RIVM report 500034001/2004

The Dutch CAFE baseline: In or out of line?
A review on the current information in the RAINS model

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This investigation has been performed by order and for the account of the Dutch Ministry of Environment and Spatial Planning – Directorate Environment, within the framework of project M/500034

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Abstract

Review of the CAFE baseline in RAINS

The European Commission is constructing a strategy on air pollution within the Clean Air For Europe (CAFE) programme. This strategy will be based on assessments using the RAINS model for different policy ambitions where the CAFE baseline scenario and control strategies are employed. The Netherlands Environment Assessment verified the data in RAINS and the CAFE baseline. In this verification the CAFE baseline was shown to be unsuitable for determining the Dutch position in negotiations for new European air pollution policy (like the NEC review). The Netherlands will have to introduce a national scenario of its own to bring forward the Dutch expectations on future developments. While the RAINS model would seem appropriate for calculating abatement scenarios, contra-expertise will still be necessary during the CAFE process to assess differences in RAINS on calculated abatement costs and emission levels.

Keywords: Air pollution, Abatement, Scenario, CAFE, RAINS

Rapport in ‘t kort

Beoordeling van de CAFE baseline in RAINS

De Europese Commissie zet een strategie op voor de aanpak van luchtverontreiniging in het Clean Air for Europe (CAFE) programma. De strategie wordt gebaseerd op beoordelingen met het RAINS model van verschillende beleidsambities met de CAFE baseline en bestrijdingsstrategieën. Het Milieu- en Natuurplanbureau van het RIVM heeft de juistheid van gegevens in RAINS en de CAFE baseline gecontroleerd. Uit deze controle bleek dat voor de positiebepaling van Nederland in onderhandelingen over nieuw Europees luchtverontreinigingsbeleid de CAFE baseline niet volstaat. Er is een eigen nationaal scenario nodig om de Nederlandse toekomstverwachtingen goed in te brengen. Het RAINS model lijkt geschikt om beleidsscenario’s uit te rekenen, maar contra expertise blijft nodig voor de beoordeling van verschillen in RAINS op berekende kosten en emissieniveaus in beleidsscenario’s.

Trefwoorden: Luchtverontreiniging, Beleid, Scenario, CAFE, RAINS

Contents

Samenvatting

De Europese Commissie stelt een strategie op voor de aanpak van luchtverontreiniging in het Clean Air for Europe (CAFE) programma. De strategie wordt gebaseerd op verkenningen van verschillende beleidsambities met het model RAINS op basis van bestrijdingsstrategieën en de CAFE baseline zoals opgesteld door de Europese Commissie. De juistheid van de gegevens in RAINS voor Nederland is gecontroleerd door deze te vergelijken met nationale cijfers uit de Emissie Registratie en de Nederlandse 'Referentie Raming'. Het doel van deze controle was na te gaan of RAINS en de CAFE baseline geschikt zijn voor het berekenen van beleidsvarianten voor nieuw luchtverontreinigingsbeleid. Veel fouten in RAINS zijn gecorrigeerd tijdens de bilaterale consultatie met IIASA, maar drie belangrijke overeengekomen voorstellen om de misinterpretatie van emissieberekeningen van visserij, om de lage NO_x-emissiefactor voor gasmotoren in de landbouw en om de hoge PM_{10}-emissiefactor voor huishoudens op te lossen, heeft IIASA niet overgenomen.

De belangrijkste verschillen tussen de aannames in het nationale scenario en de CAFE baseline zijn lager kolengebruik, hogere dieraantallen, lager aandeel dieselauto's en een hoger gebruik van huishoudelijke brandstoffen (barbecues, houtkachels) in de CAFE baseline. Deze verschillen veroorzaken de belangrijkste verschillen in emissies (tabel S.1). Het lager kolengebruik resulteert in lagere totale emissies van zwaveldioxide (SO_2) (28% in 2010). De hogere dieraantallen leiden tot hogere totale emissie van ammoniak (NH_3) (12% in 2010) en fijn stof (PM_{10}) (8% in 2010). Het hogere gebruik van huishoudelijke brandstoffen leidt tot hogere fijn stofemissies en het lagere aandeel dieselauto's leidt tot lagere emissies van stikstofdioxide (NO_x) en fijn stof voor transport in 2020 (respectievelijk 7% en 3%). Deze scenarioverschillen tussen de CAFE baseline en de nationale gegevens leiden mogelijk tot onjuiste toepassing van bestrijdingsmaatregelen en tot onjuiste emissieniveaus in de beleidsscenario's. Vooral het lage kolengebruik toont niet de bestrijdingsproblemen en kosten voor SO_2 zoals die blijken uit de nationale verwachtingen. Ook het effect van een lager aandeel dieselauto's in de CAFE baseline op lagere emissies van NO_x, PM_{10} and $PM_{2.5}$ is belangrijk omdat veel van de aandacht in CAFE zal komen te liggen op de bestrijding van emissies van $PM_{2.5}$ en NO_x van het wegverkeer.

Het RAINS model zelf levert minder verschil op dan het gebruik van de CAFE baseline gegevens en het niveau van maatregelen in RAINS komt in grote lijnen overeen met het huidig Nederlandse beleid. RAINS lijkt geschikt om totale emissies te berekenen, maar veroorzaakt op sectorniveau wel grote verschillen in emissies. Een groot verschil is toe te schrijven aan de foutieve interpretatie van visserij in RAINS, dat veel hogere totale emissies SO_2 (circa 20%), NO_x (circa 9%) in 2010 en 2020 veroorzaakt. Andere verschillen zijn het gevolg van verschillen in emissiefactoren, activiteitendefinities en bestrijdingstechnieken. Deze fouten hinderen mogelijk de berekening van bestrijdingsniveaus tegen de laagste kosten voor alle stoffen. Er is geen eenduidig antwoord te geven op het totale effect van deze verschillen voor kosten en emissieniveaus in beleidsscenario's.

Voor de positiebepaling van Nederland in onderhandelingen over nieuw Europees luchtverontreinigingsbeleid (zoals de herziening van de NEC richtlijn) volstaat de CAFE baseline niet. Er is een eigen nationaal scenario nodig om de Nederlandse toekomstverwachtingen goed in te brengen. Het RAINS model lijkt geschikt om beleidsscenario's uit te rekenen. Contra expertise blijft echter wel nodig voor de beoordeling van verschillen in RAINS op berekende kosten en emissieniveaus in beleidsscenario's.

Table S.1 Emissions for SO_2, NO_x, NH_3, PM_{10} and VOC in 2010 from RAINS calculations compared to the Dutch Reference Scenario emissions(10^6 kg). Differences are weighted to total emission in RAINS

sector	SO_2			NO_x		
	RAINS	RS2004	Weighted Difference	RAINS	RS2004	Weighted Difference
refineries	25	22	-5%	9	8	0%
domestic	1	2	2%	22	33	4%
power plants	3	19	28%	32	39	2%
industry	13	18	7%	22	25	1%
off-road	3	4	1%	59	67	3%
road traffic	0	0	0%	110	105	-2%
fishery	14	0	-23%	28	13	-6%
total	59	65	10%	283	288	2%

	NH_3		
sector	RAINS	RS2004	Weighted Difference
domestic	9	8	0%
power plants	0	0	0%
industry	3	4	0%
transport	2	3	-1%
fertilizer use	7	8	-1%
other cattle	27	25	1%
dairy cows	36	32	3%
other animals	4	1	2%
pigs	33	25	6%
poultry	22	17	4%
total	144	122	15%

	PM_{10}			VOC		
sector	RAINS	RS2004	Weighted Difference	RAINS	RS2004	Weighted Difference
refineries	2	2	0%	24	16	-4%
domestic	15	8	-13%	31	65	16%
agricultural	13	9	-8%			
power plants	0	1	1%	2	2	0%
industry	6	11	9%	83	61	-10%
off-road	6	5	-2%	10	9	-1%
road traffic	8	9	1%	24	45	10%
fishery	2	0	-2%	1	1	0%
paint				34	IE	-16%
total	52	45	-15%	210	200	-5%

Criteria on the colors:

	Green:	no significant difference between RAINS and RS2004
	Yellow:	Small difference between RAINS and RS2004
	Red:	Large difference between RAINS and RS2004

Summary

The European Commission is constructing a strategy for combating air pollution within the Clean Air for Europe (CAFE) program. The strategy will be based on assessments using the RAINS model for different policy ambitions where control strategies with the CAFE baseline scenario -as framed by the European Commission- are employed. The data in RAINS for the Netherlands was verified through comparison with national figures taken from the emission registration and the Dutch ‘Reference Scenario’. The aim of the verification is to check the suitability of RAINS and the CAFE baseline for calculating abatement scenarios for new air pollution policy. Many errors in RAINS were corrected in the bilateral consultation with IIASA. However, three essential proposals that were agreed to correct the faulty interpretation on fishery, the low NO_x emission factor for gas engines in agriculture and the high PM_{10} emission factor for residential combustion, have not been adopted by IIASA.

The main differences between the assumptions in the national scenario and the CAFE baseline -lower use of coal, higher animal numbers, lower share of diesel cars and higher use of domestic fuels (barbeques, wood stoves)- are responsible for the main differences in emissions (Table S.1). The lower use of coal results in lower power plant emissions for sulphur dioxide (SO_2) (28% on total in 2010). Higher animal numbers lead to higher emissions of ammonia (NH_3) (12% in 2010) and particulate matter (PM_{10}) (8% in 2010). Higher use of domestic fuels (barbecues and wood stoves) also leads to higher total particulate emissions. Finally a lower share of diesel cars leads to increasingly lower nitrogen dioxide (NO_x) and particulate emissions for transport in 2020 (7% and 3%, respectively, in 2020). The differences between RAINS calculations and national assessments may lead to incorrect application of abatement measures and result in incorrect abatement emission levels. Especially the low coal use conceals abatement problems and costs for SO_2 when compared with national expectations on coal-fired plants. The effect of a lower share of diesel cars in the CAFE baseline on lower emission of NO_x, PM_{10} and $PM_{2.5}$ emissions is also important because much of the focus in CAFE will be on the abatement of $PM_{2.5}$ and NO_x in road traffic.

The RAINS model itself causes less difference than the use of the CAFE baseline data and the level of implementation of control measures in RAINS in general reflects the current Dutch policy. RAINS seems appropriate for calculating total emissions but causes big differences in sector emissions. A big difference originates from the faulty interpretation of fishery in RAINS, causing much higher emissions for SO_2 (about 20%) and NO_x (about 9%) in 2010 and 2020. Other differences are caused by differences in emission factors, use of control technologies and definitions of activities. These errors can hamper calculation of abatement levels at lowest costs for all components. There is currently no unambiguous answer to what the total effect of these differences is on the abatement costs and levels.

The CAFE baseline is not suitable for determining the Dutch position in negotiations for new European air pollution policy (like the NEC review). The Netherlands will have to introduce a national scenario of its own to bring forward the specific Dutch expectations on future developments. While the RAINS model would seem appropriate for calculating abatement scenarios, contra-expertise will still be necessary during the CAFE process to assess differences in RAINS on calculated abatement costs and emission levels.

1. Introduction

The European Commission will construct in 2005 a strategy for combating air pollution within the Clean Air For Europe (CAFE) programme. In the CAFE programme future air quality up to 2020 will be assessed with respect to different policy ambitions (abatement levels) with the RAINS model. For this purpose two European-wide scenarios have already been constructed; one scenario including additional climate policy and one excluding it. To support the Dutch Government in constructing the strategy on air pollution in the CAFE program, the Netherlands Environment Assessment Agency at RIVM was asked to verify the CAFE baseline scenarios and the technical abatement options implemented in the RAINS model for the Netherlands. Since in CAFE the scenario including climate policy will draw the most attention we have chosen to focus on this scenario in our analysis. The data presented in this report is the final data for use in the CAFE project.

The aim of the verification is to check the suitability of RAINS and the CAFE baseline for calculating abatement scenarios for new air pollution policy (e.g. review of the NEC directive). Verification took place from November 2003 to September 2004 to compare the data in RAINS with Dutch data. A bilateral consultation with IIASA by sector specialists took place in March.

The data was compared with figures taken from the emission registration for the year 2000; future figures were compared with the Dutch 'Reference Scenario' (Beck et al., 2004). Since this scenario ends in 2010 the comparison was restricted to 2010 except for transport, animal numbers and use of coal for which extended or new information was available. The emissions of sulphur dioxide (SO_2), nitrogen dioxide (NO_x), ammonia (NH_3), volatile organic compounds (VOC) and particulate matter (PM_{10}) have been checked. $PM_{2.5}$ emissions were checked to compare the derived ratio from TSP. Due to lack of as well Dutch as European data in RAINS no check has been performed on abatement costs during this consultation.

The 2010 and 2020 figures are important for the strategy on air pollution. Since these figures are derived from 2000 figures, much attention has been paid to checking and analysing the 2000 figures. For 2000 figures in RAINS on activity level, abatement levels and unabated emissions were checked and differences corrected to closely match the Dutch 2000 emissions. Future developments on differences in activity and abatement level, as well as total emissions, have also been checked. Corrections in abatement levels have been made; however, difference in activity level could not be corrected because activity levels are scenario-dependent. The CAFE project offered the opportunity to supply a national scenario so as to use other activity levels; however the Netherlands chose not to submit a complete Dutch scenario and has only submitted data on animal numbers.

Chapter 2 describes the main assumptions of the CAFE baseline scenarios and the RAINS model, chapter 3 explains the observed differences, differences after correction and consequences of remaining differences and chapter 4 presents the conclusions.

2. CAFE Baseline Scenarios

The European Commission assigned the technical integrated assessment activities for the CAFE program to a consortium lead by the International Institute for Applied Systems Analysis (IIASA). The activities include the development of the baseline scenario for CAFE, interacting with stakeholders about the baseline scenario, and applying the integrated assessment model RAINS for a series of policy scenario runs to provide information on the development of the thematic strategy on air pollution.

Table 2.1 Main assumptions of the baseline scenario (EC, 2003)

year	2000	2010	2020
Population EU-25 (Million)	453	461	462
Population NL (Million)	15.9	16.8	17.4
GDP growth per year (%) EU-25	2.5[1]	2.4[2]	2.2[3]
GDP growth per year (%) NL	2.3[1]	2.3[2]	2.2[3]
Crude Oil price ($00/boe)	28	20.1	23.8
Final Energy Demand (Mtoe)	1077	1209	1316
Final Energy Demand Transport (Mtoe)	333	389	429

[1] Period: 2000-2010; [2] Period: 2010-2020; [3] Period: 2020-2030

The starting point for the European-wide baseline scenario was the energy and transport outlook to 2030 'Long Range Energy Modelling' (LREM) from the European Commission, Directorate-General for Energy and Transport (EC, 2003). This scenario for economic and energy sector development was developed with the use of the PRIMES model run at the National Technical University Athens (NTUA). Table 2.1 summarizes the main assumptions for the CAFE baselines scenarios. The LREM scenario of energy demand describes the sector's use of different fuel types over time. It includes existing trends and the effects of policies in place. Along with those in the process of being implemented by the end of 2001, whereas tax rates reflect the situation in the EU Member States as of July 2002. The LREM scenario excludes all additional policies and measures that aim at further reductions of CO_2 emissions to comply with the Kyoto emission commitments.

The CAFE baseline scenario for agriculture (livestock production and application of mineral N fertilizers) assumes that the common agricultural policy (CAP) reform is not implemented. Projections for the number of animals are based on results from a number of European and global models. For the EU-15, data for the years 2000 until 2010 are derived from the CAPRI model run at the University of Bonn (Common Agricultural Policy and Regionalised Impact Assessment). For accession countries, projections for the same time horizon originate from Directorate-General for Agriculture. For other countries and for the period beyond 2010, the projection is based on trends derived from FAO projections (FAO, 2003). A scenario including CAP reform is under preparation. The forecast of fertilizer consumption up to 2010 for EU-15, Switzerland and Norway is based on data by EFMA (European Fertilizer Manufacturers Association). For other countries and for the period beyond 2010 the projection is based on trends derived from global FAO projections (FAO, 2003).

The consortium constructed three CAFE baseline scenarios (Amann et al., 2004):

- **LREM scenario.** This is the 'Energy and Transport - Trends to 2030' of DG Transport and Energy (EC, 2003) combined with Europe-wide consistent projections of agricultural activities without CAP reform. The control strategy for air pollution in this scenario is current legislation.
- **Climate policy scenario.** In contrast to the LREM scenario, the existing of an EU-wide CO_2 emissions trading regime in this scenario is assumed, with a permit price ranging from 12 euro per tonne of CO_2 in 2010 to 16 euro in 2015 and 20 euro in 2020. These permit prices lead to adjustment of the behaviour of economic agents, i.e. producers and consumers of energy, through changes in relative prices. In contrast to the LREM scenario, this scenario incorporates new national perspectives in a Europe-wide consistency on assumptions of economic growth rates, energy prices, electricity exports and imports etc. In contrast to the LREM scenario for agriculture this scenario uses a revised version of European-wide consistent projections of agricultural activities without CAP reform. The control strategy for air pollution in this scenario is current legislation. Used as the CAFE baseline it has been reviewed in this report applying Dutch data.
- **National scenario.** This scenario contains energy projections incorporating climate policies and national agricultural projections submitted by Member States. Data for other countries are taken up in the climate policy scenario. The control strategy for air pollution in this scenario is current legislation.

RAINS

*The **R**egional **A**ir Pollution **In**formation and **S**imulation (RAINS) model is a tool for analyzing alternative strategies to reduce acidification, eutrophication, ozone and particulate matter in Europe. RAINS combines a variety of information relevant for the development of cost-effective emission control strategies in Europe, i.e.:*

- projections of future economic, agricultural and energy development in 38 European countries,
- the present and future emissions of SO_2, NO_x, NH_3, VOC and PM resulting from these activities, taking into account control strategies
- the technical options for reducing emissions and the costs of these measures,
- the atmospheric dispersion characteristics of sulphur and nitrogen compounds, particulate matter and the formation of ground-level ozone
- the environmental sensitivities of ecosystems towards acidification, eutrofication and ground-level ozone.
- the health effects of ambient levels of particulate matter and ozone

RAINS integrates the latest scientific findings, up-to-date databases and advanced systems-analytical (optimization) tools. The web version and documentation of the model are available from:http://www.iiasa.ac.at/web-apps/tap/RAINSWeb/

The RAINS model calculates air pollution from their sources (e.g. power generation, transport or cattle breeding) to their impacts on human health and the environment. The model estimates regional costs and environmental benefits of alternative emission control strategies. In the CAFE program the RAINS model will be used with an optimization mode to identify cost-optimal allocations of emission reductions in order to achieve specified deposition and concentration targets formulated in the CAFE program.

Control strategies are packages of emission control measures applied to the different source categories. Control strategies determine the percentage of activity for the entire sector to which a given control measure is to be applied. Control strategies can be considered as general descriptions of legislative packages for emission control, specifying for each individual emission category the type, the timing and the extent of required emission control.

3. Analysis of sectoral emissions

In order to determine the major differences between emissions registered by the Netherlands (and consequently reported to the convention) and emissions calculated by the RAINS model, the first step of the analysis was to compare total and sectoral emissions per compound for 2010 and 2000. Where major sectoral differences were found, the next step was to determine whether this was due to a difference in the activity level and/or the emission factor. The data for 2000 was taken from Emission Registration (ER2004) and for 2010 the data was taken from the Dutch Reference Scenario (RS2004) (Beck et al., 2004) extended to 2020 for transport (Brink, 2003).

The sectoral split followed in the analysis conformed to RAINS:

- power plants,
- refineries,
- domestic and commercial services,
- transportation,
- industrial,
- non-energy use,
- agriculture and
- other emission sources.

The major factors for IIASA in choosing these sectors were the sector split of the available energy balances (e.g., the energy statistics of UN/ECE, OECD/IEA and EUROSTAT) for the energy projections (e.g., of DG TREN) used as exogenous driver to the RAINS model and of the NFR (Nomenclature for Reporting) sector classifications.

In this chapter sections, one for each compound, describes to what extent and why the current RAINS emission (RAINSSep2004) differ from the Dutch data, what corrections have been proposed and how the implemented corrections by IIASA affected the old emission (RAINSJan2004) and last the consequence of remaining differences for calculating abatement scenarios for the Netherlands is given. More details on the consultation process can be found in the Annexes.

3.1 SO_2 emissions

Differences

In RAINS, SO_2 emissions are 6 million kg lower in 2010 and 10 million kg higher in 2000 (Tables 3.2 and 3.3). RAINS applied an incorrect NEC definition for fishery, which causes a 14 million kg higher emission in 2010. The lower SO_2 emission in 2010 is caused: firstly mainly by scenario differences due to a much lower use of hard coal in power generation, resulting in a 16 million kg lower emission in RAINS and secondly by a stabilisation instead of growth in RAINS with respect to aluminium and ceramics production, leading to 5 million kg lower emission.

Corrections
The difference in total SO_2 emissions for 2010 in RAINS went from 5 million higher before consultation to 6 million kg lower after consultation; for 2000 it went from 21 million to 10 million kg higher (Table 3.2 and 3.3).

Corrections for the missing fuel switch (oil to gas) have been implemented by refineries. Since RAINS cannot implement a fuel switch, a fuel switch for 2010 has been largely implemented in RAINS using a dummy control technology, which leads to lower emissions in 2010 and later.

The level of abatement technology for the use of heavy fuel oil for heating has been increased to match the situation in 2000 and the situation expected for 2010. Corrections have been made to accommodate a higher degree of implementation of technical measures and lower unabated emissions from industrial processes, which causes emissions to decline. RAINS upgrades to more efficient control technologies after 2000 have, however, been removed, since they are not expected to be taken under current legislation; this will cause a slight increase in future emissions. Collectively, these corrections cause industrial emissions to decline.

The sulphur content of fuel used for road transport and off-road vehicles for 2000, 2010 and 2020 have been corrected for a better match with the Dutch figures (Table 3.1, 3.2 and Annex 3).

The corrections for fishery emission calculations have not been implemented as indicated. RAINS still treats this category as marine shipping, with the sulphur content of heavy fuel and not medium distillates. This causes much higher SO_2 emissions for all years.

The corrections implemented improved the fit of the 2000 figures; however, differences for 2010 emission remain, mainly due to different scenario assumptions and a definition of fishery as mentioned above.

Consequences
Future total emissions in RAINS for SO_2 in the Netherlands (2010) are lower at 6 million kg, while on sector level differences are higher (e.g. power plants have 16 million kg lower emissions, fishery, 14 million kg higher and industry, 5 million kg lower). The sectors important for control options (refineries, power plants and industry) will differ in abated emissions due to lower scenario activity for power plants (coal use) and industry (aluminum and ceramic production) and due to missing cost effective control technology (switch from oil to gas) for refineries (Beck et al., 2004) in RAINS. Especially the low coal use may lead in the RAINS optimization to lower emission targets at lower cost than with higher coal use. This is important because the Netherlands has problems meeting its NEC target for SO_2 in 2010.

Table 3.1 Emissions of SO_2 for 2020 for RAINS calculations before and after correction and for the Dutch Reference Scenario

2020			SO_2 (10^6 kg)	
sector	RAINS Jan2004	RAINS Sept2004	RS2004	Weighted Difference
off-road transport	0	4	4	0%
road transport	1	0	0	0%
fishery	12	14	0	-22%
other	60	46	NA	NA
total	73	65	NA	NA

(NA: Not yet available)

Table 3.2 Emissions of SO_2 for 2010 for RAINS calculations before and after correction and for the Dutch Reference Scenario

2010			SO_2 (10^6 kg)	
sector	RAINS Jan2004	RAINS Sept2004	RS2004	Weighted Difference
refineries	31	25	22	-5%
domestic, commercial and agricultural use	2	1	2	2%
power plants	7	3	19	28%
industry	18	13	18	7%
off-road transport	0	3	4	1%
road transport	1	0	0	0%
fishery	11	14	0	-23%
total	70	59	65	10%

Table 3.3 Emissions of SO_2 for 2000 for RAINS calculations before and after correction and for the Dutch Emission Registration

2000			SO_2 (10^6 kg)	
sector	RAINS Jan2004	RAINS Sept2004	ER2004	Weighted Difference
refineries	31	32	33	1%
domestic, commercial and agricultural use	4	2	2	0%
power plants	17	16	15	-1%
industry	24	16	15	-1%
off-road transport	6	5	5	0%
road transport	5	3	3	0%
fishery	8	11	1	-12%
total	96	85	75	-12%

Coal-fired power plants are an important sector for abatement options. The much lower use of coal in RAINS in 2010 and 2020 may, in particular, have consequences. The RAINS forecasts of future emissions of SO_2 by power plants will be much lower. The CAFE baseline is not thought to be the source of the most likely development of coal use in the Netherlands. The cost advantage of production based on hard coal over production based on natural gas gradually diminishes due to a gradually rising price of CO_2-emission rights[1]. But the price level of CO_2-emission rights at which it is actually more expensive to operate a coal-fired plant than a gas-fired plant (around 35 euro/ton) is not reached in the CAFE baseline and the new Reference projection (annex 1) before 2020. Therefore, it is assumed that existing coal-fired plants will remain in operation until the end of their life span. Dutch comments on future coal use (Annex 1) have been submitted to NTUA for implementation in their latest CAFE baseline run using PRIMES. However, the new figures from CAFE baseline even show a 50% lower share of coal use for power generation in 2010 and 2020 when compared to the previous version. This means that the Dutch comments have not been taken into account. Low SO_2 targets for the Netherlands may be in conflict with the national assumption on power generation with hard coal.

The much higher emissions for fishery (14 million kg in 2010) may cause abatement measures to be applied in RAINS. The higher emissions are caused by RAINS supplying the incorrect NEC definitions. The corrections agreed to solve this have not been implemented by RAINS. In 2010 these emissions are hardly affected by control measures in RAINS, but in 2020 RAINS assumes that about 60% of these emissions will be suitable for abatement. The abatement measure, a switch to fuel with a lower sulphur content, is not applicable since fishery already use fuel with a lower sulphur content (medium distillates) than heavy fuel. This leads to non-existing costs and errors in calculating the cheapest abatement measures in RAINS.

Another important sector for abatement measures are refineries. Here, the projected and measured emission levels match reasonably, although an import abatement measure, ‘switch from oil to gas’, is not incorporated in RAINS. This measure will offer fewer possibilities for abatement of SO_2 emission in RAINS when calculating abatement scenarios, and may lead to higher abatement emissions.

The third important sector for abatement technologies is the industry sector. Industrial emissions are lower than in the Dutch expectations, since RAINS does not project a growth in aluminium and ceramics production. This stagnation will cause lower SO_2 levels in this sector’s policy runs for lower abatement costs than where growth is observed.

[1] In this scenario, the price of emission rights is: EUR 8/ton CO_2 in 2010, EUR 11/ton CO_2 in 2020, EUR 61/ton CO_2 in 2030 and EUR 89/ton CO_2 in 2040.

3.2 NO_x emissions

Differences

Total NO_x emissions in RAINS are currently 5 million kg lower for 2010 and 20 million kg lower for 2000 (Table 3.5, 3.6). Although the total NO_x emission in RAINS matches pretty well in 2010 there are big differences on sector level: RAINS calculates 50% higher emission for fishery (25 million kg) and lower emissions for gas engines in agriculture (11 million kg), off road transport (8 million kg) and power plants (7 million kg) in 2010. The erroneous interpretation of emissions from fishery causes the biggest difference. However, this causes higher emissions in RAINS for this particular sector. The lower total emissions in RAINS in 2010 are caused by a lower unabated emission factor in RAINS for use of gas engines in agriculture (gas engines in greenhouses have higher emissions per unit energy used). Lower emissions are furthermore caused by a lower assumed activity level for off-road transport (especially air traffic) and – just as for SO_2 – a lower assumed use of coal in power plants in the CAFE baseline.

Although road transport totals of NO_x for RAINS and national data are in line, there are differences on sub-sector level. This concerns a lower share of diesel in light duty vehicles in RAINS, causing lower emission of 3 million and 12 million kg in 2010 and 2020, respectively. This is due to a 20% higher consumption of energy by gasoline cars and a 17% lower consumption by diesels in the CAFE baseline (See Annex 3). However, these lower emissions are countered by higher emissions from heavy duty vehicles in 2010 in RAINS, because less control technology is assumed (implementation of EURO IV engines). In 2020, however, the lower diesel share and differences in the age and composition of the car fleet in RAINS cause a 17 million kg lower emissions for road transport totals.

Table 3.4 Emissions of NO_x for 2020 for RAINS calculations before and after correction and for the Dutch Reference Scenario

2020			NO_x (10^6 kg)	
sector	RAINS Jan2004	RAINS Sept2004	RS2004	Weighted Difference
off-road transport	57	50	61	4%
road transport	61	79	96	7%
fishery	28	30	10	-8%
other than transport	101	82	NA	NA
total	248	241	NA	NA

Table 3.5 Emissions of NO_x for 2010 for RAINS calculations before and after correction and for the Dutch Reference Scenario

2010			NO_x (10^6 kg)	
sector	RAINS Jan2004	RAINS Sept2004	RS2004	Weighted Difference
refineries	17	9	8	0%
domestic, commercial and agricultural use	35	22	33	4%
power plants	39	32	39	2%
industry	25	22	25	1%
off-road transport	58	59	67	3%
road transport	126	110	105	-2%
fishery	27	28	13	-6%
total	327	283	288	2%

Corrections

The difference of RAINS total NO_x emissions for 2010 decreased from 39 before consultation to 5 million kg higher after consultation, and for 2000 total emissions change was from 10 to 20 million kg lower (Table 3.4).

Corrections have been made in RAINS at the low level of penetration of selective catalytic reduction (SCR) on power plants. Levels of control in RAINS have been increased for 2000 (Annex 6); for 2010 and later the degree of implementation is expected to be 100% due to the NO_x-emission trading legislation. On the other hand for new gas-fired plant control technology (SCR) has been removed, because the unabated emission factor of these plants is already so small that control is not logical. Taken collectively, these corrections lead to lower emissions in RAINS for all years.

Emission factors for road transport and for off-road transport for 2020, 2010 and 2000 have been corrected to better match the Dutch figures for all years.

Emissions of industrial combustion processes were adjusted to fit 2000 data by lowering the degree of implementation of control technologies on all combustion fuels (see Annex 1). Industrial process emissions for cement and nitric acid production were lowered in RAINS by applying the highest level of control in RAINS according to Dutch figures. Collectively, this causes a drop in emission for all future years.

Corrections on the missing fuel switch (oil to gas) by refineries have been implemented similarly to SO_2. Since RAINS cannot implement a fuel switch, the expected fuel switch for 2010 has been largely implemented in RAINS using a dummy control technology, leading to lower emissions in 2010 and thereafter (8 million kg in 2010).

For domestic emissions from gas engines in agriculture (green houses) proposed corrections to increase unabated emission factors were not taken over by RAINS.

Table 3.6 Emissions of NO_x for 2000 for RAINS calculations before and after correction and for the Dutch Emission Registration

2000			NO_x (10^6 kg)	
sector	RAINS Jan2004	RAINS Sept2004	ER2004	Weighted Difference
refineries	22	13	10	-1%
domestic, commercial and agricultural use	34	26	48	6%
power plants	63	51	53	0%
industry	38	36	34	-1%
off-road transport	58	71	72	0%
road transport	177	182	184	0%
fishery	20	22	21	0%
total	412	402	422	5%

<u>Consequences</u>

The total NO_x emissions in RAINS match fairly well in 2010. However, there are large differences on sector level. RAINS calculates 50% higher emission for fishery (25 million kg) and lower emissions for gas engines in agriculture (11 million kg), off-road transport (8 million kg) and power plants (7 million kg) in 2010. Because power plants, (off-)road transport and agriculture are the most important sectors for (cost-effective) abatement options, these lower emissions will lead to lower NO_x abatement targets for these sectors at lower cost.

Although there is a good match on sector level for road transport there are differences on sub-sector level. These concern a lower share of diesel in light duty vehicles in RAINS. In 2010 this effect is negated by a lower degree of control technology on heavy duty transport in RAINS. However, in 2020 the lower diesel share in RAINS causes lower emissions in road transport totals. This is important because there will be much focus on traffic for abatement options in CAFE. The differences in diesel share and heavy duty emissions may lead to incorrect application of abatement measures. Current policy (implementation of control measures) in RAINS reflects Dutch policy satisfactory.

The definition for fishery emission calculations has not been implemented in the correct manner in RAINS leading to higher emissions in 2010 and 2020. For fishery there is, to date, no control technology assumed, which means that these emissions will not be affected in abatement scenarios and will have no effect on abatement costs calculated. These erroneous higher emissions are countered by the underestimation of emissions from agriculture, off-road transport and power plants. The effect of this on total abatement costs is currently unclear.

The lower emission for gas engines is caused by a lower emission factor in RAINS. Corrections to solve this have not been implemented. The lower emissions for power plants and off-road transport are caused by lower assumption on activity level in the CAFE baseline on respectively coal use (see SO_2) and air traffic.

3.3 NH_3 emissions

Differences

RAINS total NH_3 emissions for the year 2010 are 22 million kg and in 2000 6 million kg higher. Agriculture is emitting the lion's share of the total emissions and is consequently the cause of the lion's share in differences (Table 3.8 and 3.9). The higher emissions in 2010 are caused mainly by higher animal numbers in the CAFE baseline for pigs (29%), cows (10%) and chickens (18%) (Annex 4). The CAFE baseline holds higher animal numbers since it has not taken the effects into account of the nitrate directive and increasing milk production per dairy cow in the Netherlands in the context of the super levy (ceiling on milk production). The higher animal numbers lead to a 17 million kg higher emission of NH_3; 8 million kg for pigs, 6 million kg for cows (2.6 million kg cattle and 3.4 million kg dairy) and 3 million kg for chickens. Another reason for the higher emissions is that RAINS cannot incorporate typically Dutch control technologies such as feed low in nitrogen and low-emission housing for dairy cattle. On the other hand, RAINS calculates lower emissions, since the effects of the EU ban on battery cages has not been taken into account.

Table 3.7 Emissions of NH_3 for 2020 for RAINS calculations before and after correction and for the Dutch Reference Scenario

2020			NH_3 (10^6 kg)	
	RAINS Jan2004	RAINS Sept2004	RS2004	Weighted Difference
domestic, commercial and agricultural use	0	2	NA	
other emission sources	3	8	NA	
power plants	2	0	NA	
industry	0	1	NA	
transport	1	1	NA	
fertilizer use	6	6	8	-1%
fertilizer production	2	2	NA	
agriculture: livestock – cattle	54	60	56	3%
agriculture: livestock- other animals	3	4		2%
agriculture: livestock – pigs	28	34	24	8%
agriculture: livestock – poultry	27	23	18	5%
total	131	144	NA	NA

Table 3.8 Emissions of NH_3 for 2010 for RAINS calculations before and after correction and for the Dutch Reference Scenario

2010			NH_3 (10^6 kg)	
sector	RAINS Jan2004	RAINS Sept2004	RS2004	Weighted Difference
domestic, commercial and agricultural use	3	9	8	0%
power plants	1	0	0	0%
industry	3	3	4	0%
transport	2	2	3	-1%
fertilizer use	7	7	8	-1%
agriculture: livestock – other cattle	22	27	25	1%
agriculture: livestock – dairy cows	36	36	32	3%
agriculture: livestock- other animals	3	4	1	2%
agriculture: livestock – pigs	27	33	25	6%
agriculture: poultry	26	22	17	4%
total	131	144	122	15%

Corrections

The difference between RAINS and RS2004 total NH_3 emissions for 2010 increased from 9 million kg higher before consultation to 22 million kg higher after consultation; for 2000 this went from 18 million kg lower to 6 million kg higher (Table 3.9).

Dutch animal numbers for future years (Annex 4) have been submitted to IIASA to be incorporated in the CAFE baseline in RAINS. IIASA has incorporated this data, however not into the European-wide scenarios, but into the national scenario. This national scenario now holds Dutch data on animal numbers completed with European-wide energy figures from the European wide-scenario including climate policy.

The increase of 12 million kg in livestock emissions for pigs, cattle and other animals in 2010 is caused by adjustments of these emissions to match the 2000 figures. These adjustments cause emissions to increase in 2000 and in future years.

The increase of 6 million kg in the domestic, commercial and agricultural combustion sectors is caused by corrections to match the 2000 emissions of domestic emissions. This causes emissions to increase in 2000 and in future years.

RAINS has not taken into account the effect of the EU ban on battery cages for laying hens. Because of this ban in 2012 housing systems will have to switch from cages to floor-based systems. Battery caged animals excrete about 28% less NH_3 than birds in the floor-based system. RAINS underestimates the forecasted effect of ammonia emission (about 2 million kg NH_3 in 2010). Corrections have not been made since they should be applied to all countries; however, European-wide data has not been available.

RAINS cannot incorporate typically Dutch control technologies like low nitrogen feed and low emission housing for dairy cattle as these abatement options are not available for the RAINS optimization calculation.

Table 3.9 Emissions of NH_3 for 2000 for RAINS calculations before and after correction and for the Dutch Emission Registration

2000			NH_3 (10^6 kg)	
RAINS sector	RAINS Jan2004	RAINS Sept2004	ER2004	Weighted Difference
domestic, commercial and agricultural use	3	8	7	1%
centralized power plants and district heating	0	1	0	0%
industrial emissions	4	3	3	0%
transport	4	3	3	0%
fertilizer use	9	10	11	0%
agriculture: livestock – other cattle	22	29	29	0%
agriculture: livestock – dairy cows	40	40	40	0%
agriculture: livestock- other animals	3	4	0	3%
agriculture: livestock – pigs	24	38	38	0%
agriculture: poultry	23	21	21	0%
total	133	157	151	3%

Consequences

Future emissions are higher in RAINS than in RS2004 due to higher animal numbers. However, the Dutch figures have been incorporated in RAINS into the national scenario, so are taken into account in CAFE. The CAFE baseline contains more animals for the Netherlands because this projection has not incorporated the effect of the nitrate directive and the increasing milk production per dairy cow in the Netherlands in the context of the super levy (ceiling on milk production). This causes higher ammonia emissions in RAINS in 2010 and later. Higher emissions may result in more need of control. However, since RAINS is lacking some typical Dutch control technologies such as low nitrogen feed and low emission housing for dairy cattle, there are fewer control technologies available to abate ammonia. The low nitrogen feed is a cost effective measure for farms on sand ground (Beck et al., 2004), whereas low emission housing is an expensive option. The outcome of the optimization process of RAINS will lack these options and will lead to abatement levels with higher calculated emissions and costs than when using lower animal numbers and all control technologies.

3.4 VOC emissions

At the end of the first consultation period (April, 2004) the RAINS database for VOC was far from complete (compare Annexes). Only for the Transport and Gasoline Storage and Distribution, and combustion of fossil fuels had emission data been made available. This is the reason that analysis of the VOC data has been delayed and not completed yet either. Additional consultations took place between April and August 2004, resulting in more and better RAINS data in June and August 2004.

Differences

After consultation the RAINS total VOC emission matched well (Table 3.11). The differences for the sector refineries (including oil and gas distribution), domestic, industry (processes) and road transport are large. These differences are at least partly due to the fact that the emissions caused by the use of paint (a sector in RAINS) are included in the emission of several sectors in RS2004, e.g. industry, services, consumers and construction.

For road transport the main difference is the emission due to the evaporation of gasoline. Further analysis may reduce this difference, but it was not possible within the time-frame of the review to finish this analysis. Aspects to be considered here are the number of non-VOC control cars in 2010, the emission by other means of transport (mopeds, motor cycles) and the emission factors used. As can be expected, the same discrepancies exist for traffic in 2020 (Table 3.12). These aspects have been elaborated in more detail in the Annex.

The analysis of the RAINS result for industrial process emissions is complicated since the emission in RAINS due to the use of paint is partly included in the industrial emissions in the Netherlands. It is very probable, however, that the RAINS projection for VOC emissions from industrial process as well as the VOC emission due to the use of paint are too high in view of the abatement measures that have been applied in the Netherlands in the past 15 years and will be applied in the future.

Table 3.10 Emissions of VOC for 2020 for RAINS calculations before and after correction and for the Dutch Reference Scenario

2020		VOC (10^6 kg)	
Sector	RAINS Sept2004	RS2004	Weighted Difference
refineries	23	NA	NA
domestic, commercial and agricultural use	32	NA	NA
power plants	3	NA	NA
industry	82	NA	NA
road transport - combustion	18	12	NA
road transport - evaporation	4	17	NA
car products		4	NA
inland waterways transport	4	4	NA
other off-road transport	5	6	NA
transportation total	32	43	NA
paint	31	NA	NA
total	202	NA	NA

Table 3.11 Emissions of VOC for 2010 for RAINS calculations before and after correction and for the Dutch 'Reference Scenario'

2010	VOC (10^6 kg)		
sector	RAINS Sept2004	RS2004	Weighted Difference
refineries	24	16	-4%
domestic, commercial and agricultural use	31	65	16%
power plants	2	2	0%
industry	83	61	-10%
off-road transport	10	9	-1%
road transport	24	45	10%
fishery	1	1	0%
paint	34	IE	-16%
total	210	200	-5%

For the year 2000 too (Table 3.12), the total emission is more or less the same as for the two data sets; the same sectoral discrepancies exist as for 2010 (Table 3.11).

Table 3.12 Emissions of VOC for 2000 for RAINS calculations before and after correction and for the Dutch Emission Registration

2000	VOC (10^6 kg)		
Sector	RAINS Sept2004	RS2004	Weighted Difference
refineries	27	27	0%
domestic, commercial and agricultural use	36	66	11%
power plants	2	4	1%
industry	66	58	-3%
off-road transport	12	10	-1%
road transport	83	97	5%
fishery	0	0	0%
paint	38	IE	-14%
total	264	262	-1%

<u>Consequences</u>

For 2000 and 2010 the difference between the total emissions in RAINS and RS2004 are relatively small, since the higher RAINS estimate for the emissions due to industrial processes is countered by the lower estimate for road transport. However, when additional abatement scenarios are simulated in RAINS, it is possible that for the VOC emissions from industry, oil-and-gas extraction and distribution, and emissions due to the use of paint, estimates for the Netherlands are therefore too high for the associated abatement cost. The current degree of implementation of the abatement technologies for these sectors in RAINS in 2000 and 2010/2020 is lower than in RS2004. This is not the case for road transport although for this sector, the calculated emission in 2010 is too low.

3.5 Particulate Matter emissions

The PM_{10} and $PM_{2,5}$ emissions in the RAINS model are derived from estimated emissions of Total Suspended Particles (TSP). The RAINS and ER2004 and RS2004 comparison has been performed using data for PM_{10} only. $PM_{2.5}$ emissions are more closely linked to carbon-related combustion processes and less to non-energy-related mechanical processes. The fractions used to calculate $PM_{2.5}$ from TSP and PM_{10} were checked.

Differences

The discrepancy in the total PM_{10} emission is currently 7 million kg in 2010 and 9 million kg in the 2000 assessment (Table 3.14 and 3.15). However, there are big discrepancies observed in sectors. RAINS calculates 15 million kg of PM_{10} emissions from domestic and commercial use of fuels in 2010, as opposed to 8 million kg in RS2004. Further differences of 4-5 million kg are seen for emissions from agriculture and processes in industry. The 4 million kg higher emissions from agriculture in RAINS in 2010 are mainly the result of a larger livestock number, in particular, pigs. RS2004 expects a decreasing number of pigs compared to the situation in ER2004. The 5 million kg lower emission in RAINS in 2010 is unfortunately due to an unjust correction by matching emission registration (ER2004) figures for 2000. However the inventory of PM_{10} emissions from industrial processes in 2000 was incomplete. Similar to the situation with SO_2 and NO_x, the erroneous interpretation of emissions from fishery in RAINS is reflected in the 2 million kg difference in this sector in 2010.

It is interesting to note that, similar to NO_x, there is reasonable agreement on 2010 emissions from transport; the sector contributing most. In the further CAFE process this is of importance because several control options will be focusing on this sector. However, just as for NO_x, when taking a closer look at the underlying fuel mix, RAINS appears to assume a 20% higher consumption of energy by gasoline cars and a 17% lower consumption by diesels. However, higher emissions from heavy duty vehicles in 2010 in RAINS, due to lower level of control technology (implementation of Euro-4 engines) counter the above effect of energy use, resulting in similar emissions from road transport in 2010. However, in 2020 the combination of different assumptions on the share of diesel and gasoline cars, and the age and composition of the car fleet, lead to about 2 million kg higher PM_{10} emissions from road transport. These differences hold for $PM_{2.5}$ as well due to the equivalence of PM_{10} and $PM_{2.5}$ from combustion processes in road transport.

Table 3.13 Emissions of PM_{10} for 2020 for RAINS calculations before and after correction and for the Dutch Reference Scenario

2020			PM_{10} (10^6 kg)	
sector	RAINS Jan2004	RAINS Sept2004	RS2004	Weighted Difference
refineries	1	1	NA	NA
domestic and commercial use	10	13	NA	NA
agricultural	13	13	NA	NA
power plants	0	0	NA	NA
industrial processes	9	9	NA	NA
off-road transport	4	3	3	-1%
road transport	7	8	10	3%
fishery	2	2	0	-3%
total	47	49	NA	NA

Table 3.14 Emissions of PM_{10} for 2010 for RAINS calculations before and after correction and for the Dutch Reference Scenario

2010			PM_{10} (10^6 kg)	
sector	RAINS Jan2004	RAINS Sept2004	RS2004	Weighted Difference
refineries	1	2	2	0%
domestic and commercial use	10	15	8	-13%
agricultural	13	13	9	-8%
power plants	0	0	1	1%
industrial processes	12	6	11	9%
off-road transport	5	6	5	-2%
road transport	8	8	9	1%
fishery	2	2	0	-2%
total	51	52	45	-15%

Corrections

The consultation process resulted in an increase in the RAINS estimate of PM_{10} emissions of 2 million kg in 2010 (Table 3.14). The main change is found in industrial process emissions: a decrease in the RAINS calculation of 6 million kg. Unfortunately, this change was unjust. The error originates in the emission registration (ER2004), where the inventory of PM_{10} emissions from industrial processes in 2000 was incomplete.

The RAINS emissions from domestic and commercial fuel use increased by 5 million kg, leading to a 13-14% difference with the Dutch data. The increase originates, in particular, from emissions from fireplaces and wood-burning stoves. This happened despite our advice to adjust residential emissions (barbecues, smoking and firework) downward. However, RAINS currently calculates higher emissions from the domestic and commercial sector, mainly due to a 15-fold increase in energy input and a 25-fold increase in the emission factor of fireplaces.

Table 3.15 Emissions of PM_{10} for 2000 for RAINS calculations before and after correction and for the Dutch Emission Registration

2000			**PM_{10} (10^6 kg)**	
sector	RAINS Jan2004	RAINS Sept2004	ER2004	Weighted Difference
refineries	1	2	3	2%
domestic and commercial use	11	16	8	-14%
agricultural	12	12	10	-4%
power plants	3	1	0	-1%
industrial combustion	0	0	3	5%
industrial processes	13	7	6	0%
off-road transport	5	7	6	-2%
road transport	11	11	12	1%
fishery	1	1	0	-2%
total	56	58	49	-15%

<u>Consequences</u>

The higher total PM_{10} emissions (13-15%) in RAINS are caused by higher emissions from greater use of domestic fuel and animal numbers in the CAFE baseline. The unjust lower emissions from industrial process emissions in RAINS in 2010 are to some extent countered by this overestimation. The total effect of this on abatement costs is currently unclear.

Although there is a good match on sector level for road transport, there are, just as for NO_x , differences on sub-sector level. This concerns a lower share of diesel in light duty vehicles in RAINS. In 2010 this effect is negated by the lower degree of control technology in heavy duty transport in RAINS. In 2020, however, the national estimate of PM_{10} and, consequently for $PM_{2.5}$ emissions from road transport (see section on differences), are almost 2 million kg higher, resulting mainly from the higher emissions from the higher share of diesel. This is an important conclusion because the main focus of the CAFE process will be on $PM_{2.5}$: furthermore, the difference in diesel share and heavy duty emission may lead to faulty application of abatement measures.

The 7 million kg higher RAINS emissions from domestic and commercial use of fuel are expected to lead to higher abatement costs in RAINS. The control of emissions from residential sources takes place through certification of new wood stoves and the use of well-dried wood. Such options may be promising because of the possible reduction of the most health-relevant fraction at street level (Buringh and Opperhuizen, 2002). The potential of these measures, however, is much smaller in RS2004 than in RAINS. The national estimate of the potential of PM_{10} emission reductions from agriculture is somewhat lower than RAINS calculates.

Emissions from animal housing systems can be reduced by applying a filter to the air ventilation system. The cost-effectiveness of this measure is limited, however, because ventilation flows are high and dust concentrations are low.

4. Conclusions

The CAFE baseline is not suitable for determining the Dutch position in negotiations for new European air pollution policy (like the NEC review). The Netherlands will have to introduce a national scenario of its own to bring forward the Dutch expectations on future developments. While the RAINS model would seem appropriate for calculating abatement scenarios, contra-expertise will still be necessary during the CAFE process to assess differences in RAINS on calculated abatement costs and emission levels.

The main differences between the assumptions for the Netherlands in the national scenario and the CAFE baseline comprise a lower use of coal, higher animal numbers, higher domestic use of fuel and a lower share of diesel cars in the CAFE baseline. Less use of coal results in lower power plant emissions for SO_2 (28% on total) and NO_x (2% on total); higher animal numbers lead to higher total NH_3 (12%) and PM emissions (8%), while greater use of domestic fuels (barbecues and wood stoves) leads to higher total particulate emissions in 2010 and a lower share of diesel cars leads to increasingly lower NO_x and PM emissions up to 2020 (7% and 3%, respectively, in 2020). Calculations using RAINS with the CAFE baseline scenario assumptions alone are not sufficient for reflecting the national view. Differences in scenario activity between the CAFE baseline and the national scenario are responsible for the main differences in total emissions.

The RAINS model causes less difference than the use of the CAFE baseline data itself and the level of implementation of control measures in RAINS in general reflects the current Dutch policy. RAINS seems appropriate for calculating total emissions. However, RAINS causes big differences in sector emissions. A big difference originates from the faulty interpretation of fishery emission calculations in RAINS, causing much higher emissions for SO_2 (about 20%) and NO_x (about 9%) in 2010 and 2020. Other differences are caused by differences in the use of emission factors (VOC and NO_x), different definitions of activities and different use of control technologies (all components). These errors may hamper the calculation of abatement levels at lowest costs for all components. There is currently no unambiguous answer to what the total effect of these differences is on the abatement costs and levels.

Many errors in RAINS were corrected in the bilateral consultation with IIASA. However, three essential proposals that were agreed to correct the faulty interpretation on fishery, the low NO_x emission factor for gas engines in agriculture and the high PM_{10} emission factor for residential combustion, have not been adopted by IIASA.

In RAINS total emission for SO_2 are 10% lower in 2010 due to the use of coal, which was too low in the CAFE baseline according to national expectations. When calculating abatement scenarios especially differences in coal use may lead to lower levels for SO_2. This is important because the Netherlands has problems meeting its NEC target for SO_2 and newly calculated targets below this ceiling may underestimate or not reveal this problem and its associated costs.

The total NO_x emission in RAINS shows a good match with national data in 2010. However on sector level RAINS calculated higher emission due to a faulty interpretation of fishery and lower emissions due to an underestimation of emission factors of gas engines in agriculture

(11 million kg), lower air traffic levels (8 million kg) and a lower use of coal for power plants (7 million kg). The lower share of diesel cars is masked by lack of control on heavy duty in 2010; however, it becomes apparent in total emissions for transport in 2020 (12 million kg). Since these sectors with lower emissions are the most important sectors for abatement options, resulting abatement levels and associated costs in RAINS may be inappropriate.

Future NH_3 emissions are higher in RAINS (12%) due to higher animal numbers. RAINS also lacks some typical Dutch control technologies, so the result of both is leading to higher abatement levels for higher costs in RAINS with respect to national expectations.

The total VOC emissions in RAINS for 2010 match the national data. However, at sector level, the emissions from industrial processes (33 million kg) are higher due to differences in definitions and level of control. The emissions from road transport are lower (21 million kg) due to different emission factors. Emission-associated costs for abatement levels in RAINS will therefore be too high with respect to national expectations.

The higher total PM_{10} emissions (13-15%) in RAINS in 2010 are caused by higher emissions due to as well greater use of domestic fuel as higher emission factor for residential combustion (7 million kg) and higher animal numbers in the CAFE baseline (4 million kg). These are partly countered by the underestimated emissions from industrial process (5 million kg) in RAINS in 2010. The total effect of this on total abatement costs is unclear. The effect of a lower share of diesel cars on PM_{10} and $PM_{2.5}$ emissions for transport is masked by higher emissions caused by lack of control on heavy duty in 2010 but becomes apparent in 2020. This is important because much of the focus in CAFE will be on abatement of $PM_{2.5}$ from road traffic. These differences may lead to a faulty application of abatement measures.

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Annex 1 Energy & Industry

The following RAINS sector activities will be addressed in this annex.

Power plants
Fuel production and conversion: combustion
Industry, combustion in boilers
Industry, other combustion
Industrial processes

The power plant sector includes the centralized production of electricity and district heating, and is further subdivided into new power plants and existing plants. Existing plants refer to sources that came on line prior to or in 1990. In addition, existing plants are further subdivided into wet-bottom boilers and other types of boilers. The reason for this subdivision is the difference in NO_x emission factors. Such a subdivision is not necessary for calculating sulphur emissions.

The fuel conversion sector includes refineries, coke and briquette production plants, coal gasification plants etc, but does not include the power stations and district heating plants. Energy consumption for fuel conversion as recorded under combustion in the conversion sector includes only the energy consumed in the fuel conversion process and not the energy content of the input materials and final fuel products. The losses during transmission and distribution of the final product are reported under the use of electricity and heat by the fuel conversion sector and by the industrial auto -producers for their own use. The use of electricity and heat by power plants and district heating plants for their own use, and losses during the transmission and distribution of electricity and district heat, are included in this category. The reason for this subdivision is the difference in NO_x emission factors. such a subdivision is not necessary for calculating sulphur emissions.

For industrial energy use, the RAINS database distinguishes between energy combustion in industrial boilers for the auto-production of electricity, and heat and fuel combustion, in other industrial furnaces. This distinction was introduced to assure future comparability with fuel consumption data provided in the CORINAIR 1994 inventory (EEA, 1996). However, the CORINAIR inventory for 1990 did not include full information on energy consumption according to the boiler/furnace category.
The available energy statistics and forecasts also do not always enable splitting industrial combustion between boilers and furnaces. In such a case, all industrial fuel combustion is reported as fuel combustion in other industrial furnaces. In the latest version of CORINAIR (CORINAIR'94) full details on fuel consumption are available, making it possible to attune the industrial energy consumption to more detailed structures.

Furthermore, RAINS also includes the so-called 'process emissions' in the industrial sector, i.e., emissions that cannot be directly linked to energy consumption. Industrial processes included in RAINS are

- oil refineries,
- coke plants,
- sinter plants,
- pig iron - blast furnaces,
- non-ferrous metal smelters,

- sulphuric acid plants,
- nitric acid plants,
- cement and lime plants, and
- pulp mills.

In order to assess future emissions from, for example, power plants, the RAINS model uses PRIMES energy scenarios with and without climate policy. In this scenario, the input of hard coal for the years 2010 and 2020 is much lower than according to a Dutch scenario currently in development. As a consequence, RAINS forecasts of future SO_2 and NO_x emissions from power plants will be too low. NEAA believes that the PRIMES scenario is not realistic for the development of coal use in the Netherlands. It was proposed to revise the coal input figures in PRIMES in line with the trend in the latest Dutch scenario. The Dutch assumptions for future hard coal input in power plants are presented here, as well as a short description of the key features of the Dutch scenario.

Scenario background

RIVM and ECN (Energy Research Centre of the Netherlands) are in the course of developing a 'Referentie Raming' (Reference Scenario) for the Netherlands. up to the year 2020 for energy use and emissions of CO_2, other greenhouse gases, NO_x, SO_2, NH_3, NMVOC, and PM. The results of this study, commissioned by the Ministries of Economic Affairs, Environment, Agriculture and Transport, will be published in a few months. The projection is based on a scenario including climate policy, which envelops emission trading. The cost advantage of production based on hard coal compared to production based on natural gas gradually diminishes due to a gradually rising price of CO_2 emission rights[2]. But the price level of CO_2 emission rights, which actually makes it more expensive to operate a coal-fired plant than a gas-fired plant (around EUR 35/ton) will not be reached before 2020. Therefore, it is assumed that existing coal-fired plants will remain in operation for their entire lifespan, but new production capacity will be based on natural gas. Because all existing plants were built after the early eighties, closure of the first coal-fired plants is expected after 2010. The degree of capacity utilization in 2010 is higher than in 2000, resulting in a higher coal input in 2010 than in 2000.

Dutch projection of coal input in electricity plants

	2000	**2010**	**2020**
Number of coal-fired plants	8	8	5
Total capacity (MWe)	4000	4000	2340
Coal input (PJ)	210	243	160
Coal input (PJ) according to IIASA/PRIMES (without climate policy effects)	214	81	45
Difference (PJ)	-4	162	115

Compared to more recent Dutch insights, the coal input according to PRIMES is much lower. NEAA does not find the PRIMES scenario realistic about this point. The future emissions of NO_x and SO_2 calculated by IIASA are therefore also too low. It has been proposed to revise the coal-input figures in PRIMES according to the trend in the latest Dutch scenario. The gas-

[2] In this scenario, the price of emission rights is: EUR 8/ton CO_2 in 2010, EUR 11/ton CO_2 in 2020, EUR 61/ton CO_2 in 2030 and EUR 89/ton CO_2 in 2040.

input figures (especially in new plants) can be adjusted in such a way that the total fuel input in power plants according to PRIMES stays the same.

SO_2

Industrial SO2 emissions were, in particular, too high in RAINS. Process emissions were adjusted according to the Dutch Emission Register. Lowering the unabated emission factor or upgrading the control technologies for processes was sufficient to level the SO_2 emissions.

RAINS data are, in particular, too high for industry. First, process emissions were adjusted using the results of an analysis of the process emissions derived from the Dutch emission inventory by lowering the unabated emission factor for cement production (because of a high share of blast furnace slag in Dutch cement and by upgrading the control technologies for the non-ferro, pulp, sintering and sulphuric acid processes from stage 2 to stage 3. Stage 3 control is the highest level of control so that RAINS cannot impose any additional measures on these processes. It should be mentioned that the process 'non-ferro' according to RAINS does not include the production of aluminium (only zinc, lead and such). Moreover, no process covers the emissions from the other building materials industry (other than cement production). To solve this, IIASA introduced the dummy process 'OTH_SO_2', and assigned 5 million kg to this process (in accordance with the national emission inventory).

After adjusting the process emissions, the remaining difference between RAINS data and National inventory data for emission from industry was further reduced by adjusting the unabated emission factor of coal in iron production by a factor of 10. The emission factor before adjustment was too high, because it was calculated on the basis of the sulphur content of coal, and did not take the retention of SO_2 in blast furnace slag into account. However, in making this adjustment, the total emission of industry according to RAINS became too low. In other words, the total effect of all corrections was too large. To solve this, the degree of implementation of control technologies for combustion of coal and heavy fuel had to be lowered.

Table A.1 Overview of changes for SO_2 from industry 2000 (million kg)

Adjustment	**RAINS before**	**RAINS after**	**Difference**
Lowering unabated emission factor cement	1	0.1	-0.9
Upgrading control technology non-ferro	5.7	0.2	-5.5
introduction of OTH-SO_2	-	5	+5
Upgrading control technology pulp	0 3	0.1	-0.2
Upgrading control technology sintering	1.8	0.9	-0.9
Upgrading control technology sulphuric acid	3.2	1.5	-1.7
Upgrading control technology coke	1.2	0.8	-0.4
Lowering unabated emission factor coal input iron prod.	4.6	0.9	-3.7
Lowering degree of implementation of control technology on coal combustion	0.6	1.0	+0.4
Lowering degree of implementation of control technology on heavy fuel combustion	1.1	2.1	+1.0
Total			**6.9**

Power plants including auto-producers

The SO_2 emissions from power plants according to RAINS are slightly higher (1.3 million kg) than the emission according to the national inventory. However, the RAINS emissions from coal-fired plants are nearly 4 million kg too low when compared with data derived from the environmental annual reports (see Annex 5). So emissions from coal-fired plants were adjusted upwards, while emissions from plants fired with other solids (waste incinerators) and heavy fuel were adjusted downwards. The adjustment for the coal-fired plants was done by slightly lowering the degree of implementation of the control technology. For the other power plants (heavy fuel and other solids), the reverse was done.

Table A.2 Overview of changes for SO_2 from power plants 2000 (million kg)

Adjustment	**RAINS before**	**RAINS after**	**Difference**
Lowering degree of implementation of control technology on coal-fired plants	10.4	13.7	+3.3
Raising degree of implementation of control technology on heavy fuel fired plants	3.2	0.8	-2.4
Raising degree of implementation of control technology on other solids fired plants	3.3	1.3	-2.0
Total			**-1.1**

Refineries

Only very minor adjustments were made here, resulting in a 0.5 million kg higher emission. This was done by lowering the degree of implementation of the control technology on combustion of heavy fuel.

Table A.3 Overview of changes for SO_2 from refineries 2000 (million kg)

Adjustment	**RAINS before**	**RAINS after**	**Difference**
Lowering degree of implementation of control technology on heavy fuel combustion	14.0	14.5	+0.5
Total			**+0.5**

SO_2 for 2010 and 2020

Before the consultation, RAINS showed for future years either a rising degree of implementation of the control technology for many processes that was already implemented to some degree in 2000, or an upgrading to more efficient control technologies. We have stressed that we don't expect this to happen in a current legislation scenario, with one exception: just as in the Implementation Memorandum 2010 we consider the fuel switch (oil to gas) by the Shell refinery in 2007 as a measure that fits the current legislation criterion. So, as a result of the consultation the degree of implementation of the control technologies remains the same after 2000 for most processes. It was not possible, however, to implement the oil-to-gas fuel switch for refineries because changing the activity levels (i.e. fuel input) can only be done by making an official request to IIASA and NTUA. Instead, a control technology with the same effect as the fuel switch (11 million kg reduction) was introduced.

The fact that PRIMES assumes a dramatic drop of the use of hard coal in power generation means that RAINS underestimates the emissions from power plants by more than 10 million kg. As previously mentioned, we have sent our comments on this to IIASA.

NO_x

NO_x for 2000

RAINS emission data for 2000 were nearly 21 million kg larger than data from the national emission inventory (Table 5).

Table A.4 NO_x emission data (million kg): national inventory and RAINS before and after consultation

2000	National inventory	RAINS before consultation	RAINS after consultation
Industry	33.8	35.3	33.7
Power plants incl. auto-producers	51.7	62.7	51.3
Refineries	13.3	21.8	12.9
Total	**98.9**	**119.7**	**98.6**

Industry

Apparently, the difference between RAINS and the national inventory is very small for this sector. However, process emissions for cement and nitric acid production are too high, and consequently the emissions of industrial combustion processes are too low. The process emissions were adjusted using the results of the analysis of the process emissions mentioned earlier. This was done by upgrading the control technologies for cement and nitric acid from stage 1 to stage 3. Stage 3 is the highest level of control, so this means that RAINS can't impose any additional measures on these processes.

The emissions by combustion processes were adjusted in such way that the total industrial emissions in RAINS are consistent with the national inventory data. This was done by lowering the degree of implementation of the control technologies of all combustion processes.

Table A.5 Overview of changes for NO_x from industry 2000 (million kg)

Adjustment	**RAINS before**	**RAINS after**	**Difference**
Upgrading control technology cement	3.9	1.4	-2.5
Upgrading control technology nitric acid	10.7	2.3	-8.4
Lowering degree of implementation of control technology on gas combustion	14.5	22.7	+8.2
Lowering degree of implementation of control technology on hard coal combustion	2.9	3.9	+1.0
Lowering degree of implementation of control technology on heavy fuel combustion	0.2	0.3	+0.1
Total			**-1.6**

Power plants including auto-producers

The emissions according to RAINS are 11 million kg too high. One reason for this was that RAINS assumes only combustion modification and no Selective Catalytic Reduction (SCR) on coal-fired plants. On the basis of a survey of environmental annual reports it is clear that in fact 2 plants (out of 8) have SCR (Annex 6). This adjustment lowered the NO_x emissions by 7 million kg. Another downward adjustment was made by raising the degree of implementation of the control technology on existing gas-fired power plants[3]. An adjustment with a small upward effect was made for new gas-fired plants. RAINS assumed 90% of these plants to have SCR as control measure. However, the unabated emission factor is already so small that this doesn't seem to be logical. So SCR was removed.

Table A.6 Overview of changes for NO_x from power plants 2000 (million kg)

Adjustment	**RAINS before**	**RAINS after**	**Difference**
Partial implementation of SCR on coal-fired plants	30.0	23.0	-7.0
Raising degree of implementation of combustion modification on existing gas-fired plants	28.1	22.7	-5.4
Removing SCR from new gas-fired plants	0.8	1.7	+0.9
Total			**-11.5**

Refineries

The RAINS emissions are 8.5 million kg too high. One reason for this was that RAINS assumed a process emission of 12 million kg. But there aren't any process emissions of NO_x in refineries. This correction was made by setting the unabated emission factor at zero. Clearly, this makes the total emissions too low. In order to match the total emissions with data from the national emission inventory, the degree of implementation of the control technology on combustion of both gas and heavy fuel was lowered.

Table A.7 Overview of changes for NO_x from refineries 2000 (million kg)

Adjustment	**RAINS before**	**RAINS after**	**Difference**
Setting unabated emission factor for process emissions at zero	12.1	-	-12.1
Lowering degree of implementation of control technology on gas combustion	6.8	9.0	+2.2
Lowering degree of implementation of control technology on heavy fuel combustion	2.9	3.9	+1.0
Total			**-8.9**

NO_x for 2010 and 2020

Before the consultation, there was no SCR on coal-fired power plants until 2020. As mentioned before, the year 2000 was corrected for the fact that 2 out of 8 plants already had this technology. For the years 2010 and later, we expect the degree of implementation to be 100%. This expectation is based on the fact that we consider NO_x-emission trading to be current legislation. A large part of the necessary reductions is expected to come from implementation of SCR on coal-fired plants, because of relatively low marginal costs (compared to SCR on other plants). Although RAINS was corrected according to this view, there is still an erroneous drop of the use of hard coal in power generation. As this is the case for SO_2, this will mean an underestimation of the NO_x emissions from power plants.

[3] Existing means built before 1995. New means built after 1995.

RAINS assumes a gradual rising degree of implementation in the control technology ‘combustion modification’ for many combustion processes. This seems reasonable because a large part of the industry, and all refineries and power plants, will have to comply with the standard set by NO_x-emission trading (40 g/GJ in 2010). Combustion modification (low NO_x burners) has even lower marginal costs than SCR on coal-fired plants.

VOC

The emission factor for fireplaces in RAINS can be adapted (decreased) for the emission of VOC from **power plants**.

To adapt the RAINS data for **refineries** in a sense that the emission in 2000 will decrease from 11 to 7.5 million kg, it is necessary to assume the BAT technology application. In RAINS an current annual leak detection programme for 80% of the capacity is assumed; BAT corresponds to a quarterly leak detection for 100% of the capacity.

Table A.8 Overview of changes for SO_2 from industry and energy (million kg)

2000		**VOC (10^6 kg)**	
RAINS sector	RAINS April 04	**RAINS June 04**	**MB2004**
Power Plants (PP)	2.65	**4.2**	**2.1**
Industrial combustion (IN_OC + IN_BO)	1.46	**1.2**	**1.8**
Fuel conversion + production; combustion CON_COMB	0.57	**0.5**	**IE**
Gasoline – transport and depots D-REFDEP	2.14	**3.1**	**1.0**
Gasoline service stations D_GASST	2.94	**2.8**	**2.7**
Extraction/distribution oil and gas		**23.3**	**19**
Refineries – process emissions		**11.1**	**7.5**
Industry processes		**76.5**	**56**

The **industrial process emission** difference has not yet been fully analysed. The biggest contributor to the total emission is the RAINS sector Industry processes, which encompasses coke oven, rolling mills, paper pulp, asphalt production and use and some other sectors. The original number for this ‘sector’ is based on the CORINAIR 90 database and IIASA. It has added some controls like good housekeeping and substitution of cutback by emulsion bitumen. This resulted in a decrease from about 60 to 40 million kg. It is evident that this sector needs a better assessment.

PM

PM_{10} emission from power plants (0.6 million kg)

The higher emission as calculated by RAINS (was 2.6 million kg) is partly due to differences in the fuel mix. For the base year 2000, the emission factor is probably also different. Power plants that use hard coal are all equipped with best available electrostatic precipitators (ESP3) and wet flue gas desulphurisation (FGD) units. IIASA has adjusted the capacity controlled for hard coal to 100 % ESP3.

PM_{10} emission due to oil refineries (3.3 million kg)

RAINS calculated a lower emission (0.6 million kg) is partly due to low unabated emission factors for gas combustion (0.1 g/GJ) and heavy fuel oil combustion (16.58 g/GJ). Experts from the Netherlands give EF gas 7.0 g/GJ and EF heavy fuel oil about 60 g/GJ. Good housekeeping was also wrongfully considered as control technology. The EF for heavy fuel oil was changed; for gas this still has to be done.
Furthermore, process emissions from RAINS have been defined differently as to what the Netherlands considers: i.e. stock not suitable for control was (wrongfully) increased from 1 to 17%; the other 83% was considered to be controlled by one electrostatic precipitator field.

PM_{10} emission due to the production of iron and steel (1.9 million kg)
Extensive application of emission reduction, the last 10-15 years especially by Corus, and the modernization of the production processes has resulted in a lower PM_{10} emission than RAINS calculated. Implementation of best ESP technology reduces emissions of basic oxygen furnaces and implementation of good practice (stage2) reduces fugitive emissions of pig iron blast furnaces.

Future emissions
Due to technological developments emission factors will decrease. It is currently not possible to quantify this decrease.

PM_{10} emission due to the production of non-ferrous metals (0.7 million kg)
The RAINS emission is close to the Dutch registered emission.

PM_{10} emission due to the production of cement (0.2 million kg)
The RAINS emission was much higher (0.9 million kg), which is – as described in the section on SO_2 ─ clearly due to the fact that the main producer of cement (ENCI) imports most of the **clinker**, needed to produce cement. Since the production of clinker is the main source of PM_{10} emission in the cement production process, the NL emission factor has been adjusted to a number ten times lower than the average factor in Europe.

PM_{10} emission due to the production of chemicals (1.8 million kg)
The relatively low actual emission of PM_{10} in the Netherlands in 2000 is mainly due to the production of fertilizer. In the past decade the emission decreased considerably due to abatement measures to the prilling towers (fabric filters, cyclones, liquid dust collectors). IIASA has reduced capacity of stock not suitable for control to 0.5 % and considered fabric filters to be applied for the remaining 99.5%.

PM_{10} emission by small industrial and business facilities (4.9 million kg)
The emission, as determined by RAINS (2.1 million kg) was considered to be too low. Increase in this emission was achieved by less implementation of good practice and a higher unabated emission factor.

Annex 2 Domestic

NO_x

The RAINS models calculates a NO_X emission of 26 million kg in 2000 and 27 million kg in 2010 for the domestic sector. This is far below the monitoring and projection results for the Netherlands (46 million kg in 2000 and 33 million kg in 2010). The Dutch projection is based on a fuel input of about 700 PJ i.e. consistent with RAINS CAFE baseline fuel input. High NOx emission levels in the base year 2000 are explained by high NO_x emissions of Combined Heat Power gas engines (emission factors for these gas engines range from 800 to 140 g/GJ in 2000). In the Netherlands we have many such engines in place in the domestic sector, especially in the agricultural sector. The decline of emissions in the period of 2000-2010 is explained by the gradual penetration of low-NO_x technologies, which is enforced by specific Dutch legislation on small combustion sources.

NEAA proposes to calibrate NO_x emissions in RAINS with Dutch figures i.e. 46 million kg in 2000 and 33 million kg in 2010. This can be done by adjusting the unabated emission factor for the DOM-GAS-DGCCR/NOC category with a factor of (46-2.2)/(26-2.2) = 1.85. In addition to this, NEAA proposes to increase the capacities controlled for the DOM-GAS-DGCCR-category for 2010 so that the end result is 33 million kg.

For the future, thinking of the NEC review, it would be sensible to incorporate gas engines (and also gas turbines) as a specific technology in RAINS.

NH_3

Ammonia emissions due to inhabitants, pets, etc. are included in the RAINS sector OTHER. ER reports these emissions as domestic (DOM). DOM+OTHER emissions from RAINS compared to DOM+OTHER emissions in ER quite well.

VOC

Table A.9 Overview of changes for VOC emission from domestic sources

2000		**VOC (10^6 kg)**	
RAINS sector	RAINS April 04	RAINS June 04	MB2004
RESID (combustion)	8.90	6.7	9.3
Trade, services & government (DRY. VEHTR. WASTE)		6.4	12.1
Dry cleaning		*0.7*	*0.8*
Car repair		*3.4*	*3.8*
Waste		*2.4*	*1.7*
Consumers		17	18
Paint		56.9	IE
Construction			14.6

The emission factor for fireplaces in RAINS can be adapted (decreased) for the emission of VOC from **households**. Since the emission due to the **use of paint** for decoration in RAINS is treated as an individual sector, while in the NL data is distributed between three sectors (Trade, services, government, construction and consumers), it cannot yet be determined definitely whether there is a discrepancy between the two data sets for paint. The following information on the splitting of VOC emission into categories (consumer, metal industry, carpentry, etc.) was supplied to IIASA (Kees Peek, RIVM-NEAA) in August 2004.

VOC emissions in 2000 due to the use of PAINT
per source category for the Netherlands

SECTOR	VOC Emission (in million kg)
Construction	9.487
Steel conservation	5.254
Consumers (DIY)	6.702
Car repair	3.777
Shipbuilding	4.250
Industry (incl. the manufacture of automobiles)	10.135
TOTAL	41.184

PM

Sector activities following specific RAINS-PM have been addressed in the following:
RES Residential process emissions
STH Storage and handling process emissions
WASTE Waste process emissions

PM_{10} emission from residential sources (3.8 million kg)

The differences are small when comparing the total emission, but large at a sub sector level.
Emission factors were adjusted for the following sectors:
Barbecues (RES_BBQ): 0.2 ton / M persons (was 75)
Smoking (RES_CIGAR): 102.7 ton / M persons (was 16.5)
Firework (RES_FIREW): 6.3 ton / M persons (was 35)

PM_{10} emission due to storage and handling (4.4 million kg)
The RAINS emission (4.4 million kg) has the same order of magnitude as the Dutch registered value (3.3 million kg).

Annex 3 Transport

Activity levels in 2000 (energy use) for the sectors:

ROAD TRANSPORT
OFF-ROAD TRANSPORT
FISHERY

Road traffic: Use of fuel (gasoline, diesel, LPG) in RAINS was corrected and agrees reasonably with the NL data.

Off-road machinery: The initial differences in activity levels were large. A reasonable fit was reached by shifting energy from other sectors (domestic). Emissions from off-road machinery in RAINS are now quite close to the Dutch Emission Inventory; it remains however unclear what the effect is of the shift in energy from domestic to transport.

Shipping (FISHERY): The attribution emissions of international sea-shipping, national fishing, and inland shipping to NL emissions and/or international emissions have led to the conclusion that for Dutch understanding only fishery should be included for NEC calculations.

SO_2

The main issues are differences in the future emissions of OFF-ROAD TRANSPORT and FISHERY.

Particularly the low emissions in OFF-ROAD TRANSPORT in combination with increasing activity levels are peculiar. Activity levels increase but emissions drop by a factor of 10. A factor of 2 can be explained by the change in sulphur content to 1000 ppm from 2010 onwards, although ten times seems too much.

RAINS uses ‘low sulphur fuel use’ as an abatement option. The actual sulphur content of fuels that IIASA uses to calculate emissions is often different to the sulphur content of ‘raw fuels’. Consequently, the unabated emission factor does not reflect the emission factor associated with a low sulphur fuel. Reason for this is to remain consistent on the cost side of further measures. The split of 81% LSMD1 and 17 % LSMD2 reflects exactly the 1700 ppm sulphur content. The IIASA abatement strategy assumes sulphur content to decrease to 10 ppb for TRA_OT by 2010. There are no reasons to believe tractors and construction engines will use a different fuel once a 10 ppb fuel is standard output of all refineries. The question from the Dutch is will it be realistic to assume that all fuel will contain only 10 ppm by 2010?

The difference in FISHERY is the result of different assumptions on fuel type used by fishery. In the Dutch Emission Inventory it is assumed that fishing ships use medium distillate oil with a sulphur content of approximately 1700 ppm. RAINS however assumes that approximately half of fuel used by fishing ships is Heavy fuel oil with a (much higher) sulphur content of 27000 ppm

The Dutch 2000 data of international shipping initially led to the split of fuel used by FISHERY in 50% of heavy fuel oil (HFO) and 50% of Medium Distillates (MD). During the bilateral consultation it was acknowledged that international shipping should not be included in the NEC total. Since activity levels for international shipping and fishery do not differ much; these positions were simply swapped by IIASA. However, IIASA has neglected to change the share of heavy fuel oil to 0% and the share of medium distillates to 100%, which agrees with the assumptions in the Dutch Emission Inventory. So, although activity levels for fishery and FISHERY match fairly well, SO_2 emissions in the Dutch Emission Inventory and RAINS differ a lot.

It would be nice to compare the 2010 emissions according to the adjusted RAINS database to the emission projections in the Implementation Memorandum . However, the adjustments made during the consultation have not yet been incorporated into the data shown on the RAINS website. So this has to wait.

Table A.10 Overview of changes for SO_2 from transport (million kg)

Sector		2000	2010	2020
Sulphur dioxide emissions				
ROAD TRANSPORT	RAINS	3.2	0.2	0.2
	RS2004	3.3	0.2	0.2
OFF-ROAD TRANSPORT	RAINS	5.2	0. 4	0.4
	RS2004	5.1	3.6	4.0
FISHERY	RAINS	14.4	14.9	15.7
	RS2004	1.0	0.4	0.4
Sum	RAINS	22.8	15.5	16.4
	RS2004	9.3	4.2	4.6

RAINS uses ‘low sulphur fuel use’ as an abatement option. The actual sulphur content of fuels that IIASA uses to calculate emissions is often different to the sulphur content of ‘raw fuels’. Consequently, the unabated emission factor does not reflect the emission factor associated with a low sulphur fuel. Reason for this is to remain consistent on the cost side of further measures. The split of 81% LSMD1 and 17 % LSMD2 exactly reflects the 1700 ppm sulphur content. The IIASA abatement strategy assumes sulphur content to decrease to 10 ppb for OFF-ROAD TRANSPORT by 2010. There are no reasons to believe that tractors and construction engines will use a different fuel once a 10ppb fuel is standard output of all refineries. Question from Dutch is will it be realistic to assume that all fuel will contain only 10 ppm by 2010?

The Dutch 2000 data of FISHERY have led to the assumption of the split of FISHERY in two-thirds of heavy fuel oil (HFO) and one-third Medium Distillates (MD). International shipping in national waters was included, national sea traffic in international waters (fishing) was not and total fuel was the same so these positions were simply swapped by IIASA. All fishery ships are assumed to be fuelled by diesel oil, i.e. medium distillates. The same applies for the sulphur content of these ships; maybe only coastal fuel of international ships were accounted for where 0.6% S for MD and 2.6% for HF were used.

It would be interesting to compare the 2010 emissions according to the adjusted RAINS database to the emission projections in the Implementation Memorandum. However, the adjustments made during the consultation are not yet incorporated in the data shown on the RAINS website. So this has to wait.

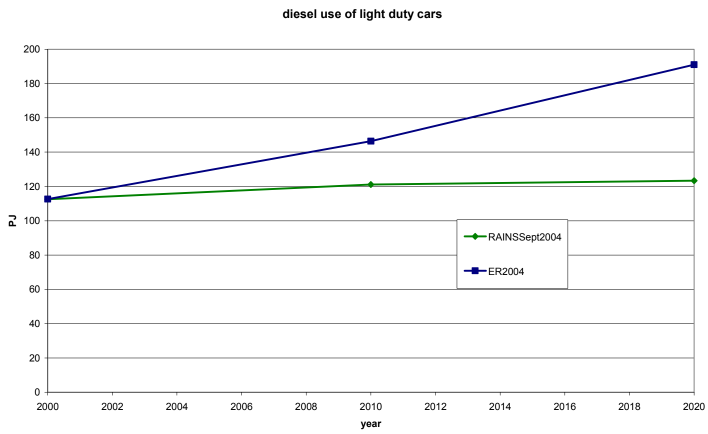
NO_x

Diesel shares

Both RAINS and RS2004 assume the energy demand for light duty vehicles to increase in the 2000-2020 period; however, the fuels for which the increase occurs are different. RAINS has a different way than RS2004 to determine whether diesel cars are economically more viable than gasoline cars; RAINS assumes that diesel energy use remains around the level of 113-123 PJ for the 2000-2020 period, whereas RS2004 assumes this rises from 113 PJ to 146 PJ in 2010 and to 191 PJ in 2020.

Table A.11 Overview of energy consumption by road transport (PJ)

Road transport category	2000		2010		2020	
	RAINS Sept2004	ER2004	RAINS Sept2004	RS2004	RAINS Sept2004	RS2004
Light duty vehicles - gasoline	176	189	186	153	204	131
Light duty vehicles - diesel	113	113	121	146	123	191
Light duty vehicles - LPG	24	21	28	18	28	26
Heavy duty vehicles - diesel	91	91	119	126	187	187



Unabated Emission factors
Road transport

For several important RAINS sectors the unabated emission factors were increased significantly. The unabated emission factors were derived from the methodology used in the Dutch Emission Inventory. Changes are given in Table 1.

Table A.12 Old and altered emission factors for 2000

NO_x	Old unabated emission factor	New unabated emission factor
ROAD TRANSPORT_HD-MD	1.40	1.29
ROAD TRANSPORT_LD4-GSL	0.83	1.12
ROAD TRANSPORT_LD4-LPG	0.71	0.87
ROAD TRANSPORT_LD4-MD	0.29	0.31

Changing emission factors raises some concern regarding differences that may occur between countries on unabated emission factors (see *other issues* like *emission factors for light and heavy duty*).

As a result NO_x emissions for these sectors in RAINS increased significantly and were much better in line with the Dutch Emission Inventory. Table 2 gives the changes in RAINS and the value as reported by the Dutch Emission Inventory.

Table A.13 Old and new NO_x emissions in RAINS after changing emission factors and comparison with Dutch Emission Inventory

4.1.1.1.1.1.1.1 NO_x	Old Emission (million kg NO_x)	New Emission (million kg NO_x)	Dutch Emission Inventory (million kg NO_x)
Freight transport, diesel	78.0	87.1	84.8
Light duty, gasoline	35.4	50.1	54.1
Light duty, -LPG	4.1	7.7	6.6
Light duty, diesel	17.7	34.4	32.4

The 50.1 million kg for light duty, gasoline cars was altered on March 30 by changing capacities controlled. Information provided by the Netherlands originally assumed 20% of uncontrolled vehicles. This resulted in an emission of around 70 million kg of NO_x.

Table A.14 Old and new NO_x emissions in RAINS after changing emission factors

Subsector activity	2000		2010		2020	
	Old	New	Old	New	Old	New
Fishery	21.6	16.7	28.4	12.5	29.7	10.4
Air traffic	1.4	3.1	1.5	4.6	2.1	6
Mobile machinery	34.5	37.5	23.1	23.7	12.7	16.7
Inland water ways	33.5	36.1	34.2	36.8	35.1	35.3
Rail transport	2.1	1.8	0.7	1.9	...	2.7
Road traffic, heavy duty	91.2	86.8	68.9	60.1	46.8	49
Road traffic, light duty, gasoline	50.1	58.1	9.8	7.5	6.6	3.4
Road traffic, light duty, LPG	4.5	6.6	1.6	3	1.0	4
Road traffic, light duty, diesel	34.9	32.4	29.0	33.8	23.5	38.9
Road traffic, motorcycles, gasoline	0.1	0.6	0.2	0.8	0.3	0.8
Sum	275.6	279.7	197.8	184.7	158.6	167.2

VOC

Table A.15 Overview of changes for VOC emissions from transport

2000		VOC (10^6 kg)	
RAINS sector	RAINS April 04	RAINS June 04	MB2004
Transportation – machinery, construction, agriculture (OFF-ROAD TRANSPORT)	1.22	5.9	3.9
Transportation – seagoing ships (FISHERY)	0.45	0.5	0.8
Transportation – other rail (FISHERY)	0.28	0.3	0.1
Transportation road (ROAD TRANSPORT)	68.7	64	97
Transportation – inland water	**5.3**	4.5	4.2
Transportation – other air		1.3	1.1

The main problem in VOC emission due to (road) **transport** is the per cent of capacities controlled in 2000. However, to formulate new country-specific NEC goals it is more important that the RAINS estimates for 2010 and beyond are comparable to the national forecasts. Since the 'capacities controlled-problem' no longer exists from 2010 and onwards (the differences in VOC emissions between RAINS and RIVM-MNP forecasts are much smaller), it may be effective to leave the 2000 VOC value in RAINS as it is now. Another solution is to alter the VOC removal efficiency only for 2000, thus keeping a higher share of NOC vehicles in 2000.

RAINS has two sectors that refer to **car evaporative emissions** and the split is done on the basis of implementation of catalysts, either EURO I or II, etc.:
CAR_EVAP_C - refers to cars without catalyst and assumes that the carburetor is present; therefore the losses are large (currently estimated emission factor is about 0.49 g/MJ). CAR_EVAP - refers to cars with catalysts where the fuel system is 'closed' and losses are low (about 0.08 g/MJ current estimate for NL in RAINS); additionally, RAINS assumes that all these cars are equipped with the small carbon canister (SCC) required by law since the beginning of 1992. In effect, the emission factor for this category is only about 0.011 g/MJ VOC (about 85% efficiency), The main reason for the super fast drop in emissions is the trajectory of penetration of catalysts in the current control strategy in RAINS, in 1990 (20%), in 1995 (55%) in 2000(98%).

Emission factors are uncertain; in order to estimate them IIASA uses a number of parameters (country specific) such as:

- RVP of summer and winter gasoline,
- average summer and winter temperatures and daily raises,
- average fuel consumption,
- mileage, etc., basically like the COPERT stuff.

Effectively adjusting these parameters might result in a better match with the NL estimates of emission factors. BUT the real problem is somewhere else, so we will need to start with the traffic control strategy.

In the Netherlands (info RIVM) about 20% of fuel (gasoline) was burned by cars without catalyst in 2000. This would generate emissions of about 20 million kg of VOC (evaporative) but in order to adjust NO_x emissions, the NL control strategy in RAINS was modified and some mix of EUROI and II was defined to achieve these NO_x emissions as reported by NL. As a consequence, only 2% of cars are without controls in the current RAINS strategy. This is because RAINS assumes that the first generation of catalysts (EURO I) was not performing very well and that it achieves an average efficiency of only 77% (for NO_x), or similar, during its lifetime and only EURO II is a lot more efficient. Apparently the NL assumes that all catalysts perform better than assumptions in RAINS if the activity is the same.

What to do? If control efficiencies are not changed and the control strategy is not modified to take it into account then it is possible to adjust it artificially to increase the share of EURO II vehicles (with higher efficiency). In this way 20% of uncontrolled vehicles is achieved, which would lead to an emission of approximately 20 million kg. This is still too little so it would require revision of emission factors or revision of the assumption that all vehicles with catalysts have also SCC (dropping the last one would lead to a total of about 30 million kg VOC from this source). The no control emission factor is fairly sensitive to assumptions on number of start-ups per day (currently 4.6), temperature parameters and RVP (these come, in fact, from the legislation).

Annex 4 Agriculture

CAFE Baseline Projection for Agriculture for 2020

Introduction

Evaluation of EU policies and new policy development on abatement of air pollution take place through the Clean Air for Europe (CAFE) programme. The objective of the CAFE programme is to determine a long-term, strategic and integrated policy in the EU to protect human health and the environment from the effects of air pollution.

The CAFE programme aims to establish an EU-wide baseline projection for 2020 by the end of March 2004. This will provide the basis for negotiations on measures for reducing air pollution by the member countries. From the baseline projection the International Institute for Applied Systems Analysis (IIASA) will calculate the emissions and the most cost-effective measures in Europe to reach the objectives agreed on. Bilateral in-depth consultations will be organized by IIASA with the stakeholders (including member states) between September and December 2003 to establish the data and emission factors to be used.

The EU commission made two projections (with and without Kyoto policies), which were presented to the member states for comment and/or submission of a country-specific projection. This report presents brief comments on the EU baseline projections for agriculture, along with the projection for the Netherlands, in which national policies are taken into account.

EU baseline projections for agriculture in the Netherlands

EU 2000-2020 baseline projections for agriculture for the years 2000 and 2010 are based on CAPRI (NUTS2). These projections, based on an economic growth of agriculture of 1% per year and an increasing productivity and nutrient efficiency, have been extended to 2020 using AGLINK and the FAO Agricultural Outlook, 2030. Results of the most recent CAP reform plans (2003) are not taken into account. Contrary to the assumptions in the EU projection, agricultural production in the Netherlands is expected to decrease between 2000 and 2010/2020 due to national environmental policies. This is the reason for the Netherlands submitting a national baseline projection of agricultural activity data.

National projection for 2000-2020

The most important emissions into air from agriculture are the ammonia emissions. IIASA will calculate these on the basis of the agricultural activity data submitted. In spring 2003 a projection of 2020 ammonia emissions for 2020 was made for UNECE on the basis of two preceding projections:

1. A projection from the Environmental Outlook up to 2030 (Van Egmond et al., 2001).
2. An updated projection of ammonia for 2010. This updated projection takes into account the effect of ammonia and manure policies up to January 2003 and new information on emission coefficients (Hoogeveen et al., 2003).

The long-term projection from the Environmental Outlook was used to expand the updated projection for 2010 to 2015 and 2020. The projections for livestock and fertilizer use for 2010, 2015 and 2020, as presented in the annexes of the Environmental Outlook uses the NFR format as requested by the EU commission. Figures for 2000 are based on historical data.

The most important factors for the development of livestock farming in the Netherlands are the environmental policies on manure and ammonia. The effect of ammonia and manure policies established up to January 2003 were also taken into account. The projection foresees a decrease of livestock production in 2010 as a result of the manure policy, while from 2010 onwards, the number of poultry increases slightly. The decrease in the number of dairy cattle makes it possible to apply more manure from other livestock.

Environmental policy will lead to an increase in nutrient efficiency. Under the influence of the manure policy nitrogen, fertilizer application is expected to decrease from 339 million kg N in 2000 to 251 million kg N in 2010. The steady decrease in the total area of agricultural land and the decrease in dairy cattle numbers lead to a further decrease in fertilizer use to 240 million kg N in 2020. The almost negligible share of urea fertilizer is assumed to remain constant in the 2000-2020 period.

Development of dairy farming also highly depends on the EU policies on milk quota. From an economic point of view the milk production per cow will increase and as a consequence – when milk quota remain the same – dairy cattle numbers will decrease. In the 2000 -2010 period an increase in milk productivity of 1.8% per year is foreseen to yield up to an average milk production of about 8500 kg per cow in 2010. An increase of 1.3% per year in milk production is expected in the 2010-2020 period. Milk quota are assumed to remain constant until 2010, and from 2010 onwards an increase of 0.6% per year is foreseen.

The updated projection does not take into account the decisions on the CAP taken by the EU Ministers of Agriculture in Luxembourg in June 2003 and the outcome of the derogation request of the EU Nitrate Directive. The way the measures necessary to comply with the EU Nitrate Directive will be implemented is still uncertain. This baseline projection was to be updated in early 2004 if new information on the implementation of these policies had become available by the end of 2003. This also would depend on whether these policies had considerable consequences for this baseline projection.

Table A16. Activities of agricultural data in Rains and ER/RS2004 for 2000-2020

Animals	**Unit: (1000 head)**	**2000**		**2010**		**2020**	
		RAINS Sep2004	ER2004	RAINS Sep2004	RS2004	RAINS Sep2004	RS2004
DL	Dairy cows - liquid(slurry) systems	1,504	1,504	1,363	1,237	1,333	1,154
DS	Dairy cows - solid systems						
OL	Other cattle - liquid(slurry) systems	2,403	2,403	2,286	2,067	2,037	1,967
OS	Other cattle - solid systems	163	163	180	163	161	165
PL	Pigs - liquid (slurry) systems	13,118	13,118	14,561	11,286	14,651	11,130
PS	Pigs - solid systems						
LH	Laying hens	41,844	51,534	43,956	46,863	43,761	51,042
OP	Other poultry	63,128	53,438	72,581	51,916	75,541	59,644
SH	Sheep and goats	1,487	1,487	1,475	1,487	1,407	1,496
HO	Horses	121		125		125	
FU	Fur animals	5,003	5,003	4,503	5,003	4,503	5,003

The numbers for 2000 are similar for RAINS and ER. Differences within the poultry section are due to the different allocations of young laying hens.

NH_3

The RAINS model uses animal numbers as standard units. For the base year, all relevant data such as nitrogen excretion rate, volatilization rates in animal houses, storage of manure and application of manure are defined in fixed values of emission factors (EF). Changes that occur in other years, such as measures on feed intake or low emission houses are converted to reduction to the EF standard values in the base year. The Dutch LEI Manure and Ammonia model is a nitrogen flow model in which the specific data are used directly without linking to a base year value. The ammonia emissions in the different stages (animal house, storage, pasture, application) are dynamic, meaning that when the nitrogen flow changes, the ammonia emissions change simultaneously.

The LEI model is more flexible than RAINS, meaning that it is impossible to introduce all the typical Dutch adjustments in the RAINS model. Both models work with a limited number of animal categories, of which some are not congruent. The RAINS model category, ‘other cattle’, comprises young stock for replacement of dairy cattle, beef cattle and the category, sheep and goats. The LEI model has categories for young stock, replacement of dairy cattle, and one for veal calves, one for beef cattle at pasture (including sheep) and, finally, one for beef cattle in the stable (including goats). The same holds for poultry. IIASA has a category just for laying hens (excluding young laying hens) and one category other poultry (including young laying hens, broilers, turkeys, ducks etc.). The LEI model has one category for laying hens, young laying hens and mother hens, and one category for meat poultry, including broilers and turkeys.
Because of the structure of the IIASA model and due to the fact that some animal types are grouped into different animal categories, it is not possible to create equal national emissions with the RAINS and LEI models for the same year.

Notwithstanding the above, the RAINS model is suitable for ammonia emission calculations on a European scale.

DUTCH INPUT DATA
The discussion with IIASA clarified many obscurities in specific animal numbers, emission factors and so forth. Re-calculating Dutch values to the RAINS format is practically finished and IIASA will incorporate them as soon as possible. After this, a final check can be done on the Dutch values in the RAINS model. However, the time available for guaranteeing that all corrections be made is limited.

There are, however, two discussion points. Dutch animal numbers for pigs and poultry for the future are not in line with the European numbers. Firstly, the lower Dutch animal numbers are the consequence of the agricultural policy in the Netherlands, which is not only economically based, but based on manure management restrictions. IIASA will adopt the Dutch forecasts. Secondly, the IIASA model uses a fixed milk production and nitrogen excretion per dairy cow for the base year and for all other future years. In the Netherlands the milk production per dairy cow is, along the nitrogen excretion, continually increasing. Dutch farmers have to take measures to lower the nitrogen excretion per dairy cow, resulting in only a slight increase in nitrogen excretion between 2000 and 2010; RAINS uses the same excretion rate in 2000 and 2010.

IIASA confirms this problem, stating that such corrections should be done for all countries or none, not for some and not others.

INTERNATIONAL COMPARISON

Although a quick look at the data from other countries revealed some discrepancies, IIASA stated that some of them have already been corrected. One point is the increasing milk yield per dairy cow, as described above for the Dutch situation. At present RAINS uses the same milk production and nitrogen excretion per dairy cow for all years, while it is reasonable to assume increasing values. This implies that most countries have higher ammonia emissions for future years than indicated by RAINS.

FINAL REMARKS ON AMMONIA EMISSIONS

As stated above, a correction for the increasing the milk production per dairy cow would seem necessary for all countries. To make all the data used in RAINS suitable for negotiations, a consistency check on the definition of animal categories and corresponding values for excretion and other factors will be necessary. Below the problems in RAINS in the animal categories are summarized.

1. DAIRY CATTLE: RAINS uses fixed numbers for both milk production per cow and N excretion. However, both milk production and N excretion are expected to increase, meaning that RAINS underestimates the forecasted ammonia emission across Europe.

2. DAIRY CATTLE: Additional efforts of low nitrogen feed and low emission housing are not incorporated in the RAINS model.

3. DAIRY CATTLE: The control option of feed adaptation to reduce the urea content of milk does not exist in RAINS. This control option results in a lower ammonia emission rate during housing;

4. LAYING HENS: Because of the EU ban on battery cages in 2012, RAINS does not reflect the future increase in N excretion caused by the switch to floor-based systems. nitrogen excretion of laying hens depends on the housing systems: floor-based systems show higher emissions than battery cages. Battery-caged animals excrete 0.67 kg nitrogen per bird per year and floor-based housed hens excrete 0.86 kg nitrogen. The increase is the result of more movements by the birds. So RAINS underestimates the forecasted ammonia emission.

5. LAYING HENS: Low-emission housing measures have not been inserted in the scenario

6. OTHER POULTRY: For young laying hens and breeders, RAINS also differs with the Dutch scenario similarly to points 3 and 4.

PM

DUTCH FINE PARTICLES AND COSTS FOR EMISSION REDUCTION
A discrepancy shown between the PM_{10} emissions from pigs by the IIASA consultation was solved by justly interpreting the definition of sows and piglets.