time of compiling this report, no studies had yet been conducted in other Member States which describe the expected air quality situation in as much detail as the Dutch CE study of problem areas along motorways. In AUTO-OIL II (2000), calculations were made for two streets (Schildhornstrasse in Berlin and Viale Murillo in Milan) for a short period in 2010. The result gives an indication of the annual average. Here two typical, busy streets (45,000-50,000 vehicles a day) were taken; but they were not the busiest street in the city. Scenario data on the European NO_x emissions used are given in Annex 8.

In Viale Murillo, the limit value is still well exceeded, while the background concentration in Milan (38 $\mu g/m^3$ (AUTO-OIL II, 2000) does comply with the standard in 2010. There is no longer any exceedence in the Schildhornstrasse in Berlin in 2010 (table 5.2).

It is difficult to draw general conclusions from this limited study, but the calculation suggests a reduction in the NO_2 concentration that is larger than the reduction in the background concentration. This is caused by a relatively large reduction in emissions from road traffic. The absolute value will remain higher in most cases in street canyons, which means that a number of exceedences of the air quality standards can still occur in cities where the background concentration complies with the standard.

Table 5.2 NO_2 street concentrations in Milan and Berlin

Milan Viale Murillo Average 14/11-17/11 NO_2 (µg/m^3)	1997	2010
East side	96	67
West side	87	63
Berlin Schildhornstrasse Average 21/02-25/02 NO_2 (µg/m^3)	1995	2010
Downwind	48	30
Upwind	39	26

Source: AUTO-OIL II. (2000)

6. Discussion and conclusions

6.1 Discussion

The findings of the CE study on problem areas along the motorway network in the Netherlands (4400 houses along 25 road links) are – in view of the large uncertainties - of the same order of magnitude as the RIVM findings (2100 houses along 14 road links). The difference of a factor of 2 in the number of houses appears large, but as is shown below, a slight change in concentration of +10% produces an increase or decrease in the number of dwellings by a factor of 9-13 against the reference situation.

The RIVM calculations were calibrated against those of CE. The differences result from the fact that CE used higher emission factors. In the CE calculations, traffic moves on average 10km/hr faster than in the RIVM calculations. Consequently, the CE emission factors are 15% higher for cars and 2% higher for trucks. The RIVM's background concentrations are on average slightly higher than those used by CE, however. This is primarily the result of a different spatial emission distribution. As a result, on a number of road links the RIVM exceedence distance is higher, but on average the scale dips towards lower values.

In the case of calculations with higher exceedence distances than CE, as in the reference for adverse meteorology, exceedences are likely to occur also near dwellings along other road links, apart from the 25 considered in this study.

Uncertainties

The calculation from emission to concentration, exceedence, exposure and cost of tackling the problem, passes through different stages. The uncertainty in each stage accumulates in the end result. There are uncertainties in future emission estimates and concentration calculations. There are also uncertainties in the calculation of the concentration on an individual road link caused by uncertainties in emission factors and traffic intensity. An indication of uncertainties in emissions is given by the use of different alternatives for traffic intensities and different emission scenarios.

Uncertainties in the background concentration come to about 10% (based on $1*\sigma$). Uncertainties in concentration calculations on an individual road link amount to a chance error of about 20% (on the basis of $1*\sigma$). For the average of 25 road links this drops to 4%. In total, this produces an error of about 10-15% in the concentration calculation for an average road link. The uncertainty may increase as a result of future uncertainties in the national emissions, the number of vehicles and the accuracy of the emission factors (e.g. representativeness of vehicle fleet and driving conditions). An uncertainty of 10-15% can be taken as the lower limit.

The number of dwellings (as per 2000) can be determined fairly accurately down to 5 metres, but the type of dwelling (in connection with demolition costs) is uncertain. Calculating with average costs per road link and omitting the direct costs of traffic measures introduces an additional error in the cost calculation. It should therefore be noted that the costs are only indicative.

Especially, the estimates for exceedence distances in 2010 are highly sensitive to changes in concentration. This is due to uncertainties in emissions (traffic and background) and meteorological conditions. This has a considerable impact on the number of houses in exceedence zones and, hence, on the cost calculation for local measures near motorways. The reason for this is that the exceedence distance can differ by a factor of 3-4 as the result of a variation of 10% in the concentration in 2010 in the reference situation. Because there is a quadratic link between the average exceedence distance and the number of dwellings, a 10% concentration change produces a difference of a factor of 9-13 in the number of dwellings for the reference situation. In view of an uncertainty of 10-15%, it is impossible to give an accurate estimate of the number of dwellings in 2010.

Thus, in 2010 we are talking about the proverbial tip of the iceberg as far as exceedences are concerned. A slight change (a 10% change in the concentration) can cause the iceberg to rise out of the water or may cause it to almost disappear beneath the waves. In scenarios with lower emissions, e.g. NEPP4, the absolute range over the number of dwellings does decline, though. Here, the concentrations are lower and the number of affected dwellings is fewer, but the relative range is just as large. In the 2010 scenario in which both NEPP4 and BOR are implemented, the concentrations fall to such a level that dwellings are no longer affected by concentrations which are 10% lower. The iceberg of exceedences disappears here, as it were, beneath the waves for a 10% lower concentration than average. This reduces the uncertainty over the number of dwellings substantially (see figure 4.4).

In 2015 and 2020 the iceberg of exceedences (dwellings) slowly disappears further beneath the waves for average and 10% lower concentrations, and the range in the number of houses is consequently a great deal smaller and the estimate a great deal less uncertain. As in the alternatives for maximum emission reduction policy in 2015 and 2020, a 10% higher concentration still causes exceedences near dwellings. In 2015 the number of houses for which the limit is exceeded is 130; in 2020 this number is 40. Average or 10% lower values do not result in exceedences.

6.2 Conclusions

Exceedence of the EU 2010-2020 standard

Under average meteorological conditions, the air quality for NO_2 in the Netherlands with current policy and implementation of the Gothenburg protocol will improve considerably, but will not comply with the new EU standard in 2010. According to the European Coordination reference scenario (CPB, 1997), the standard will still be exceeded in that year near about 2100 dwellings located along motorways, and in the urban background concentration of the Rotterdam agglomeration, under average meteorological conditions. Of the above dwellings along motorways, about half are located in Rotterdam (ring road, A16, A13) and half in Amsterdam (A10 west). Even if the Fourth National Environmental Policy Plan (NEPP4) is implemented, the standard will still be exceeded in 2010 but only along motorways, and the number of dwellings where the standard is exceeded will drop considerably to about 350. If, in addition to the NEPP4, the separate traffic policy (BOR) is also implemented, the number of dwellings subject to exceedence will drop further to around 140. Only if the emission reductions and policy on traffic are **maximally** enforced across Europe in 2010 after implementation of the NEPP4 policy, will there be no more exceedences near dwellings in 2015 and beyond.

Under adverse meteorological conditions the exceedences are larger and more persistent. The standard for the EC 2010 scenario is exceeded for more than 14,000 dwellings along around 22 road links (45 km of motorway). If NEPP4 is implemented, the number of dwellings with exceedences will fall to around 3000. There will still be exceedence in the urban background of the Rotterdam agglomeration. If, in addition to the NEPP4, the separate Randstad traffic policy (BOR) is also implemented, the number of dwellings subject to exceedence will drop to around 1700. If, after implementation of the NEPP4 in 2010, **maximum** emission reduction and traffic policy is implemented Europe-wide, exceedences will then only occur near 140 dwellings in 2015 and 40 dwellings in 2020.

In a favourable meteorological year the problem areas in 2010 can be resolved by implementing NEPP4 and BOR. If only NEPP4 is implemented, this will leave about 20 houses in exceedence zones. If no policy is pursued, around 160 dwellings will be located in exceedence zones. After 2010, there will be no more problem areas if maximum reduction policy is continued.

Cost of potential modifications to local infrastructure
To resolve problem areas in 2010 the costs of local measures (demolition of dwellings, installation of pitched barriers and construction of tunnels) are estimated at 0.4 to 1.6 billion euro under average meteorological conditions. If the NEPP4 is implemented, the cost falls to 60-90 million euro. Implementing the Randstad transport policy plan (BOR) on top of the NEPP4 in 2010 will produce an additional reduction of 40-60 million euro. After 2015, there will be no exceedences and hence no associated cost if maximum reduction policy is implemented.

To prevent exceedences even under adverse meteorological conditions the cost of modifications for the reference situation, at 1.5-3.2 billion euro, is a factor of 2-4 higher. With the NEPP4 the cost in the case of average conditions, at 0.5-2.1 billion euro, is a factor of 9-23 higher. In 2015 and 2020, if maximum reduction policy is implemented, 20-70 and 10-20 million euro, respectively, will still be required for local modifications.

Under favourable meteorological conditions 30-40 million euro will be required for modifications in the reference situation. If the NEPP4 is implemented, this sum falls to 3 million euro. If the BOR is then implemented as well, there will be no more problem areas and no more associated costs.

The cost of implementing NO_x policy from the NEPP4 is, at around 78 million euro a year, much lower than the total costs that would be needed for modifications to local infrastructure.

Health effects and the EU standard for NO_2
Long-term exposure to NO_2, and to traffic-related particulate air pollution, for which NO_2 is taken as an indicator, can be expected to result in effects on health as well above as below the annual average EU NO_2 standard. It is understood for NO_2 (and the associated air pollution) that long-term multi-year chronic exposure is more important than short-term exposure. Thus, for the development of policy measures the long-term trend in concentrations probably carries more weight than the concentration in any isolated year, which may turn out to be relatively higher as a result of very unfavourable meteorological conditions.

NO_x sources in urban areas

If current policy is implemented the traffic sector will continue to be the major contributant to urban NO_x emissions (60%) in Amsterdam and Rotterdam in 2010. However, households, together with the trade, services and government sector (space heating) will also constitute a major emissions source by 2010 (30-35%). If additional policy (NEPP4) is pursued, this relative contribution first declines, only to increase again between 2010 and 2020 because the emissions from the trade, services and government sectors rise slightly in the NEPP4 scenario. Reductions in these sectors would result in an even further substantial reduction in the urban concentrations.

Effect of complementary policy in other EU Member States in 2010

If other Member States of the EU implement additional policy on top of the Gothenburg protocol (e.g. the Commission's NEC proposal for 2010), there will be no, or virtually no, reduction in the problem areas in the Netherlands in 2010. However, the implementation of technologies (e.g. cleaner cars), as assumed in the maximum policy after NEPP4 2010, will require a European approach.

Feasibility of the NO_2 standard in other EU Member States

Urban air quality in relation to NO_2 in the Netherlands is better than the EU average, now as well as in 2010. It is therefore to be expected that, compared to the Netherlands, the feasibility of meeting the standard for nitrogen dioxide will be even more of a problem for other (southern) EU Member States.

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Annex 1 NO_x emissions in the Netherlands

Emission (ktonne)	2010 MV5-EC	2020 MV5-EC	2010 NEPP4	2015 NEPP4	2020 NEPP4
Industry & Energy					
Food industry	4	4	3	3	2
Oil refinery	12	13	11	10	9
Chemical industry	17	18	14	13	12
Building materials & others	9	9	8	7	6
Iron & steel industry	8	8	7	6	5
Metallurgical industry	2	2	1	1	1
Other industry	2	2	2	2	2
Power plants	20	21	17	15	14
Building industry and demolition	1	1	1	0	0
Traffic					
Cars	21	16	19	13	7
Light-duty vehicles	7	6	7	5	3
Heavy-duty vehicles	41	36	38	37	36
Coaches	3	2	3	3	2
Rail transport	2	2	2	2	2
Ships inland	35	32	29	8	8
Ships sea	27	31	27	24	21
Ships recreation	1	1	1	1	1
Aviation	5	6	5	6	6
Traffic other (mobile machinery)	9	9	9	7	6
Agriculture					
Mobile machinery agriculture	11	8	10	8	5
Agriculture Others	12	10	6	6	6
Consumers	14	12	7	8	8
Trade, services and government	8	8	3	5	8
Waste burning	2	2	1	1	1
Nature	16	16	16	16	16
Subtotal	288	273	248	208	188
Total anthropogenic	272	257	231	192	172

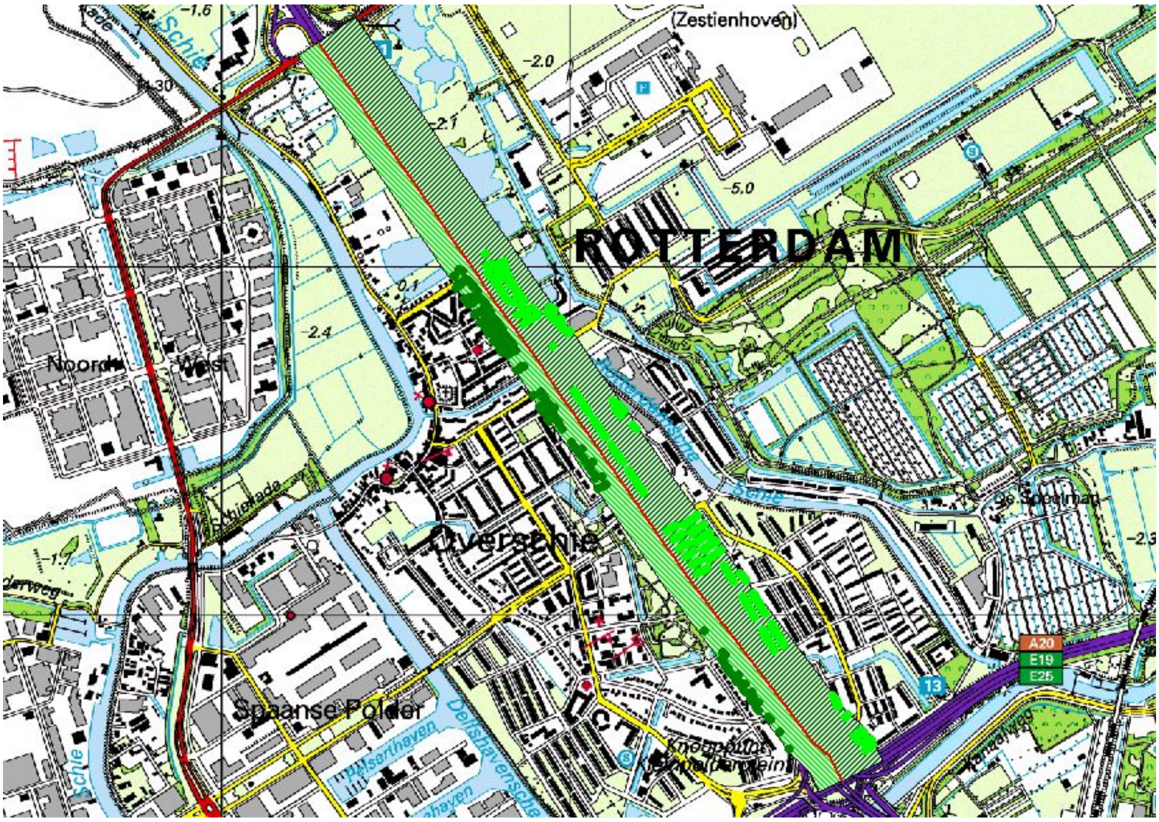
N.B. Inaccuracy of emissions at subsector level is relatively great.

Annex 2 Traffic intensities

Traffic intensity (weekday average[3])			2010Reference			2010 BOR			2020 Reference			2020NVVPmix		
road link		length	heavy	light	total	heavy	light	total	heavy	light	total	heavy	light	total
A12-3	Voorburg-Bezuidenhout	1430	1998	115141	117138	1958	111770	113728	2558	118366	120923	2606	114546	117151
A20-10	Kethelplein-Schiedam	2925	12610	122462	135073	10013	110391	120404	13120	97582	110702	12870	109393	122262
A13-5	Rotterdam Airport-Kleinpolderplein	2451	11490	140182	151672	5702	112478	118179	6627	103819	110446	8223	114126	122350
A20-7	Kleinpolderplein-Centrum	2034	12594	138969	151562	11687	136955	148642	16015	133564	149579	16619	136959	153578
A20-6	Centrum-Krooswijk	1173	13367	138230	151597	12362	136010	148371	16674	128922	145596	17346	136534	153880
A15-7	Charlois-Vaanplein	5161	30838	62439	93276	32170	56581	88751	43071	63896	106967	43703	53845	97548
A16-3	Kralingen Centrum	1670	15731	202284	218015	13835	196871	210706	21811	233212	255023	18120	189248	207368
A16-2	Prins Alexander-Kralingen	1954	15038	159196	174233	13233	155735	168968	20958	191045	212002	17304	147008	164312
A16-4	Centrum-Feyenoord	2214	18686	205049	223734	16565	199587	216152	25487	230310	255798	21757	190770	212527
A15-8	Vaanplein- jct Ridderkerk	2884	29186	104106	133292	27784	98903	126687	38029	109392	147420	37247	89230	126477
A16-5	Feyenoord-v. Zoelenlaan	1695	19006	192477	211484	16310	186924	203234	26445	219891	246336	22086	179194	201280
A16-7	Jct Ridderkerk-A15 (Jct Ridderkerk)	2756	16370	121339	137709	14826	118906	133733	22117	131037	153154	19530	104260	123791
A16-8	A15-Hendrik-Ido-Ambacht	2473	24262	127448	151710	22816	125048	147864	30872	133077	163949	29528	113286	142814
A16-9	Hendrik-Ido-Ambacht-Zwijndrecht	2955	24362	127435	151797	21705	121696	143401	30809	131812	162620	28939	107315	136254
A16-10	Zwijndrecht-Dordrecht	2220	22216	123069	145285	19641	118835	138476	28436	130945	159381	26256	107720	133976
A16-11	Dordrecht-'s-Gravendeel	1515	18475	74723	93199	15963	71803	87766	23426	80186	103612	21556	67765	89321
A9-9	Jct Badhoevedorp-Badhoevdorp	2170	5082	78249	83332	5414	94856	100270	7404	84624	92028	9351	99311	108662
A4-2	Sloten-Jct Badhoevedorp	1776	11008	141767	152775	9598	138663	148261	11461	146687	158148	10643	129540	140183
A10-13	Osdorp-Sloten	1426	10889	156126	167015	9542	154159	163701	11377	159089	170466	12922	155124	168045
A10-14	Osdorp-Geuzenveld	1593	10901	116658	127559	9528	114701	124229	11463	122445	133909	12667	115268	127936
A10-15	Geuzenveld-Haarlem	1182	11187	106591	117779	10094	108124	118217	12095	115207	127303	13465	109796	123261
A10-16	Haarlem-Havens West	1075	12715	100430	113145	10270	101625	111895	11531	109019	120551	13921	102909	116830
A2-11	Nieuwgein Zuid-Vianen	1427	5682	69511	75193	2784	56342	59126	2866	50922	53788	4182	59998	64180
A27-4	De Bilt-Bilthoven	4368	7984	98217	106201	7963	96826	104789	9649	109274	118923	10023	99179	109203
A50-4	Jct Valburg-Jct Ewijk	6941	22869	89802	112671	22778	89813	112591	31206	93071	124277	31398	77117	108515

[3] weekday average(heavy); = 0.8*workday average(heavy) weekday average(light) = 0.94*workday average (light)

Annex 3 Road links[4] – with exceedence distances as per CE[5]-



A13-5 Rotterdam Airport-Kleinpolderplein

A10-15 Geuzenveld-Haarlem

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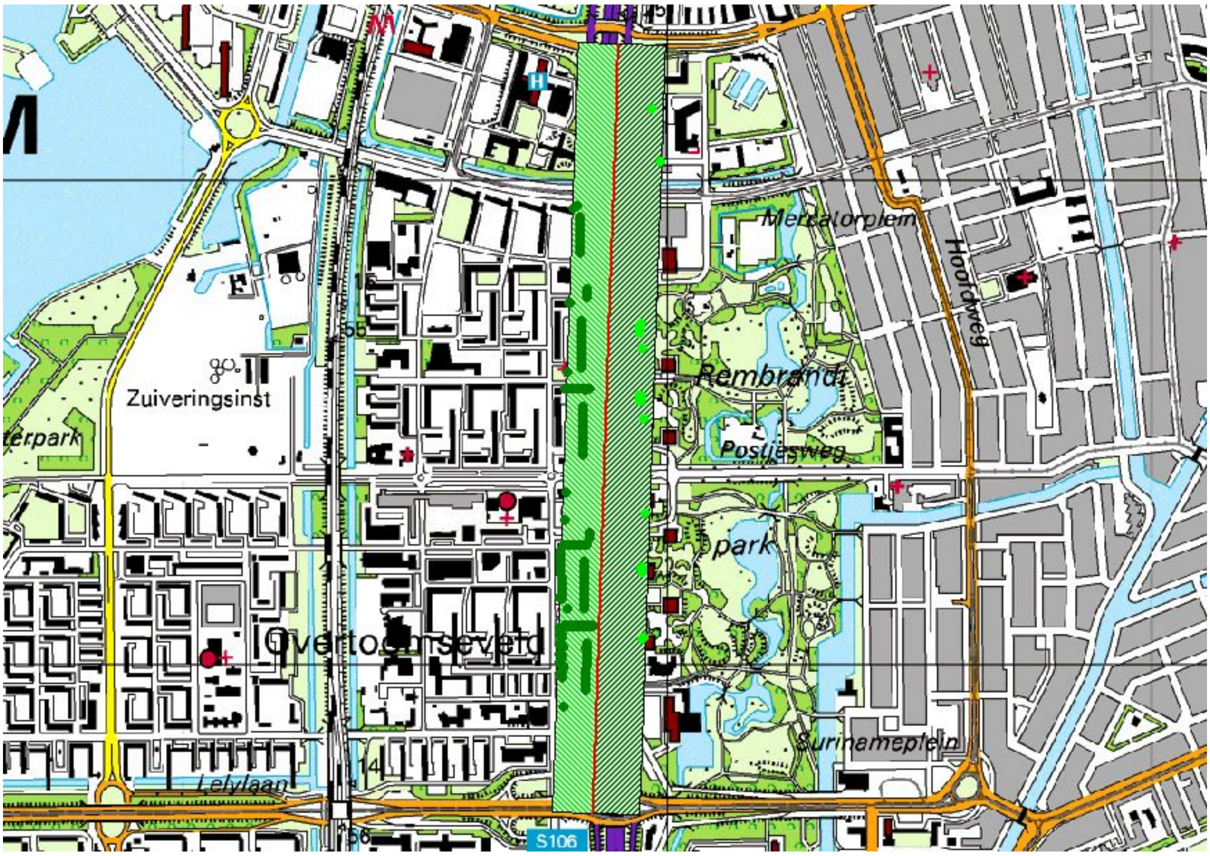
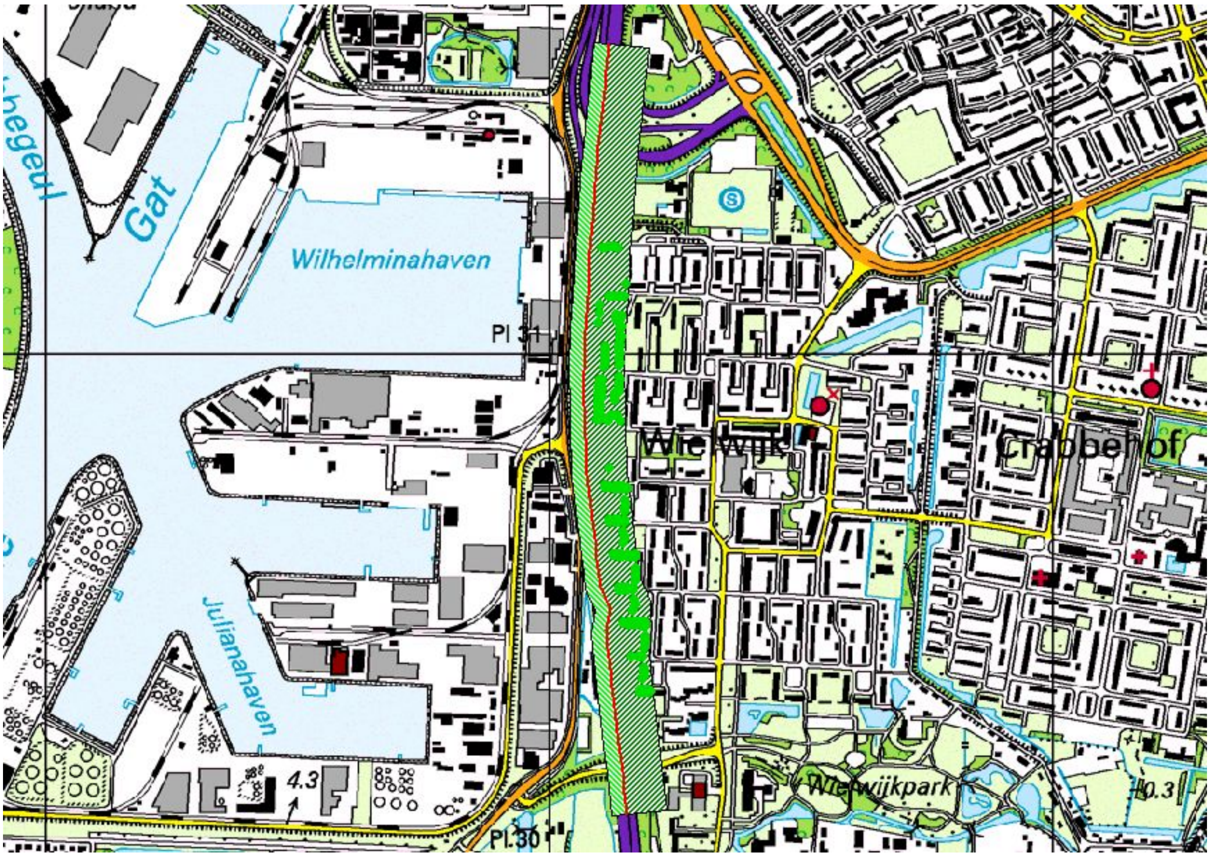
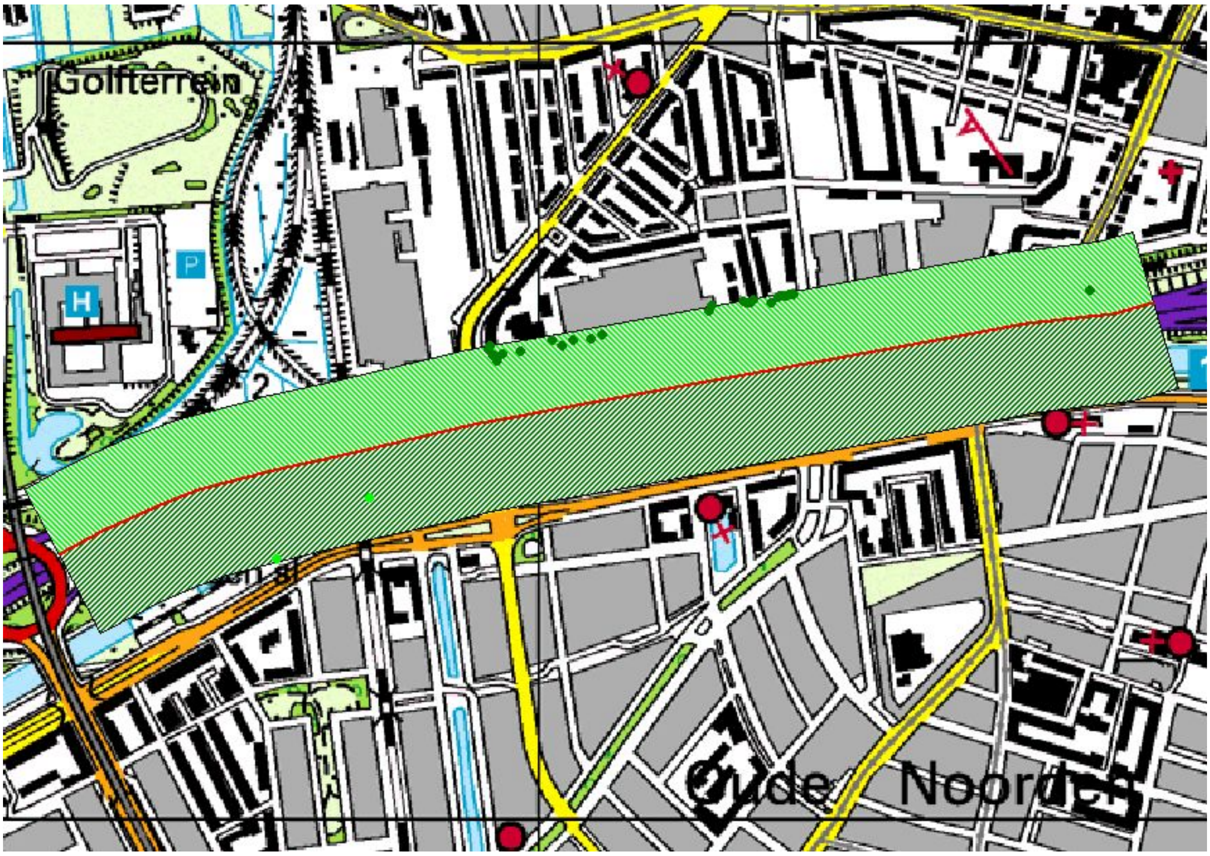
[4] © Copyright Topografische Dienst Nederland
[5] Metz et al., 2000.



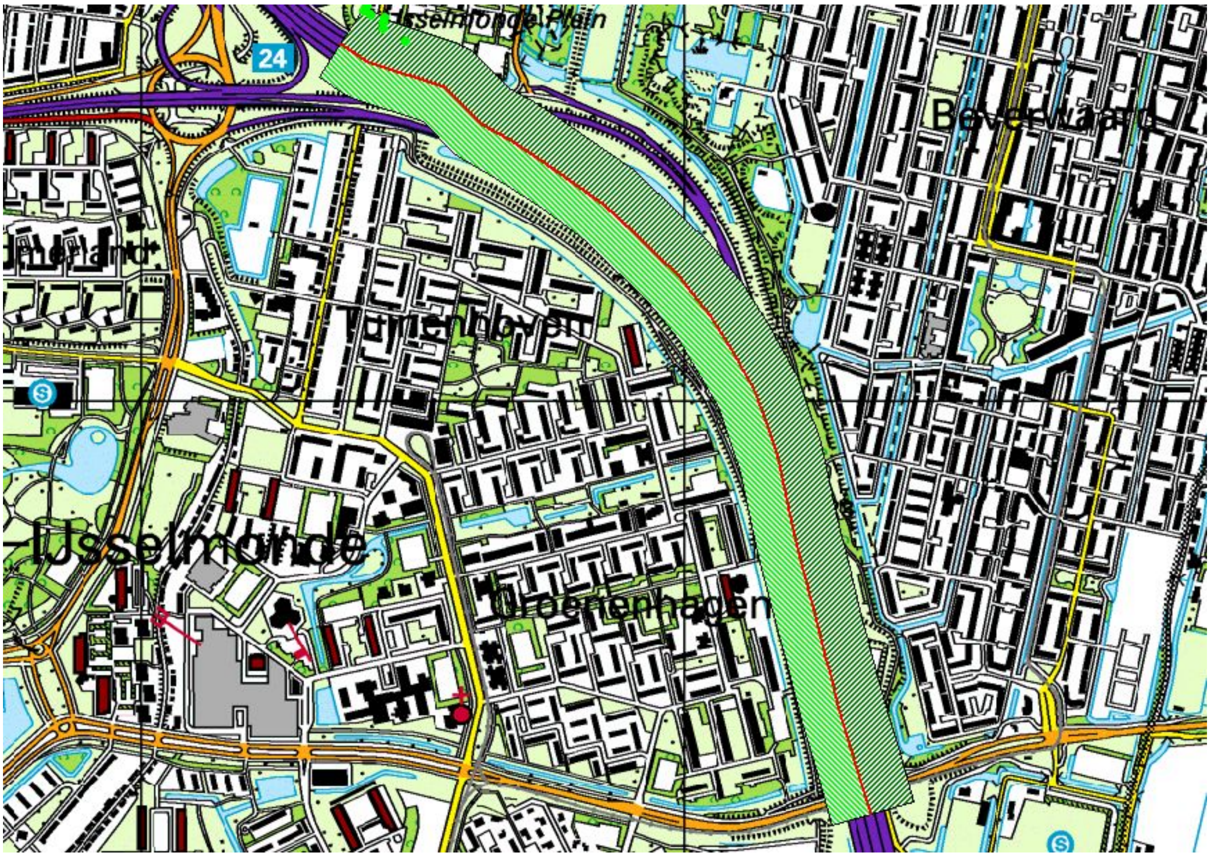
A10-14 Osdorp-Geuzenveld



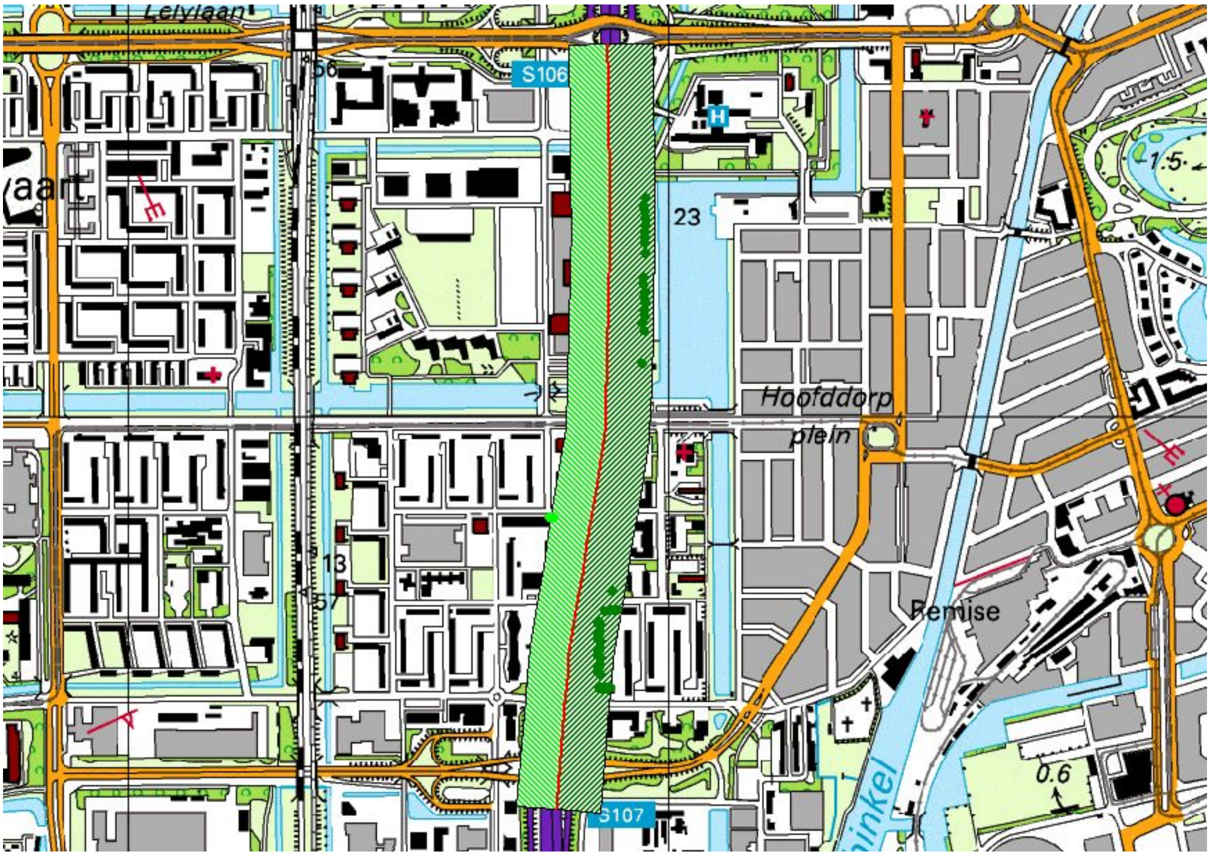
A16-11 Dordrecht-‘s-Gravendeel



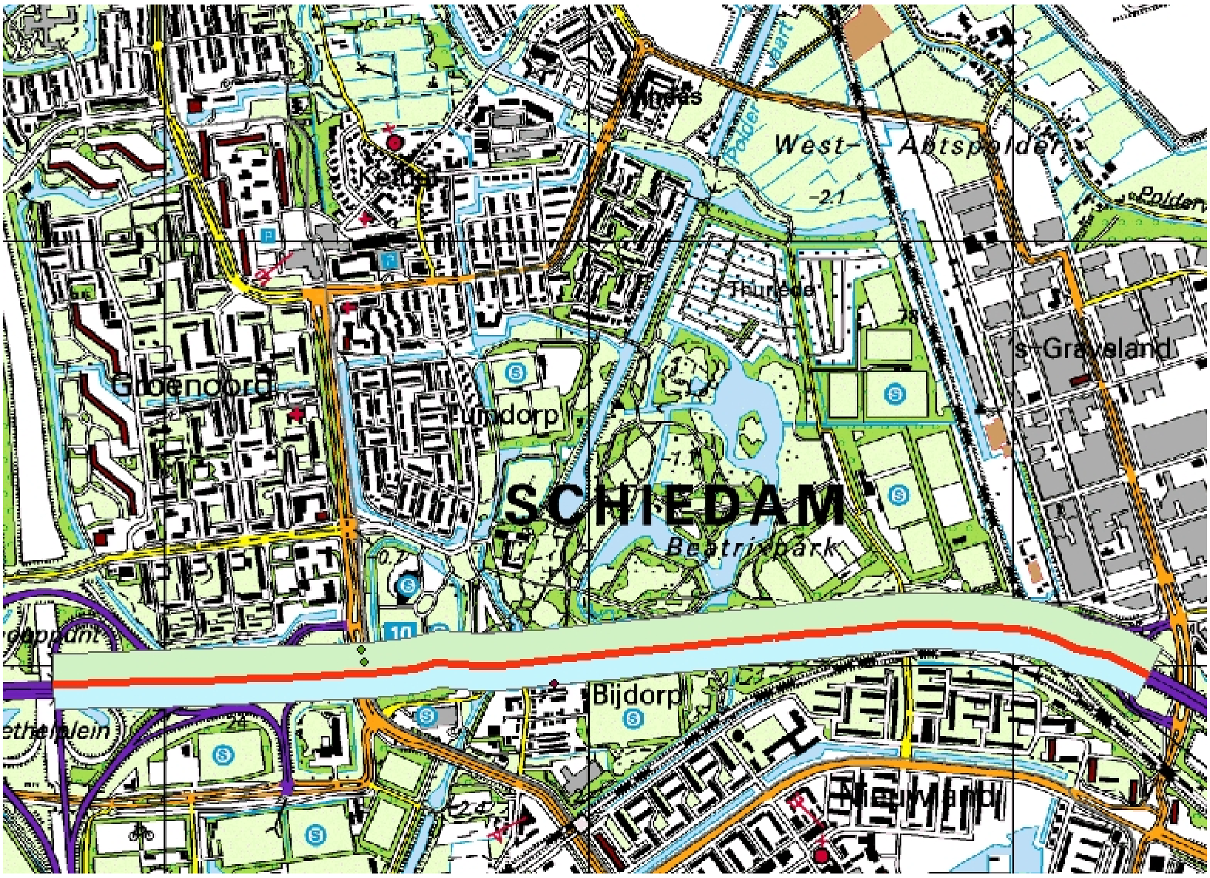
A20-6 Centrum Krooswijk



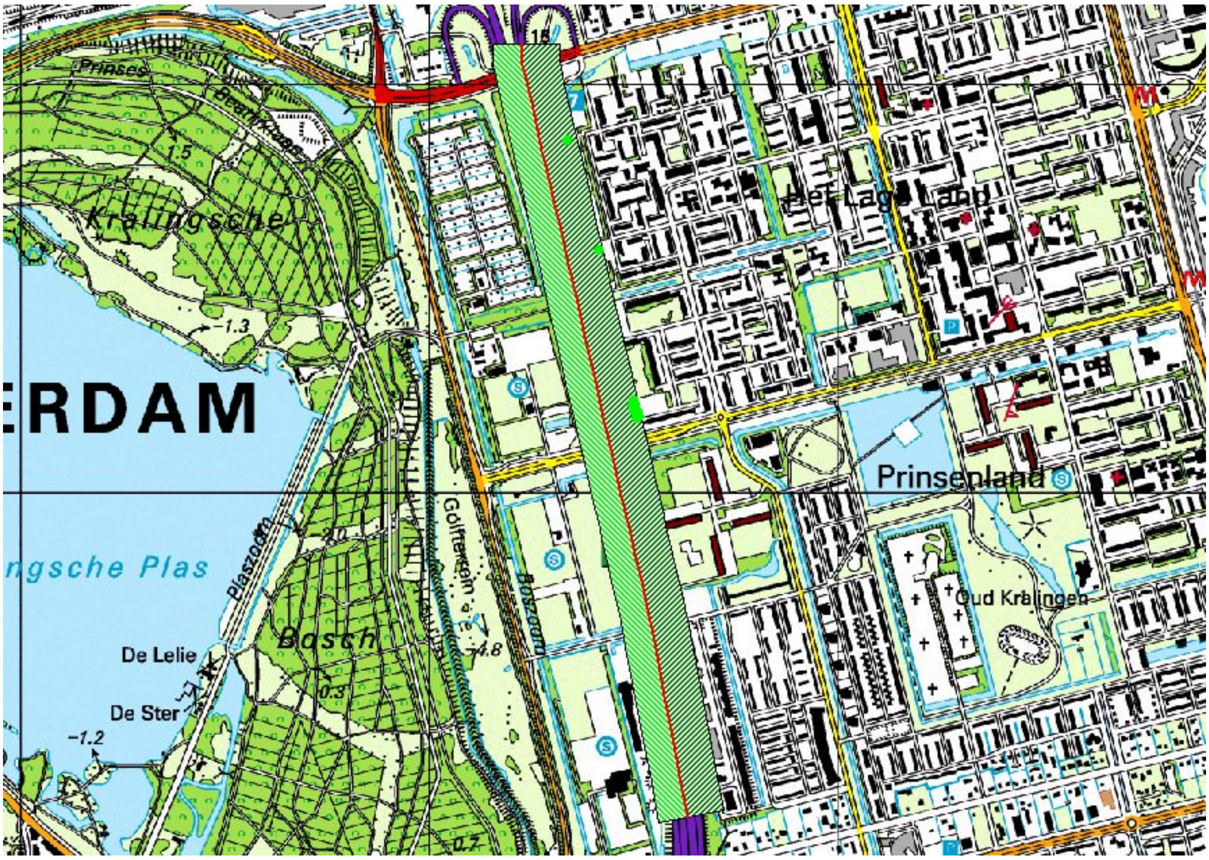
A16-5 Feyenoord-v. Zoelenlaan



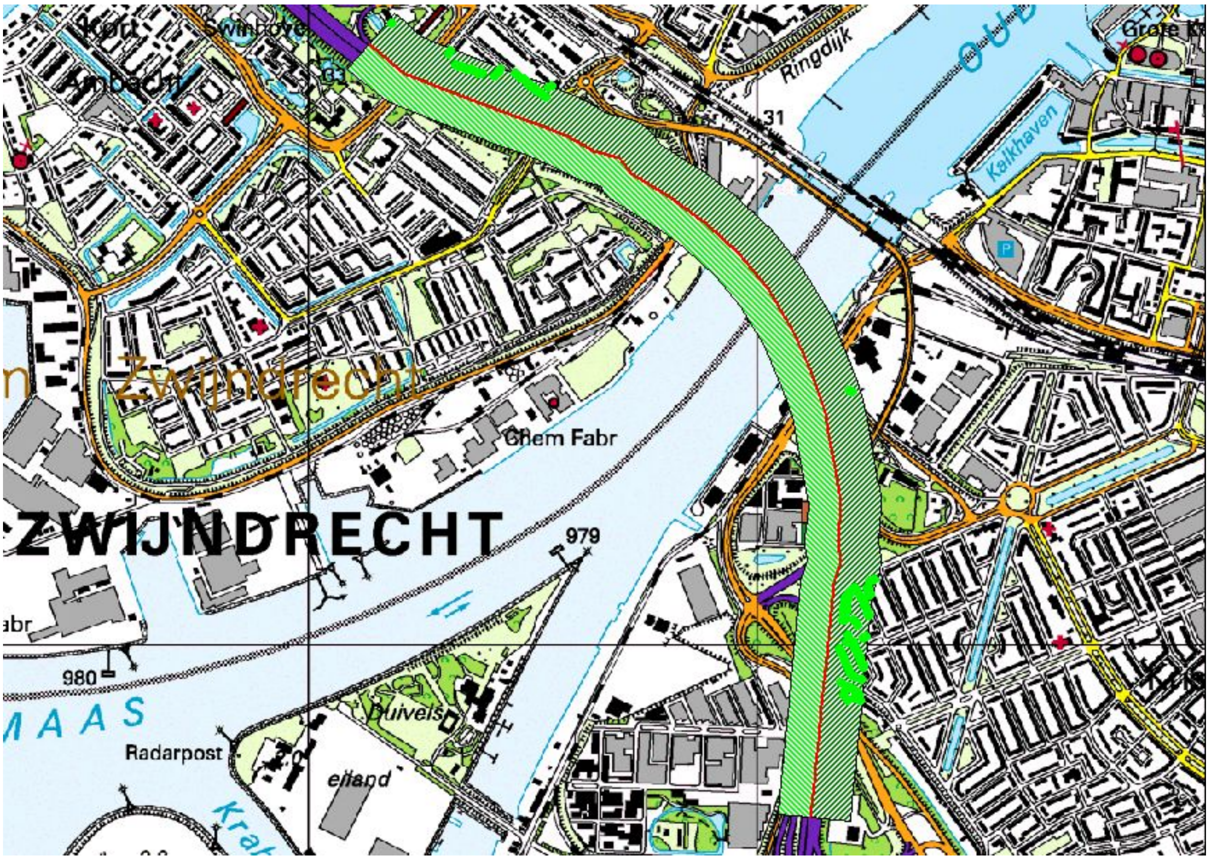
A10-13 Osdorp-Sloten



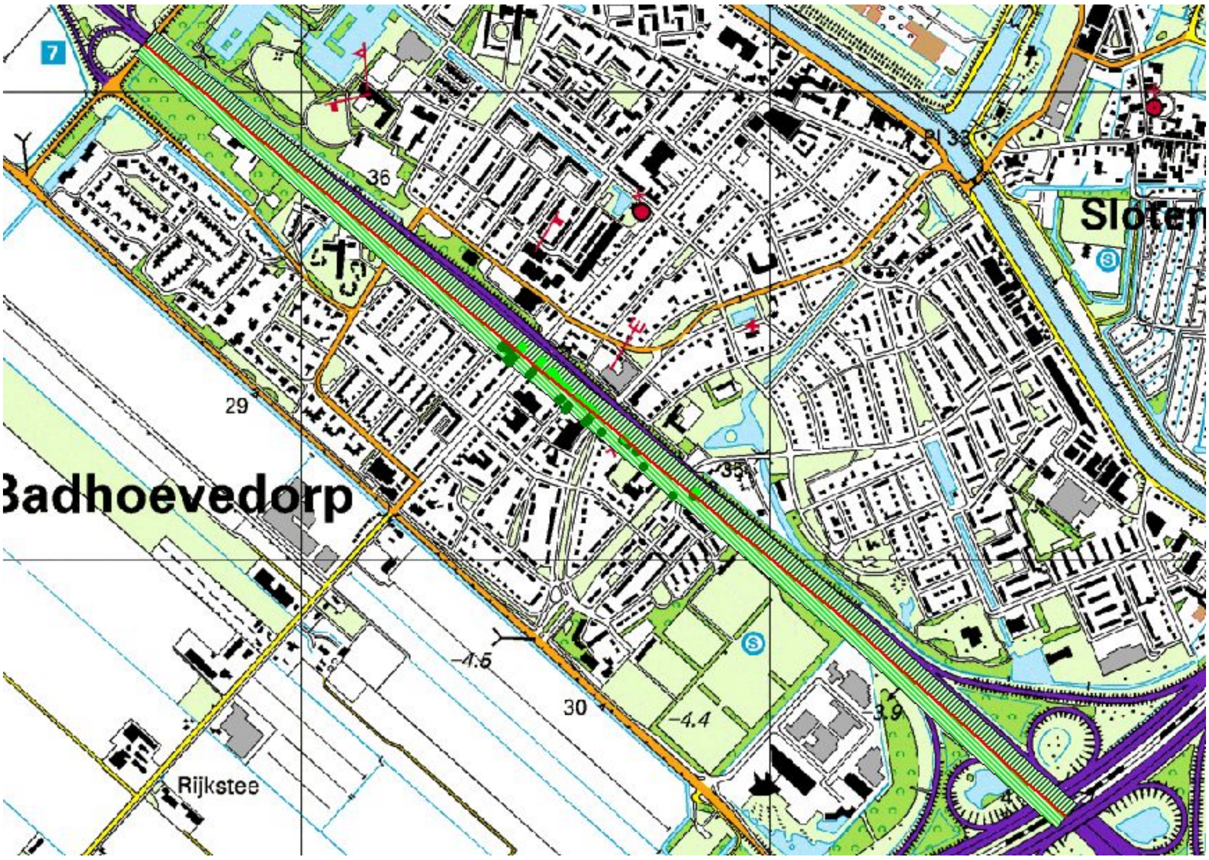
A20-10 Kethelplein-Schiedam



A16-2 Prins Alexander- Kralingen

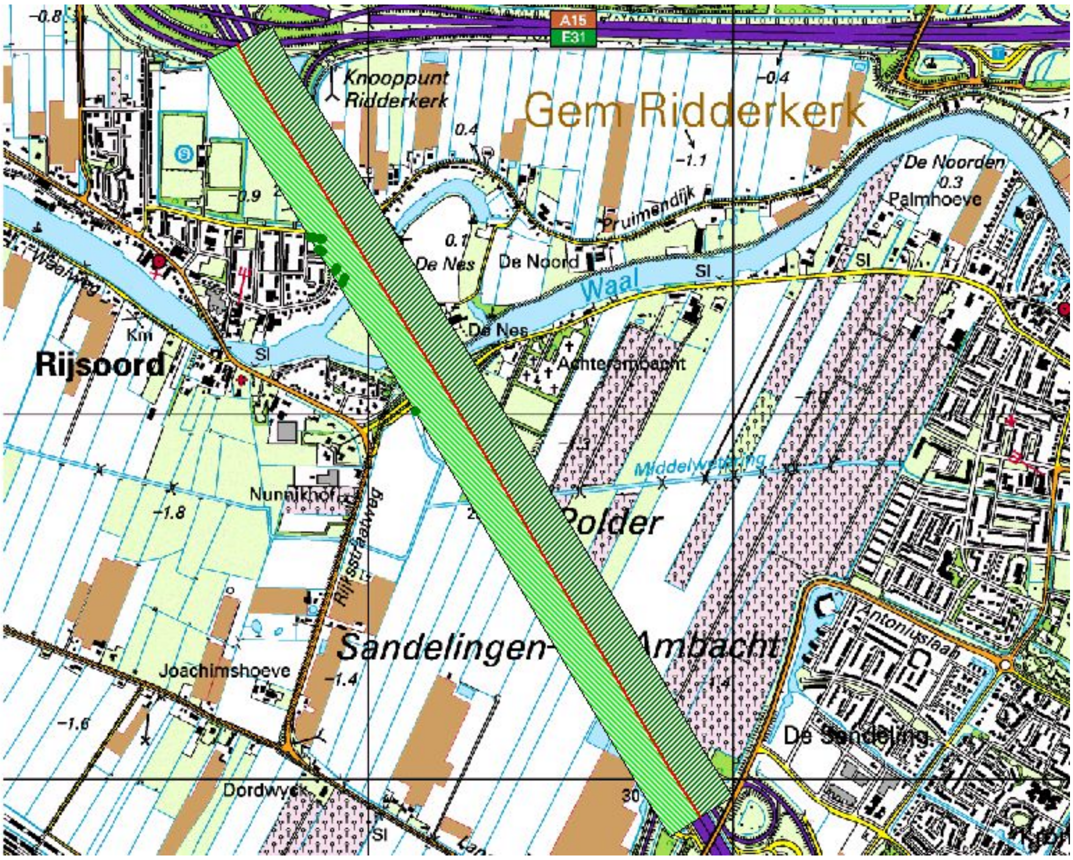


A16-10 Zwijndrecht-Dordrecht

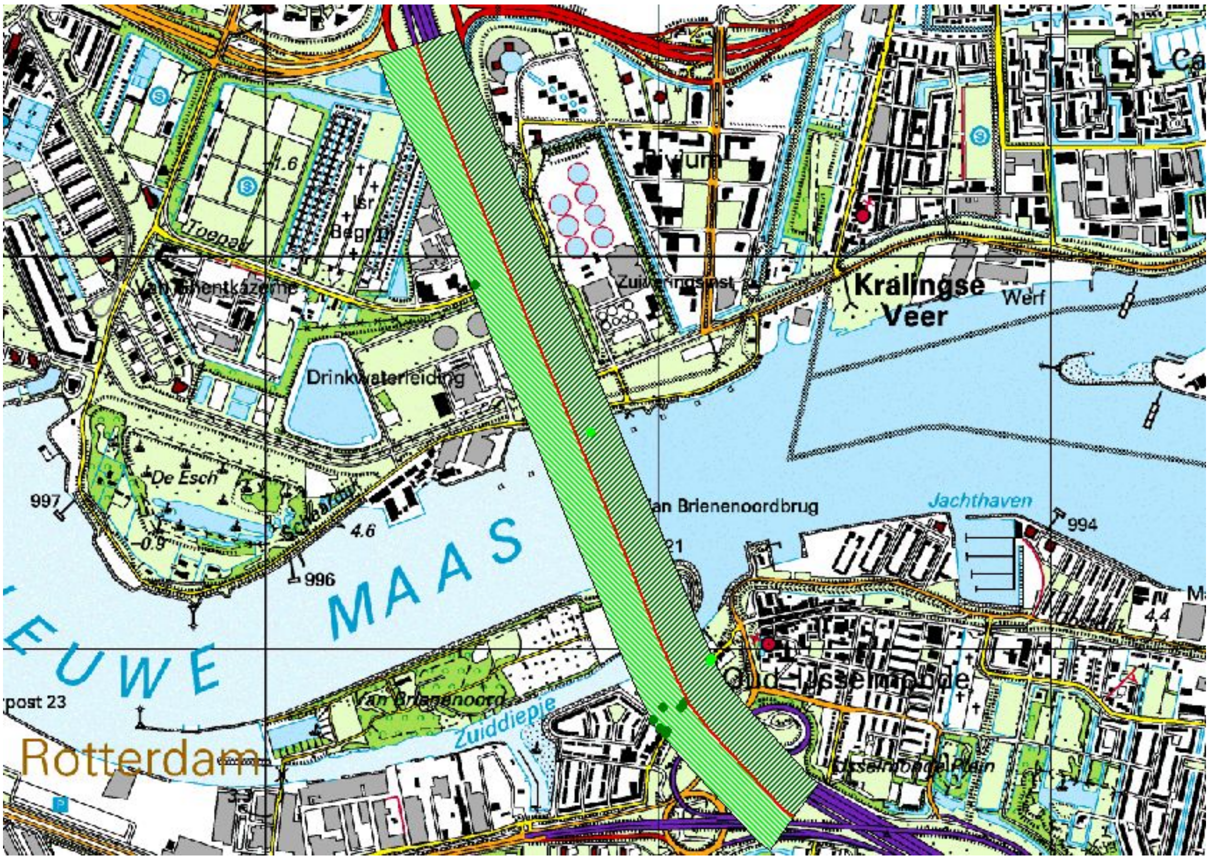


A9-9 Junction Badhoevedorp-Badhoevedorp

A12-3 Voorburg-Bezuidenhout

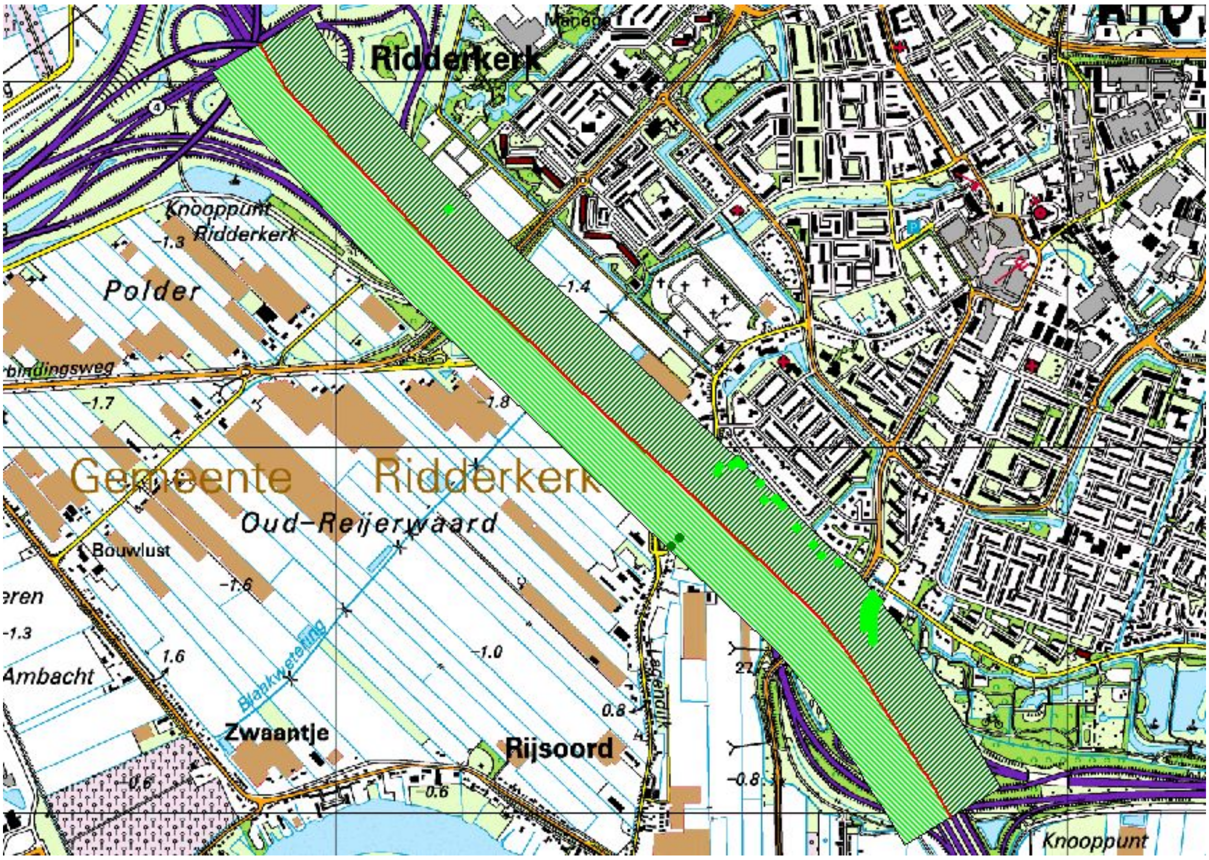


A16-8 Hendrik-Ido-Ambacht-Junction Ridderkerk A15

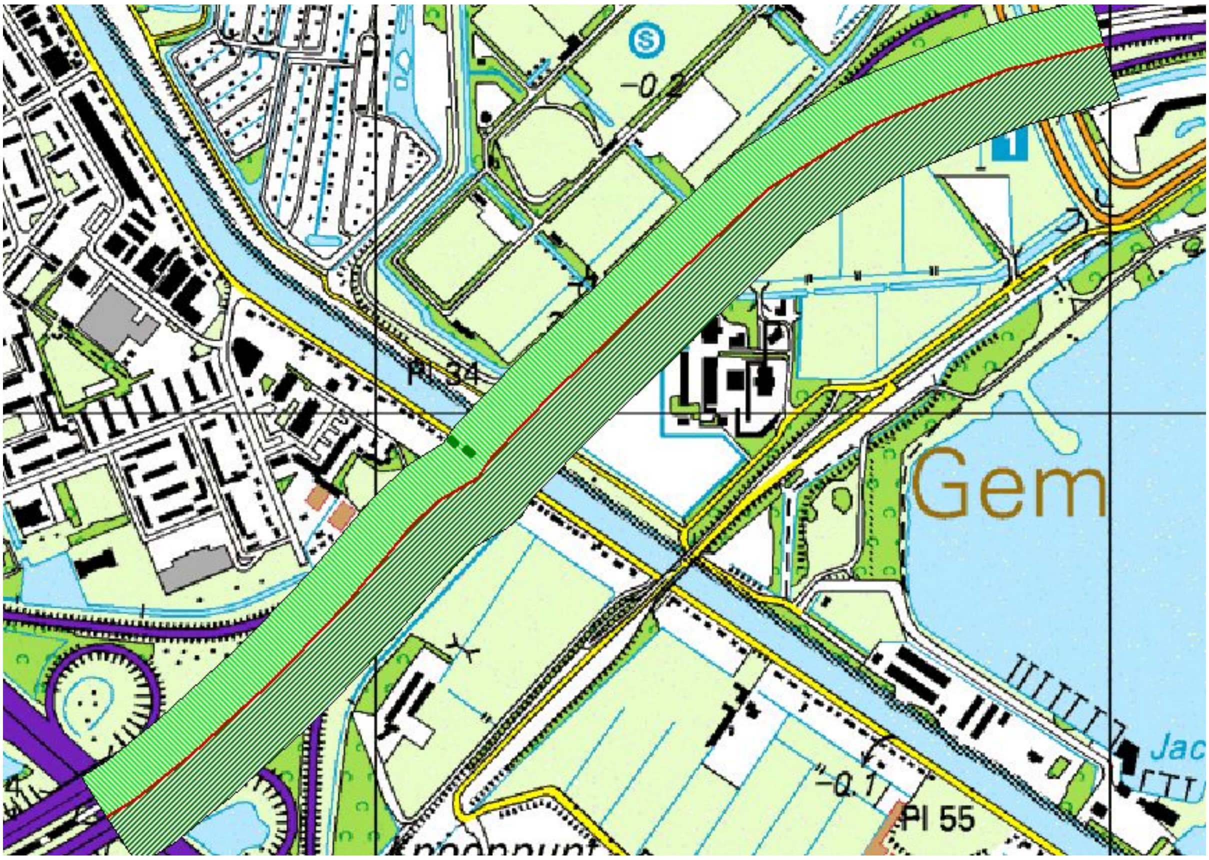


A16-4 Centrum-Feyenoord

A16-9 Hendrik-Ido-Ambacht-Zwijndrecht

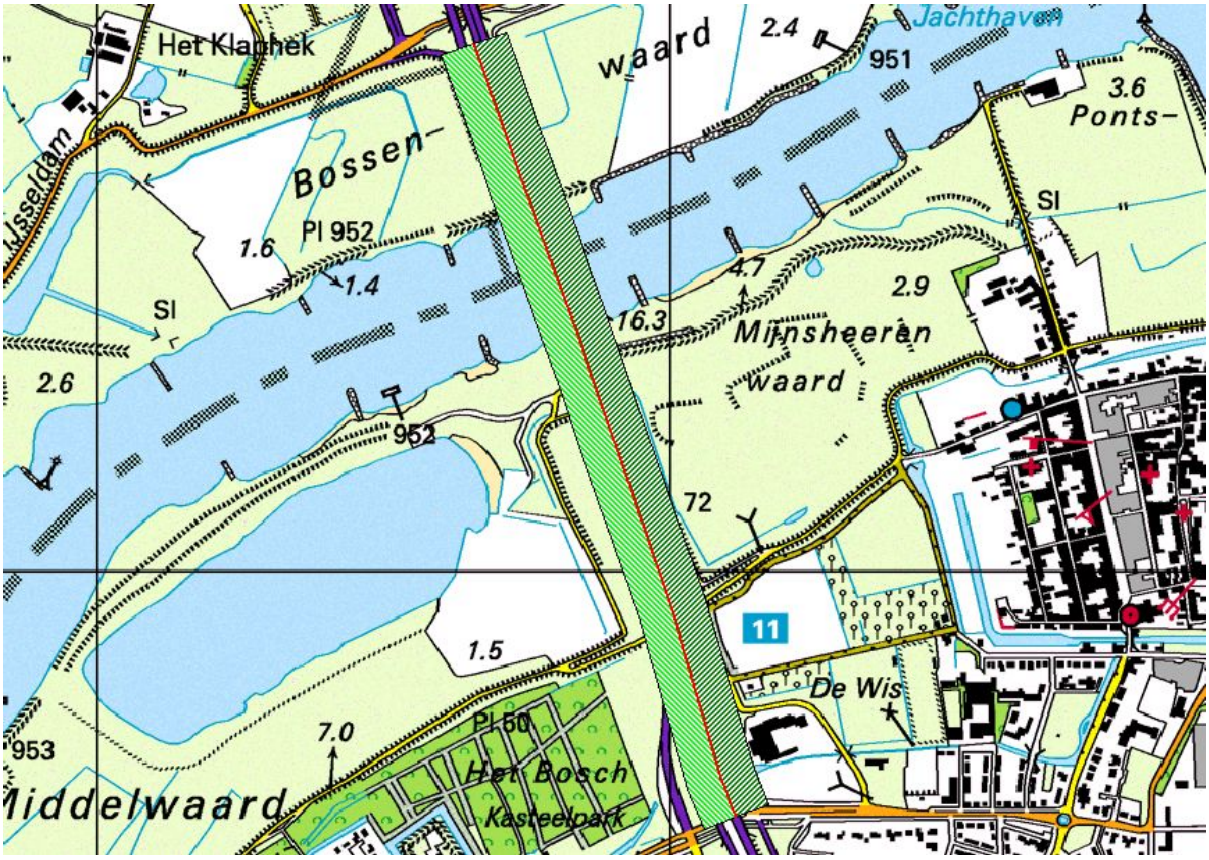


A16-7 Junction Ridderkerk- Junction Ridderkerk A15

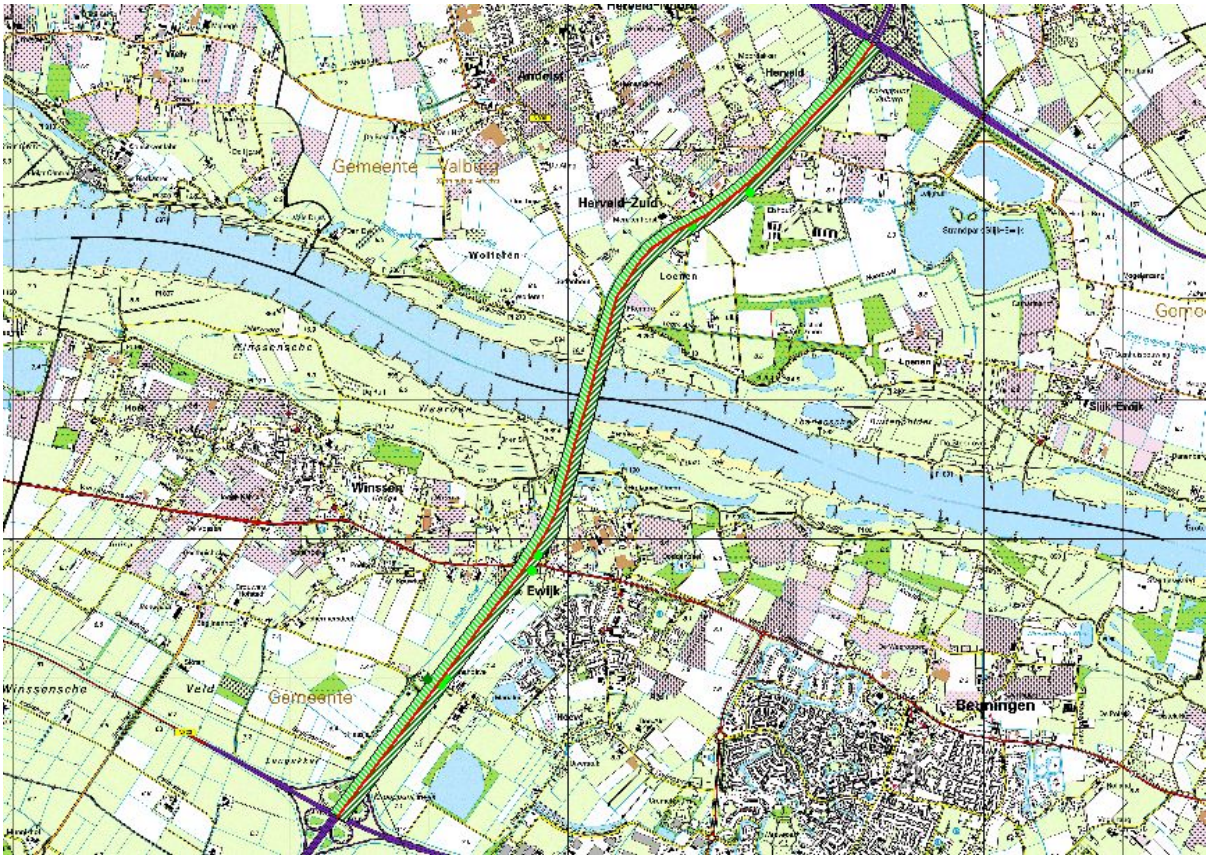


A4-2 Sloten-Junction Badhoevedorp

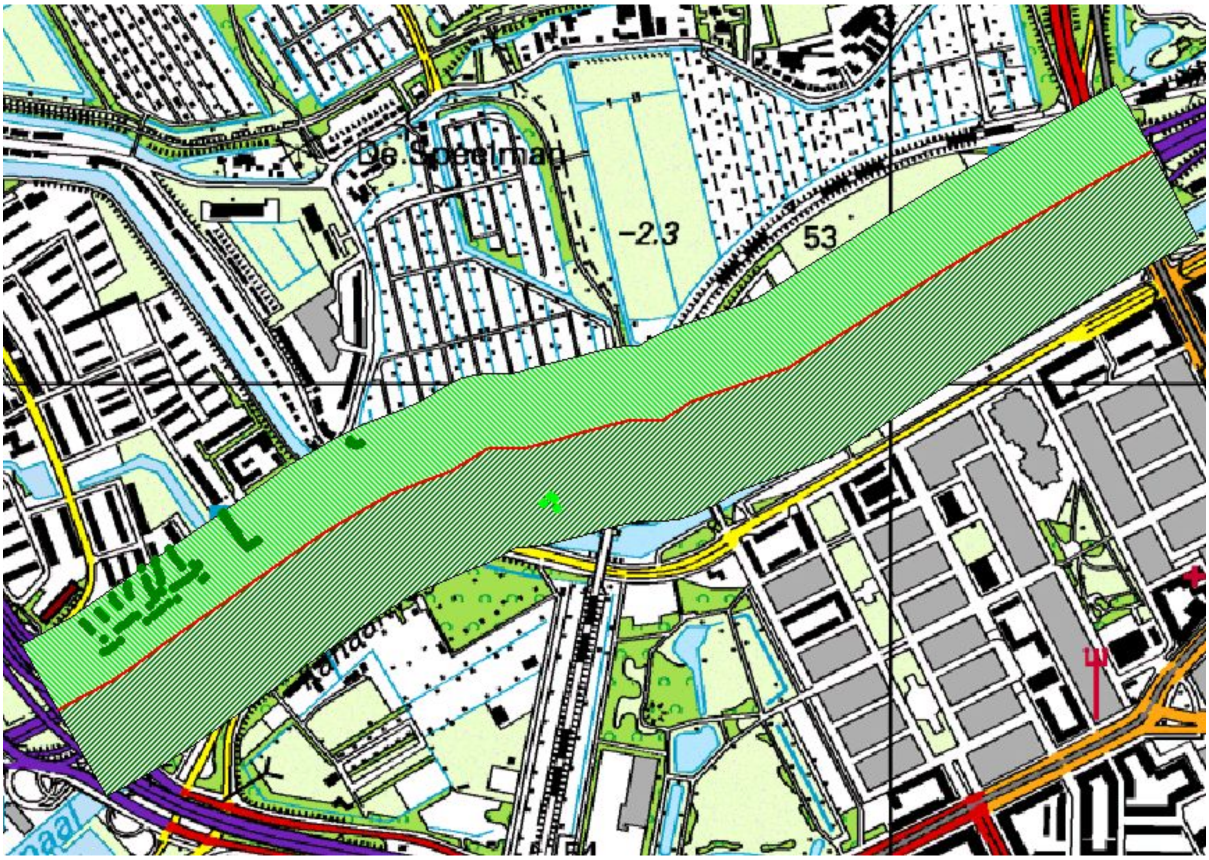
A27-4 De Bilt-Bilthoven



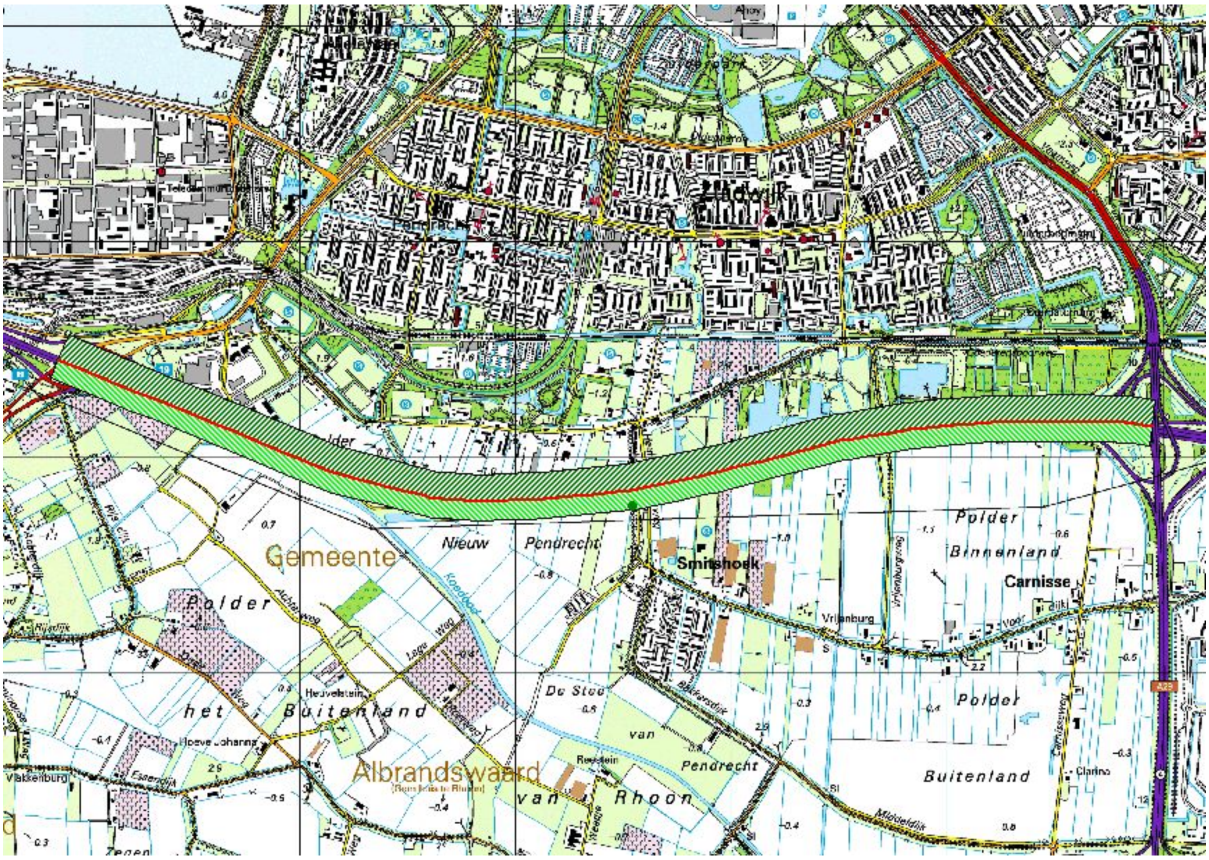
A2-11 Nieuwegein-Vianen



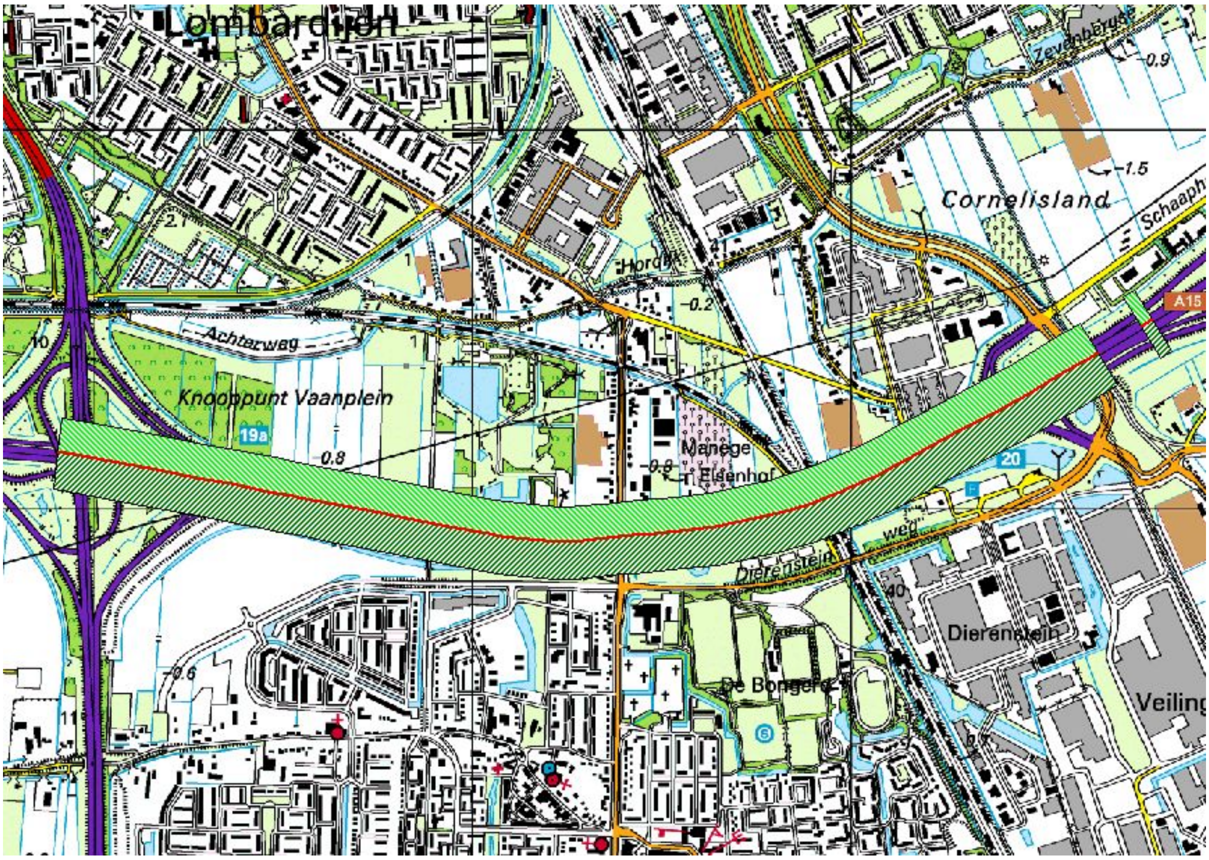
A50-4 Junction Valburg-Junction Ewijk



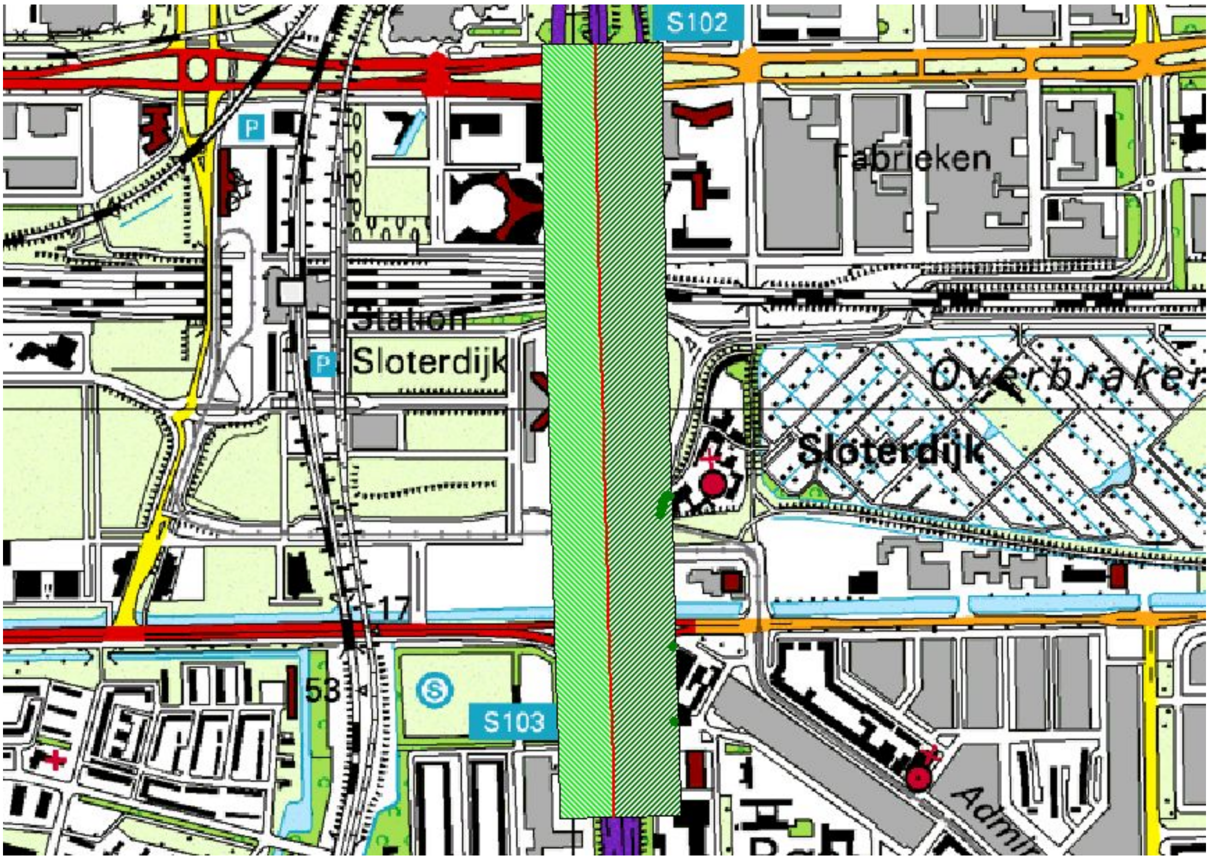
A20-7 Kleinpolderplein-Centrum



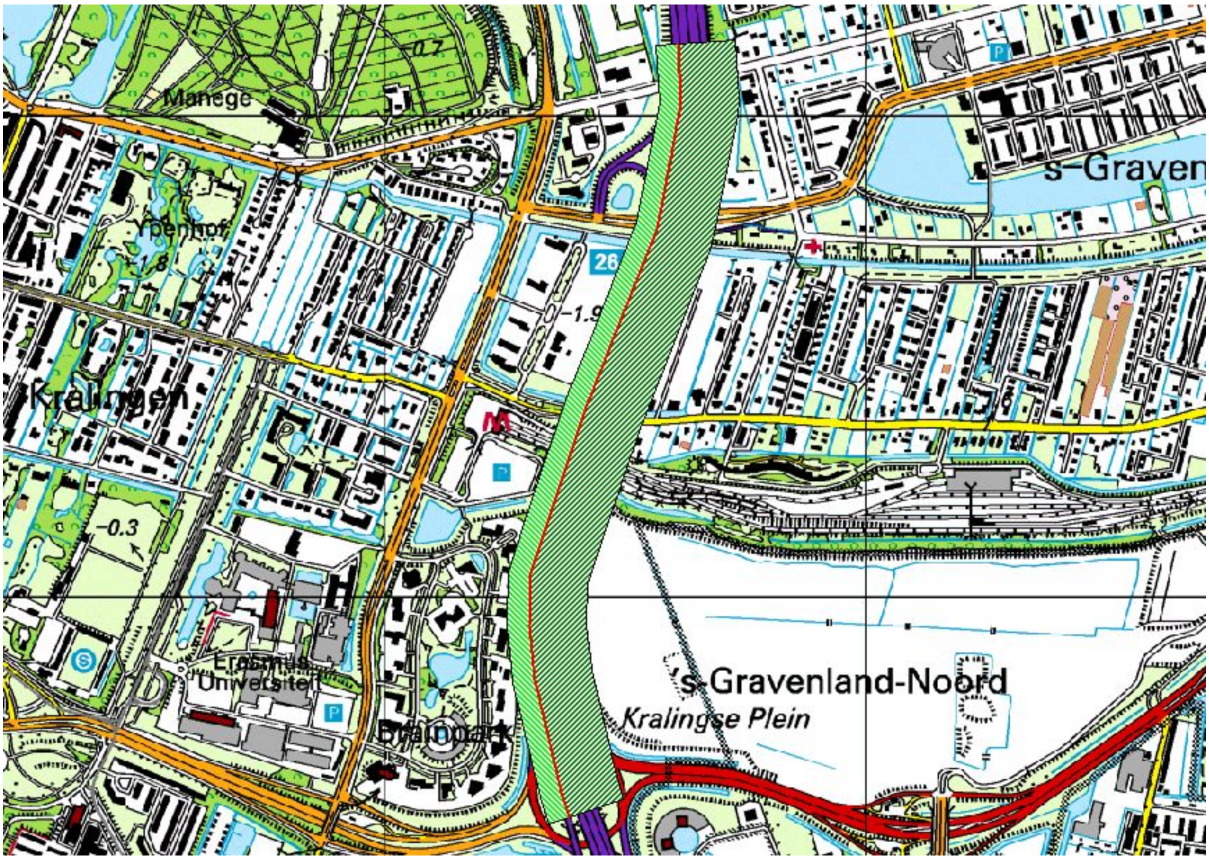
A15-7 Charlois-Vaanplein



A15-8 Vaanplein-Junction Ridderkerk



A10-16 Haarlem-Havens West



A16-3 Kralingen-Centrum

Annex 4 Background concentrations

Annual average NO_2 background concentrations (µg/m^3)

Road link		CE	2010MV5EC	2010nepp4 NEC Commission	2015nepp4	2020nepp4
A10 –13	Osdorp-Sloten	32	30.6	26.8	26.0	25.4
A10 –14	Osdorp-Geuzenveld	33	34.4	30.4	30.0	29.8
A10 –15	Geuzenveld-Haarlem	33	34.4	30.4	30.0	29.8
A10 –16	Haarlem-Havens West	33	34.4	30.4	30.0	29.8
A12 –3	Voorburg-Bezuidenhout	32	32.6	27.4	26.8	26.6
A13-5	Rotterdam Airport-Kleinpolderplein	34	33.7	29.6	28.0	27.3
A15-7	Charlois-Vaanplein	30	32.5	28.4	27.0	26.5
A15-8	Vaanplein- jct Ridderkerk	31	32.4	28.5	27.0	26.2
A16-10	Zwijndrecht-Dordrecht	29	33.4	29.5	23.2	22.4
A16-11	Dordrecht-'s-Gravendeel	30	33.4	29.5	23.2	22.4
A16-2	Prins Alexander-Kralingen	31	31.3	27.1	25.4	24.8
A16-3	Kralingen Centrum	31	31.3	27.1	25.4	24.8
A16-4	Centrum-Feyenoord	30	31.3	27.1	25.4	24.8
A16-5	Feyenoord-v. Zoelenlaan	31	32.4	28.5	27.0	26.2
A16-7	Jct Ridderkerk-A15 (Jct Ridderkerk)	35	32.4	28.5	27.0	26.2
A16-8	A15-Hendrik-Ido-Ambacht	30	30.3	26.3	24.4	23.6
A16-9	Hendrik-Ido-Ambacht-Zwijndrecht	30	30.3	26.3	24.4	23.6
A20-10	Kethelplein-Schiedam	31	33.7	29.6	28.0	27.3
A20-6	Centrum-Krooswijk	34	36.1	31.8	30.8	30.6
A20-7	Kleinpolderplein-Centrum	35	36.1	31.8	30.8	30.6
A2-11	Nieuwgein Zuid-Vianen	26	28.9	25.0	23.5	22.6
A27-4	De Bilt-Maarssen	32	33.7	29.7	28.8	28.4
A4-2	Sloten-Jct Badhoevedorp	32	30.6	26.9	26.0	25.4
A50-4	Jct Valburg-Jct Ewijk	28	24.9	20.9	19.1	18.2
A9-9	Jct Badhoevedorp-Badhoevdorp	32	34.3	31.9	31.8	31.9

Annex 5 Exceedence distances

Exceedence distances (m) for different scenarios for annual average NO_2 concentration of 36, 40 and 44 $\mu g/m^3$ for highest (e) and lowest (w) side of road

	2010refMV5ec						2010refnepp4nec						2010bornepp4nec				2015nepp4				2020nepp4			
	>36e	>36w	>40e	>40w	>44e	>44w	>36e	>36w	>40e	>40w	>44e	>44w	>36e	>36w	>40e	>40w	>36e	>36w	>40e	>40w	>36e	>36w	>40e	>40w
A10 –13	110	38	42	<25	<25	<25	52	29	31	<25	<25	<25	46	<25	27	<25	33	<25	<25	<25	<25	<25	<25	<25
A10 –14	>250	71	87	28	34	<25	104	38	40	<25	<25	<25	80	29	32	<25	41	<25	<25	<25	34	<25	<25	<25
A10 –15	>250	43	124	<25	37	<25	137	27	44	<25	<25	<25	121	<25	39	<25	50	<25	29	<25	39	<25	<25	<25
A10 –16	>250	65	80	25	31	<25	96	35	38	<25	<25	<25	78	29	32	<25	42	<25	<25	<25	35	<25	<25	<25
A12 –3	103	40	29	<25	<25	<25	31	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
A13 -5	>250	55	73	<25	32	<25	83	33	37	<25	<25	<25	52	<25	<25	<25	30	<25	<25	<25	<25	<25	<25	<25
A15-7	>250	73	84	37	42	<25	97	46	50	30	34	<25	92	44	48	29	57	37	38	25	48	33	35	<25
A15-8	165	124	58	50	34	31	71	63	40	38	28	<25	65	57	38	35	45	41	31	29	38	35	27	<25
A16-10	>250	77	91	36	40	<25	112	46	50	28	32	<25	96	40	43	<25	37	<25	25	<25	30	<25	<25	<25
A16-11	>250	46	99	<25	39	<25	119	32	47	<25	28	<25	98	26	39	<25	34	<25	<25	<25	27	<25	<25	<25
A16-2	164	48	53	26	31	<25	62	34	36	<25	<25	<25	55	30	33	<25	36	<25	<25	<25	27	<25	<25	<25
A16-3	>250	41	80	<25	40	<25	89	32	47	<25	32	<25	79	29	42	<25	45	<25	31	<25	33	<25	<25	<25
A16-4	200	58	65	33	37	<25	75	40	43	27	30	<25	67	37	39	<25	42	28	29	<25	33	<25	<25	<25
A16-5	>250	69	78	35	39	<25	93	44	48	28	32	<25	81	39	41	<25	46	29	31	<25	35	<25	<25	<25
A16-7	>250	56	63	28	33	<25	75	37	39	<25	<25	<25	65	32	34	<25	39	<25	25	<25	31	<25	<25	<25
A16-8	147	53	59	32	36	<25	69	39	41	26	30	<25	62	36	38	<25	41	28	30	<25	34	<25	<25	<25
A16-9	215	44	70	27	39	<25	81	35	46	<25	33	<25	70	31	40	<25	45	<25	32	<25	37	<25	26	<25
A20-10	>250	59	70	26	31	<25	81	35	37	<25	<25	<25	64	27	30	<25	36	<25	<25	<25	26	<25	<25	<25
A20-6	>250[1]	>250[1]	81	57	31	<25	94	69	38	33	<25	<25	84	63	35	29	48	40	26	<25	38	33	<25	<25
A20-7	>250[1]	>250[1]	99	47	34	<25	111	59	40	29	<25	<25	99	53	37	<25	52	36	27	<25	40	29	<25	<25
A2-11	98	45	48	28	32	<25	58	36	37	<25	27	<25	60	37	39	26	50	36	37	27	<25	<25	<25	<25
A27-4	>250	47	56	<25	<25	<25	66	28	31	<25	<25	<25	62	25	29	<25	38	<25	<25	<25	28	<25	<25	<25
A4-2	104	37	40	<25	<25	<25	49	27	29	<25	<25	<25	44	<25	<25	<25	30	<25	<25	<25	<25	<25	<25	<25
A50-4	61	37	39	26	29	<25	45	32	34	<25	<25	<25	42	30	31	<25	35	26	27	<25	31	<25	<25	<25
A9-9	>250	46	56	<25	<25	<25	122	30	34	<25	<25	<25	97	<25	26	<25	43	<25	<25	<25	35	<25	<25	<25

[1] Here, the background concentration is above 36 $\mu g/m^3$

Annex 6 Number of dwellings in exceedence zone

Number of dwellings within the exceedence distance in the various alternatives. The number of dwellings was established with exceedence distances on either side of the road for adverse, average and favourable meteorological conditions.

	2010refMV5ec			2010refnepp4nec			2010bornepp4nec			2015nepp4		2020nepp4		CE
	adv	av	fav	adv	av	fav	adv	av	fav	adv	av	adv	av	av
A10 –13	174	0	0	20	0	0	0	0	0	0	0	0	0	120
A10 –14	1246[1]	365	0	499	0	0	365	0	0	0	0	0	0	750
A10 –15	2490[1]	701	0	935	6	0	661	0	0	6	0	0	0	800
A10 –16	52[1]	2	0	8	0	0	1	0	0	0	0	0	0	10
A12 –3	186	20	0	23	0	0	0	0	0	0	0	0	0	50
A13 –5	2337[1]	406	48	530	148	0	0	0	0	6	0	0	0	1200
A15-7	7	0	0	0	0	0	0	0	0	0	0	0	0	20
A15-8	4	0	0	0	0	0	0	0	0	0	0	0	0	15
A16-10	886[1]	161	32	224	55	0	176	36	0	25	0	0	0	90
A16-11	1213[1]	339	79	420	110	16	321	79	0	55	0	20	0	300
A16-2	533	0	0	0	0	0	0	0	0	0	0	0	0	100
A16-3	138	0	0	1	0	0	0	0	0	0	0	0	0	10
A16-4	77	6	0	9	4	0	6	1	0	2	0	0	0	50
A16-5	561	5	0	9	0	0	5	0	0	0	0	0	0	150
A16-7	143	0	0	1	0	0	0	0	0	0	0	0	0	40
A16-8	10	0	0	0	0	0	0	0	0	0	0	0	0	50
A16-9	206	7	0	10	0	0	7	0	0	0	0	0	0	40
A20-10	324[1]	2	1	2	1	0	2	1	0	1	0	1	0	100
A20-6	2278[1]	2	0	2	1	0	2	0	0	1	0	1	0	250
A20-7	1396[1]	22	0	49	0	0	27	0	0	0	0	0	0	50
A2-11	0	0	0	0	0	0	0	0	0	0	0	0	0	30
A27-4	95[1]	0	0	0	0	0	0	0	0	0	0	0	0	30
A4-2	3	0	0	1	0	0	0	0	0	0	0	0	0	30
A50-4	2	0	0	0	0	0	0	0	0	0	0	0	0	30
A9-9	619[1]	29	0	201	22	0	91	22	0	29	0	22	0	70
Total	**14980**	**2067**	**160**	**2944**	**347**	**16**	**1664**	**139**	**0**	**125**	**0**	**44**	**0**	**4385**

[1] In these cases the exceedence distance on one side of the road > 250m. The number of dwellings was determined at 250m.

Annex 7 Air quality in EU cities in 2010

Annual average concentrations NO_2 (µg/m^3) in various EU cities, maximum values on 2x2 km^2 grid and at street level

		1990			Policy in pipeline (pipp) 2010			Kyoto 2010		Best available technology 2010		
	city	annual av	max 2x2km no2>40 ug/m3	streets	annual av	max 2x2km no2>40 ug/m3	streets	annual av	max 2x2km no2>40 ug/m3	annual av	max 2x2km no2>40 ug/m3	streets
Ireland	Dublin	17	<40	30	11	<40	21	9	<40	7	<40	13
Portugal	Lisbon	17	<40	31	16	<40	30	12	<40	10	<40	19
Luxembourg	Luxembourg	33	<40	51	17	<40	30	11	<40	10	<40	20
UK	Birmingham	47	52	65	26	<40	44	24	<40	18	<40	32
Denmark	Copenhagen	34	<40	53	24	<40	41	20	<40	18	<40	32
Netherlands	Amsterdam	43	46	61	27	<40	44	20	<40	19	<40	34
Belgium	Brussels	46	49	64	31	<40	49	19	<40	21	<40	37
UK	Manchester	53	56	70	31	<40	49	28	<40	22	<40	38
Spain	Madrid	36	52	56	30	<40	48	25	<40	23	<40	40
France	Marseille	49	61	69	32	<40	50	27	<40	25	<40	42
UK	London	61	66	78	39	44	57	36	<40	28	<40	46
Sweden	Stockholm	46	53	64	34	<40	53	27	<40	28	<40	46
Germany	Cologne	58	62	75	36	41	55	33	<40	28	<40	46
Germany	Berlin	45	49	63	36	<40	55	23	<40	29	<40	47
Austria	Vienna	57	61	74	34	<40	53	38	43	34	<40	53
Germany	Stuttgart	67	71	85	44	50	63	42	48	36	<40	54
Finland	Helsinki	60	71	81	43	49	62	37	42	36	41	55
Greece	Athens	47	54	66	47	53	65	43	48	37	42	56
France	Lyon	62	73	82	46	51	64	40	45	38	43	57
France	Paris	67	71	85	49	55	67	43	48	41	46	59
Spain	Barcelona	54	68	74	47	53	65	42	48	42	47	61
Italy	Milan	68	76	88	53	59	70	48	53	47	53	65
Italy	Rome	89	109	128	71	79	92	67	74	66	74	84

Annex 8 NO_x emissies EU 1990-2020 in AIR-OIL II

	Emission in ktonne						
Country	1990	1995	2000	2005	2010	2015	2020
Belgium	287	259	223	190	161	154	152
Denmark	268	234	199	164	133	124	121
Germany	2707	2307	1889	1474	1099	990	945
Finland	260	241	211	182	154	144	139
France	1920	1706	1406	1120	873	798	772
Greece	334	354	361	364	368	356	354
Ireland	106	99	88	75	63	58	57
Italy	1862	1773	1541	1286	1048	978	954
Luxembourg	19	17	14	12	10	9	9
Netherlands	485	436	375	311	260	245	243
Austria	212	187	157	126	98	88	84
Portugal	208	202	180	154	130	121	117
Spain	1206	1200	1092	960	832	778	757
UK	2620	2283	1913	1540	1235	1160	1135
Sweden	331	310	271	233	198	184	178
EU15	12824	11608	9920	8190	6661	6188	6015

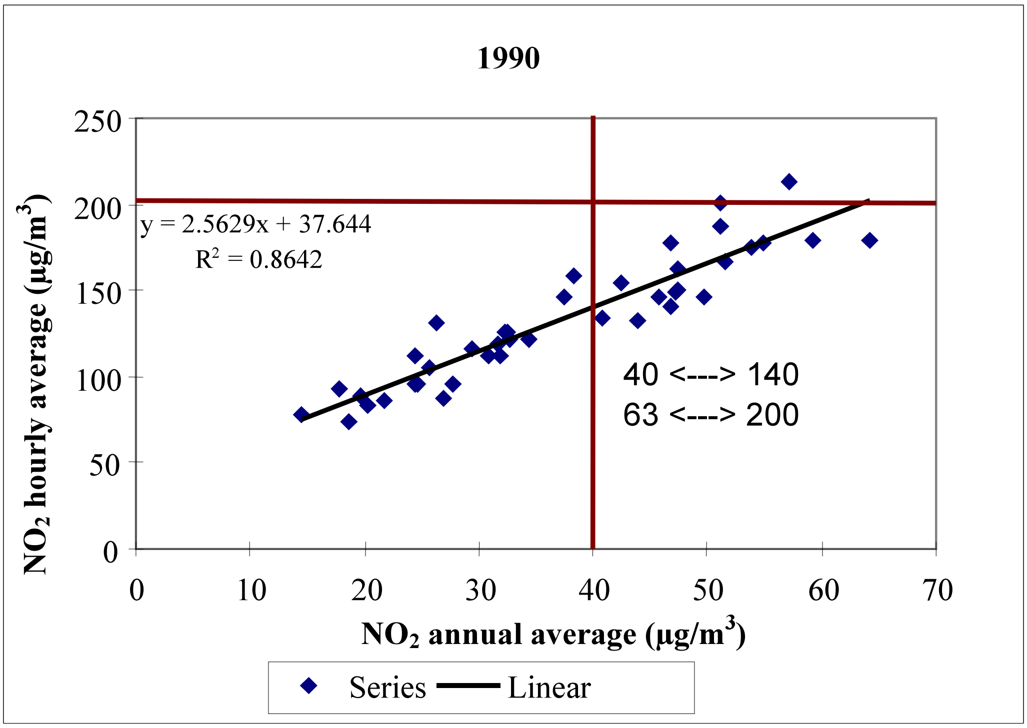
Annex 9 Emission ceiling NEC/Gothenburg

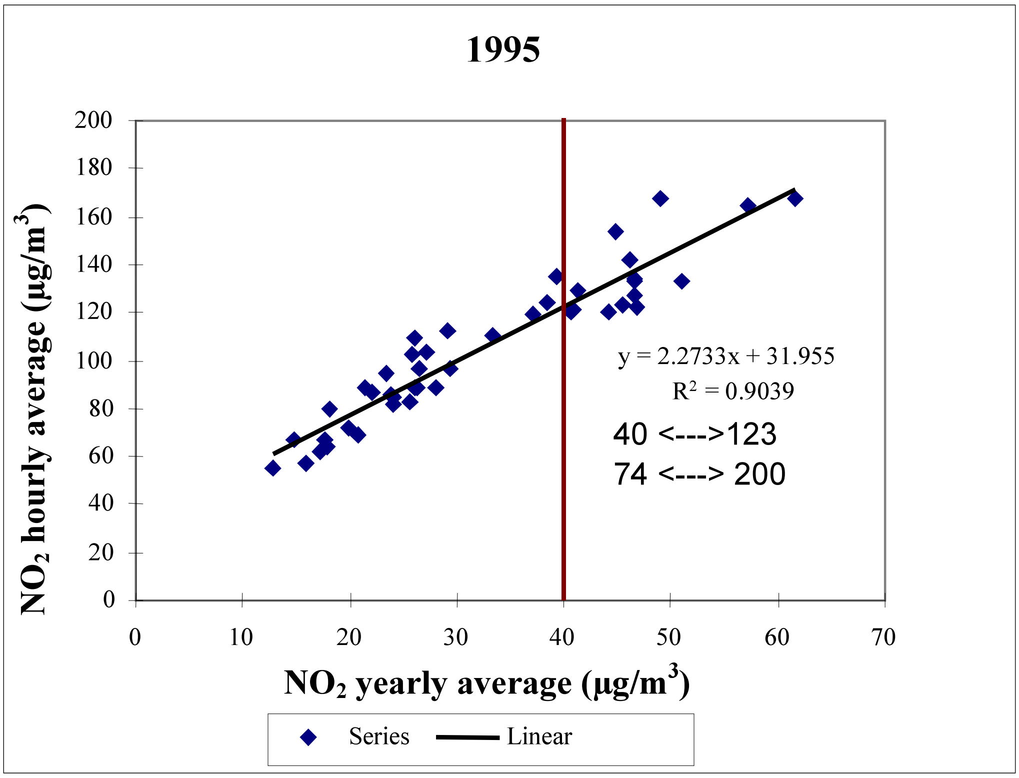
NO_x emission ceilings (in ktonne) from the NEC Directive (EU, 2001) and the Gothenburg protocol (UNECE, 1999) for 2010

Country	NEC Commission proposal	NEC	Gothenburg[1]
Austria	91	103	107
Belgium	127	176	181
Denmark	127	127	127
Finland	152	170	170
France	679	810	860
Germany	1051	1051	1081
Greece	264	344	344
Ireland	59	65	65
Italy	869	990	1000
Luxembourg	8	11	11
Netherlands	238	260	266
Portugal	144	250	260
Spain	781	847	847
Sweden	152	148	148
United Kingdom	1181	1167	1181
Total EU-15	5923	6519	6648

[1] Contrary to the NEC directive, the Gothenburg protocol also contains emission ceilings for countries outside the EU. These ceilings are not given here, though.

Annex 10 Connection between annual and hourly average NO_2 standard





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