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TNO-report

R 2004/428

Particulate Matter in the Dutch Pollutant Emission Register: State of affairs

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Order no.	004.34973
Keywords	Particulate matter Emission Monitoring
Intended for	Ministry of VROM

Preface

The project has been carried out from October 2003 to October 2004 for the Ministry of Housing, Spatial Planning and the Environment (VROM), where it is referred to as VROM 200307270. The project has been supervised by a Steering Committee that consisted of Mr. Klaas Krijgsheld (chair), Mr. P. van der Most (Ministry of VROM) and Mr. Benno Jimmink (RIVM).

The authors would like to thank all the members of the Steering Committee for their valuable discussions, contributions and cooperation.

Contents

1. Introduction

1.1 Background

An important part of the national emission estimates in the Dutch Pollutant Emission Register (PER) is assessed on the basis of emissions assessments at large individual plants and companies. These individual assessments are based upon measurements and/or estimation methods. In the past, the research organisation TNO conducted company surveys to collect and check the company emission data. Since 1999, these individually assessed emissions are reported in annual environmental reports and checked by the regulatory body at Provinces. These environmental reports are also being used as a basis for estimation of primary Particulate Matter (PM) emissions from industrial sources in the Netherlands. The estimations according to this methodology resulted in a significant change in the historical emission trend as estimated according to the previous methodology based upon monitoring at company level by external consultants. Therefore, national PM_{10} emission estimates for the years 1999-2002 have been corrected by PER experts by using total dust figures in combination with PM_{10} fractions based upon literature or data of similar company.

International requirements for the monitoring of PM are becoming more and more strict as a result of increasing harmonisation. Monitoring of PM will become even more important if a National Emission Ceiling on PM will be adopted in the European Union. Also, more than a decade of international research has improved PM emission monitoring methods considerably.
On the other hand, the situation with respect to PM emissions has become more complex over the last decade, since many companies have implemented a broad range of mitigation measures to fulfil increasingly stricter emission standards.
Last but not least, it becomes more and more likely that $PM_{2.5}$ becomes the important standard for air quality in the European Union, while Dutch monitoring only considers PM_{10}.

Given the unclear quality and international validity of present PM emission monitoring in the Netherlands, a need exists for a documentation, analysis and improvement of the present Dutch primary PM emission monitoring in general and in the framework of the Dutch Pollutant Emission Register in particular (the ‘Emissiemonitor’).

1.2 Aim

Given the unclear quality of the present national PM emission estimates, the shifts in monitoring methodology and the international developments on emission standards, mitigation measures and particularly on particle size, the aim of the project is:

1. to document the present monitoring of primary PM_{10} emissions in the Netherlands and
2. to analyse the scope and needs for improvement of the existing monitoring and extension to $PM_{2.5}$ and mitigation measures.

The analysis takes the growing international monitoring requirements explicitly into account.

The study delivers a condensed description of the present PM_{10} monitoring methodology in the Netherlands. It does not provide detailed source by source description nor the quantitative details on emission estimates, emission factors etc. For that type of information, the reader is referred to [ref. 34] and the sector reports mentioned in Chapter 5. The study does report an analysis of the weaknesses of PM monitoring as well as the possibilities for monitoring mitigation information and $PM_{2.5}$ emissions in the near future. Proposals are given for the improvement of emission estimations, monitoring methodologies and protocols.

1.3 Reading instruction

The report will describe in Chapter 2. Approach the vision of the authors on the quality of monitoring in general and the resulting steps, which have been taken to address the policy requirements and to meet the research objective as has been formulated in the previous paragraphs.

The actual documentation of the present Particulate Matter monitoring methodology takes place in Chapter 3. Documentation of present methodology. It will sketch the definitions of PM, the emission monitoring process in the Dutch Pollutant Emission Register (PER) in general, the existing PM assessment methods varying from measurement methods to validation procedures and the present international PM reporting requirements.

Chapter 4. Conditions and priorities sets the framework for the critical analysis to improve the present PM monitoring in Chapter 5. Analysis of strengths & weaknesses. In this chapter, the monitoring will be analysed for the presently identified anthropogenic sources, missing anthropogenic sources, resuspension and natural sources. In the analysis, the methodology and procedures as well as the measurement and data will be taken into account.

The possibilities for extension of the monitoring in two directions towards viz. PM2.5 and information on mitigation measures taken, are presented in Chapter 6 Extension to PM2.5 and mitigation measures.

The report will close with Chapter 7. Conclusions and recommendations. The recommendations are directed towards all relevant parties involved in the Dutch PER.

The recommendations have been operationalised for the client in the form of project ideas that have been provided to the Ministry of VROM in the form of a discussion note, separately from this report.

2. Approach

2.1 Vision

Any documentation, analysis and particularly assessment will require some explicit or implicit guiding or yardstick, which is based upon a certain vision. In our view, it is needed to explicitly communicate this vision in order to be able to make a clear, well-defined and acceptable quality assessment. For the project at hand on the present inventory of Particulate Matter, we will reflect our vision on the quality of emission monitoring in general and Particulate Matter emissions in particular. Here, we are aware of the situation that the Dutch Pollutant Emission Register (PER, in Dutch the 'Emissiemonitor') and its methodology has developed as a result of considerations on the accuracy and efficiency of the monitoring of a large number of pollutants. The special focus on one pollutant being PM can result in conclusions that are not necessarily consistent with the accuracy and efficiency of the overall monitoring process of the total of pollutants. However, it will be tried to keep the total context in sight in order to come up with robust conclusions that are not contrary with the emission monitoring in total.

The quality of emission inventories is often expressed in terms of verification and validation. Verification refers to ensuring that monitored emissions are truly accurate, i.e. correspond to emissions in reality [ref. 25]. This normally involves referring to outside sources of information (e.g. control measurements performed by certified laboratories). Verification of national or regional emissions can be done directly by combining the verifications on plant level or indirectly by comparison of results of calculations of immission concentrations based on monitored emissions with actual national or regional air quality.
Validation refers to the process of ensuring that emission monitoring has followed the governing accounting rules and emissions determination protocols. When a monitoring report is validated, it has been agreed that the guidelines have been correctly applied, and the emissions report should be accepted for compliance purposes. If verification then shows that the emissions report does not accurately reflect true emissions, this means that emissions determination guidelines need to be changed.

Types of uncertainty
Verification can reveal that the emissions as assessed in an inventory do not exactly reflect the emissions in the real world. To put it in other terms: the monitored emissions are surrounded with uncertainty. A large number of sources for uncertainty have been documented and categorised into three main types of uncertainty [van der Sluijs 2002, ref. 38]:

1. Technical (inexactness)
2. Methodological (unreliability)
3. Epistemological (ignorance)

Technical (inexactness) uncertainty is the intrinsic uncertainty (variability, heterogeneity) and technical limitations (unclear definitions, aggregation and resolution errors). In practice, these aspects are particularly relevant in **Measurements**.

Methodological (unreliability) uncertainty refers to internal strengths and weaknesses (use of proxies, methodological rigour, empirical basis, validation) and external strengths and weaknesses (completeness, acceptability, transparency, accessibility, biases of discipline & utilisation). These are particularly important in inventory **Methods** and validation procedures.

Epistemological (ignorance) uncertainty includes epistemological limitations (theoretical understanding, system indeterminacy, active ignorance for functionality, passive ignorance or errors). In the situation of PM monitoring, this could be summarised as **Missing sources**.

The IPCC uses for its emission monitoring the following principles on data quality (with between brackets the previous uncertainty classifications by Van der Sluijs):
- Accuracy/confidence (exactness)
- Consistency (reliability: internal methodological strength)
- Transparency, Comparability/compatibility, Completeness (reliability: external methodological strength)
- Efficiency and
- Timeliness.

It is clear that the technical and methodological limitations are being addressed in the IPCC principles, but the epistemological limitations have been ignored. Apparently, the IPCC disregards the fact that the IPCC methodology could ignore certain sources in reality. The policy perspective, e.g. the definitions of the emission objectives and protocols, is determining the system boundaries of the IPCC method. Note that this approach is not adopted in the present project.

It is interesting that the IPCC method covers additionally another aspect, namely that of practicality. It states explicitly that the emission inventory should be established efficiently and in time. It is not within the scope of the present research question to determine exactly these aspects here. However, another practical aspect is very relevant for the assessment of the data quality. The aim and usage of emission inventory data in general and of PM in particular determines the necessary level of quality. Or: how accurate is accurate enough?

Required quality level

The aims of the Dutch emission inventory consist of:

1. National and target group emission estimates for the parliament and the target group policy
2. International reporting obligations: National Format for Reporting (NFR) annually and each 5 year EMEP grid reporting to UNECE (CLRTAP), LCP to EU EPER [1]
3. Informing the public: various forms, although a 5 km x 5 km grid reporting is chosen for priority substances.

The latter is only obliged from 2007 on (UNECE Arhus convention) and the exact form of the information is undetermined yet. This type of information is also interesting for environmental research institutes, Provinces and other local authorities.

This means that for PM_{10} especially the national and target group emissions are important, covering all sources that are prescribed for international reporting. $PM_{2.5}$ will probably in the near future become a reporting obligation.
Mitigation measures are not of direct importance, but are relevant for assessing the quality of reported emission data and designing effective future mitigation policies. Localised emissions are an obligation for the 5 yearly EMEP grid reporting and the annual EPER of Large Combustion Plants. Localised emissions are needed for local policies and research on emission dispersion modelling and effects. For this latter purpose, speciation and fractionation are also of interest.

Different source types

In summary, the quality level of the present PM inventory is assessed with respect to its aim and usage as well as by benchmarking with international inventories. To do so, the present project considers the following issues for assessment and recommendations for improvements:

- Measurements
- Methodology
- Missing sources

These issues are not equally relevant for the different methods that are used to estimate PM emissions for different source categories. In terms of monitoring methodology, four main groups of sources can be distinguished. In chapter 4, a detailed description will be given of the different four types of monitoring. Table 2.1 presents for the four groups of sources that use each a different type of monitoring methodology an indication of the relevant issues. These have received special attention in the analysis of the present emission monitoring.

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[1] EMEP: Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe, UNECE: United Nations Economic Commission for Europe, CLRTAP: Convention on Long-Range Transboundary Air Pollution, LCP: Large Combustion Plants, EPER: European Pollutant Emission Register

Table 2.1 Indication of the relevant issues for the four groups of sources that use each a different type of monitoring methodology.

Quality relevant issue	**Types of monitoring methodology / sources**			
	Large individual sources	**Collective industrial sources**	**Area sources**	**Natural sources**
Measurement	X			X
Methodology	X	X	X	X
Missing sources			X	X

A simple quantitative uncertainty analysis will be conducted for each of the type of sources with their monitoring methodologies. In order to be able to understand this analysis, the basic principles of quantitative uncertainty analysis are demonstrated with a simple example on the propagation of errors in Appendix C.

The main messages regarding quantitative uncertainty analysis are as follows. First, a large number of relatively small, independent sources in the inventory may have a large individual uncertainty and still result in an accurate national emission estimation. Here, independence of the measurement of the sources should be a relevant issue to address, as well as the relation to enforcement of standards. From a point-of-view of enforcement, emission assessment might be too uncertain while it is accurate enough for the estimation of national emissions.

Second, collective emission estimation methods using the famous relation between activity and EF ‘preserve’ uncertainty up to the national level. Here, the focus should be on representativeness of measurements of EF and the accuracy of activity data.

2.2 Steps

To address the questions on the documentation, improvement and extension of the PM emission monitoring in the Netherlands, the following steps are taken:

1. Documentation of present methodology
2. Priority setting for analysis
3. Present strengths & weaknesses: Options for improvement
    a. Present anthropogenic sources
    b. Missing anthropogenic sources
    c. Resuspension
    d. Natural sources
4. Future extensions: Options for $PM_{2.5}$ and mitigation measures
5. Formulation of project ideas

These steps are represented in the structure of the report. The recommendations have been operationalised for the client in the form of a table with project ideas, including a specification of target groups, indicative budgets etc. These project ideas have been provided to the Ministry of VROM in the form of a discussion note, separately from this report.

The documentation of the present methodology is largely based upon documents and data from the Dutch Pollutant Emission Register (PER). To assess the options for improvement, three approaches have been used, viz.:

1. International and national literature;
2. Analysis of data from the PER;
3. Interviews with experts outside and inside the PER.

The experts cover the relevant sectors and subjects. All Task forces that contribute to the PER have been interviewed in the project, not only to use their knowledge but also to prepare already the process of embedding the suggested improvements in the emission monitoring process in the PER.

3. Documentation of present methodology

3.1 Definitions of PM

In the context of this study is should be stated that dust or total particulate matter (PM) or total suspended particulates (TSP) is defined as the particles that are emitted from diffuse or point sources in the air. To distinguish this kind of emitted particulate matter from the particulate matter that is (formed by all kinds of physical and chemical processes) present in the atmosphere, the emitted particulate matter from these sources is called **primary particulate matter**. The extra particulate matter formed in the atmosphere is called secondary particulate matter. As in the PER, this report uses the term particulate matter only for primary particulate matter. Furthermore it should be mentioned that emissions of particulate matter in this study only include particulates (aerosols) that are present in waste- or flue gas streams and not the condensable gases in these streams. That means that gaseous compounds, which form condensable particulate matter when cooling, are not considered to contribute to particulate matter emissions.

Particulate matter consisting of particles with a diameter of 10 µm or smaller is referred to as PM_{10}. PM with a diameter smaller than 2.5 µm is referred to as $PM_{2.5}$, while PM with a diameter smaller than 0.1 µm is named ultra fine particulate matter or $PM_{0.1}$. In international context, $PM_{2.5}$ is also called ‘fine’ particulate matter, while $PM_{2.5}$-$_{10}$ is referred to as ‘coarse’ particulate matter. The Dutch PER registers PM_{10} (called in Dutch ‘fijn stof’) and also particulate matter with a diameter larger than 10 µm (called in Dutch ‘grof stof’). The sum of the two is TSP.

3.2 The emission monitoring process

The Pollutant Release and Transfer Register (PRTR) or Pollutant Emission Register (PER), comprises the inventory, analysis, localisation and presentation of emission data of both industrial and non-industrial sources in the Netherlands [ref. 27]. The PRTR is used as the national instrument to monitor the emissions from all sources to all compartments on a (sub-)national scale. About 800 substances are included in the PER. Emissions of PM with both a diameter of 10 µm or smaller, as well as with a diameter larger than 10 µm are annually registered in the Dutch PER. $PM_{2.5}$ and ultra fines are not monitored. $PM_{2.5}$ is being estimated for international reporting in separate projects, though.

Emission data is gathered from the source categories industry, public utilities, traffic, households, agriculture and natural sources. Agreement on definitions, methods and emission factors, based on reports by expert groups, is achieved in the Coordination Committee for the Monitoring of Target Sectors (CCDM).

The emission data are updated every year and the results on approximately relevant 170 substances are reported yearly in a joint publication with all the actors in the field and stored in the central national database, from which information for policy or research applications is provided.

The estimation of emissions is conducted by task forces, constituting of representatives of all involved institutes with relevant expertise. The inventory is established in a cooperation between the Inspectorate of the Ministry of Housing, Spatial Planning and the Environment (VROM/Inspectorate), Statistics Netherlands (CBS), the National Institute of Public Health and the Environment (RIVM), the Ministry of Agriculture, Nature Conservation and Fishery (LNV) through representation by the Expert's Centre of Agriculture, Nature Conservation and Fishery (EC-LNV), the Ministry of Transport, Public Works and Water Management (V&W) through representation by the National Institute of Water Management and Waste Water Treatment (RIZA) and the Netherlands Organization for Applied Scientific Research (TNO).

The national emission data database of the PER, which is centrally managed by TNO, includes of three types of sources:

1. The individually registered sources ('ERI');
2. the collectively estimated industrial sources ('Bijschatting');
3. the collectively estimated area sources.

Together they account for the total national emission, which are geographically distributed with the aid of the national distribution database and stored in the ER-C database (Emission Registration-Collective).

The individually monitored large sources rely for a large part on company estimations of PM emissions, which are being reported in annual Environmental Reports (ER). Information on mitigation measures is published on an ad hoc basis. Metadata are lacking in the present ERs, which makes validation on the basis of solely ER data impossible. In order to be obliged to publish an ER, the plant/site's emission has to be above a certain threshold value or the plant/site has to be selected by the provincial authorities for other reasons. The provincial authorities validate and verify the reported emissions in the ERs. The ERs are processed by FO-I and transferred to the database at TNO. In the last years, checks on emission values and data processing are not anymore performed at TNO. Recently, the electronic ER has been introduced.

In addition to the ERs, TNO registers emissions from companies to complete the emission monitoring for individual emission reporting for large combustion plants and different environmental themes and branches. The first is necessary to fulfil the emission regulation for large combustion plants ('Besluit Emissie Eisen Stookinstallaties', BEES) and also the EU Large Combustion Plant directive. The last is needed to complete the set of emission factors (EF) for all branches to be able to estimate collectively the additional industrial sources (in Dutch ‘bijschatting’). This theme related selection of companies is becoming smaller and smaller each year. The collective estimation of emissions from other industrial sources is based upon the individually reported emissions in the same branch. In fact, the emission of the individually registered companies are scaled up to branch level by means of a scaling parameter that represents the physical or economic production volume of the branch. So, it is assumed that the collectively estimated emissions within the branch have the same specific emission or emission factor as the average of the individually registered companies within the same branch.

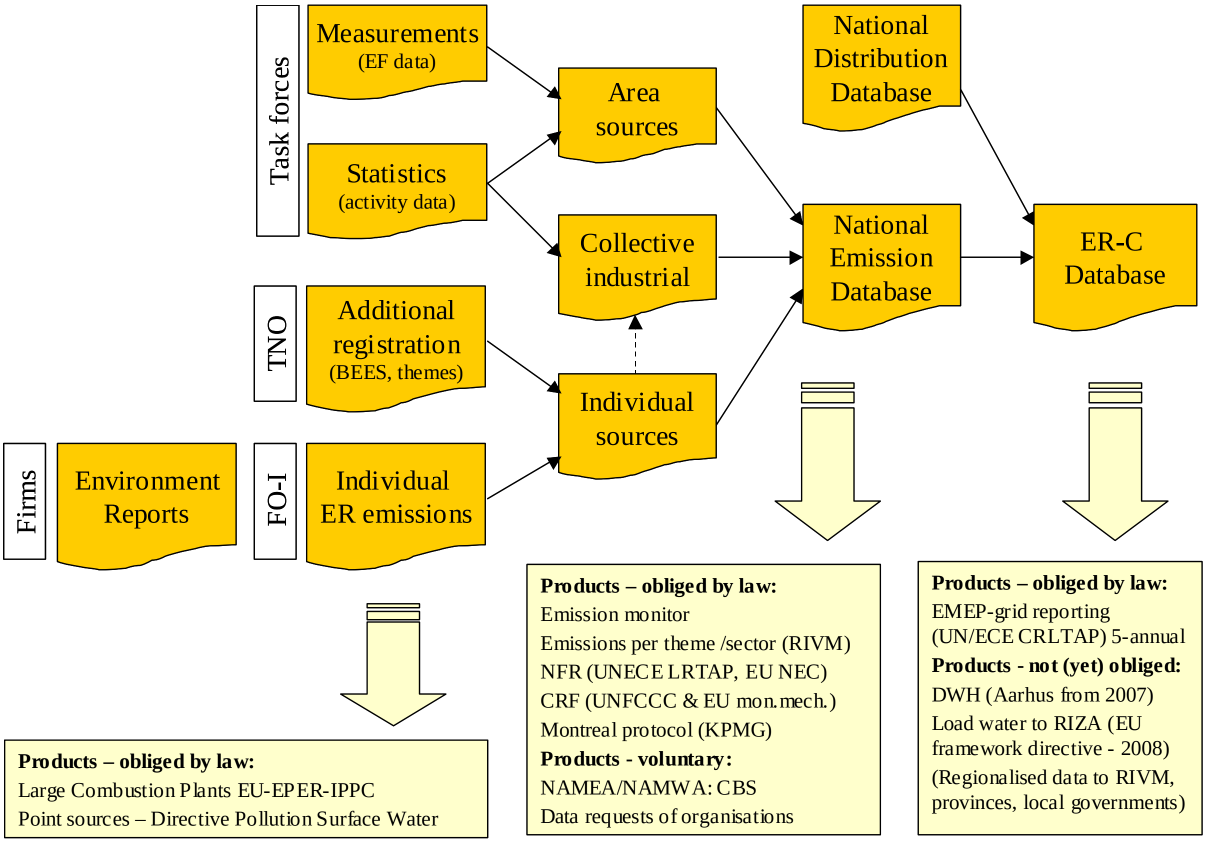

Figure 3.1 Overview of the steps and products in Dutch emission monitoring process.

The third group of sources, area sources, are also collectively estimated sources but for non-industrial sectors. It concerns not strictly area sources but also e.g. line sources (such as traffic). The emission methodology is based upon the well-known formula Emission = Activity x Emission Factor. The basis of the Emission Factors is measurement and literature. Activity data are based upon statistics of very detailed emission source categories. The data processing is conducted in already quite complex models. The estimation of collective emissions is conducted by the task forces, constituting representatives of all involved institutes.

The PER produces annually a number of products, of which some are obligatory by law while others are voluntary. In fact, the more extensive PER from the early nineties has been trimmed to a more focussed and lean PER that has exactly the elements to deliver efficiently the required products such as the Large Combustion Plants, the Nomenclature For Reporting, Common Reporting Format, the UN-ECE Convention on Long Range Transport of Air Pollution and the EMEP gridded emission reports in international frameworks and some national emission reports of which the PER (the emission estimations themselves) is the basis and is the most important. Finally, the located emissions of the PER are reported for professionals on Internet in the Data Ware House of the PER (at www.emissieregistratie.nl).

The present PER is efficiently dedicated to the present national and international reporting obligations.
The collective estimations are being made on the basis of activity data and emission factors by the institutes involved in the Emission Monitor.
The individually registered emissions are assessed, transferred, validated, verified and processed by a number of organisations:

1. Companies: assessment of emissions by measurement and/or estimations
2. Provincial authority: validation and verification of emissions
3. FO-I: processing of emissions
4. TNO: processing of emissions (final check has been omitted)

All these parties and operations are important for the accuracy of the assessment of individually registered emissions.

3.3 PM$_{10}$ assessment methods

3.3.1 Evaluation of PM$_{10}$ emissions of companies by regulatory bodies

In this paragraph we will address the validation and verification of the data on fine particulate matter (PM$_{10}$) emissions by regulatory bodies. Each year a large group of companies have to publish their environmental performance in annual environmental reports. The provincial authority, being the regulatory body responsible for validating the emissions in these reports can be considered as an important actor in the assessment of emission data of sector and national levels.

The guidelines for reporting and validating environmental data (in Dutch: ‘Handreiking validatie milieujaarverslagen’, [ref. 14]) have recently been updated (December 2003). The criteria for validation of the environmental annual reports are in general:

1. delivered in time;
2. the form;
3. completeness;
4. reliability.

The result of a validation is positive if the presented data have been generated according to the, with the regulatory bodies agreed, methods and are also corresponding to other information available at the regulatory body. The information and reliability in the environmental annual report can also be assessed by certified external experts.

A documented measurement - and registration system
In the directive on Environmental Reporting (‘Besluit Milieuverslaglegging’) it is stated that companies must compose their quantitative data (emissions) on a thorough and verifiable manner. For that purpose one must use a documented measurement and registration system. To be able to make a good assessment of the reliability of data in the environmental annual report, an evaluation of the contents of the documents and the functioning of these documented measurement and registration systems is necessary. The guidelines (‘handreiking’) state that special attention should be paid to the reliability of the data.

To support this assessment, a checklist Measurement and registration systems (‘Meet- en registratiesystemen’) is provided. This checklist gives guidelines for the parameters to be reported for all emissions to water and air and gives a uniform format. In this way the regulatory body can form a judgement concerning the reliability. This checklist can be used in the regular enforcement.

3.3.2 Importance of PM_{10} emissions

The Guidelines on validation of Environmental Reports (‘Handreiking validatie milieujaarverslagen’, [ref. 14]) gives regulatory bodies some guidance where to expect PM emissions. Combustion installations are marked as a major source of PM_{10} emissions and the relation between fuel input and emissions is discussed. Emissions above the threshold limit values for particulate matter (and also CO_2, NO_x, SO_2, CO, C_xH_y and CH_4) are expected from large combustion installations. The (degree of) capacity utilization is of influence and should be presented.

There is discussion on which companies should make annual environmental reports. 11% of the currently reporting companies think that they should be exempted from this demand [ref. 48].

According to the directive on Environmental Reporting (‘Besluit milieuverslaglegging’, December 2002, [ref. 46]), companies have to report PM with a diameter of

10 µm or more and PM_{10}. So the sum is Total Suspended Particulates. Companies that measure only TSP cannot specify this in the ER.

Companies emitting more PM emission than the threshold limit value must measure and report these emissions to the regulatory body. In Table 3.1 the threshold limit value (kg/year) for PM are given. The higher the emission above the threshold limit values, the more accurate the emissions have to be determined.

Table 3.1 Threshold limit values for reporting obligations for particulate (matter) emissions.

	Threshold limit values Emissions to Air 1) [kg/year]
Total PM:	
- PM > 10 µm	10,000
- PM_{10}	10,000

1. Legally established value 'Stoffenlijst Besluit milieuverslaglegging, dec. 2002' [ref. 46]

Besides the general threshold limit values, mass flow verification values in the National emission Regulation guidelines (NeR, [ref. 24]) determine whether emission limit values are valid. At mass flow verification values of 200 g/hr or higher, an emission limit value of 5 mg/m^3 is valid if filtrating separation devices can be applied.

Companies can be forced in their environmental permits to report PM emissions by measurement following certain reporting requirements. However, generally the National emission Regulation (NeR) is being followed. The NeR speaks only of TSP. This is understandable from the history of air quality policy, where in the early years dust was perceived especially as a local problem of nuisance. So, generally companies have to measure TSP for their permit and PM>10 µm and PM_{10} for their Environmental Report.

According to the regulatory bodies at the Provinces, permits and legislation (NeR) seem to be clear on PM, since 'there are no issues or cases known at the Council of State on PM matters' [Personal communication Province of Friesland, Van Scheltinga]. The lacking national PM emission estimates are not perceived as a problem at the provincial authorities.

Furthermore, the Guidelines on validation of Environmental Reports ('Handreiking validatie milieujaarverslagen', [ref. 14]) consider in the validation of emission data the importance of these emissions at company level in relation to threshold limit values and national and sector totals. This happens on the basis of two criteria:

1. First of all, emissions are classified in a certain category, related to the threshold limit value for that substance. Each class relates to a prescribed monitoring method. For example, the threshold limit value for reporting particulate matter is an annual emission of 10,000 kg.
2. Secondly, if the national and particularly the branch emission objective has been reached, the company emission might be monitored according to a one step lower classified monitoring method. This is indicated as the 'distance to the Integrated Environmental Target ('Integrale Milieu Taakstelling - IMT') 2010'.

In Table 3.2 an overview of the importance of emissions is given in relation to the threshold limit value.

Table 3.2 Overview of the importance of emissions is given in relation to the threshold limit value.

Emission category	**Description**		**Class**
Very large emission	Greater ore equal to 5 times the threshold value	φ >= 5φd	IV
Significant emission	Greater than the threshold value but smaller than 5 times the threshold value	φd <= φ < 5φd	III
Emission with attention	Smaller than the threshold value but larger than half the threshold value	0,5 φd <= φ < φd	II
Normal emission	all other cases	φ < 0,5 φd	I

Note: φ = annual emission
φd = threshold limit value

The class category determines the method of monitoring of emission. As emissions fall in a higher class the requirements on the monitoring methods increase. For emissions in:

1. Class I, one can use a single measurement or make an estimation based on emission relevant parameters (ERP's).
2. Class II emissions require measurements twice a year and additional ERP based calculations.
3. Class III emissions require an even more strict measurement protocol.
4. Class IV emissions require (semi) continuous measurements and calculations.

3.3.3 Emission measurement methods for PM_{10}

Basically yearly emissions are determined with the formula:
<concentration>*<flow>*<duration of emission>

where the three variables are determined in very different way's (see Table 3.3). It should be realised that emission factors or other calculation methods are based on measurements according to this formula. This paragraph briefly addresses the most common methods to determine these variables.

Table 3.3 The most important variables for yearly emission determination.

Variable	Determination method
Concentration	Online (semi) continuous measurement: frequency seconds to daily; Discontinuous measurement: several times a year, directly in air flow; Off line: sampling en analyses in laboratory
Flow	Flow speed measurement in air flow; Surface of flow channel; Calculation based on fuel or raw materials/production quantities; At diffuse emissions: calculation or air flow over source
Time (duration of emission)	Calculation based on process control data

The measurement methods presently available for PM_{10} are presented in detail in Table 3.4. These are derived from the methods used for measuring total PM (TSP) emissions. By measuring TSP and multiplication with the PM_{10} fraction of TSP, the PM_{10} emission can be established.

In Annex IX to 'Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air', it is prescribed that the reference method for the sampling and measurement of PM_{10} is gravimetric mass detection according to standard EN 12341. Ambient air is passed through a size-selective inlet, specifically designed to allow the PM_{10} fraction to pass through, at a known, constant flow rate. The PM_{10} fraction is collected on a filter for a known period of about 24 hours. The mass of PM_{10} material is determined by weighing the filter at constant conditions before and after collection of the particulate matter.

EPA encourages inclusion of condensable particulate matter testing for sources that generate significant quantities of vapour phase material that would pass through a conventional filterable particulate sampling train.
Currently, the EPA test method for condensable material is Method 202 in which only the mass in a solvent extraction and the mass in an aqueous extraction is determined after separation of the filterable particulates.

In periodical measurements the quantity of PM_{10} in a waste- or flue gas stream can be measured directly by separating particulate matter > 10 µm in-stack from the total PM (by means of a cyclone) and collecting the passing PM_{10}.

Common equipment for continuous measurement of dust measures the total PM (TSP) concentration. To determine the PM_{10} fraction of the dust, samples must be collected and analysed on particle size periodically. If the quantity of PM_{10} in total PM is almost equal to total PM, then only total PM concentration is measured and considered to be PM_{10}. When a considerable amount of particulate matter > 10 µm is found then the measured total PM concentration is corrected for this fraction to determine PM_{10} concentration. This assessment can be quite accurate (25% to 50%) if the proper NEN-ISO measurement protocols are being used.

The exact measurement method to be used for each emission class has only recently explicitly determined in the Guidelines on validation of Environmental Reports (‘Handreiking validatie milieujaarverslagen’, [ref. 14]) after a project of the provincial umbrella organisation IPO (‘InterProvinciaal Overleg’). Up to now, much room existed for interpretation of the guidelines, both by the company as well as by the regulatory authority. The revised guidelines including prescribed measurement methods are presently under discussion. If the updated version of the guidelines is adopted, the PM emission estimates from 2005 onwards could be assessed according to the new guidelines.

Generally companies have to measure TSP for their permit and PM>10µm and PM_{10} for their Environmental Report.
Common equipment for continuous measurement of dust measures the total PM (TSP) concentration, which have to be corrected with periodically measured particle size. This assessment can be quite accurate (15% to 50%) if the proper NEN-ISO measurement protocols are being used.
Extended guidelines determine which companies have to publish an Environmental Report and which method of emission monitoring has to be used for a class category of company emissions. For PM, the exact measurement methods by emission class are under discussion and will be effectuated at the earliest in the 2005 emission assessment.

Table 3.4 Measurement methods and accuracy of yearly PM_{10} emission.

Source type	**Measurement methods**	**Protocol, experience Equipment**	**Measurement frequency (number a year)**	**Indication of accuracy (±) based on 95% confidence interval**
Point sources	Continuous PM measurement after separating dust with cloth / electro filter + monitoring of ERPs 1)	NEN-ISO 10155 NEN-ISO 14164 VDI 2066 / 4 en 6	(semi) continuous	± 25%
	Continuous PM_{10} measurement	Standard PM_{10} (in preparation) NEN-EN 13284-1 NEN-ISO 14164 PM_{10} monitor	(semi) continuous	15-25%
	Continuous PM measurement in combination with separate measurement of PM_{10} / PM ratio + monitoring ERPs	NEN-ISO 10155 NEN-ISO 14164 NEN-EN 13284-1 VDI 2066 / 4, 5, 6 EPA 201/201A	(semi) continuous and ½ – 2 (ratio)	25-50%
	Frequent PM_{10} measurement + monitoring ERPs	ISO-NEN 9096 NEN-EN 13284-1 EPA 201A or VDI 2066 / 5	½ – 2	Factor 2
	Single PM_{10} measurement at start-up + monitoring ERPs	ISO-NEN 9096 NEN-EN 13284-1 EPA 201A or VDI 2066 / 5	Not applicable	Factor 2 to 3
Diffuse emissions	Calculation based on separate measurement PM_{10} concentration in production room i.c.w ventilation fold	EN 12341 PM_{10} monitor	1	Factor 2 to 3
	Calculation based on separate PM_{10} measurements in de open air (windward / weather side)	EN 12341 Calculation / modelling PM_{10} monitor	1	Factor 3
	Calculation based on actual situation (and ERPs)	Emission factors from handbooks (PM en PM_{10} / PM) i.c.w. product throughput	1	Factor 3 to 5

1) Emission Relevant Parameters (ERPs) according to the NeR

Legend Frequently used Sometimes used Not yet used

3.3.4 Measurement of types of PM

Primary emissions of particulate matter are defined as particulates (aerosols) that are present in waste- or flue gas streams and not the condensable gases in these streams. That means that gaseous compounds, which form condensable particulate matter when cooling, are not considered to contribute to particulate matter emissions.

The result of a measurement of PM in waste gases, however, depends on the measurement method:

- In stack continuous methods measure the amount of particles (aerosols) at waste gas conditions and particles can contain solid and / or fluid material
- In stack collection of particles on filter material also contains solid and / or fluid material but the determination of the amount of PM collected is based on dried samples
- Out of stack continuous methods measure the amount of particles (aerosols) at measuring conditions that usually differ from waste gas conditions and thus can included condensed material or exclude material evaporated in the sampling line
- Out- of stack discontinuous collection of particles on filter material can contain condensed material but the determination of the amount of PM collected is based on dried samples

For total PM, results are usually more or less comparable, but for PM_{10} this can give big differences because condensation often is restricted to PM_{10} (e.g. diesel engine particulates).

As in the future more PM_{10} measurement methods are going to be used, for some methods a correction has to be specified and applied for condensable particulate matter, which is according to the present European definition not a part of PM.

3.4 International PM reporting

One of the international statutory obligations is the annual submission of the emissions of the Large Combustion Plants to the European Pollutant Emission Register (EPER). The Netherlands has fulfilled its obligations for all industrial plants, although it is not exactly explicit whether the companies that are obliged to publish an Environmental Report are also the companies that meet the international EPER conditions. It is theoretically possible that a few companies have to report to EPER and are not included in the ER selection. This is in fact the case for the large agricultural sources and landfills. These are missing in the EPER submission.

The second international statutory obligation is the annual submission of Nomenclature For Reporting (NFR) to the Convention of Long-Range Transport of Air Pollutants (CLRTAP) of the UN-ECE and the EU National Emission Ceiling (NEC). It concerns the reporting of acidifying emissions (SO_2, NO_x, NH_3) and air quality related pollutants (CO, NMVOC, PM) as well as heavy metals (Pb, Cd, Hg, As, Cr, Cu, Ni, Se and Zn).

The Dutch PER is performed on a more detailed level than the NFR. Therefore, a NFR reporting code has been defined for each emission source that is distinguished in the PER. This way, the NFR reporting is secured.

Nevertheless, it is not a completely automatic operation since the definitions of categories change each year and are subject to interpretation. Moreover, PM for the NFR is reported in terms of Total Suspended Particulates (TSP), PM_{10} and $PM_{2.5}$. The Dutch PER does not provide $PM_{2.5}$, which means that it has to be calculated especially for the NFR submission. The procedure is simple. For each sector or branch and major source type (e.g. combustion or process), the PM_{10} emission is multiplied with a $PM_{2.5}$ fraction to estimate the $PM_{2.5}$ emission.

The set of $PM_{2.5}$ fractions (of PM_{10}) is presented in Table 3.5. Clearly, this is a quite crude estimation method, which might be suited for the calculation of a national total. However, the sector and branch estimations are probably quite in accurate using average fractions for sectors. The fractions are mostly based upon CEPMEIP data for the Netherlands, implying that the fractions are valid for the year 1995 or to put it more realistic, the period 1990-2000. The $PM_{2.5}$ fractions, however, are very dependent on process types as well as the type and extend of mitigation measures applied. Therefore, $PM_{2.5}$ fractions can change substantially over time. This implies that this table should be updated every few (e.g. five) years.

This simple method does not produce acceptable results at sector level. For estimation of the sector emissions, more detailed fractions should be applied at more detailed emission sources. For the assessment of company emissions, this method is not suited. If $PM_{2.5}$ emission monitoring will become obliged for companies, it means that companies will have to measure or calculate $PM_{2.5}$ themselves. The calculation would have to be based upon the present measurement methodology of PM_{10} and receive in combination with guidelines on detailed, technology dependent calculation of $PM_{2.5}$.

The Dutch PER reports on a higher level of detail than the required international reporting obligations of the NFR. Reporting is secured by reporting codes. Assessments of $PM_{2.5}$ on the detailed source level, e.g. companies, are not available within the PER and are only made for international reporting on branch and national level.
The $PM_{2.5}$ fractions that are used for the calculation of national $PM_{2.5}$ totals should be updated every few (e.g. five) years since the $PM_{2.5}$ fractions are very dependent on process types as well as the type and extend of mitigation measures applied.
For acceptable sector estimations of $PM_{2.5}$ emissions, the method needs to be improved in terms of detail (sources instead of sectors).
For acceptable company estimations of $PM_{2.5}$ emissions, either $PM_{2.5}$ measurements have to be conducted according newly developed protocols or technology dependent $PM_{2.5}$ estimation guidelines have to become available.

Table 3.5 The set of $PM_{2.5}$ fractions of PM_{10} that is used for the calculation of $PM_{2.5}$ emissions for submission to NFR.

Branch / source type	**$PM_{2.5}$ fraction of PM_{10}**		**Date**	**Reference**
	Rounded of to 0.05	**Not rounded**		
Transport				
exhaust	1.00			Expert estimation, RIVM
wear: tyres	0.10	0.09		Expert estimation, RIVM
wear: brakes	0.50			Expert estimation, RIVM
wear: road	0.20			Expert estimation, RIVM
Industrial fugitive emissions from fuels				
oil refining (process + combustion)	0.80	0.88	22-10-01	TNO-CEPMEIP and expert estimation RIVM
Industrial processes, incl. building venting				
food products and beverages	0.35	0.34	22-10-01	TNO-CEPMEIP '241400: Fugitive emissions from small industrial emitters'
chemicals and chemical products	0.65	0.67	22-10-01	TNO-CEPMEIP
mineral products	0.85	0.83	22-10-01	Tauw report 1998, table 3.36 p. 46)
basic metals	0.55	0.54	22-10-01	TNO-CEPMEIP sum 0303: Processes with contact' + '04: production processes' basic metal processes only
metal working	0.50	0.72	22-10-01	TNO (pers. comm. Antoon Visschedijk, Nov. 2001)
other	0.35	0.34	22-10-01	TNO-CEPMEIP '241400: Fugitive emissions from small industrial emitters'

Branch / source type	$PM_{2.5}$ fraction of PM_{10}		Date	Reference
	Rounded of to 0.05	Not rounded		
Industrial combustion	0.60	0.62	22-10-01	TNO-CEPMEIP
Consumers				
combustion wood	0.95	0.95	24-9-01	TNO-CEPMEIP '130000: Residential, commercial, institutional and other combustion'
combustion fossil fuels	0.95	0.95	24-9-01	TNO-CEPMEIP '130000: Residential, commercial, institutional and other combustion'
smoking cigarettes	1.00	1.00	24-9-01	TNO-CEPMEIP
other	1.00	1.00	24-9-01	TNO-CEPMEIP
Agriculture				
livestock houses	0.20			Expert estimation, RIVM
wind erosion agricultural land	Not included			
combustion	1.00			CEPMEIP
other agricultural sources	0.20			Expert estimation, RIVM
Storage and handling (excl. industry)				
storage and handling	0.10	0.11	24-9-01	TNO-CEPMEIP
combustion	0.95	0.11	24-9-01	TNO-CEPMEIP '130000: Residential, commercial, institutional and other combustion'
Construction				
combustion	0.95	0.95	24-9-01	TNO-CEPMEIP '130000: Residential, commercial, institutional and other combustion'
process	0.10	0.10	24-9-01	TNO-CEPMEIP
Energy sector				
public electricity/heat production	0.85	0.84	22-10-01	TNO-CEPMEIP
oil/gas extraction/distribution	1.00	1.00	22-10-01	TNO-CEPMEIP
Public waste incineration	1.00	1.00	22-10-01	TNO-CEPMEIP

4. Conditions and priorities

4.1 Objectives for emission monitoring

Priority setting with respect to improvement of the present monitoring methodologies can only take place effectively after the clear assessment of the objectives that have to be reached by the monitoring.

The objectives of the PER as communicated to the public have been presented in chapter 2.1 Vision. However, these are more formal duties, which might not always correspond with the wishes and requirements of the policy departments that are in fact the clients of the PER. Therefore, a more complete overview has been made of different possible aims for the PER.

Different objectives require different types of information from the PER. To illustrate the relation between the type of information that is needed and the objective that has to be fulfilled, Table 4.1 presents the potential objectives along two axes, viz. the size and character of the information and the detail and accuracy of the information. Both can be limited and low or extended and high. With regard to efficiency and effectiveness, it is recommendable to put effort only in large detail, accuracy and the size of the data if it is required to meet the objective.

Table 4.1 clearly shows that different objectives need different levels of detail and sizes of data sets. The ‘straightforward’ emission monitoring required for international reporting of national emissions (such as the Nomenclature For Reporting – NFR, see Appendix), needs only low levels of detail, accuracy for a limited set of data on emissions at sector level. Wanting to follow the mitigation of emissions requires additional detail and accuracy in order to be able to distinguish significant emission reduction trends. Understanding of the mitigation trends requires more data on e.g. dust concentrations of waste gas flows and mitigation technologies applied in order to be able to develop a mitigation policy. On top of this, compliance with National emission Regulation (NeR) requires more detailed and accurate data in order to show that emission standards have been respected. The Arhus protocol on dissemination of information to the public (‘right to know’) requires the same amounts of data with similar accuracy. The presently operational Data Ware House on emissions, approachable by Internet, focuses on professional users and fulfils not all requirements of the Arhus protocol.

More extended information is needed for the development of environmental policy and scientific aims, where a true understanding of emissions, dispersion, exposure and health effects in relation to each other is required. This type of information is needed, but not on an annual basis, since these insights concern not trends but mechanisms and interrelations. It would be cost-effective to collect this information by studies that are conducted not every year. In that case, the PER is not the most suitable instrument to collect these extended amounts of data (this area is shaded dark grey in Table 4.1). A policy research program such as the National Aerosol Program [ref. 4] seems a suitable instrument that integrates different types of information and focuses towards a central policy question in order to work efficiently in a project manner.

The other objectives have to be met by the PER with the exception of the NeR compliance, which is performed by the provincial authorities, but is closely related to the individual registration of companies within the PER.

Table 4.1 Different monitoring objectives and corresponding requirements in terms of detail & accuracy and size & character of the information needed.

INFORMATION		***Size & character***		
		Limited		**Extended**
Detail & accuracy	**Low**	Compliance with (inter) national reporting obligation ***(emission assessment)***		
		Assessment of emissions and trends ***(mitigation assessment)***	Understanding of mitigation ***(mitigation policy)***	Understanding of emission, exposure and mitigation of health effects ***(environmental policy)***
	High		Compliance with standards / National emission Regulation ***(compliance with law)*** Dissemination of information to the public ***(right to know - Arhus)***	Understanding of emission, dispersion, exposure and health effects ***(science)***

Legend	2001 situation	1995 situation	Extended situation

As a general observation or characterisation of the present state of the PER, Table 4.1 indicates that only the international compliance of emission reporting is being met [1], requiring low detail and accuracy for a limited data set. Assessment of emissions and trends has not been able for a large number of substances among which PM. Also, the background information on the state of (mitigation) technologies is not available since the introduction of the annual Environmental Report. These

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[1] In fact, the Dutch PER does not fulfill the obligation to report national emissions for each year since 1990, since emissions are not recalculated for all years after a methodological revision. This is only done for index years and the last three years.

more demanding objectives could be reached in the 1995 PER where individual company registration was executed intensively and primarily for the PER. The budget for the PER was in those days much larger than presently is the case.

The reconstruction of the PER has been saving costs at the expense of certain functionalities. In the present analysis, we will explore the possibilities for restoring the 1995 functionalities in a cost-effective way.

At this moment the monitoring of PM and PM_{10} emissions doesn't seem to cause many questions. Infomil, an intermediate organization on environmental regulation between the various authorities and target groups, operates a helpdesk and handles questions on PM emission. Infomil only has a few questions per year on monitoring of PM emissions related subjects [Personal communication Infomil, Peeters Weem]. This picture is confirmed by an interview with a regulatory body. Currently PM (and PM_{10}) emissions do not seem to be an issue of concern [Personal communication Province of Friesland, Van Scheltinga].

The present PER does largely meet the objectives on (inter)national emission reporting. However, the accuracy, detail and character of the data fall short for the assessment of mitigation developments and mitigation policy. Compliance with NeR is arranged outside the PER.
Additional study is necessary to assess what is needed to meet the requirements of the Arhus protocol on public availability of information.
Information to understand the emission, exposure and health effects in the context of science and environmental policy development is not included in the PER and can be gathered most efficiently by dedicated studies, for example in a policy research program.

4.2 Importance of national PM to air quality

Besides national PM emissions (primary aerosols), three other source categories contribute significantly to national aerosol concentrations in the Netherlands. SO_2, NO_x and NH_3 emissions form through atmospheric reactions in the air secondary aerosols. Furthermore, both primary and secondary aerosol can stem from Dutch sources or foreign sources.

Figure 4.1 illustrates the contributions of each source category to the national aerosol concentrations in the Netherlands in 1995. It clearly shows that the importance of primary Dutch aerosols, being monitored in the Dutch PER, is limited to approximately 10%. Dutch secondary aerosols, although stemming from a much larger amount of emissions (about 15 times more weight than PM_{10}), contributes approximately the same share to national aerosol levels.

Primary natural aerosols contribute a substantial quarter to national aerosol concentrations. Natural aerosols stem from outside and within the country. Not all emissions in this category are completely natural and outside the influence of policy measures. For instance semi-natural emissions from land-use fall in this category. The report will treat this subject in more detail in Chapter 5 Analysis of strengths & weaknesses.

Furthermore, it should be noted that the Netherlands also exports a substantial share of its emissions to neighbouring countries. These areas are partly dependent on Dutch emission mitigation, like the Netherlands is dependent on their mitigation efforts.

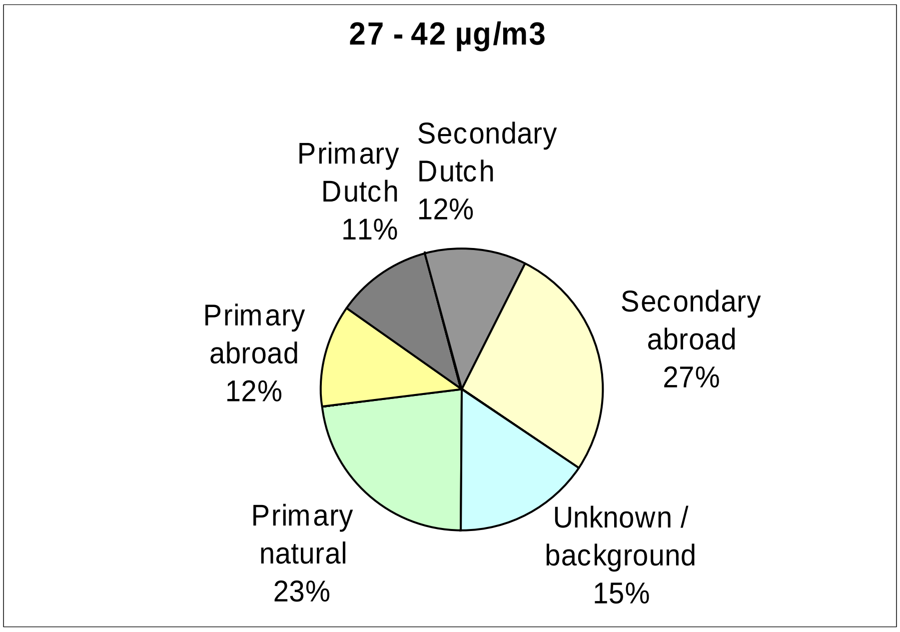

Figure 4.1 Estimate of the annual average PM$_{10}$ contributions of various sources to aerosol levels in the Netherlands [ref. 4].

4.3 International comparison

4.3.1 Emission monitoring systems

The Dutch emission monitoring in general and that of Particulate Matter in particular is good and stands internationally on a relatively high level. The collective estimations of sources based upon the proportionality of emissions with activities and emission intensities are comparable with those of other countries in terms of methodology and detail of data.

A special feature of the Dutch PER that occurs in only a few other countries is the use of individual reporting of large companies for estimations of the industrial emissions. This approach has the advantage of connecting environmental policy on different levels ranging from environmental regulation of companies to national emission ceilings. In this sense, this consistent approach where each involved actor has to carry its responsibility, is sophisticated and has to be preferred above top-down estimation methods. However, this does not mean that this system produces the most accurate national emission estimates. In order to do so, the system should be implemented and function correctly. This will be the subject of analysis in the chapter 5. Analysis of strengths & weaknesses.

Furthermore, the quality of a top-down emission estimation can be more accurate than that of a bottom-up estimation. Emissions of some pollutants, e.g. CO_2, emissions, which can be estimated well on the basis of product or fuel properties, can be estimated more precisely in a top-down approach. However, when process condition related emissions from e.g. NO_x or PM are monitored, bottom-up estimation by individually measured and reported emissions is potentially more accurate.

The general features of the Dutch PER are such that a more thorough international methodological analysis of the monitoring of Particulate Matter is not justifiable in the context of the present project.

The quality of the Dutch emission monitoring in general and that of Particulate Matter in particular is good and internationally on a relatively high level.

4.3.2 PM emission profiles

Figure 4.2 illustrates the sector contributions to PM_{10} in 2001 for the Netherlands, EU15 and AC10 countries respectively. In EU15, PM_{10} emissions are dominated by sectors including road transport, industry and ‘other’ (which is primarily fuel combustion in the residential sector).

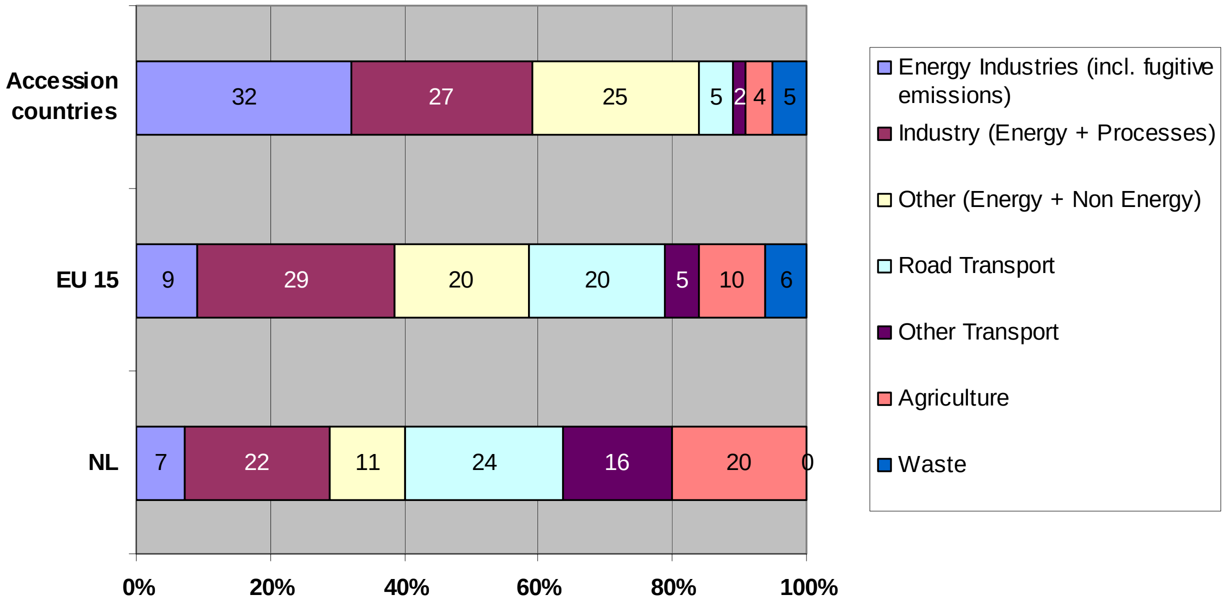

Figure 4.2 Netherlands, EU 15 and Accession country sector contribution to PM_{10} in 2001 (CAFÉ, 2003).

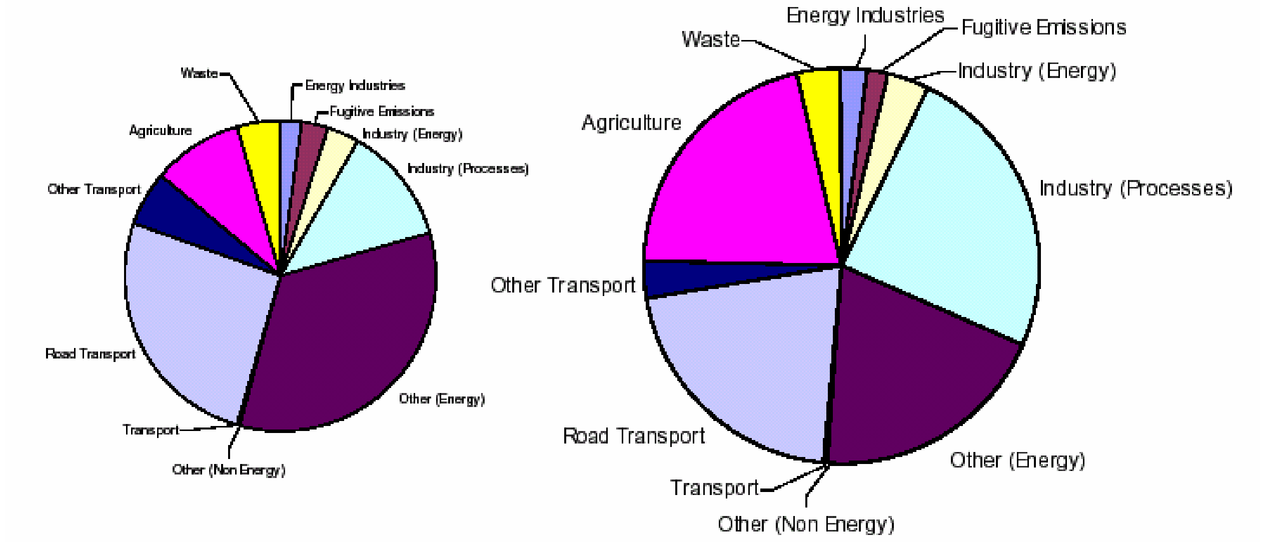

Figure 4.3 Emissions of $PM_{2.5}$ (left) and PM_{10} (right) by sector, France 2000 (CAFÉ, 2003).

In the Accession countries, the largest sectoral contribution of PM_{10} emissions comes from the energy industries sector, with only a small contribution from road transport. This difference is probably due to smaller vehicle fleets in Accession countries, the greater relative use of solid fuels in comparison to natural gas in power generation, and the less wide use of effective abatement technologies in the power generation sector. With state-of-the- art abatement equipment installed, this sector is only of minor importance relative to other emission sources. (CAFÉ, 2003). The difference between the Netherlands and EU-15 is interesting with relatively large contributions by 'other transport' (high activity levels of ships and off-road vehicles in agriculture) and 'agriculture' (relatively high activity levels) and lower contributions for industry and 'other' (other being mostly construction and consumers) due to a high share of natural gas combustion resulting in relatively low combustion emissions.

Official $PM_{2.5}$ inventories are scarce in Europe because the directive focused on PM_{10}. In the EU Draft position paper on PM (CAFÉ, 2003) France is presented as an example as it had one of the more complete inventories. The sector breakdown for $PM_{2.5}$ and PM_{10} emissions in 2000 for France is shown in Figure 4.3. The PM_{10} emission total is approximately twice the size of the $PM_{2.5}$ inventory, which is represented by the relative area of the two figures. For PM_{10}, the industry and agricultural fractions are much more significant, relative to other sectors, illustrating the significant sectoral differences between the size fractions.

Differences of PM profiles between the Netherlands and Europe are well explainable on headlines by structural and economic differences.

4.4 Importance of monitoring methodologies

Four main types of emission sources with each their specific monitoring methodology can be distinguished within the Dutch PM emission monitoring process:

1. Large individual sources;
2. Collective industrial sources;
3. Area sources;
4. Natural sources.

Emissions from each source type are being estimated with quite different monitoring methodologies, each having their own merits with respect to measurement, methodology and completeness of sources. Therefore, it is important to distinguish them in a first prioritisation.

The first three types of monitoring methodologies are being applied within the framework of the Dutch PER [ref. 34]. The fourth, the emission estimation of natural sources has been conducted by non-regular measurements and studies as a basis for air quality modelling and is not part of the annual Dutch PER.

Table 4.2 presents the Dutch PM_{10} emissions for each source type for the years 1995 and 2001, both in absolute and relative terms, as monitored by the PER in 2003 [ref. 49].

Table 4.2 PM_{10} emissions by group of sources that use each a different type of monitoring methodology for the years 1995 and 2001 [source PER 2003, ref. 49].

Type of monitoring methodology	**Source type**	**1995**	**2001**	**1995**	**2001**
		[kton]	**[kton]**	**[national share]**	**[national share]**
Large individual sources	Process	12	5	19%	11%
	Combustion	7	2	11%	3%
Collective industrial sources	Process & Combustion	5	6	8%	12%
	Additional Fugitive	3	3	4%	6%
Subtotal industry [1]		**26**	**15**	**42%**	**32%**
Area sources	Traffic	22	19	36%	40%
	Agriculture	10	9	16%	20%
	Households	4	4	7%	8%
Natural sources		n.e.	n.e.		
Total		**61**	**48**	**100%**	**100%**

[1] including Energy supply sector and Trade & Services

n.e. = not estimated

The collectively estimated area sources contribute in 1995 and 2001 almost 60% to 70% respectively of the national PM emissions and stem from three main sectors, being in order of importance Traffic, Agriculture and Households. The emissions of these sectors have decreased slightly or have stabilised over the period 1995-2001. Their shares in the national total have increased substantially due to the decreasing emissions in industry.

Total industrial emissions (including the Energy supply sector and Trade and Services) contribute over 26 kton or 42% in 1995 and 15 kton or 32% in 2001 to national PM emissions. The two years represent two different situations with respect to monitoring of industrial emissions. This will be described in detail in the next paragraph.

The individually reported industrial emissions can be split into process and combustion emissions, where the first always need specific estimation methods and the latter can be estimated with relatively general methods. Both had substantial shares in the national total in 1995. Both the individually reported process and combustion emissions have been reduced substantially in the period up to 2001.

Logically, both source categories appear also in the collectively estimated industrial emissions. This collectively estimated part has relatively increased in the same period, but is hardly compensating the decrease in individually reported emissions, resulting in a reported decrease of industrial PM emissions of 10 kton over the period 1995-2001, which is in fact more than one third.

Finally, additional fugitive emissions contribute another 3 kton to industrial emissions. These estimates concern factory building emissions which are based upon the estimates in the Haskoning report. These estimates are not updated annually.

Industry, trade and services account for one third of national PM emissions. This part of the emissions is (direct or indirect) largely determined by individual registration. Transport contributes 40%, agriculture 20% and households less than 10%. Emissions from these sources are estimated collectively.
Trend analysis over the period 1995-2001 indicates that priority should be put on the analysis of the strong decrease of emissions from certain large individual sources and the collective estimation of industrial emissions that is largely based upon data from these large sources.

5. Analysis of strengths & weaknesses

5.1 Anthropogenic sources

In Table 5.2 the PM_{10} emissions for different sources and sectors are given. The sectors industrial (includes storage and handling and power production), traffic and transport, agriculture, households and construction are listed with their subsectors and corresponding sector codes (NACE). For each subsector the PM_{10} emissions for 1995 as well as the PM_{10} emission estimates for 2001 are presented with their relative contribution to the total national PM_{10} emission.

Also the estimation method used on establishing this PM_{10} emission value is described. The uncertainty is indicated qualitatively in terms of monitoring methods A to E and listed in uncertainty percentages, which mean that with 95% certainty it can be expected that the given PM_{10} emission can range from half of it towards twice the value, i.e. the 95% confidence interval. The national contribution multiplied by the uncertainty results in a priority percentage. Large and uncertain emissions are given priority upon small and / or certain emissions.

Industry / the companies
The PM_{10} emissions from industrial activities contribute with 14 kton almost 30% to the national total PM_{10} emissions. This PM_{10} emission is composed by a large diversity of companies and activities like food production, oil refining, manufacturing of organic chemicals, fertilizers and building materials and glass, primary metallurgical companies, metal working, storage and handling and public power plants.

The PM_{10} emissions from the food producing companies are more than 2 kton and are emitted from various sources mainly regarding drying, among which the green crop driers, grain, potatoes and dairy are dominant. Another important source is the pet food industry. These PM_{10} emissions have a uncertainty of 100%. The oil refineries have a PM_{10} emission of nearly 3 kton and also an uncertainty of 100%. Both these sectors should be subject to investigation on improvement of their emission data when assessing the quality of national PM_{10} emissions.

The same can be mentioned for the manufacturing of organic chemicals and the fertilizer production. Manufacturing of organic chemicals causes more than 1.5 kton of PM_{10} emissions with a high uncertainty of 200%. Fertilizer production is with an uncertainty in PM_{10} emission data of 200% and a small number of manufacturers also likely to be a candidate for improving the PM_{10} emission data. The process emissions that are monitored on company level are estimated to be of class E with an uncertainty of 200%.

Manufacturers of building materials and glass have PM_{10} emissions of more than 1 kton from processes, combustion and fugitive sources. The uncertainty is considered to be class B or 100%.

Primary metallurgical processes are major sources of PM_{10} emissions and emitted more than 1 kton of PM_{10} emissions in 2001. For combustion no data is available for 2001 but from the 1995 data with 0.8 kton is can be seen that these PM_{10} emissions could be significant. The uncertainty is with 100%, class D, relatively high and should be focus of discussion when assessing quality of national PM_{10} emissions totals.

Metal working is only of minor importance when considering PM_{10} emissions. The PM_{10} emissions are based on emission factors and production data or data on the value added by sub activity. The uncertainty in the PM_{10} emissions is considered high but since the metalworking sector has no importance to national total PM_{10} emissions there is no priority to improve these emission data.

Storage and handling causes mostly fugitive PM_{10} emissions. These emissions are only partly monitored and for the most (90%) collectively estimated. The level of uncertainty is classified to be of class E and considered high, 200%. Together with a total PM_{10} emission of 2.5 ton the sector is considered to be of priority when improving the quality of the national PM_{10} emissions.

In the public power sector the PM_{10} emissions are caused by the use of coal in coal-fired power plants. In these plants the PM_{10} emissions from combustion are determined with a low uncertainty of 50% while the smaller fugitive PM_{10} emissions are considered having a high uncertainty of 200%.

Factory buildings

Due to concern caused by the relatively high ambient levels of PM_{10} in the Netherlands several additional studies to missing PM sources have recently been performed. For the larger part, the results of these studies have not yet been incorporated into the ER since they are not fully validated yet. The main addition consists of an estimate for fugitive emissions from small industries of 2.5 kton. These diffuse factory building emissions are used as reported by Haskoning [ref. 19]. These are calculated from measurements of exposure concentrations for Arbo (Working place safety) and the total ventilation flow. The idea behind this estimate was a potentially considerable collective contribution from these sources although emission from individual companies might appear small and are hence neglected otherwise.

These emissions are distributed over the different subsectors. However, it is very well possible that a part of these emissions are counted double because some individually registered companies report hall emissions. This issue could be addressed in an update of the estimate of diffuse industrial emissions, which could be useful every 5 years [Personal communication RIVM, Peek].

Traffic and Transport

One of the largest sources of PM_{10} emissions in the Netherlands is traffic and transport. With almost 20 kton this sector contributes to more than 40 % of national PM_{10} emissions in 2001. The PM_{10} emissions are generated using emission factors for various different types of vehicles. Major sources are diesel trucks (nearly 5 kton) followed by passenger cars fueled with diesel (nearly 2.5 kton) and other mobile diesel engines (more than 3.7 kton).

International comparison of 1995 Emission Factors indicated that Dutch Emission Factors for diesel cars are relatively high, resulting in approximately 1 kton higher emissions. Since the year 2000, the time at which CEPMEIP (Coordinated European Particulate Matter Emission Inventory Program, [ref. 43]) was developed, new information has been added to both the COPERT (COmputer Programme to calculate Emissions from Road Transport, [ref. 30]) programme and the Dutch emission estimation methodology. Notably for the COPERT model, this has resulted in a more refined approach that gives significantly more accurate results compared to previous versions of the module. Based on currently available information, a new however preliminary comparison between the Dutch methodology and COPERT can be made. Table 5.1 shows the calculation results for the 1998 Dutch situation as derived aggregated emission factors (in mg/km).

From this table it can be concluded that the past situation in which the Dutch methodology gave twice as high results in some cases no longer exists. In fact, both methods produce about the same results if one looks at more recent reference years. There can still be differences in vehicle mileages though but it is at present not known to what degree these are significant.

No longer is there an urgent need for comparison of COPERT and the Dutch methodology.

The Dutch Emission Factors are updated annually and published in public database of Statistics Netherlands on internet (Statline). The only difficulties for international comparison are differences in vehicle categories and (actual) differences in driving style and vehicle park.

Rail wear is included in the PER as erosion of overhead wires, which is important for heavy metals. Rail wear of wheels and rails is believed to be significant in terms of PM_{10}, but is not included in the PER. This source is estimated to be in the order of 1 kton (± 0.5 kton).

Table 5.1 Comparison of emission factors [mg/km] for diesel fuelled cars by type of traffic form Statistics Netherlands (CBS, Statline) for two years and COPERT.

Diesel fuelled car type	**Urban**			**Rural**			**Highway**		
	CBS '95	**CBS '98**	**COPERT**	**CBS '95**	**CBS '98**	**COPERT**	**CBS '95**	**CBS '98**	**COPERT**
Passenger	259	180	194	141	94	53	151	111	102
Light duty	460	316	416	247	174	290	253	186	376
Heavy duty	1040	805	958	585	450	500	440	340	358

Inland and ocean shipping also contribute to this significant emission from various mobile sources. International shipping is included in the monitoring, but is not (all) reported. In the national reporting, both national and international inland shipping is reported, while the international reporting formats NFR and CRF only include national inland shipping, being one third of 2 kton. More importantly, sea going ships are not reported in the international reports, and only partly (almost 2 kton) in the national reports. The emissions from shipping on the national continental shelf, being approximately 8.5 kton, are not reported. With respect to air quality, this emission is important. Emissions from the international territory could contribute as well substantially. This applies not only for PM but also for NO_x and SO_2.

The level of accuracy of determination of PM_{10} emissions of the traffic and transport activities is considered as high. It can be seen in the table that all fuel related emissions are assumed to be of class C or D and range from 35% to 50% uncertainty. All non-fuel related PM_{10} emissions from sources as wear from road, tires and breaks are more uncertain however. These are assumed to be of an uncertainty level of D or even E having an uncertainty of 100%.

A shift of focus by measuring $PM_{2.5}$ or even PM_1 combustion emissions from traffic and transport will be of no effect on PM emissions since most of the PM emission consists of smaller particles [Personal communication TNO Automotive, Gense].

Agriculture

The PM_{10} emissions of agriculture contribute with almost 10 kton a 20% to the national PM_{10} emission totals. The largest source of PM emissions is found in animal housing. These emissions are supposed to be accurate [Chardon, Alterra & Peek, RIVM] and based on measurements, which is also to be seen in the table where the uncertainty is assumed to be of class C and estimated to be 50%. But because of the size of the source, animal housing is nevertheless considered to be of priority when improving the quality of the national PM_{10} emissions.

Private Households

The PM_{10} emissions of private households attribute with almost 3.7 kton to almost 8% of national PM_{10} emission totals. Woodstoves, fireplaces (1.8 kton) and smoking (1.5 kton) are major sources of PM_{10} emissions where smoking is less certain (100%). Other sources as heating and hot water, fireworks, and activities like charbroiling and candles are minor sources. All of the PM_{10} emission data of the private households is generated using emission factors and activity data. The uncertainty ranges from medium to high, class C and D and from 50% - 100%.

Construction

Construction activities form with an annual PM_{10} emission of nearly 1.2 kton a relative minor contribution to national total PM_{10} emissions. These emissions are estimated by assessing the added value of the activities in relation to fixed emission factors. The uncertainty of these PM_{10} emissions are considered to be high and of class D or E and ranging from 100% for diffuse emissions to 200% for other fuel related and process PM_{10} emissions. Improvements can be made by making the PM_{10} emission estimates more dependent on activity rates [Personal communication RIVM, Peek].

Priorities

Improvement of the quality of the total national PM_{10} emission can be achieved by improving the quality of the emission data of these sectors with the highest contribution and / or uncertainty. Multiplying the uncertainty in the PM_{10} emission and their relative contribution to the national totals gives a priority setting. This way large and uncertain emissions are given priority upon small emissions with a large uncertainty. From Table 5.2 it can be seen that when focusing on quality of national PM_{10} emissions the following sources and sectors should be given priority:

1. animal housing
2. process emissions from primary metallurgical processes
3. other mobile sources fueled with diesel
4. oil refineries
5. storage and handling (company and collective)
6. road transport (diesel)
7. manufacturers of fertilizer
8. companies in the food industry

It is interesting that the interviewed persons from different sectors, hardly mentioned missing sources. The more or less all conveyed that from their sector perspective, they consider the PER for Particulate Matter as being quite complete.

Miscellaneous

The monitoring methodologies are published in reports for all sectors. The used data with respect to activities are based upon data from known and mostly public sources. The EF data are not always published. Here lies a dilemma on actuality and quality versus transparency and accessibility. Nevertheless, EF should be **publicly referable**.

Furthermore, the PER seems to have the policy to monitor **only legal** emissions [personal communication L. Brandes, RIVM]. However, arguments that illegal emissions can not be known or can not be controlled are only partially valid. In fact, natural emissions can not be controlled either, and for instance the emissions from discharges from ships ('bilgewater') are not permitted. Both emission sources, however, are included in the PER. The same could therefore apply for emissions from illegal fires. Illegal emissions can be very important to judge air quality and should therefore be monitored, to be included e.g. at least as a memo-item.

Another issue is the **composition** of PM and the relation with heavy metals. Up to now, monitoring of PM is completely separated from that of heavy metals. For a consistent monitoring in the long run, a consistent and preferably integrated approach for heavy metals and PM should be developed.

The European definition of PM as dry solid material without condensables makes measurement with different measurement methods and international comparison tricky. For combustion emissions, **condensables** can be in the order of magnitude of half of PM_{10} if 10% of Non-Methane Volatile Organic Compounds emissions is assumed to become condensated PM.

Finally, for a number of emission sources which might have substantial PM emissions, it is **unclear** to which extend these are included in the present (individual) PER:

- flares in oil production and refineries;
- wood combustion in coal fired power plants as a CO_2 mitigation measure.

Animal housing is of most priority. Although the current PM_{10} emission data on these sources is considered to be of a relative low uncertainty (D, 50%) it attributes significant to the national total PM_{10} emission (20%). Improving the PM_{10} emission data of process emissions from **primary metallurgical processes** is second most important. The PM_{10} emission data of other **mobile sources fueled with diesel** (mostly agricultural) and **diesel road transport** to some lesser content also can also enhance quality. **Rail wear** of wheels and rails is believed to be a significant source with an estimated emission of 1 kton, but is not included in the Emission Monitor. The emissions from **ocean shipping on the national continental shelf**, being approximately 8.5 kton, are not reported.

The sector **fertilizer production** is with a high uncertainty in PM_{10} emission data and a small number of manufacturers also likely to be a candidate for improving the PM_{10} emission data. The same can be mentioned for companies in the **food industry, manufacturers of organic chemicals and oil refineries.**

Factory building emissions are based upon a single estimation which should be updated e.g. every 5 year. Part of these emissions is possibly double counted if companies individually report these emissions.

The monitoring methodologies are published in reports for all sectors. The EF data are not always published but should be publicly referable.

Table 5.2 Overview of PM_{10} emissions, characteristics and uncertainties for main sectors and sources in the Netherlands for the year 2000 [PER 2003].

Sector / emission source	**Sub sector / Process / Fuel**	**Sector code [NACE[1]]**	**PM_{10} 1995 [ton]**	**PM_{10} 2001 [ton]**	**National contribution 1995 [%]**	**National contribution 2001[%]**	**Estimation method**	**Documentation**	**Activity unit**	**Activity level**	**Derived EF [ton/unit activity]**	**PM concentration [mg/Nm^3]**	**Uncertainty [qualitative]**	**Uncertainty [%]**	**National priority [%]**
Companies															
Food	Process	15/16	1570	800	2.6%	1.7%	Company	1	-				D	100%	2.6%
Food	Combustion	15/16	170	0	0.3%		Company	1	-				D	100%	0.3%
Food	Fugitive	15/16	90	90	0.1%	0.2%	EF	2	Production or Value Added by sub-activity				D	100%	0.1%
Food	Process	15/16	1190	1620	1.9%	3.4%	Collective	4	Production or Value Added by sub-activity				D	100%	1.9%
Food	Combustion	15/16	10	10	0.0%	0.0%	Collective	5	TJ fuel consumed by sub-activity (minus Industry reported part)				B	20%	0.0%
Oil Refineries	Process	232	160	1680	0.3%	3.5%	Company	1	-				D	100%	0.3%
Oil Refineries	Combustion	232	4620	1260	7.5%	2.6%	Company	1	-				D	100%	7.5%
			0	0											
Organic Chemicals	Process	24	1100	470	1.8%	1.0%	Company	1	-				E	200%	3.6%
Organic Chemicals	Combustion	24	440	0	0.7%		Company	1	-				D	100%	0.7%
Organic Chemicals	Process	24	60	100	0.1%	0.2%	Collective	3	Production or Value Added by sub-activity				E	100%	0.2%
Organic Chemicals	Combustion	24	20	0	0.0%		Collective	5	TJ fuel consumed by sub-activity (minus Industry reported part)				B	20%	0.0%
Fertilizer	Process	24	1580	370	2.6%	0.8%	Company	1	-				E	200%	5.1%
Fertilizer	Combustion	24	10	10	0.0%	0.0%	Company	1	-				D	100%	0.0%
Fertilizer	Process	24	70	0	0.1%		Collective	3	Production or Value Added by sub-activity				E	200%	0.2%
Building Mat. & Glass	Process	261-8	980	280	1.6%	0.6%	Company	1	-				D	100%	1.6%
Building Mat. & Glass	Combustion	261-8	90	0	0.1%		Company	1	-				D	100%	0.1%
Building Mat. & Glass	Fugitive	261-8	1040	1040	1.7%	2.2%	EF	2	Production or Value Added by sub-activity				D	100%	1.7%
Building Mat. & Glass	Process	261-8	320	180	0.5%	0.4%	Collective	3	Production or Value Added by sub-activity				D	100%	0.5%
Building Mat. & Glass	Combustion	261-8	60	20	0.1%	0.0%	Collective	5	TJ fuel consumed by sub-activity (minus Industry reported part)				B	20%	0.0%

Sector / emission source	Sub sector / Process / Fuel	Sector code [NACE[1]]	PM_{10} 1995 [ton]	PM_{10} 2001 [ton]	National contri-bution 1995 [%]	National contri-bution 2001[%]	Estimation method	Docu-menta-tion	Activity unit	Activity level	Derived EF [ton/unit activity]	PM con-cen-tration [mg/Nm^3]	Uncer-tainty [quali-tative]	Uncer-tainty [%]	Na-tional prio-rity [%]
Primary Metallurgical	Process	231, 27	4830	700	7.9%	1.5%	Company	1	-				D	100%	7.9%
Primary Metallurgical	Combustion	231, 27	810	0	1.3%		Company	1	-				D	100%	1.3%
Primary Metallurgical	Fugitive	231, 27	350	350	0.6%	0.7%	EF	2	Production or Value Added by sub-activity				D	100%	0.6%
Primary Metallurgical	Process	231, 27	140	40	0.2%	0.1%	Collective	3	Production or Value Added by sub-activity				D	100%	0.2%
Metal Working	Process	28-35, 4531	10	0	0.0%		Company	1	-				E	200%	0.0%
Metal Working	Fugitive	28-35, 4531	260	260	0.4%	0.5%	EF	2	Production or Value Added by sub-activity				D	100%	0.4%
Metal Working	Process	28-35, 4531	400	350	0.7%	0.7%	Collective	6	Production or Value Added by sub-activity				E	200%	1.3%
Storage & Handling	Fugitive	631	970	330	1.6%	0.7%	Company	1					E	200%	3.2%
Storage & Handling	Fugitive	631	1320	2220	2.1%	4.7%	Collective	3	Ton displaced				E	200%	4.3%
Public Power; Coal-Fired	Combustion	40	360	310	0.6%	0.7%	Company	1					C	50%	0.3%
Public Power; Coal-Fired	Fugitive	40001	170	30	0.3%	0.1%	Company	1					E	200%	0.6%
Other small sources			1660	1561	2.7%	3.3%							E	50%	1.4%
Subtotal Process	Company		10230	4300	16.7%	9.0%	Company							63%	10.5%
Subtotal Process	Collective		2180	2290	3.6%	4.8%	Collective							68%	2.4%
Subtotal Combustion	Company		6500	1580	10.6%	3.3%	Company							73%	7.7%
Subtotal Combustion	Collective		90	30	0.1%	0.1%	Collective							14%	0.0%
Subtotal Fugitive	Company		1140	360	1.9%	0.8%	Company							173%	3.2%
Subtotal Fugitive	Collective		3060	3960	5.0%	8.3%	Collective							94%	4.7%
														50%	1.4%
Subtotal Companies			**24860**	**14081**	**40.5%**	**29.6%**								**36%**	**14.5%**

Sector / emission source	Sub sector / Process / Fuel	Sector code [NACE[1]]	PM_{10} 1995 [ton]	PM_{10} 2001 [ton]	National contri-bution 1995 [%]	National contri-bution 2001[%]	Estimation method	Docu-menta-tion	Activity unit	Activity level	Derived EF [ton/unit activity]	PM con-cen-tration [mg/Nm^3]	Uncer-tainty [quali-tative]	Uncer-tainty [%]	Na-tional prio-rity [%]
Traffic & Transport															
Road transport	Gasoline		55	33	0.1%	0.1%	EF	7	Fuel (TJ)	5281	1.04E-02		C	50%	0.0%
Road transport	Diesel		6774	4994	11.0%	10.5%	EF	7	Fuel (TJ)	109361	6.19E-02		D	50%	5.5%
Road transport	LPG		4	3	0.0%	0.0%	EF	7	Fuel (TJ)	1136	3.45E-03		D	50%	0.0%
Passenger cars	Gasoline		1006	644	1.6%	1.4%	EF	7	Fuel (TJ)	167191	6.02E-03		C	35%	0.6%
Passenger cars	Diesel		3721	2477	6.1%	5.2%	EF	7	Fuel (TJ)	52145	7.14E-02		C	35%	2.1%
Passenger cars	LPG		63	28	0.1%	0.1%	EF	7	Fuel (TJ)	26504	2.37E-03		C	35%	0.0%
Inland shipping	Diesel		1840	2186	3.0%	4.6%	EF	7	Fuel (TJ)	36551	5.03E-02		D	50%	1.5%
Seagoing ships	Marine diesel oil		404	434	0.7%	0.9%	EF	7	Fuel (TJ)	3888	1.04E-01		D	100%	0.9%
Seagoing ships	Heavy fuel oil		1148	1307	1.9%	2.7%	EF	7	Fuel (TJ)	9844	1.17E-01		D	100%	2.7%
Other mobile sources	Gasoline		8	8	0.0%	0.0%	EF	7	Fuel (TJ)	572	1.36E-02		D	100%	0.0%
Other mobile sources	Diesel		3870	3706	6.3%	7.8%	EF	7	Fuel (TJ)	33806	1.14E-01		D	100%	6.3%
Other mobile sources	Kerosene		154	176	0.3%	0.4%	EF	7	Fuel (TJ)	8699	1.77E-02		D	100%	0.3%
Tyre wear			643	757	1.0%	1.6%	EF	8	Wear (ton)	12857	5.00E-02		E	100%	1.0%
Break wear			1115	1313	1.8%	2.8%	EF	8	Wear (ton)	22290	5.00E-02		E	100%	1.8%
Road wear			1016	1196	1.7%	2.5%	EF	8	Wear (ton)	20318	5.00E-02		E	100%	1.7%
Rail overhead wire wear			7	7	0.0%	0.0%	EF	9	Wear (ton)	35	2.00E-01		E	100%	0.0%
Subtotal			**21827**	**19269**	**35.5%**	**40.4%**								**26%**	**9.4%**
Agriculture		**A.1**													
Animal housing		A.1.20	9009	8959	14.7%	18.8%	EF	10	Animal places (multiple)				C	50%	7.3%
Fodder supply		A.1.20	90	90	0.1%	0.2%	EF	10	Fodder (multiple)				D	100%	0.1%
Harvesting, fertilizers, pesticides		A.1	287	287	0.5%	0.6%	EF	10	Various (multiple)				D	100%	0.5%
Combustion and heating		A.1	150	90	0.2%	0.2%	EF	11	Fuels (GJ)				C	50%	0.1%
Subtotal			**9536**	**9426**	**15.5%**	**19.8%**								**47%**	**7.4%**

Sector / emission source	**Sub sector / Process / Fuel**	**Sector code [NACE[1]]**	**PM_{10} 1995 [ton]**	**PM_{10} 2001 [ton]**	**National contri-bution 1995 [%]**	**National contri-bution 2001[%]**	**Estimation method**	**Docu-menta-tion**	**Activity unit**	**Activity level**	**Derived EF [ton/unit activity]**	**PM con-cen-tration [mg/Nm^3]**	**Uncer-tainty [quali-tative]**	**Uncer-tainty [%]**	**Na-tional prio-rity [%]**
Private Households		**N.A.**													
Wood stoves, fire places			1906	1775	3.1%	3.7%	EF	12, 13	Wood, Waste (TJ)	9837	1.94E-01		C	50%	1.6%
Heating and hot water			329	293	0.5%	0.6%	EF	14	Fuels (TJ)	734430	4.48E-04		D	100%	0.5%
Smoking			1682	1533	2.7%	3.2%	EF	15	Cigarettes, cigars				D	100%	2.7%
New Year Fireworks			150	90	0.2%	0.2%	EF	16	Fireworks (kton)	8.2	1.83E+01		C	50%	0.1%
Other (candles, charbroiling)			3	3	0.0%	0.0%	EF	17, 18	Meat, candles				D	100%	0.0%
Subtotal			**4069**	**3694**	**6.6%**	**7.8%**								**48%**	**3.2%**
Construction		**F.45**													
Diffuse dust emissions			1004	1180	1.6%	2.5%	EF	19	VA	76940	1.30E-02		D	100%	1.6%
Other fuel related			97		0.2%	0.0%	EF	20					E	200%	0.3%
Other process			7	0.4	0.0%	0.0%	EF	20					E	200%	0.0%
Subtotal			**1108**	**1180**	**1.8%**	**2.5%**								**92%**	**1.7%**
TOTAL			**61400**	**47650**	**100.0%**	**100.0%**								**19%**	**19%**

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[1] NACE is a pan-European classification system that groups organisations according to their business activities.

Notes Table 5.2

The following definitions of the emission quality classification have been used:

A. A figure based upon a large number of measurements of representative sources .
B. A figure based upon measurements of sources partly representative for a part of the sector.
C. A figure based upon a few measurements, complemented with estimates based upon technical knowledge of the process.
D. A figure based upon a small number of measurements, complemented with estimates based upon assumptions.
E. A figure based upon technically founded calculations on the basis of a number of assumptions.

References:

1. Emission data are self-reported by industry; Previously, a variety of methods, ranging from simple emission factors-based approaches (e.g. from various TNO manuals) to extensive use of specific monitoring data was used; Currently used methodologies are not reported anymore; No assurance of completeness of source coverage and quality of estimates; Source: Annual Environmental Reports (MJV) collected and processed by various members of the Taskforce ENINA; Documented at: http://dm.milieumonitor.net/pls/portal30/docs/FOLDER/ERCMETADATA/INDUSTRIE_INDIVIDUEEL_ERILUCHT.HTM
2. Emission data are intended to account for previously neglected industrial emission sources; Data are prepared by various members on the Taskforce ENINA and the estimates are based on: Kimmel, J.P.F., Diffuse emissies van fijn stof door (semi-)industriële activiteiten, Haskoning, februari 2000
3. Emission data are estimated by various members of the Taskforce ENINA (CBS); Several methodologies (e.g. extrapolation of self-reported data from indus-try and estimation with emission factors) are used depending on the activity; Methodology is documented at: http://dm.milieumonitor.net/pls/portal30/docs/FOLDER/ERCMETADATA/INDUSTRIE_BIJSCHATTING_PROCES_LUCHT.HTM
4. Emission data are estimated by various members of the Taskforce ENINA; Several methodologies (e.g. extrapolation of self-reported data from industry and estimation with emission factors) are used depending on the activity; Methodology is documented at: http://dm.milieumonitor.net/pls/portal30/docs/FOLDER/ERCMETADATA/INDUSTRIE_BIJSCHATTING_VOED%2BGENOT.HTM
5. Emission data are estimated by the Taskforce ENINA (CBS - E. Zonneveld); Several methodologies (e.g. emission factors) are used depending on the activ-ity; Methodology is documented at: http://dm.milieumonitor.net/pls/portal30/docs/FOLDER/ERCMETADATA/VUURHAARDEN+IN+INDUSTRIE%2C+HUISHOUDENS+EN+OVERIGE.HTM

6. Emission data are estimated by various members of the Taskforce ENINA (RIVM); Several methodologies (e.g. extrapolation of self-reported data from in-dustry and estimation with emission factors) are used depending on the activity; Methodology is documented at: http://dm.milieumonitor.net/pls/portal30/docs/FOLDER/ERCMETADATA/INDUSTRIE_BIJSCHATTING_PROCES_LUCHT.HTM
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5.2 Individually registered sources

The two years 1995 and 2001 represent different situation with respect to monitoring of industrial emissions. In 1995, the PM emissions of more than 300 mainly large companies were registered at technology level, including data on activity levels, emission factors, flows, concentrations etc. The basic data were supplied by the companies themselves and processed and verified by TNO. TNO made a selection of companies that have both a major contribution to and also form a representative part of the emissions of industrial companies. The number of industrial companies was 40,000 while the total number of companies including Trade and Services was 250,000.

In the year 2001, this situation has completely changed. The number of companies that individually register their PM emissions is reduced to approximately 150. The large majority of these companies are obliged by law to report their emissions in annual Environmental Reports. It is not obligatory to include technical information on concentrations, flows and mitigation measures, which makes it hard to externally verify the figures. However, in the new system, the provincial authority is validating the report. The PM emissions of only a limited number of companies are additionally monitored to increase the representativeness and the share in total emissions.

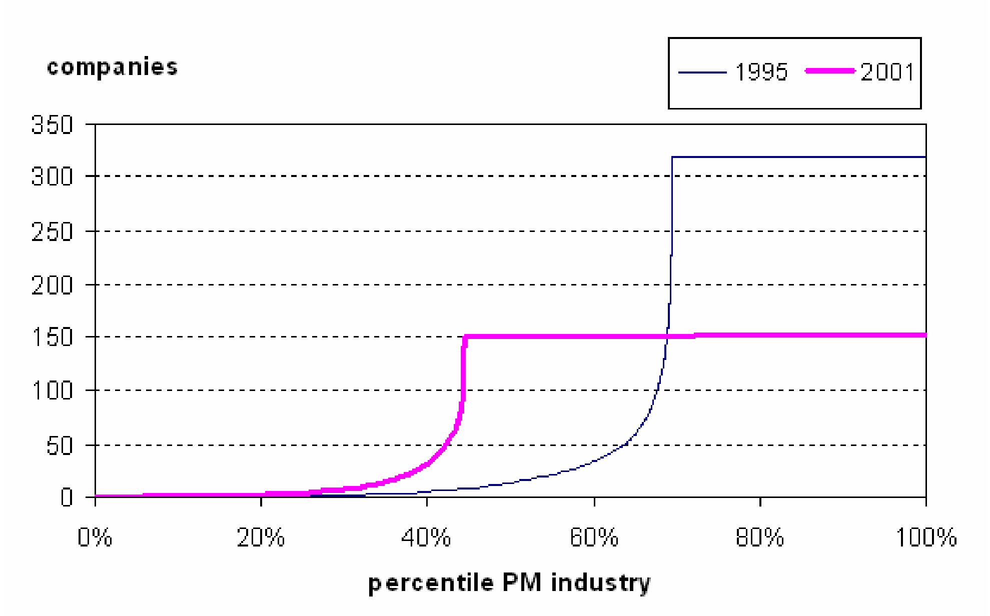

Figure 5.1 Cumulative contribution of individually registered companies to the total industrial PM_{10} *emissions in the years 1995 and 2000.*

The situation with respect to individually monitored emissions is illustrated in figure 5.1. It presents the cumulative PM emissions, ranked from high to low, as a function of the number of companies. It shows that the number of individually registered companies has decreased from 1995 to 2001 from over 300 down to 150. Furthermore, the share of individually registered industrial emissions has decreased from two third to less than half of the industrial emissions.

We will address both issues in the following paragraphs. The decreasing share of individually registered emissions will be discussed in coherence with the accuracy of the reported emission figures. The decreasing number of individually registered companies will be analysed together with the reasons for erroneous registration.

5.2.1 Decreasing individually monitored emissions

The share in total industrial emissions of individually registered emissions is in 2001 much lower than in 1995.

The individually registered emissions of companies are used to estimate the emission factors for each branch. These are being used to estimate collectively the emissions of the other companies within the branch. Various activity data are being used to estimate the emission level of the rest of the branch. Combustion emissions are estimated on the basis of fuel consumption data from Statistics Netherlands. The process emissions are estimated by e.g. the number of employees, the Value Added or the production volume in ton. The combustion emission estimation is a pretty accurate estimation method while the process emission data is less accurate. In almost all cases, collectively estimated emissions from processes are less accurate than the total of individually registered emissions. The collectively estimated industrial emissions add the uncertainty of the activity data used and the representativeness of the emission factor of the individually registered companies to the uncertainty of the total of individually registered industrial emissions. Hence, the increase of the share of collectively estimated industrial emissions has resulted in an increase of the uncertainty of the total emission estimate.

The decrease of the emission share of individually registered companies has resulted in a decrease of the overall confidence.

Finally, it is necessary to conclude that the share of individually registered emissions is decreasing fast due to (alleged) large reductions at large point sources. This means that the collective estimates with their higher uncertainties become more important, resulting in higher overall uncertainties. Therefore it becomes increasingly important to recognise that besides the individual registration as a basis for additional collective estimations, the collective estimation of Small and Medium-sized Enterprises (SME's) contribute substantially to industrial emissions.

This collective estimation could be approached in the same way as the area sources are estimated, on the basis of a mixture of literature and company data, resulting in a consistent trend.

The collective estimation of SME's becomes increasingly important due to the large reductions at large companies and should be modelled after the present area source approach.

5.2.2 Accuracy of individual emission estimates

Besides the share of individually registered emissions, the accuracy of the reported emission figure is of importance for the overall accuracy of the emission assessment.

The impression exists that, with the introduction of Environmental Reports, the accuracy of individual emission estimates has decreased. This has been one of the reasons for the Task force on Energy, Industry and Waste emissions (ENINA) within the organisation of the Dutch PER to refuse to produce a national PM emission number for the years 1999, 2000 and 2001. The estimate of the last year has been repaired in a separate project. In chapter 3.3 PM_{10} assessment methods we will elaborate on the technically feasible ranges of confidence intervals, which vary from 15% to 100% for individually measured sources to 50% to 300% for collectively estimated area sources. Without structural errors, the sum of individually measured emissions can easily have a higher confidence.

The lower accuracy of company emissions results in an increase of the overall uncertainty of individually registered emissions, directly through the contribution of individually registered emissions to the total, but also indirectly since the individually registered emissions are being used to estimate the collective industrial emissions. Hence, the uncertainty of the individual emission estimate propagates to the collective part. For this reason, an improvement of the validation of individually registered emissions is effective and needed.

In principal, the provincial authorities are responsible for the validation of the large company emissions. Improvement of existing guidelines or supporting tools to verify individually reported emissions can increase the quality of validation.

Validation of individually registered emissions at companies can result in very accurate assessments. Therefore, it is potentially effective to improve individual registration to increase the reliability of overall industrial emissions, especially through propagation via the collective estimation.

5.2.3 Decreasing number of individual registrations

Besides the accuracy of the reported emission figure, the selection of companies for individual registration and the correctness of the data processing is of importance for the overall accuracy of the emission assessment.

First we analyse the impact of the decrease in the number of individually registered companies from over 300 down to 150.

Calculations with the formula on error propagation as presented in section 2 Approach show that this can have a moderate effect on the confidence interval of the overall emissions. Assuming no change in uncertainty, a decrease of the number of sources from 300 to 150 leads to a decrease in confidence of (300/150) = 2 ≈ 1.5. For example, a confidence interval of 20% would increase to 30%.

However, analysis of the data set of PM emissions from companies in 1995 and 2001 shows that the difference is not a factor 1.5 but only 1.012. This means that the decrease in the number of individually registered company emissions from 300 to 150 in itself resulted in an increase of uncertainty of less than 2%. This is due to the uneven distribution of emissions, where a small number of companies with large emissions dominate the overall confidence leaving less contribution to the long ‘tail’ of companies with relatively small emissions. This uneven distribution has not changed over the years.

If an average confidence interval of 50% is assumed for each individual emission source (see 3.3.3 Emission measurement methods for PM_{10}), the overall confidence interval of individually registered industrial emissions of the 1995 selection of approximately 300 companies would be 16.7%. The 2001 selection, mostly consisting of companies that are obliged to produce an Environmental Report, would result under the same assumption on uncertainty in overall individually registered emissions with a confidence interval of 16.9%.

It is interesting that, the other way around, increasing the number of registered companies, thus is not a panacea for increasing the accuracy of the national PM emission estimation.

The decrease in the number of individually registered companies is in itself not a reason for a decrease of the confidence; an increase in registered companies will not result in a higher confidence. An increase in registered emissions would increase the confidence.

However, the decrease of the number of registered companies could have affected the representativeness of the individually registered companies for each branch. This will be discussed in the next section.

5.2.4 Branch analysis

The decrease of the number of registered companies over the period 1995-2001 from over 300 down to 150 could have affected the representativeness of the individually registered companies for each branch. Table 5.3 presents the PM_{10} emissions by branch for the years 1995 and 2001. Approximately 40 branches are relevant for PM_{10}. However, only 10 branches are important for PM.

The first 9 branches contribute 80% (2001) to 90% (1995) of the industrial PM emissions. The emissions of the other 30 branches are hardly affected by the individually registered emissions of large companies. This means that the smaller selection of companies has hardly had any effect on the representativeness of companies for the other 30 branches.

In other words, the 9 major branches are dominating the total industrial emissions. Therefore, their quality and accuracy is important.

We see in Table 5.3 that the major contributing branches are changing enormously from 1995 to 2001 with respect to total emission level and contribution of individually registered emissions. Especially the individually registered and total emissions in the Basic metals, Basic chemicals and Fertiliser industry have decreased drastically without any compensation in the collective emission estimate. This suggests that severe mitigation measures have been taken in the complete sector. It is more likely that this is (partly) caused by methodological differences and/or data (processing) errors than by technical measures taken in the plant. This asks for closer investigation.

The presently smaller selection of individually registered companies compared to 1995 has had hardly any effect on the representativeness and the emission estimation of companies within the 30 low emitting branches.
Especially the individually registered emissions in the Basic metals, Basic chemicals and Fertiliser industry are causing suspicion.

Table 5.3 Individually and collectively registered and estimated total PM_{10} emissions and the number of individually registered companies by industrial branch (incl. Services & trade and Construction) for the years 1995 and 2001 [source PER 2003].

Branch	Individual 1995 [ton]	Individual 2001 [ton]	Individual difference [index '95]	Individual 1995 [companies]	Individual 2001 [companies]	Individual difference [index '95]	Collective 1995 [ton]	Collective 2001 [ton]	Collective difference [index '95]	Branch 1995 [national share]	Branch 2001 [national share]
Basic metals	5640	706	-87%	33	17	-48%	497	394	-21%	10%	2%
Refineries	4782	2935	-39%	8	7	-13%	1	0	-52%	8%	6%
Food	1736	804	-54%	73	45	-38%	1285	1719	34%	5%	5%
Fertiliser	1581	383	-76%	8	6	-25%	71	2	-98%	3%	1%
Basic chemicals	1540	466	-70%	49	24	-51%	79	101	27%	3%	1%
Building materials & glass	1064	281	-74%	53	20	-62%	1412	1230	-13%	4%	3%
Storage & handling	971	326	-66%	0	0		1315	2224	69%	4%	5%
Power production	558	360	-35%	13	8	-38%	0	12		1%	1%
Other chemical products	248	205	-17%	10	5	-50%	16	3	-78%	0%	0%
Subtotal	**18120**	**6466**	**-64%**	**247**	**132**	**-47%**	**4676**	**5685**	**22%**	**37%**	**26%**
Other industrial branches	264	193	-27%	71	19	-73%	2958	2888	-2%	5%	6%
Total industry	**18384**	**6659**	**-64%**	**318**	**151**	**-53%**	**7634**	**8573**	**12%**	**42%**	**32%**

5.2.5 Reasons for erroneous registration

The decrease of individually registered emissions is often ascribed to the effect of the limitation of the additional selection of companies by TNO. Due to this limitation, the individually registered companies are, more randomly, selected by the obligation to publish an Environmental Report. This way it is possible that large PM sources are missed in individual registration. But is this true?

Figure 5.2 looks in more detail into the different monitoring methods that lie under the industrial emission estimates. Then it becomes clear that the collective estimates of industrial emissions have not changed much over the years. Distinguished are the collective additional estimation of emissions from high emitting industrial branches, which are based upon emission factors from the individually registered emissions from companies, and the collective estimation of emissions from Small and Medium-sized Enterprises (SME's). It is surprising that the additional collective emission estimation has increased hardly, since some compensation is expected to occur if the number of companies and the coverage of emissions decrease.

This leads (again) to the question what the reason is for the large decrease in individually registered emissions. If the decrease is caused by 'real' reduction of emissions, the picture is consistent. Therefore, an analysis has been made of the impact of the use of the 2001 selection of companies on the 1995 emissions. The resulting emissions are also presented in Figure 5.2 and can be compared easily with the actual 1995 and 2001 emissions. A comparison with the actual 2001 emissions gives an indication of the reduction that has been achieved over the period 1995-2001 in the 2001 selection of companies. The emission reduction that is reported by the companies themselves, amounts to 4 kton or almost 40% emission reduction. This reduction is not directly affected by the number or type of selected companies, since these are kept constant. It is difficult to assess whether the registered emission reduction of 40% over a period of 6 years is realistic, but it seems a high reduction. A more strict validation of emissions according fixed guidelines would be the only structural way to guarantee the quality of emission reports.

A comparison of the 1995 emissions according to the 2001 selection of companies and the real individual 1995 emissions indicate that the difference between 2001 emissions and 1995 emissions stems primarily from changes in the company selection. Changes, as we saw, that are hardly compensated by an increase in collective emissions. The difference in emissions is 8 kton or more than 40% of the 1995 emissions. This indicates that the change in company selection affects the individually registered emissions and thus the total industrial emissions to a high extend. However, the effect will be less if we assume that the missing companies have reduced their emissions to the same degree as the other companies.

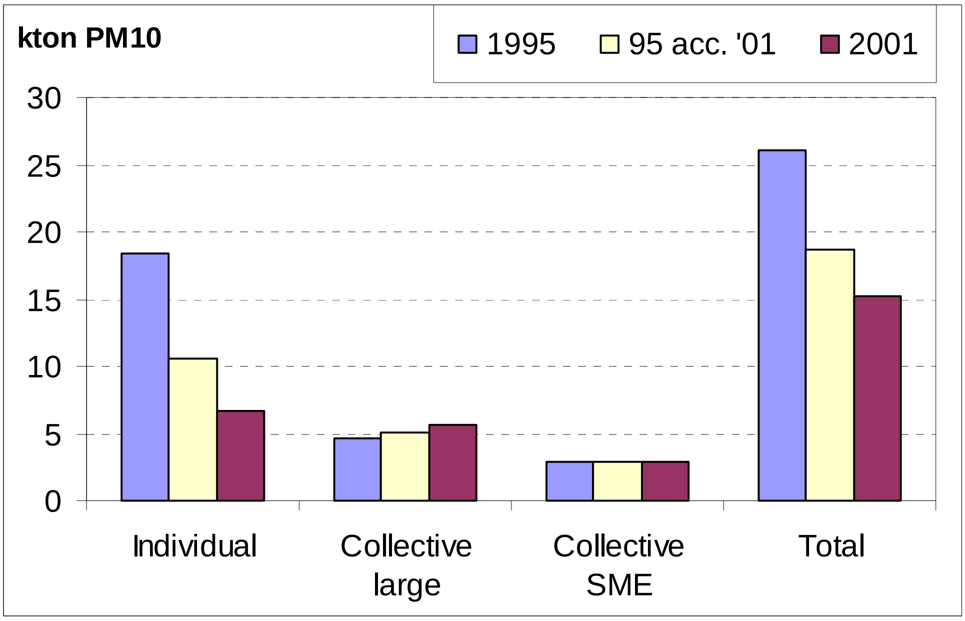

Figure 5.2 Industrial (incl. Services & trade and Construction) PM emission monitoring by source type in the years 1995 and 2001 and in 1995 according to the 2001 selection of companies.

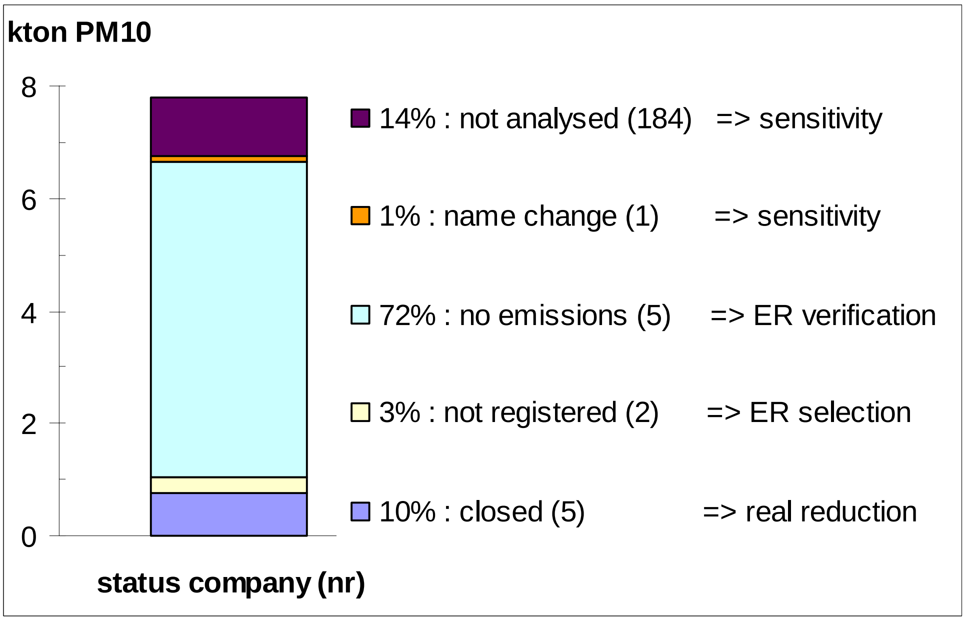

Figure 5.3 The theoretical impact on the 1995 emissions of using the 2001 se-lection of companies presented by the change of monitoring status of the companies, viz. closed, not registered, no PM emission sub-mitted or change of name.

But the question remains whether this impact of the change in company selection is correct or not?

To answer this question, we have to look into more detail what the causes of the differences in company selection are. This in-depth analysis is illustrated in Figure 5.3, where the gap that is caused by using the 2001 selection of companies is presented by change of monitoring status of the companies. With the change in monitoring status we have an indication for the reason of the omission of emissions, e.g. whether a company is closed or not registered, no PM emission is submitted or the company has changed its name. Each cause gives a different understanding of why emissions are missing and moreover, leads to a different interpretation of the missed emissions. If a company is closed, the emission reduction is realistic. If a company is not registered, it has to be compensated in the additional collective estimation of emissions. If simply no emissions have been submitted, we have to be sure that emissions are below the threshold.

Figure 5.3 shows that 10% of the reduction is reliable since it is due to the closure of companies. In contrast with what is often heard, the amount of registered emissions has decreased only with 3% due to a smaller number of selected companies. Hence, the Environmental Reports seem to cover the major sources of PM. This means that, vice versa, increasing the number of companies in itself does not increase the reliability of the present PM emission estimation.

> The impact of a smaller selection of companies due to the introduction of the Environmental Report on the emission coverage is limited in the industrial sectors with high PM emissions. Hence, an increase in the number of monitored companies will not increase individually registered emissions and therefore not result in a higher confidence.

A majority of almost three quarter of the ‘missing’ emissions is lacking in the emission reporting, either in the Environmental Report or the additional emission registration. It is possible that this is correct, however, the trends suggest that it is very unlikely that these large companies have reduced their emissions under the threshold of 10 ton per year.

Moreover, one large company is responsible for 80% of the unreported PM emissions, having reported ‘dust’ in their ER. The company has done this consistently over the last years, however, the data processing has resulted for 2001 in emissions of PM>10 μm and none of PM_{10}. This is in contrast with previous years, where ‘dust’ has been registered as PM_{10}. The company reported a dust emission of 1.5 kton, which means that it reduced the emissions with two third. If we additionally correct for the (assumed 40% reduced) emissions of other missed companies (including not analysed and not registered), we can add in total 3 kton of emissions to the estimate of 7 kton individually registered emissions in 2001, resulting in a total of individual registered industrial emissions of 10 kton. This leads to a corrected total industrial emission of 18 kton instead of 15 kton. This is a correction of 20%.

This important example indicates that the ‘lacking of emissions’ can have two different causes:

1. The data interpretation and processing of the figures in the companies’ Environmental Report executed at FO-I is inconsistent or incorrect;
2. The Environmental Report by the company does incorrectly not mention a figure for dust for the particular year.

The first situation is the most important reason for the missing emissions in this gap analysis. Here, the interpretation and data processing has shortcomings. Up to now, no explicit guidelines on how tot process data have been given by the ministry of VROM to FO-I. In the past, the central data collection unit at TNO checked emissions from FO-I, however, this has been stopped the last years for budgetary reasons. Besides the reintroduction of this crosschecks, a simple standard data processing protocol would suffice to avoid inconsistencies and mistakes. This would decrease the amount of missed emissions substantially.

In the second situation, where the emission reporting itself falls short, the company is responsible. It should be held responsible for incorrect emission reporting by the provincial authority. The functioning of both organisations could be supported and improved, e.g. by (more) explicit monitoring guidelines and protocols and supporting software tools.

Improvement of the data processing of companies’ Environmental Reports could avoid simple mistakes with high emission impacts. Data processing could be improved with relatively simple guidelines and protocols and herewith decrease the share of missed individually registered emissions.

5.2.6 Individual monitoring procedures

Figure 5.4 gives a tentative classification of the emissions from individually registered companies on the basis of the relation with the PM emission threshold as described in the Guidelines on validation of Environmental Reports (‘Handreiking validatie milieujaarverslagen’, [ref. 14]). Here, a class IV emission is a very large emission, characterised by an weight of more than five times the threshold value, thus being larger than 50,000 kg. Class I is the smallest emission, being smaller than 5000 kg (half the threshold value). See also Table 3.2 in Chapter 3. This assessment is tentative since all emissions from one company are summed up and the allowance to lower one class in case the emission objective of the branch has been met, has been ignored.

As has been said in Chapter 3, up to now the exact measurement method to be used for each emission class was not explicitly determined and is presently under discussion. Nevertheless, a comparison can be made with an analysis by Kees Peek (RIVM) of the database of 1995 individually registered emissions. He estimated that, of the individually reported industry emission, about 5% of these emissions are being monitored continuous, about 1 - 2 % of the emissions are based on actual periodical measurements, 5-8 % on old and about 85 % of the reported emissions are estimated to be based on other methods as mass balances and emission factors [Personal communication RIVM, Peek]. Because most of the PM_{10} emission is based on old measurements it is difficult to tell what the effects of new developments in monitoring and mitigation are [Personal communication RIVM, Peek].

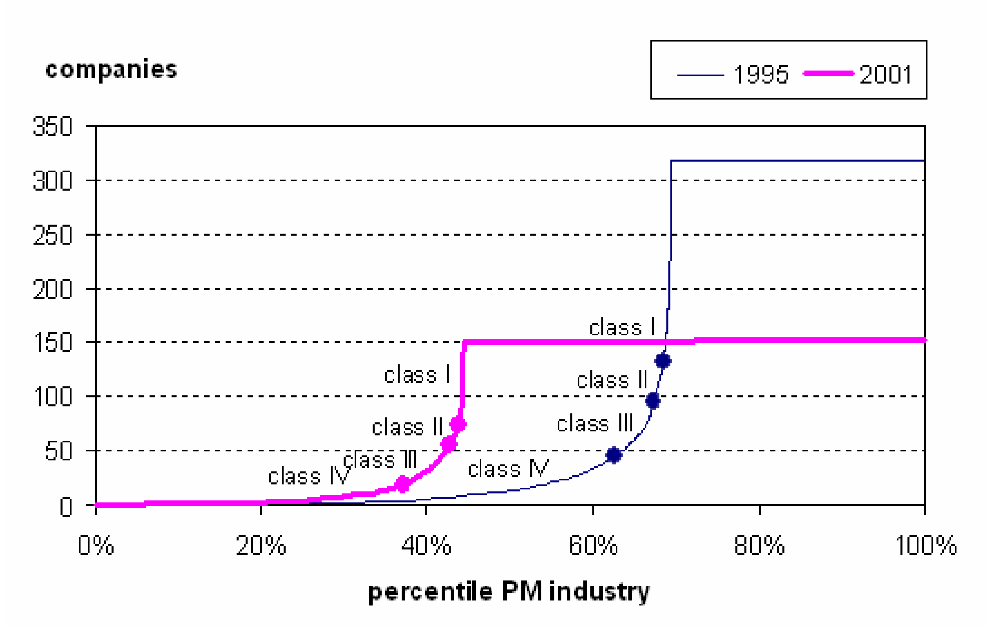

Figure 5.4 *Tentative classification in monitoring categories of the cumulative contribution of individually registered companies to the total indus-trial PM_{10} emissions in the years 1995 and 2000.*

Despite the fact that it concerns 1995, we conclude that it seems likely that a substantial share of the large emission sources are not monitored according to the methodology and level of accuracy required for their classification, even if we correct for the release due to meeting the branch PM objective. Also, in practice, one company is often treated as a set of different smaller emission sources. Nevertheless, continuous and periodical measurement of 7% of the emissions is such a low level that it is hardly justifiable to the companies that are conducting those measurements.

Common equipment for continuous measurement of dust measures the total PM (TSP) concentration, which has to be corrected with periodically measured particle size. This assessment can be quite accurate (15% to 50%) if the proper NEN-ISO measurement protocols are being used.
It is estimated that in 1995, of the reported industry emission, about 5% of these emissions are being monitored continuous, about 1 - 2 % of the emissions are based on actual periodical measurements, 5-8 % on old and about 85 % of the reported emissions are estimated to be based on other methods as mass balances and emission factors. It is difficult to estimate what the impact of new methods will be.
It seems likely that a substantial share of the large emission sources are not monitored according to the methodology required for their classification as recently has been included in the validation guidelines.

5.2.7 Individual reporting procedures

From studies by VROM [ref. 45] and TNO [ref. 21] concerning the environmental annual reports of the year 2000 it becomes clear that in general there are no large errors in the reports with respect to emissions to air or water. However, there are large uncertainties around the emissions of particulate matter (and also on CO_2, VOC emissions). The stakeholders interviewed (FO-Industrie, CBS and RIVM) have doubts whether the quality of the government reports is sufficient for EU reporting. Reasons indicated for insufficient reliability are insufficient transparency of emission figures. PM emissions are incomplete; PM_{10} is not mentioned sometimes whereas this is, however, registered on EU level [ref. 48].

Companies have to report PM with a diameter of 10 µm or more and PM_{10}. So the sum is Total Suspended Particulates. Companies that measure only TSP cannot specify this in the ER. In practice, some companies create a new line or pollutant in order to specify TSP. Or, they specify the TSP value in the category PM > 10 µm. At this moment, there is no check on this type of errors except for the provincial authority. For them, this incorrect specification is probably already good enough for the permit, since they understand what was meant. But in the monitoring system, a number in the wrong place gives simply wrong national emissions.

On the quality of the contents, and specially the PM data, in the current annual environmental reports it is stated that [ref. 48]:

- the Provinces find in majority that the Environmental Report is sufficiently reliable for the use in the PER.
- the consumers, among which the PER, find that the current reporting concerning emissions to air of PM (heavy metal, persistent organic substances) is insufficient and offer too little basis for the national PER.

The last point is illustrated by the uncertainty assessment of experts of the PER as presented in table 5.1. The estimated uncertainty of branches here is much higher than the technically expected uncertainty of the emission measurement and estimation. Partly this is caused by the fact that PM_{10} emissions are required instead of TSP. But also, the translation from measurement to reporting according the correct definitions and the branch representativeness add much uncertainty to the assessment on branch level. To improve this, existing protocols need to be applied in practice by the companies and validation by the provincial authorities should also take place according existing validation protocols. A problem here is that the provincial authorities look more at permits, which are in terms of TSP while ERs are in terms of PM_{10} and PM>10 μm. Permits and protocols should therefore be in terms of PM_{10} and not TSP.

Originally, the first reason for regulation was nuisance of local residents by dust, which was and is TSP related. Due to mitigation, TSP has been reduced severely. Furthermore, EU air quality regulation is expressed nowadays in terms of PM_{10} and in the future maybe in $PM_{2.5}$. It is important to follow this consistently. The present situation of measuring TSP and deriving PM_{10} should be reversed: PM_{10} should be measured and TSP derived form that.

It is difficult to assess the available reported emission on completeness and accuracy. A blank in the data table can be caused by an omission or a value below the threshold due to taken measures. Also there is no insight in the value of the available emission data. Is the data generated by estimation or by means of measurements? It could enhance the quality of the estimated sector totals if the individual emission data on PM_{10} is presented with corresponding accuracy and type of determination [Personal communication CBS, Guis]. The electronic Environmental Reporting could support this.

The translation from measurement to reporting according to the correct definitions and the branch representativeness add much uncertainty to the assessment on branch level. To improve this, existing protocols need to be applied in practice with the emission assessment by the companies and the validation by the Provincial authorities. To avoid confusion and double work, permits should be like Environmental Reports in terms of PM_{10} and not TSP.
It could enhance the quality of the estimated sector totals if the individual emission data on PM_{10} is presented with corresponding accuracy and type of determination (CBS, Guis). The electronic Environmental Reporting could support this.

To gain a better picture of the total PM and PM_{10} emission in the Netherlands there is also discussion about which companies should report their environmental performance in an annual environmental report. IPO and RIZA (2002) have mentioned that ‘Op- en overslag’ companies in the sector Storage and handling of bulk materials with surface area larger than 50,000 m^2 should be included because these have significant PM and PM_{10} emissions. From the interviews with the Provinces it is concluded that the green crop driers (‘grasdrogerijen’) should be included.

Storage & handling with surface areas larger than 50,000 m^2 and green crop driers should be obliged to publish an annual Environmental report or be included in the individual registration of companies.

Note:
Some companies also publish public versions of their annual environmental reports (MJV’s). On these reports no formal quality assessment takes place. One third (47) of these companies have sometimes received questions or comments on their public reports. These questions were mostly concerning the reliability of the data, sustainable development, fuel consumption, particulate matter. So far there has not been send any complaint on the contents of a public annual environmental report to the environmental report Commission (Milieuverslagcommissie).

5.2.8 Conclusions on individually registered emissions

We conclude that with reference to 1995, the 2001 inventory of individually registered companies:

1. Reveals an actual reduction within selected companies of almost 40% (4 kton);
2. Includes a reduction of almost 1 kton due to the closure of companies;
3. Overestimates the reduction of some companies with approximately 3 kton due to mistakes in the data processing;
4. Shows only a limited 0.3 kton (incorrect) reduction due to the smaller number of companies selected for registration;

This means that the total industrial emissions are probably approximately 3 kton or 20% higher due to (mainly) incorrect data and data processing of Environmental Reports.

The impact of the increased uncertainty of individually reported emissions is hard to quantify. It is also difficult to assess whether the registered emission reduction of 40% or 8 kton over a period of 6 years is realistic. This means that a reduction of 30% instead of 40% equals 2 kton higher emissions.

The report on individually registration of industrial emissions [ref. 20] calculates a probable emission correction of 5 kton, of which the largest part is located in the iron & steel and the chemical industry. We conclude that the figures are consistent.

It seems likely that a substantial share of the large emission sources are not monitored according to the methodology required for their classification. The exact monitoring methodology that will be required for each class is currently under discussion.

The analysis has shown that approximately 25 companies are responsible for almost 90% of the individually registered emissions in 2001 and more than 50% of total industrial emissions (if registration is correct). Validation would be more effective if it was directed towards these 25 high emitting companies.

In principal, the provincial authorities are responsible for validation of these important large company emissions. Guidelines to point out this limited number of companies (on average less than 2 per Province!) are easy to formulate. Attention should be paid to the equality principles, which should not be violated by the authorities. Also, it is possible that the Dutch PER organisation performs this not too extended task.

The individually registered emissions for the year 2001 are 3 kton too low due to data processing errors by FO-I and possibly additionally 2 kton too low due to insufficient verification by Provincial authorities.
Effective verification by Provincial authorities or a PER organisation should be directed at the 25 major emitting companies with the help of a simple set of guidelines.

5.3 Missing $PM_{2.5}$ sources compared with US

The US reported $PM_{2.5}$ emissions are summarized by sector in Table 5.4. The $PM_{2.5}$ emissions for each sector can be presented as the relative contribution to total reported $PM_{2.5}$ emissions. Some of the listed sources are not included in the Dutch emission inventory because they are of little relevance for the Netherlands e.g., prescribed forest burning and forest fires. However, Table 5.4 illustrates that some sources may be relevant for the Dutch emission reporting and are presently missing such as open fires (wild or residential), fugitive dust from paved and unpaved roads and agricultural tilling. Also, the emissions from the wood processing industry are included in the PER by means of the Haskoning report on diffuse emissions [ref. 19]. The extent to which emissions from combustion of wood in wood stoves is taken into account is not clear. These emissions might be substantial, like in household sis the case. Furthermore, in the Netherlands wood in electric utilities is increasing in the Netherlands as a result of CO_2 mitigation. It should be checked whether this source is taken into account.

The US inventory does not include wind blown dust (considered as a natural source). It would be interesting to look at the exact definition of these sources and distinction between anthropogenic and natural (re-)emissions.

Table 5.4 Reported US PM2.5 emissions for 1999.

	$PM_{2.5}$ emissions[1)]	Relative contribution	Present in Dutch inventory
Sector	**kton / yr**	**(%)**	
Electric utilities - coal	92	1.6	+
Electric utilities - petroleum	4	0.1	+
Electric utilities - natural gas	17	0.3	+
Electric utilities - wood/other	**3**	**0.1**	**?**
Industrial combustion - coal	21	0.4	+
Industrial combustion - petroleum	22	0.4	+
Industrial combustion - natural gas	49	0.8	+
Industrial combustion - wood	**44**	**0.7**	**?**
Commercial combustion - coal	7	0.1	+
Commercial combustion - petroleum	4	0.1	+
Commercial combustion - natural gas	7	0.1	+
Residential combustion - natural gas	13	0.2	+
Residential combustion - wood	340	5.8	+
Onroad diesel vehicles	151	2.6	+
Onroad gasoline vehicles	58	1.0	+
Marine transportation	36	0.6	+
Locomotives - diesel	25	0.4	+
Aircraft	25	0.4	+
Nonroad - gasoline	75	1.3	+
Nonroad - diesel	211	3.6	+
Miscellaneous fuel combustion	73	1.2	**?**
Wildfires	**212**	**3.6**	**-**
Prescribed forest burning	**478**	**8.1**	**-**
Agricultural burning	**85**	**1.4**	**-**
Open burning - residential	**157**	**2.7**	**-**
Open burning - other	**275**	**4.7**	**-**
Incineration - residential	28	0.5	+
Incineration - other	15	0.3	+
Industrial - metals processing	94	1.6	+
Industrial - asphalt manufacture	4	0.1	+
Industrial - petroleum refining	12	0.2	+
Oil and gas production	1	0.0	+
Rubber and plastics products	2	0.0	+
Fugitive dust - unpaved roads	**1283**	**21.8**	**-**
Fugitive dust - paved roads	**620**	**10.5**	**-**
Fugitive dust - construction	355	6.0	+
Fugitive dust - other	133	2.3	+
Agriculture - tilling	**782**	**13.3**	**-**
Agriculture - livestock	81	1.4	+
Total	5894	100.0	

[1)] Dated presented by battye et al. 2002; original source: 1999 *National Emissions Inventory*. U.S. Environmental Protection Agency, Emission Factors and Inventory Group, Research Triangle Park, NC. Data available: http://www.epa.gov/ttn/chief/net /index.html

In general, the dominant source for $PM_{2.5}$ is energy combustion and resuspension. For PM_{10} other sources are also important, e.g. process emissions, (semi)natural crustal material and sea salt.
Sources in the USA that are missing in the Dutch and European inventories are open fires (wild or residential), fugitive emissions from roads (resuspension) and tilling from agricultural activities.
It is not clear whether wood combustion in the wood industry and power generation are included correctly in the PER.
The definition of and distinction between anthropogenic and natural (re-) emissions is crucial for the establishment of international comparable inventories.

5.4 Resuspension

Resuspension is currently not included in Dutch PM inventories. Important sources of resuspension of particles are agriculture, wind blown dust (part of the natural sources) and road transport. According to the draft second position paper on PM (CAFÉ, 2003) the road transport sector is a main source of 'resuspended' particles (resuspension of loose material on the road surface).

Resuspension is much higher from unpaved roads than from paved roads. However, since the traffic activity on unpaved roads in the Netherlands is only a minute part of the total traffic activity, the resuspension from paved roads is much more important. This is in contrast with the US (see Table 5.3) where $PM_{2.5}$ emission from resuspension from paved and unpaved roads are in the order of 10% respectively 20% of national $PM_{2.5}$ emissions.

Another issue complicating the inclusion of resuspension in emission inventories is the possibility of double counting. Double counting could be an issue given that particles that are re-entrained in the air have already been emitted and deposited. Fore example, in the United Kingdom, estimates are made of the re-entrainment of dust (or resuspension) from road transport. Such estimates are not included in official reported estimates since it is considered as a re-emission instead of a primary emission. In 2000, the estimate for PM_{10} in the United Kingdom for this source sector was 19.4 kton. Other emissions from road transport were estimated to be 31 kton (Goodwin et al., 2002). Again, these estimates underline the importance of resuspension as a PM_{10} source.

The results from the many studies and models on resuspension of PM from roads show a large spread in the results in terms of emission factors for various PM fractions, as well as in terms of calculated total national emissions. However, the available data suggest that PM resuspension from roads represents a PM source that is of the same order of magnitude as the exhaust particle source, in terms of total national PM_{10} emissions (CAFÉ, 2003).

Up to now, resuspension has not been included in European emission inventories such as NFR, since it has been considered as a re-emission and not a primary emission. Since the attention is growing for resuspension, it is recommended to develop common and transparent methods to calculate resuspension and include it as a memo item in the inventories.

Emission factors for resuspension from roads

The emissions from resuspension depend on a number of different parameters, including traffic density, road surface material, state of the road, maintenance of the road, driving patterns, fleet composition and climatological factors, and there are large differences in all these parameters between countries and within countries. Therefore, the EU working group on PM (CAFÉ, 2003) concluded that it has not been possible to derive commonly accepted emission factors that are applicable at a large range of different situations. Thus the uncertainty is large and a separate action would be needed to define the resuspension source strength for the Netherlands. Internationally, the ratio of resuspension to tail pipe PM_{10} emissions differ largely from a factor of 0.5 to 10, the higher values being caused by the use of studded tires which is not applicable for the Netherlands. In general this ratio is considerably lower for $PM_{2.5}$, since all tail pipe emissions are in this size fraction, while the main part of resuspension falls under the coarse mode.

However, even if the lowest fraction of 0.5 is being used for estimation of the resuspension of road transport, the Netherlands resuspension would be in the order of 6 kton or 9% of national PM_{10} emissions. This estimate results in a slightly lower but comparable ratio between resuspension and other traffic emissions as reported by Goodwin et al. (2002) for the UK.

$PM_{2.5}$ from resuspension

The dominant part of the mass of the particles from the resuspension source falls in the course fraction (PM_{10} - $PM_{2.5}$). In the AP-42 model, the base emission factor for resuspension from roads is about 4 times lower for $PM_{2.5}$ than for PM_{10} (USEPA, 1995). Thus, the resuspension source is also of importance for $PM_{2.5}$, especially in hot spot situations near roads during dry road conditions.

Even in a conservative estimation, the resuspension of road transport in the Netherlands would be in the order of 6 kton or 9% of national PM_{10} emissions. The contribution to $PM_{2.5}$ would be less but still relevant (~ 1-2 kton).
Up to now, resuspension has not been included in European emission inventories such as NFR, since it has been considered as a re-emission and not a primary emission. Since the attention for resuspension is growing, it is recommended to develop common and transparent methods to calculate resuspension and include it as a memo item in the inventories.

5.5 Natural sources

Natural emissions of particulate matter are often not reported and/or not modelled because these emissions are not subject to regulation and policymaking. However, this severely hampers the understanding of the source contributions to ambient PM concentrations and increases the uncertainty surrounding the anthropogenic source emissions due to unclear definitions. It is therefore useful to try to quantify the natural emissions to the best of our knowledge. The main sources to be considered are sea salt aerosol and soil dust (or crustal material). The latter is often related to anthropogenic activities, e.g. wind erosion of (bare) agricultural fields, and therefore is not a truly natural source. Sea salt and crustal material are discussed separately because the consequences for reporting and documenting PM emissions from the Netherlands are different for both sources.

5.5.1 Sea Salt

Energy supply from surface winds to the sea surface results in wave breaking and (consequently) whitecap formation. The most prominent mechanism generating sea salt aerosol is believed to be entrained air bubbles bursting during whitecap formations (Monahan et al., 1986). The production of sea-salt aerosols by wind is proportional to the whitecap coverage. The literature describing sea salt aerosol formation is rather extensive because sea salt particles are important cloud condensation nuclei (CCN), thus influencing climate, and the sea salt aerosol has a large influence on the atmospheric sulphur cycle (Chamides and Stelson, 1992).

The scope of the present study is the reporting and documenting of particulate matter emissions from the Netherlands. Strictly speaking this would imply quantification of the sea salt aerosol emissions from the Dutch part of the North Sea. This is feasible and could be achieved by applying source functions as described by e.g., Monahan et al. (1986), Fitzgerald (1991) and Gong (1997 and 2003) [ref. 33, 13, 16, 15]. However, as sea spray is a truly natural source, which cannot be influenced by mitigation, the separation of Dutch sea spray emissions from e.g., UK emissions appears an irrelevant exercise. Instead, the sea salt contribution to PM_{10} in the Netherlands should be quantified and reported as a background concentration. This background concentration describes, for regulatory purposes, the estimate of the contributions from natural (and possibly other) sources that cannot be controlled by abatement measures. It is important that the build-up of this background concentration is well defined to avoid confusion and miscommunication about what is incorporated in different studies and by different countries. The objective is to come to a good approximation of the contribution of sea salt aerosol to particulate matter concentrations as observed at Dutch monitoring sites. This could be achieved following two paths:

1. incorporation of sea salt parameterisation functions in regional models (e.g. LOTOS model) and

2. by analysing the available information on sea salt tracers (Na, Mg, Cl) in particulate matter samples that are analysed for elemental composition e.g., by Visser et al. (2001).

Incorporation of sea salt parameterisation functions in predictive modelling. Inclusion of sea salt in predictive modelling of ambient PM concentrations with a model such as LOTOS can be rather simple. The number of components in the model needs to be increased with at least two (Na, Cl), both for the fine and the coarse fraction and source functions need to be defined. The exact description of these source functions will depend on the meteorological variables that are available within the model.

Background concentrations from sea salt aerosols should be identified and included as functions of meteorological conditions in air quality forecasting models in order to be able to understand the natural contribution to observed PM levels and to reduce the overall uncertainty of emission concentrations in the Netherlands.

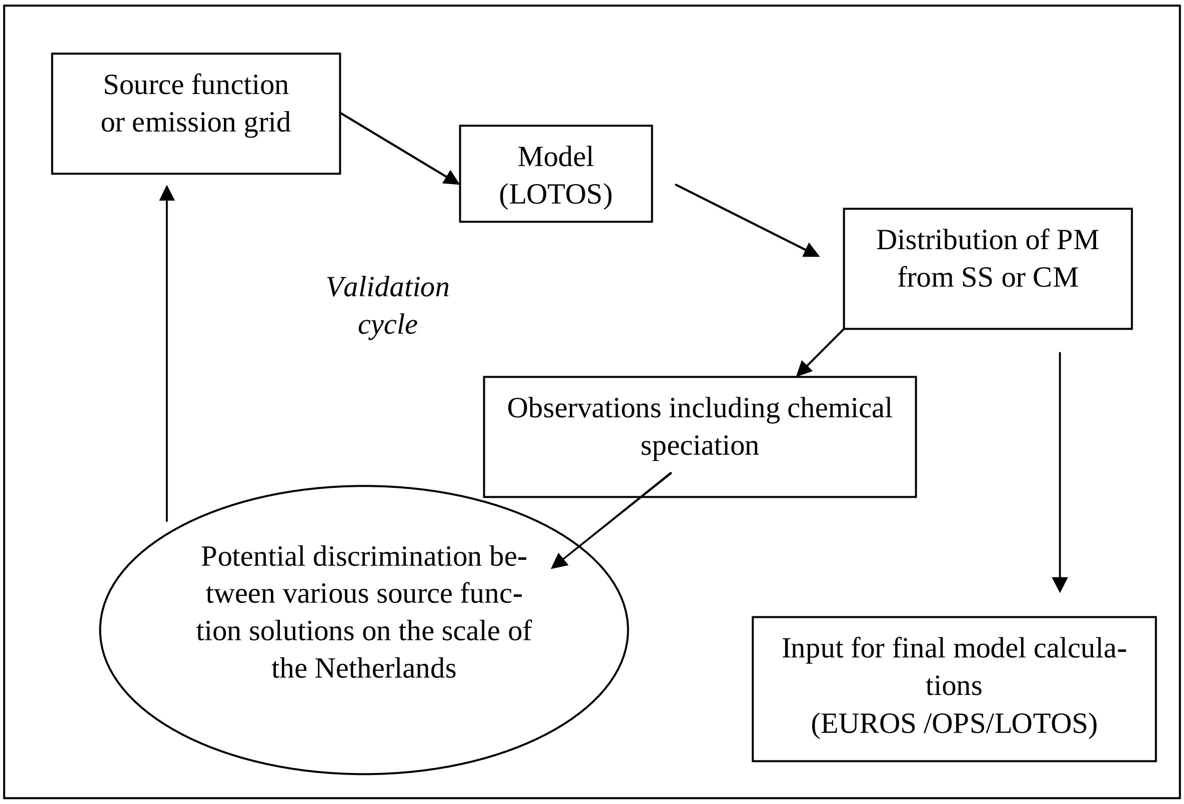

Figure 5.5 Possible implementation scheme for sea salt aerosol in predictive regional models.

Estimated contribution of sea salt to Dutch ambient PM from observations

The composition and origin of airborne particulate matter in the Netherlands was studied by Visser et al. (2001). Samples of the fine fraction ($PM_{2.5}$) and the coarse fraction ($PM_{2.5-10}$) were collected at six sites during one year (1998-99) and analysed for elemental composition. The data of Visser et al. (2001) can be used for an approximation of the sea salt contribution of Dutch ambient PM levels. Chloride is selectively lost from the aerosol as the aerosol ages (e.g., Yao et al. 2003). This was also observed in the Netherlands when looking at samples from the coast to more inland locations (Denier van der Gon et al, 2003). Therefore, Na is found to be the best tracer for sea salt. The contribution of sea salt can be calculated using the chemical composition of sea salt and the weight % of Na [1].

$$\text{Sea salt} = 3.24\,[\text{Na}] \qquad [1]$$

The correlation with observed Cl concentrations is important to verify that no other sources of Na contribute significantly which would result in an overestimation of the sea salt aerosol. Three important observations can be made using the data from Visser et al. (2001). 1) The concentration of sea salt components is higher with western winds coming from the sea both at the coast and inland, 2) the absolute concentrations caused by sea wind are lower at more inland locations and, 3) a sea salt contribution appears to be always present even when winds are not coming from the sea. This base-line sea salt contribution is equal at coastal and at inland sites (Denier van der Gon et al, 2003).

Using sodium and chloride as tracers for sea salt, Visser et al. (2001) estimated that the average sea salt contribution in the Netherlands was between 4–7 $\mu g/m^3$ on an annual basis. Slightly more than 50% of this sea salt was in the coarse fraction. Denier van der Gon et al. (2003) used the same data and estimated the average contribution of sea salt to $PM_{2.5-10}$ in the Netherlands at 4.2 – 2.7 $\mu g\ m^{-3}$ going from coastal to more inland locations.

However, compared with the estimates of sea salt contribution in neighboring countries (e.g. the UK) the annual average values presented in the Netherlands seem to be quite large. It may therefore be good to revisit the data. Theoretically, Na concentrations are the most reliable estimator for sea salt aerosol because these are less influenced by aging of the aerosol than Cl. Unfortunately, when looking at the available Dutch data on Na in PM_{10}, these appear insufficient to make definitive conclusions. In Figure 5.6 an illustration is given of the calculated concentrations of sea salt aerosol at location Vredepeel based on Chloride and sodium concentrations, respectively. During the first half of the measurement year the estimates based on Na are more than a factor 2 higher, however in the second half of the year the estimates based on Cl and Na appear to be in line. Since there is only one year of data available it is difficult to discard a particular period as being unreliable or an outlier. It should be noted that the selection shown in Figure 5.6 involves non-western winds, thus a direct sea loading – causing peaks in sea salt aerosol -is not the case. Since we cannot find an explanation for the rather extreme estimates based on Na in the first half of the year, a conservative estimate based on the second half year appears most reliable. Sea salt background contribution to PM_{10} in the Netherlands is estimated to range between 1-4 µg /m^3 with higher excursions during periods of sea winds (western direction). The importance of wind direction for sea salt contribution to PM_{10} is illustrated in Figure 5.7. Western winds (e.g. 210-330 degrees) coming directly from sea salt source regions cause a clear signal in sea salt aerosol concentrations. The contributions are higher close to the sea (de Zilk, Overschie) than more inland (Vredepeel, Nijmegen). Aging of the aerosol may cause an underestimation of the sea salt contribution due to depletion of chloride which is used as the basis of of the above calculations. This underestimation is expected to vary between 10-20% (based on crude calculation with the data). The contribution of sea salt could be averaged over the year and all wind directions but as can be seen in Figure 5.7, this would disguise the high contributions during certain meteorological conditions and elevate the background concentrations, causing higher overall uncertainty. Predictive modelling in combination with monitoring should be used to properly include sea salt aerosol in the Dutch PM inventories.

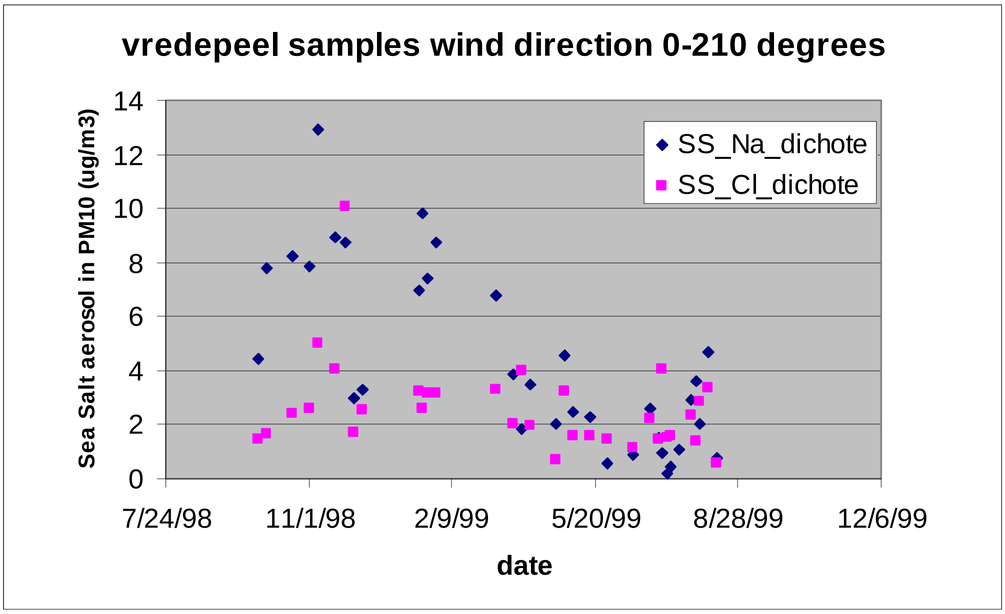

Figure 5.6 Sea salt concentration in PM_{10} at location Vredepeel during non-western winds calculated based on chloride en sodium concentrations.

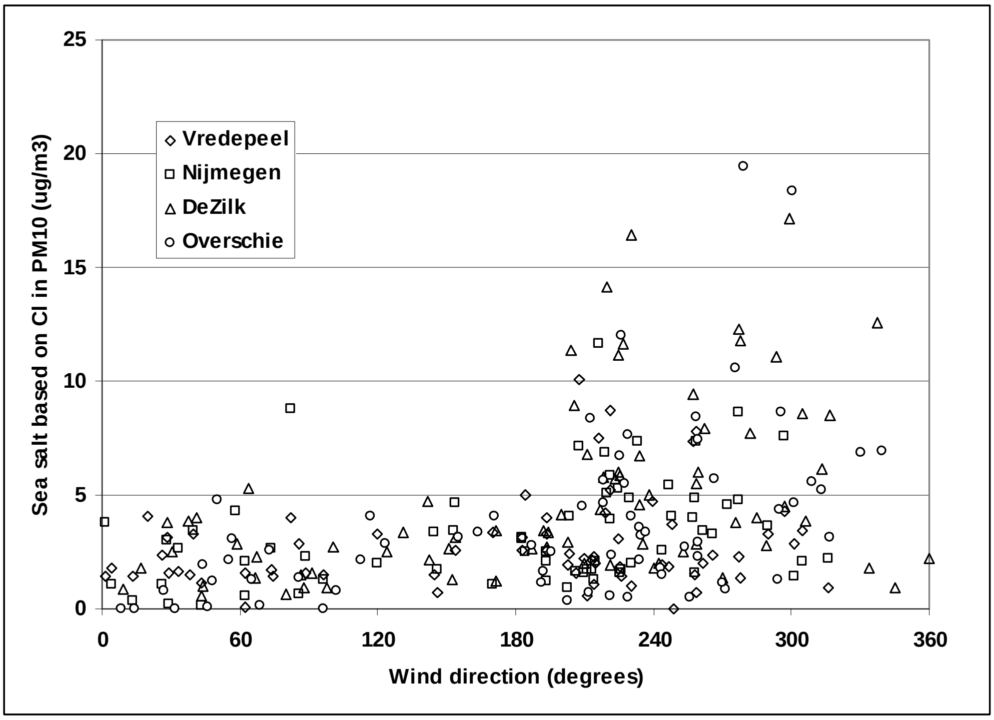

Figure 5.7 Sea salt contribution based on chloride concentrations to PM_{10} for four locations in the Netherlands distributed by wind direction.

Suggested action: The analysis of elemental composition (Na, Cl) allows quantification of the contribution of salt aerosol to the total PM_{10} or $PM_{2.5}$ concentration. Sampling and analysis of these variables at a limited number of sites where PM_{10} is measured routinely could provide important calibration data for modelling the sea salt contribution. Moreover it would make quantification of average sea salt contribution to Dutch PM_{10} levels a routine exercise. The temporal resolution of sampling and analysis could be low to limit the costs involved or possibly samples could be pooled.

The average sea salt contribution to Dutch PM levels is very important, viz. in the order of 10% of total ambient PM_{10}.
The analysis of routinely measured elemental composition (Na, Cl) allows for a more exact quantification of the contribution of salt aerosol to the total PM_{10} or $PM_{2.5}$ concentration.

Road salt

Not all salt aerosol can be attributed to natural formation. Some salt aerosol will be formed due to (preventive) de-icing of roads with road salt. This anthropogenic source of salt aerosol should be assessed separately but is thought to be of limited importance. On principle the contribution of road salt to ambient PM could be estimated based on the data of Visser et al. (2001). By excluding all western winds and looking at the elevation of salt aerosol in winter months as compared to summer months an estimation of the road salt contribution could be made. However, this is hampered by a possible off-set in the data for Na: measurements in the first half of the year indicate much higher salt aerosol concentrations than in the second half of the year (Figure 5.6). Moreover, long term data would be needed as the use of road salt may vary considerable from year to year depending on the weather conditions. A crude and preliminary estimation would be that road salt may contribute ~0.5 µg/m^3 on average during winter months (Table 5.4). Obviously this will be higher during periods of application and/or measured next to roads. The zero contribution at site de Zilk appears quite realistic, as this is located in the dunes. Please note that Table 5.4 nicely illustrates that the background concentration of sea salt aerosol is uniform at all locations when only non-Western winds are considered. RIVM (2002) used the OPS dispersion model to calculate that an emission of 1 kton/year, evenly distributed over the Netherlands, results in a contribution of 0.05 to 0.1 µg/m^3 to the annual average PM_{10} concentration. A similar reasoning can be used to quantify the source strength necessary to result in a 0.5 µg/m^3 increase during 3 winter months caused by road salt use. A first approximation of the road salt emission source is in the range of 1-2.5 kton per year. Average road salt use in the Netherlands is 60-70 kton/year (Pers. Comm, Els Kuppens, Rijkswaterstaat/DWW/IM, 2004), suggesting that ~3% of road salt use will be entrained in air as PM_{10}, intuitively the order of magnitude of these estimates appear reasonable.

Table 5.5 Background sea salt concentrations in aerosol during non-seawind conditions in winter and non-winter months.

Location	**Vredepeel**	**Nijmegen**	**Overschie**	**de Zilk**
	Salt aerosol in PM_{10} (µg/m^3)			
Winter (Dec-Feb)[a)]	2.57	2.78	2.31	2.49
Non-winter (April-Oct)[a)]	1.86	1.61	1.83	2.54
Potential road salt contribution	0.71	1.18	0.49	-0.06

[a)] November and March excluded as buffer between winter and non-winter.

> Resuspended road salt should be considered as a memo item since the contribution to Dutch concentrations can be significant, being 1-2.5 kton.

5.5.2 Crustal material from natural sources

A part of the particulate matter in ambient air consists of ‘crustal’ or earth-based material and enter the air through a variety of actions including ‘entrainment’ into the atmosphere by wind blown dust. Crustal material may originate from anthropogenic sources such as pavement wear, resuspension of road dust and driving over

unpaved roads. The generation of wind blown dust is probably best quantified as semi-natural; areas of (bare) soil susceptible to wind erosion exist in Western Europe due to agricultural (anthropogenic) activities. Furthermore, wind blown dust may be generated during soil preparations such as plowing. If the country would be in a 'natural state' the Dutch soils would be covered and little or no wind erosion would occur.
Since various poorly defined sources (e.g. erosion, resuspension) may contribute to the crustal material in PM, source apportionment based on elemental composition is more difficult than for sea salt. Moreover, as the crustal material contribution is related to in-country activities and may be partly controllable, it is important to report and understand the national contribution as opposed to sea salt where only the background concentration is relevant. Several attempts have been made to quantify the amount of PM_{10} emission due to entrainment of soil material.

1. Chardon en van der Hoek (2002) present estimates of the annual PM_{10} emission due to wind erosion from agricultural soils in the Netherlands based on extrapolation of limited data. Their estimated wind erosion emissions are10-20 kton PM_{10} / year. However, these authors qualify this estimate as highly uncertain. The emission factors currently used for wind erosion are based on old measurements, mostly done in the United States in the 1930ies on dust storms and at that time only for dust in respect to wear of paints etc. [Personal communication Chardon]. For that reason Chardon en van der Hoek have not included windblown dust in the CCDM PER. Chardon en van der Hoek (2002) assumed that 1/3 – 2/3 of all windblown dust originates from Dutch agricultural soils, the total emission of windblown dust was estimated at 30-45 kton PM_{10} / year.
2. Visser *et al.* (2001) estimated the wind-blown crustal material from non-anthropogenic sources at 2 $\mu g/m^3$. Using the OPS dispersion model, it was calculated that an emission of wind-blown dust of 1 kton/year, evenly distributed over the Netherlands, results in a contribution of 0.05 to 0.1 $\mu g/m^3$ to the annual average PM_{10} concentration (RIVM, 2002). Consequently, based on a mean contribution of 2 $\mu g/m^3$, 20–40 kton/year is the input of crustal material needed for long-term modelling to estimate an annual average regional increase of 2 $\mu g/m^3$ in the Netherlands.
3. Vrins and Schulze (2000) estimated the wind blown component from all surfaces as 3 $\mu g/m^3$ and estimated the source strength as 30 kton/year.
4. Denier van der Gon (2002, 2003) reported an average annual contribution of 3-6 $\mu g/m^3$ depending on the location (Table 5.5) based on the data by Visser et al. (2001). The figures in Table 5.5 include a contribution of e.g., resuspension and pavement wear which will be more substantial in urban environments (Overschie, Overtoom). For location Vredepeel the contribution of windblown dust from e.g. Germany may be significant. Thus, a first approximation suggest a contribution of ~3 $\mu g/m^3$ by wind blown dust from soils, equivalent to 30-60 kton/year if the same conversion as under 2) is followed.

Table 5.6 Average concentration of crustal material in PM_{10} during 1998-1999 at four locations (Denier van der Gon et al., 2002; 2003).

Location	**De zilk**	**Vredepeel**	**Overschie**	**Overtoom**
	(µg/m^3)			
PM_{10} crustal	3.17	5.54	5.78	3.56

Currently windblown dust is not reported as a source of PM_{10}, this appears incorrect. The above cited data suggest a total source strength of 40 ± 20 kton/year, although a part of this emission may come from outside of the Netherlands. Although the ranges are quite large, the overall conclusion that wind blown soil material is a substantial source of PM_{10} is confirmed by the (limited) data available. Uncertain as it may be, by not including the source in inventories the information disappears and our knowledge of total source contributions decreases.

As shown above it may be a substantial source and knowledge of the source strength will further elucidate the composition and mitigation potential of the ambient PM_{10} concentrations. Belgium (MIRA, 2003) has recently included windblown dust as a PM_{10} source albeit with a clear statement that this source is highly uncertain. The environmental report for Flanders states that agriculture is now the most important source of PM_{10} but that this is mostly due to the inclusion of wind blown dust (Figure 5.8). The contribution is in the same order of magnitude as the first estimation of 40 ± 20 kton/year for the Netherlands. The soil dust contribution is entirely allocated to the coarse fraction of PM_{10} and the contribution of agriculture to $PM_{2.5}$ in Flanders is relatively low (Figure 5.9).

Although the source strength is estimated at 40 ± 20 kton/yr, it is highly uncertain how much of the total crustal material as observed in ambient PM is coming from abroad. To properly report, even as a memo item, the Dutch soil/crustal emissions in a similar way as e.g. Dutch combustion emissions, a first step would be to quantify the Dutch contribution.

The relevance of quantifying crustal contributions to PM for policy making may be that there is evidence that crustal material is not or less harmful than PM from combustion sources. In the (re)analysis of the six city studies of the US, Schwartz et al. (1996) reported that daily mortality was associated with fine particle mass ($PM_{2.5}$) but not with coarse particle mass (> $PM_{2.5}$). This already excluded a substantial fraction of the crustal material as this is mostly found in the coarse fractions. In a follow-up study Laden et al. (2000) used elemental composition of the $PM_{2.5}$ fraction to identity several distinct source-related fractions of $PM_{2.5}$. Laden et al. (2000) reported that $PM_{2.5}$ crustal particles were not associated with daily mortality (as opposed to combustion derived particles). So, (in the future) it is conceivable that the crustal fraction of PM is removed from the list of targets for reduction and that only PM concentrations without natural and crustal contributions are to be subject to regulation.

It is recommended to include crustal material or windblown dust as a memo item in the Dutch inventory, since the potential contribution is 40 ± 20 kton/year, however, the health effects are expected to be limited.
It is interesting to see whether it is possible to make a distinction between national and foreign natural and agricultural wind blown dust in view of possible policy measures (although wind blown dust in rural areas will not likely be a constraint for meeting air quality targets).

Contribution of sea salt and crustal material to $PM_{2.5-10}$
Chemical composition and source profiles were used by Denier van der Gon et al. (2003) to break down the PM mixture into source contributions and leading to the following conclusions:
Crustal matter on four Dutch locations has a similar composition with constant ratio's between elements (e.g., Si/Al = 2.98). The average contributions of crustal material and sea salt are about 70 % of the $PM_{2.5-10}$ concentration in the Netherlands. Due to opposing wind direction dependency the total contribution of sea salt and crustal material is rather constant.

Contribution to $PM_{2.5}$
Based on the data of Visser et al. (2001) it is estimated that approximately 40% ± 7% of the sea salt aerosol is in the fine fraction ($PM_{2.5}$) but for crustal material this is max. 10-20%. Thus sea salt aerosol will remain of interest even if the attention shifts from PM_{10} to $PM_{2.5}$ but the importance of crustal material is largely connected to the coarse fraction ($PM_{2.5-10}$).

Sea salt consists for 40% of $PM_{2.5}$ while crustal material only for 10%-20%.
However, the emission levels are also for crustal material still significant.

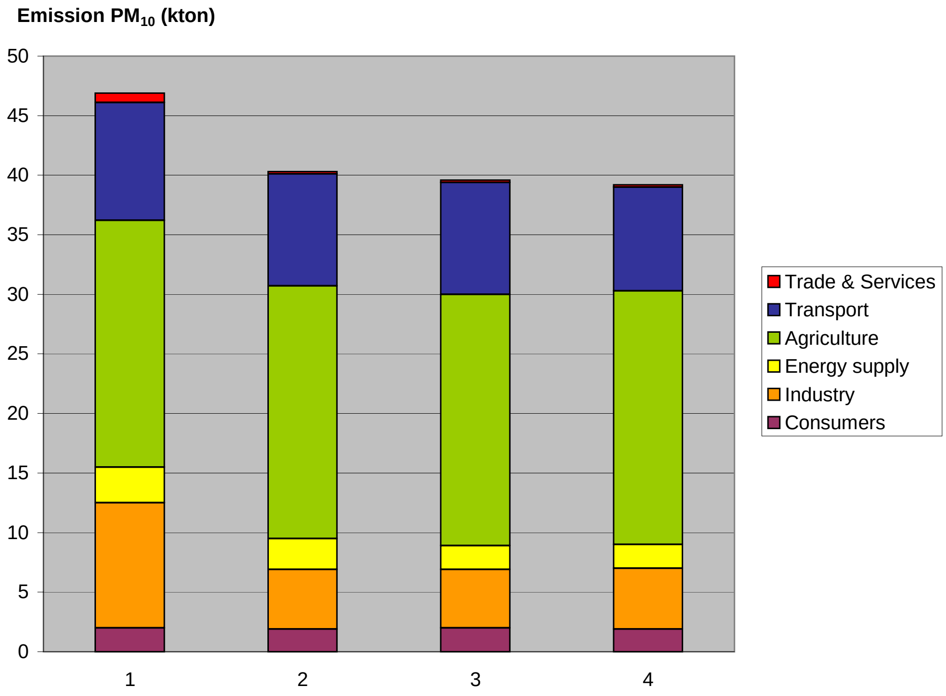

Figure 5.8 PM_{10} emissions in Flanders (Mira, 2003).

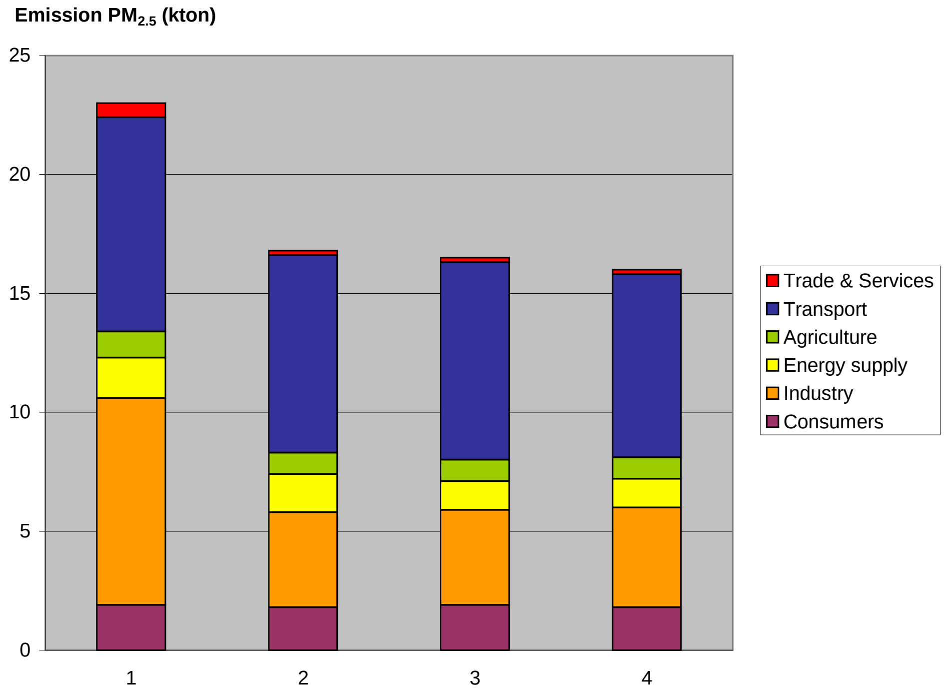

Figure 5.9 $PM_{2.5}$ emissions in Flanders (MIRA, 2003).

5.5.3 New natural sources

Primary marine organic aerosol
Besides sea salt, there is an organic component in the primary marine aerosol of which we know very little. It results from organic compounds, both biogenic and anthropogenic, dissolved in the water or present as surface films. Recent studies have found a large and variable flux of volatile primary marine particles, presumably organic compounds (Nilsson, 2004 personal communication). To proceed further on this matter additional measurements are required, including chemically specified fluxes. Although such studies are foreseen in the next years, these data are not yet available. At present it suffices to state that there is likely to be a significant contribution of marine aerosol to the natural OC component in particulate matter in coastal or near-coastal regions such as the Netherlands.

It is possible that volatile primary marine particles, presumably organic compounds, have a significant contribution to PM concentrations in near-coastal regions such as the Netherlands.

The following important natural emission and re-emission sources have been identified:

Source	**Type**	**Emission [kton]**	**Recommendation**
Road resuspension	Anthropogenic	~6	Annual monitoring
Road salt	Anthropogenic	1 - 2.5	Annual monitoring
Crustal wind blown	Semi-natural	40 ± 20 [a)]	Annual monitoring / Study for modelling
Sea salt	Natural	30-60 [b)]	Study for modelling
Marine VOC	?	?	Explore

[a)] domestic and foreign
[b)] for an omnipresent diffuse source like the sea and oceans, a source strength is only an indication of importance in comparison to inland sources. In reality the source strength is much higher.

It is recommended to monitor anthropogenic sources annually since these can have a meaning for policies and measures, while natural sources only need to be assessed for air quality modelling e.g. every five year.

5.6 Organisation of the monitoring process

The approach to use individual reporting of large companies for estimations of the industrial emissions has the advantage of connecting consistently environmental policy on different levels ranging from environmental regulation of companies to national emission ceilings. The disadvantage is that this way, the emission estimation process within the PER is complex and involves many actors, ranging from companies, regulatory authorities at Provinces to several institutes for sectors or coordinating tasks (RIVM, RIZA, LEI, Statistics Netherlands, TNO etc). The process is that difficult and not transparent that hardly anybody understands the complete process.

The interviews revealed that most actors involved have a limited view on the monitoring of (PM) emissions. Many actors involved are performing their task with their own perspective that is not necessarily similar to that needed for high quality emission monitoring. Each actor might have its own interest or interpretation of its task, risking a fragmented process of emission monitoring. Prerequisite to estimate accurate national emissions is that all involved actors cooperate and conduct their own part in the play according to guidelines that are effective in producing the overall result.

Consistent with the fragmented picture of the PER, it is observed that the different actors perceive hardly a (general) problem. The lacking quality of individually reported emissions has been brought up and is recognised by the Task force on Industrial Emissions (ENINA). However, the companies and the Provinces do not perceive a problem (‘the permits are legal and the standards are respected’). The resulting omission in the national PM emission figures is not of interest to them. The supervising organisation and the coordinating institute RIVM and TNO do perceive a problem, since they are communicating directly with the main client of the PER, the ministry of VROM. The client has the obligation to report national emissions.

This fragmented organisation can only be addressed by improving the commitment by communication, co-ordination and guidance.

The process within the PER is complex. Lack of attention for coordination and transparency, particularly in the individually registered emissions of companies, has resulted in a fragmented organisation, at the costs of overall quality and overall problem perception.
This can only be addressed by improving the commitment by communication, co-ordination and guidance.

6. Extension to $PM_{2.5}$ and mitigation measures

6.1 Extension to $PM_{2.5}$

6.1.1 First approach to assess $PM_{2.5}$

The present approach to assess branch estimations of $PM_{2.5}$ is to use $PM_{2.5}$ fractions on PM_{10} emissions. This approach in the emission monitoring process could be extended to produce estimations in a source by source manner. Several projects have already been performed to this subject at TNO-MEP in which particle size distributions have been prepared for nearly all relevant sources of PM. To increase the effectiveness, actuality and reliability of these $PM_{2.5}$ estimates, $PM_{2.5}$ estimations preferably have to be embedded in the PER itself instead of conducting these in separate projects. In that way, the $PM_{2.5}$ estimation would be similar to PM_{10} as the PM_{10} calculation to TSP.

Table 6.1 $PM_{2.5}$ emissions by group of sources for the year 1995 [source: NFR 2003].

Source type	**PM_{10} [kton]**	**$PM_{2.5}$ [kton]**
Industry [1] - combustion	7.4	4.6
Industry [1] - process	20.3	8.5
Traffic	20.3	19.8
Agriculture	9.5	2.0
Households	2.3	2.3
Natural sources	n.e.	n.e.
Total	**59.8**	**37.3**

[1] including Energy supply sector and Trade & Services

n.e. = not estimated

However, the disadvantage of this top-down approach is that, like now is the case, the definitions of policy (air quality) and company regulation are inconsistent and even become further apart. In that situation, a company is regulated on TSP while the policy and monitoring is directed at $PM_{2.5}$. This is undesirable.

In case of switching to $PM_{2.5}$, it is therefore preferable to change both the definitions of the NeR, the permits and the Environmental Reports. However, this would make adjustments in emission measurements at company level necessary. A number of companies have to measure their $PM_{2.5}$ fraction of TSP or PM_{10}. Also, companies have to switch their equipment to $PM_{2.5}$. The following paragraph will address this issue.

Besides particle size, the monitoring of the composition of PM is internationally discussed, in the context of air quality modelling and possible differences in health effects. The present source types give an impression of the PM components, e.g. organic carbon, crustal material, salt and heavy metals. A more detailed composition on the level of chemical elements requires an adaptation of the present monitoring system. Particularly measurements will become much more expensive and are economically infeasible on an annual time scale.

As a transitional arrangement, the present approach to assess branch estimations of $PM_{2.5}$ by using $PM_{2.5}$ fractions on PM_{10} emissions could be extended to source level. To this end, $PM_{2.5}$ estimations preferably have to be embedded in the PER itself and not separate projects, in order to increase the effectiveness, actuality and reliability of these $PM_{2.5}$ estimates.
For the long term, however, it is preferable to change both the definitions of the NeR, the permits and the Environmental Reports in order to consistently regulate companies, monitor emissions, develop policy measures and regulate air quality.
The present source types give an impression of the PM composition. Further details require detailed and thus single analysis.

6.1.2 Possible emission measurement methods for $PM_{2.5}$

At the moment there is no monitor available for continuous measurement of $PM_{2.5}$ concentration in waste gases. Measurement methods presently available for $PM_{2.5}$ are derived from the methods used for measuring total PM (TSP) emissions (in the way explained in Chapter 3). By measuring TSP and multiplication by $PM_{2.5}$ fraction in TSP the $PM_{2.5}$ emission can be established.
A standard (Draft NEN EN 14907) is in preparation for the gravimetric measurement of the $PM_{2.5}$ mass fraction of suspended particulate matter. The suggested measuring principle is based on standard EN 12341 for PM_{10}.

Direct measurements still provide the most reliable estimates of emission rates for $PM_{2.5}$, but different methods will be needed to accurately capture the total (filterable plus condensable) $PM_{2.5}$ mass.

What has been said in Chapter 3 about PM_{10} in relation to primary and secondary particulate matter and condensation of gaseous material is also valid for $PM_{2.5}$. For $PM_{2.5}$ the difference between condensation included and excluded is more pronounced than for PM_{10} because most particles resulting from condensation belong to $PM_{2.5}$ (e.g. diesel engine particulates). Visibility impairment is caused primarily by scattering and absorption of light by $PM_{2.5}$.

Table 6.2 Measurement methods for yearly $PM_{2.5}$ emission.

Source type	**Measurement methods**	**Protocol, experience Equipment**	**Measurement frequency (number a year)**
Point sources	Continuous PM measurement after separating dust with cloth filter + monitoring of ERPs [1)]	NEN-ISO 10155 NEN-ISO 14164 VDI 2066 / 4 en 6	(semi)continuous
	Continuous PM measurement in combination with separate measurement of $PM_{2.5}$ / PM ratio + monitoring ERPs	NEN-ISO 10155 NEN-ISO 14164 NEN-EN 13284-1 VDI 2066 / 4, 5, 6 EPA 201/201B	(semi)continuous and ½ – 2 (ratio)
	Frequent $PM_{2.5}$ measurement + monitoring ERPs	ISO-NEN 9096 NEN-EN 13284-1 EPA 201B or VDI 2066 / 5	½ – 2
	Single $PM_{2.5}$ measurement at start-up + monitoring ERPs	ISO-NEN 9096 NEN-EN 13284-1 EPA 201B or VDI 2066 / 5	Not applicable
Diffuse emissions	Calculation based on separate measurement $PM_{2.5}$ concentration in production room i.c.w ventilation fold	NEN EN 14907 (in preparation)	1
	Calculation based on separate $PM_{2.5}$ measurements in de open air (windward / weather side)	NEN EN 14907 (in preparation) Calculation / modelling	1
	Calculation based on actual situation (and ERPs)	Emission factors from handbooks (PM en $PM_{2.5}$ / PM) i.c.w product throughput	1

1) Emission Relevant Parameters (ERPs) according to the NeR

6.1.3 Parallel measurement of PM_{10} and $PM_{2.5}$

Comparing measurement methods for PM_{10} ad $PM_{2.5}$ leads to the conclusion, that the effort in measuring $PM_{2.5}$ is the same as for PM_{10}. This means that if in future it is decided to measure $PM_{2.5}$ instead of PM_{10} the costs per measurement will be about the same. For the determination of total primary $PM_{2.5}$ emission in the Netherlands instead of total primary PM_{10} the total costs could be less than for PM_{10} because less sources are important for total $PM_{2.5}$ emission than for total PM_{10} emission. If it is decided to measure both fractions by the methods NEN EN 12341 (for PM_{10}) and Draft NEN EN 14907 (for $PM_{2.5}$) sampling of stack gases can be done simultaneously with minor extra costs.

Maybe the two methods can be combined in a new method according to the same principles in a cascade impactor. Then costs could be the same as for the determination of one of the PM fractions.

For acceptable company estimations of $PM_{2.5}$ emissions, either $PM_{2.5}$ measurements have to be conducted or technology dependent $PM_{2.5}$ estimation guidelines have to become available.
The total costs of measuring $PM_{2.5}$ instead of PM_{10} is less because the number of sources is smaller. If both fractions have to be measured, sampling of stack gases by NEN EN 12341 (for PM_{10}) and Draft NEN EN 14907 (for $PM_{2.5}$) can be done simultaneously with minor extra costs.

6.2 Extension to mitigation measures

The bulk of the information on the state of the technology in the Dutch industry stems still from the SPIN documents with project descriptions in the industry [‘Samenwerkingsproject Projectbeschrijvingen Industrie Nederland (SPIN)’, ref. [51]], which were published in the early nineties. Technical information on concentrations, flows and mitigation measures is not included in the PER after 1995. The present annual Environmental Reports require only reporting of emissions, which makes it hardly possible to verify the figures. Compliance with NeR is arranged outside the PER. Information to understand the emission, exposure and health effects in the context of science and environmental policy development is not included in the PER.

Nevertheless, meta data are necessary to be able to validate and verify emissions from companies for their permit. The present Environmental Reports are not transparent enough. It is expected that the Arhus protocol on public availability of transparent information will support the extension of emission reporting with meta data. Also the introduced electronic Environmental Reports provide an opportunity for the introduction of meta data to increase the transparency of emission assessment. Particularly information of flows, concentrations, operation hours etc. will increase the transparency of emission assessment.

Information to understand the emission, exposure and health effects in the context of science and environmental policy development can be gathered most efficiently by dedicated studies, for example in a policy research program. Detailed studies can cover technology and environment in a broad context but also focus on PM. In the last case, data has to be collected and analysed of only 30 companies since these form the majority of the individually registered PM emissions.

The options and actors for improvement of the meta data are presented in Table 6.3 in an ordered way, providing a simple framework for discussion and decision making on how to include meta data for what purpose.

Table 6.3 Options (and actors) to improve the meta data for PM emission monitoring as a function of aggregation level and frequency.

Meta data		**Depth & detail**		
		Aggregated		**Detailed**
Frequency	**single**			Study SPIN / BAT (Research)
	periodic		Permits (Provinces)	
	annual	Electronic Environmental Reports (Companies)		

Additional study is necessary to assess what is needed to meet the requirements of the Arhus protocol on public availability of information. The electronic Environmental Reporting provides possibilities to include meta data and establish transparency in emission assessment.

Information to understand the emission, exposure and health effects in the context of science and environmental policy development can be gathered most efficiently by dedicated studies, for example in a policy research program.

7. Conclusions and recommendations

The quality of the last years' national Particulate Matter (PM) emission estimates has been unclear. With the introduction of Environmental Reports (ER) as a basis for individual monitoring, a major shift in monitoring methodology has occurred. Furthermore, international emission standards and monitoring have developed, changing its focus to smaller particle size. Therefore, the present methodology for PM emission estimation as applied in the Dutch Pollutant Emission Register (PER) is described and analysed on the scope and needs for improvement.

7.1 Present situation

7.1.1 Headlines of the Dutch Pollutant Emission Register

The present Dutch PER (in Dutch 'Emissiemonitor') is efficiently dedicated to the present national and international reporting obligations.

Industry, trade and services account for one third of national PM emissions. This part of the emissions is (direct or indirect) largely determined by individual registration. Transport contributes 40%, agriculture 20% and households less than 10%. Emissions from these sources are estimated collectively.

The collective estimations are being made on the basis of activity data and emission factors by the institutes involved in the PER. The individually registered emissions are assessed, transferred, validated, verified and processed by a number of organisations:

1. Companies: assessment of emissions by measurement and/or estimations
2. provincial authority: validation (and verification) of emissions
3. FO-I: processing of emissions
4. TNO: processing of emissions

All these parties and operations are important for the accuracy of the assessment of individually registered emissions. The final check on data by TNO in its role of process coordinator has disappeared the last years for budgetary reasons.

7.1.2 Measurement at individually registered companies

Extended guidelines determine which companies have to publish an Environmental Report and which method of emission monitoring has to be used for a class category of company emissions. Generally, companies have to measure TSP for their permit and PM_{10} and PM>10 µm for their Environmental Report. The exact measurement methods by emission class are under discussion and will be effectuated at the earliest in the 2005 emission assessment.

Common equipment for continuous measurement of dust measures the total PM (TSP) concentration, which has to be corrected with periodically measured particle size. This assessment can be quite accurate (25% to 50%) if the proper NEN-ISO measurement protocols are being used.

It is estimated that, of the reported industry emission, about 5% of these emissions are being monitored continuous, about 1-2 % of the emissions are based on actual periodical measurements, 5-8 % on old and about 85 % of the reported emissions are estimated to be based on other methods as mass balances and emission factors. It is difficult to estimate what the impact of new methods will be. It seems likely that a substantial share of large emission sources are not monitored according to the methodology required for their classification as recently has been included in the validation guidelines.

As in the future more PM_{10} measurement methods are going to be used, for some methods a correction has to be specified and applied for condensable particulate matter, which is according to the present European definition and in contrast with the US not a part of PM. For combustion emissions, condensables can be in the order of magnitude of half of PM_{10} if 10% of Non-Methane Volatile Organic Compounds emissions is assumed to become condensed PM.

7.1.3 Situation $PM_{2.5}$

In general, the dominant source for $PM_{2.5}$ is energy combustion and resuspension. For PM_{10} other sources are also important, e.g. process emissions, (semi)natural crustal material and sea salt.

The Dutch PER reports on a higher level of detail than the required international reporting obligations of the NFR. Reporting is secured by reporting codes. Assessments of $PM_{2.5}$ on detailed source level, e.g. companies, are not available within the PER and are only made for international reporting on branch and national level.

7.1.4 Information on mitigation

The accuracy, detail and character of the data within the present PER fall short for the assessment of mitigation developments and mitigation policy. Technical information on concentrations, flows and mitigation measures is not included in the PER after 1995. The present annual Environmental Reports require only reporting of emissions, which makes it hardly possible to verify the figures. Compliance with

NeR is arranged outside the PER. Information to understand the emission, exposure and health effects in the context of science and environmental policy development is not included in the PER.

7.1.5 International comparison

Differences of PM profiles between the Netherlands and Europe are well explainable on headlines by structural and economic differences. The PER is a relatively detailed monitoring system compared to international standards and is able to fulfil in essence the international reporting obligations. It can be concluded that the quality of the Dutch emission monitoring in general and that of Particulate Matter in particular is good and internationally on a relatively high level.

Sources in the USA that are missing in the Dutch and European inventories are open fires (wild or residential), fugitive emissions from roads (resuspension) and tilling from agricultural activities.

The definition of and distinction between anthropogenic and natural (re-) emissions are crucial for the establishment of international comparable inventories.

7.2 Weaknesses and improvements

7.2.1 Methodological weaknesses and improvements

The decrease in the number of individually registered companies is in itself not a reason for a decrease of the confidence; an increase in registered companies will not result in a higher confidence. The decrease of the emission share of individually registered companies has resulted in a decrease of the overall confidence.

The impact of a smaller selection of individually registered companies due to the introduction of the Environmental Report is limited in the industrial sectors with high PM emissions. It also has had hardly any effect on the representativeness and the emission estimation of companies within the 30 low PM emitting branches. Hence, an increase of the number of monitored companies will not increase individually registered emissions and therefore not result in a higher confidence.

Especially the individually registered emissions in the Basic metals, Basic chemicals and Fertiliser industry are causing suspicion. The individually registered emissions for the year 2001 are missing 3 kton due to data processing errors as a result of the absence of clear guidelines for FO-I and possibly additionally 2 kton due to insufficient validation by provincial authorities. Effective validation by provincial authorities or a PER organisation should be directed at the 25 major emitting companies (covering 90% of individually registered emissions) with the help of a simple set of guidelines and / or software tools.

Validation of individually registered emissions at companies can result in very accurate assessments. Therefore, it is potentially effective to improve individual registration to increase the confidence of overall industrial emissions, especially through propagation via the collective estimation.

The collective estimation of Small and Medium-sized Enterprises becomes increasingly important due to the large reductions at large companies and should be modelled after the present area source approach.

Improvement of the data processing of companies' Environmental Reports could avoid simple mistakes with high emission impacts. Data processing could be improved with relatively simple guidelines and protocols and herewith decrease the share of missed individually registered emissions.

The translation from measurement to reporting according to the correct definitions and the branch representativeness add much uncertainty to the assessment on branch level. To improve this, existing protocols need to be applied in practice with the emission assessment by the companies and the validation by the provincial authorities. To avoid confusion and double work, permits should be like Environmental Reports in terms of PM_{10} and not TSP. It could enhance the quality of the estimated sector totals if the individual emission data on PM_{10} is presented with corresponding accuracy and type of determination. The electronic Environmental Reporting could support this.

Storage & handling with surface areas larger than 50,000 m^2 and green crop driers should be obliged to publish an annual Environmental report or be included in the individual registration of companies.

7.2.2 Weakly assessed sources

Trend analysis over the period 1995-2001 indicates that priority should be put on the analysis of the strong decrease of emissions from certain large individual sources and the collective estimation of industrial emissions that is largely based upon data from these large sources.

Animal housing is of most priority. Although the current PM_{10} emission data on these sources is considered to be of a relative low uncertainty (D, 50%) it attributes significant to the national total PM_{10} emission (20%). Improving the PM_{10} emission data of process emissions from **primary metallurgical processes** is second most important. The PM_{10} emission data of other **mobile sources fuelled with diesel** (mostly agricultural) and **diesel road transport** to some lesser content also can also enhance quality. **Rail wear** of wheels and rails is believed to be a significant source with an estimated emission of 1 kton, but is not included in the PER.

The sector **fertilizer production** is with a high uncertainty in PM_{10} emission data and a small number of manufacturers also likely to be a candidate for improving the PM_{10} emission data. The same can be mentioned for companies in the **food industry, manufacturers of organic chemicals and oil refineries.**

Factory building emissions are based upon a single estimation which should be updated e.g. every 5 year. Part of these emissions is possibly double counted if companies individually report these emissions.

Finally, for a number of emission sources which might have substantial PM emissions, it is **unclear** to which extend these are included in the present (individual) PER:

- flares in oil production and refineries;
- wood combustion in coal fired power plants as a CO_2 mitigation measure and in the wood processing sector.

The monitoring methodologies are published in reports for all sectors. The EF data are not always published but should be **publicly referable**.

7.2.3 Missing sources

Illegal emissions from e.g. fires to combust waste are important for air quality and therefore should be monitored to be include e.g. as a memo-item.

Ocean shipping on the national continental shelf is not included in reporting, but is a major source of 8.5 kton PM (and NO_x and SO_2), significant for air quality. It should be reported as a memo-item.

Even in a conservative estimation, the resuspension of road transport in the Netherlands would be in the order of 1 kton or 1.5% of national PM_{10} emissions. The contribution to $PM_{2.5}$ would be less but still relevant. Up to now, resuspension has not been included in European emission inventories such as NFR, since it has been considered as a re-emission and not a primary emission. Since the attention for resuspension is growing, it is recommended to develop common and transparent methods to calculate resuspension and include it as a memo item in the inventories.

Background concentrations from sea salt aerosols should be identified and included as functions of meteorological conditions in air quality forecasting models in order to be able to understand the natural contribution to observed PM levels and to reduce the overall uncertainty of emission concentrations in the Netherlands.

The average sea salt contribution to Dutch PM levels is very important, viz. in the order of 30-60 kton per year. For an omnipresent diffuse source as the sea, the source strength is only an indication for comparison with inland sources. The analysis of routinely measured elemental composition (Na, Cl) allows for a more exact quantification of the contribution of salt aerosol to the total PM_{10} or $PM_{2.5}$ concentration.

Resuspended road salt should be considered since the contribution to Dutch concentrations can be significant, viz. up to one third of total (sea) salt, being 1-2.5 kton. Monitoring methods should be developed to include it as a memo item.

It is recommended to include crustal material or windblown dust as a memo item in the Dutch inventory, since the potential contribution is 40 ± 20 kton (national and foreign), however, the health effects are expected to be limited. It is interesting to see whether it is possible to make a distinction between natural and agricultural wind blown dust in view of possible policy measures (although wind blown dust in rural areas will not likely be a constraint for meeting air quality targets). For that purpose, also foreign and inland emissions need to be distinguished.

Sea salt consists for 40% of $PM_{2.5}$ while crustal material only for 10%-20%. However, the emission levels are also for crustal material still significant.

It is possible that volatile primary marine particles, presumably organic compounds, have a significant contribution to PM concentrations in near-coastal regions such as the Netherlands.

7.2.4 Conclusions on missing and weak sources

The following important natural emission and re-emission sources that are not included in the PER have been identified:

Source	Type	Emission [kton PM_{10}]	Recommendation
Road resuspension	Anthropogenic	6	Annual monitoring
Road salt (resuspension)	Anthropogenic	1-2.5	Annual monitoring
Crustal wind blown	Semi-natural	40 ± 20 [a)]	Annual monitoring
Sea salt	Natural	30-60 [b)]	Study for modelling
Marine VOC	?	?	Explore

[a)] domestic and foreign

[b)] for an omnipresent diffuse source like the sea and oceans, a source strength is only an indication of importance in comparison to inland sources. In reality the source strength is much higher.

It is recommended to monitor anthropogenic sources annually and at least include them as a memo-item since these can have a meaning for policies and measures, while natural sources only need to be assessed for air quality modelling e.g. every five year.

The following anthropogenic sources that are included in the PER are weakly assessed or reported and need improvement:

Source	**Type**	**Maximum impact [kton PM_{10}]**	**Recommendation**
Ocean shipping	Collective	+ 9	Report as memo
Industrial companies (primary metallurgy, refineries, fertiliser)	Individual	+ 5	Improve registration
Factory buildings	Indiv./collective	- 2.5	Improve registration / update 5-yearly
Rail wear	Collective	+ 1	Improve
Mobile sources on diesel	Collective	± 6	Improve
Animal housing	Collective	± 4.5	Improve
Storage & handling	Individual	± 2	Improve registration
Food	Individual	± 2	Improve registration
Open fires (wild or residential)	Collective	+?	Improve activity data
Flares, wood combustion power plants & wood processing	Individual	+?	Improve registration

Improvement means that the existing data, methods, procedures or reporting have to be improved. The uncertainty related to these sources is a quarter of the total uncertainty of PM. Public referability is a point of attention to increase the quality in the long run.

The process within the PER is complex. Lack of attention for coordination and transparency, particularly in the individually registered emissions of companies, has resulted in a fragmented organisation, at the costs of overall quality and overall problem perception. This can only be addressed by improving the commitment by communication, co-ordination and guidance.

7.2.5 Possibilities for extension to $PM_{2.5}$

As a transitional arrangement, the present approach to assess $PM_{2.5}$ at branch level by using $PM_{2.5}$ fractions on PM_{10} emissions could be extended to source level. The $PM_{2.5}$ fractions should be updated every few (e.g. five) years since the $PM_{2.5}$ fractions are very dependent on process types as well as the type and extend of mitigation measures applied. To this end, $PM_{2.5}$ estimations preferably have to be embedded in the PER itself and not in separate projects as now is the case, in order to increase the effectiveness, actuality and reliability of these $PM_{2.5}$ estimates.

However, it is preferable to change both the definitions of the NeR, the permits and the Environmental Reports in order to consistently regulate companies, monitor emissions, develop policy measures and regulate air quality.

For acceptable company estimations of $PM_{2.5}$ emissions, either $PM_{2.5}$ measurements have to be conducted (according newly developed protocols) or technology dependent $PM_{2.5}$ estimation guidelines have to become available. The total costs of measuring $PM_{2.5}$ instead of PM_{10} is less because the number of sources is smaller. If both fractions have to be measured, sampling of stack gases by NEN EN 12341 (for PM_{10}) and Draft NEN EN 14907 (for $PM_{2.5}$) can be done simultaneously with minor extra costs.

Besides the fractionation, the present source types give an impression of the PM composition, which is relevant for modelling and health effects. Further details require detailed and thus single research analysis; annual monitoring seems economically infeasible.

7.2.6 Possibilities for information on mitigation measures

Additional study is necessary to assess what is needed to meet the requirements of the Arhus protocol on public availability of information. The electronic Environmental Reporting provides possibilities to include meta data and establish transparency in emission assessment.

Information to understand the emission, exposure and health effects in the context of science and environmental policy development can be gathered most efficiently by dedicated studies, for example in a policy research program.

7.3 Closure

It can be concluded that the quality of the Dutch emission monitoring in general and that of Particulate Matter in particular is good and internationally on a relatively high level. Nevertheless, scope for improvement exists since international developments indicate the need for a focus on smaller particle sizes. Also, information on mitigation measures is presently lacking. Furthermore, specific reasons for a critical review have occurred in the recent years, viz. the lack of reliability and verifiability of the individual company reports of emissions.

For the years 2000-2002, the Dutch national PM emissions figure has been established only after specific projects that ‘repair’ the individually registered emission assessments for Particulate Matter on the basis of PM_{10} fractions of total dust emissions. Except for the PER, however, companies, provincial authorities and FO-I are not aware of any problem.

It has been shown that emission validation for the purpose of accurate national emission assessment is not considered as a task by the provincial authorities. The protocols exist but are not applied to the last detail since this seems not relevant for the purpose of checking permits. A substantial share of large emission sources are not monitored according to the methodology required for their classification, e.g. emissions are estimated instead of measured (continuously). Although the provincial umbrella organisation IPO has recently improved the guidelines in this aspect by specifying explicit classes and methods, the provincial authorities do not feel a direct problem since they have no regulation problem. The inconsistency of PM definitions (TSP versus PM_{10}) in permits (NeR) and Environmental Reports, however, remains to lead to monitoring problems. If the regulation and monitoring is based upon consistent definitions, the validation of permits and ER will be effective for emission monitoring as well. Furthermore, guidelines and software tools could support the validation by regulatory bodies. One way to increase the effectiveness of validation for the use of national emission estimations is to focus attention to a selection of e.g. 25 companies covering approximately 90% of the individually reported industrial emissions. Improved accuracy of these emissions would substantially improve the accuracy of total industrial emissions.

The more or less automatic data processing of Environmental Reports have lead to the largest mistakes. These mistakes are simple to avoid by guidelines for processing. Also, a smart adjustment of the electronic ER could avoid errors.

The presently fragmented organisation, particularly in the individually registered emissions of companies, needs improved transparency and coordination to establish a common problem perception and increase the overall quality. This can only be addressed by improving the commitment of all involved actors by communication, co-ordination and guidance.

Next to the inaccuracy of the present individual registration of emissions, scope for improvement of the assessment of some sources have been identified. Furthermore, it has been recommended to extend the PER to (semi)natural sources and resuspension and include these as memo items, since these are important for both some types of mitigation as well as a general understanding of PM dispersion and air quality.

Also, (re)inclusion of meta information is recommended in order to be able to follow and develop mitigation policies and measures as well as to provide a transparent and high quality emission monitoring system that meets the requirements on the public right-to-know of the Arhus convention.

The present international $PM_{2.5}$ reporting can be fulfilled by top-down estimates. These are conducted in separate projects but could be embedded in the PER to increase effectiveness, actuality and reliability. The present international developments indicate that $PM_{2.5}$ becomes more important, viz. it is likely that the air quality standards will become formulated (also) in terms of $PM_{2.5}$. Effective regulation by the NeR would rely on consistent definitions, implying that measurements at company level would have to adjust to $PM_{2.5}$. This looks in first instance technically and economically feasible, but has to be investigated in more detail.

The recommendations have been processed into concretely formulated project ideas. All projects are feasible in terms of presently available know-how and data. The project ideas have been presented according a number of criteria, viz.:
- urgency of the improvement, related to the objective to reach, resulting in short term and long term improvements
- size of necessary budget

The project ideas have been presented in a separate supplementary note for the ministry of VROM, being responsible for the Dutch environmental policy in general and that on Particulate Matter in particular, and RIVM, being the supervisor of the Dutch PER.

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9. Authentication

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Names and establishments to which part of the research was put out to contract:

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Date upon which, or period in which, the research took place:

October 2003 - October 2004

Signature:	Approved by:
A.K. van Harmelen, M.Sc. Project Leader	H.S. Buijtenhek, M.Sc. Head of Department

Appendix A. List of interviewees

Person	**Organisation**	**Subject**
Wim Chardon	Alterra	agriculture
Tjeerd van Scheltinga	Prov. Friesland	regional authority
André Peeters Weem	Infomil	companies
Mat Beelen & Piet de Haas	Corus	company
Bas Guis	CBS	estimation other industry
Dick Heslinga	TNO-MEP	individual registration
Kees Peek	RIVM	industry
Gerard Kuipers	TNO-MEP	measurement
Koos Hollander	TNO-MEP	measurement
Pieter Hammingh	RIVM	storage and transfer
Raymond Gense	TNO-WT	transport

Appendix B. List of interviewees

TABLE IV 1A: **National sector emissions: Main pollutants, particulate matter and heavy metals**		
Version 2002-1		
COUNTRY:	NL	(as ISO2 code)
DATE:	13.02.2004	(as DD.MM.YYYY)
YEAR:	1995	(as YYYY, year of Emmissions)

NFR sectors to be reported to CLRTAP			A = Allowable Aggregation			
				Particulate matter		
				TSP	PM10	PM2.5
				Mg	Mg	Mg
1 A 1 a	(a)	1 A 1 a Public Electricity and Heat Production		890,9	558,7	447,0
1 A 1 b	(a)	1 A 1 b Petroleum refining		4622,9	4622,9	2773,7
1 A 1 c	(a)	1 A 1 c Manufacture of Solid Fuels and Other Energy Industries		231,9	86,2	69,0
1 A 2	(a)	**1 A 2 Manufacturing Industries and Construction**	**A**	2068,5	1861,5	1116,9
1 A 2 a	(a)	1 A 2 a Iron and Steel		818,4	779,0	467,4
1 A 2 b	(a)	1 A 2 b Non-ferrous Metals		2,6	2,5	1,5
1 A 2 c	(a)	1 A 2 c Chemicals		627,1	564,4	338,6
1 A 2 d	(a)	1 A 2 d Pulp, Paper and Print		11,0	10,9	6,6
1 A 2 e	(a)	1 A 2 e Food Processing, Beverages and Tobacco		252,5	215,0	129,0
1 A 2 f	(a)	1 A 2 f Other (Please specify in a covering note)		356,8	289,7	173,8
1 A 3 a ii (i)		1 A 3 a ii Civil Aviation (Domestic, LTO)		154,3	154,3	154,3
1 A 3 a ii (ii)		1 A 3 a ii Civil Aviation (Domestic, Cruise)		IE	IE	IE
1 A 3 b	(a)	**1 A 3 b Road Transportation**	**A**	14335,9	14335,9	14335,9

NFR sectors to be reported to CLRTAP			A = Allowable Aggregation			
				Particulate matter		
				TSP	PM10	PM2.5
				Mg	Mg	Mg
1 A 3 b i		1 A 3 b i R.T., Passenger cars		3937,6	3937,6	3937,6
1 A 3 b ii		1 A 3 b ii R.T., Light duty vehicles		3163,6	3163,6	3163,6
1 A 3 b iii		1 A 3 b iii R.T., Heavy duty vehicles		4246,1	4246,1	4246,1
1 A 3 b iv		1 A 3 b iv R.T., Mopeds & Motorcycles		215,9	215,9	215,9
1 A 3 b v		1 A 3 b v R.T., Gasoline evaporation		0,0	0,0	0,0
1 A 3 b vi		1 A 3 b vi R.T., Automobile tyre and brake wear		1756,9	1756,9	1756,9
1 A 3 b vii		1 A 3 b vii R.T., Automobile road abrasion		1015,9	1015,9	1015,9
1 A 3 c	(a)	1 A 3 c Railways		72,5	67,8	67,8
1 A 3 d ii		1 A 3 d ii National Navigation		1970,3	1970,3	1519,5
1 A 3 e	**(a)**	**1 A 3 e Other (Please specify in a covering note)**	**A**	1191,9	1191,9	1191,9
1 A 3 e i		1 A 3 e i Pipeline compressors		IE	IE	IE
1 A 3 e ii		1 A 3 e ii Other mobile sources and machinery		1191,9	1191,9	1191,9
1 A 4 a	(a)	1 A 4 a Commercial / Institutional		41,5	38,7	36,7
1 A 4 b	(a)	**1 A 4 b Residential**	**A**	3993,8	2238,8	2238,8
1 A 4 b i		1 A 4 b i Residential plants		3993,8	2238,8	2238,8
1 A 4 b ii		1 A 4 b ii Household and gardening (mobile)		NA	NA	NA

NFR sectors to be reported to CLRTAP			A = Allowable Aggregation	Particulate matter TSP Mg	 PM10 Mg	 PM2.5 Mg
1 A 4 c	(a)	**1 A 4 c Agriculture / Forestry / Fishing**	**A**	2721,7	2705,2	2705,2
1 A 4 c i		1 A 4 c i Stationary		166,6	150,0	150,0
1 A 4 c ii		1 A 4 c ii Off-road Vehicles and Other Machinery		2555,2	2555,2	2555,2
1A 4 c iii		1A 4 c iii National Fishing		IE	IE	IE
1 A 5 a	(a)	1 A 5 a Other, Stationary (including Military)		9,2	9,2	9,2
1 A 5 b	(a)	1 A 5 b Other, Mobile (Including military)		NO	NO	NO
1B1	(a)	**1B1 Fugitive Emissions from Solid Fuels**	**A**	NO	NO	NO
1 B 1 a	(a)	1 B 1 a Coal Mining and Handling				
1 B 1 b	(a)	1 B 1 b Solid fuel transformation				
1 B 1 c	(a)	1 B 1 c Other (Please specify in a covering note)				
1 B 2	(a)	**1 B 2 Oil and natural gas**	**A**	323,9	278,9	215,1
1 B 2 a	(a)	**1 B 2 a Oil**	**A**	204,7	159,7	95,8
1 B 2 a i	(a)	1 B 2 a i Exploration Production, Transport		IE	IE	IE
1 B 2 a iv	(a)	1 B 2 a iv Refining / Storage		204,7	159,7	95,8
1 B 2 a v	(a)	1 B 2 a v Distribution of oil products		0,0	0,0	0,0
1 B 2 a vi	(a)	1 B 2 a vi Other				
1 B 2 b	(a)	1 B 2 b Natural gas		119,2	119,2	119,2
1 B 2 c	(a)	1 B 2 c Venting and flaring		IE	IE	IE

NFR sectors to be reported to CLRTAP			A = Allowable Aggregation	Particulate matter TSP Mg	 PM10 Mg	 PM2.5 Mg
2 A	(a)	**2 A MINERAL PRODUCTS (b)**	**A**	2603,7	2332,0	816,2
2 A 1	(a)	2 A 1 Cement Production		234,5	234,5	82,1
2 A 2	(a)	2 A 2 Lime Production		IE	IE	IE
2 A 3	(a)	2 A 3 Limestone and Dolomite Use		IE	IE	IE
2 A 4	(a)	2 A 4 Soda Ash Production and use		IE	IE	IE
2 A 5	(a)	2 A 5 Asphalt Roofing		IE	IE	IE
2 A 6	(a)	2 A 6 Road Paving with Asphalt		IE	IE	IE
2 A 7	(a)	2 A 7 Other including Non Fuel Mining & Construction (Please specify in a covering note)		2369,2	2097,5	734,1
2 B	(a)	**2 B CHEMICAL INDUSTRY**	**A**	6572,8	4323,6	2378,0
2 B 1	(a)	2 B 1 Ammonia Production		IE	IE	IE
2 B 2	(a)	2 B 2 Nitric Acid Production		IE	IE	IE
2 B 3	(a)	2 B 3 Adipic Acid Production		IE	IE	IE
2 B 4	(a)	2 B 4 Carbide Production		IE	IE	IE
2 B 5	(a)	2 B 5 Other (Please specify in a covering note)		6572,8	4323,6	2378,0
2 C	(a)	2 C METAL PRODUCTION		6044,0	5276,4	2638,2
2 D	(a)	2 D OTHER PRODUCTION (b)	**A**	6324,9	3192,0	459,5
2 D 1	(a)	2 D 1 Pulp and Paper		386,1	386,1	38,6
2 D 2	(a)	2 D 2 Food and Drink		5938,8	2805,9	420,9
2 G	(a)	2 G OTHER (Please specify in a covering note)		1410,5	1338,6	133,9

NFR sectors to be reported to CLRTAP			A = Allowable Aggregation	Particulate matter		
				TSP	PM10	PM2.5
				Mg	Mg	Mg
3 A	(a)	3 A PAINT APPLICATION		6,2	6,2	0,6
3 B	(a)	3 B DEGREASING AND DRY CLEANING		0,0	0,0	0,0
3 C	(a)	3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING		IE	IE	IE
3 D	(a)	3 D OTHER including products containing HMs and POPs (Please specify in a covering note)		7082,8	2001,9	200,2
4 B	(a)	**4 B MANURE MANAGEMENT (c)**	**A**	9009,0	9009,0	1801,8
4 B 1	(a)	4 B 1 Cattle		1042,0	1042,0	208,4
4 B 1 a	(a)	4 B 1 a Dairy		NE	NE	NE
4 B 1 b	(a)	4 B 1 b Non-Dairy		NE	NE	NE
4 B 2	(a)	4 B 2 Buffalo		IE	IE	IE
4 B 3	(a)	4 B 3 Sheep		IE	IE	IE
4 B 4	(a)	4 B 4 Goats		IE	IE	IE
4 B 5	(a)	4 B 5 Camels and Llamas		IE	IE	IE
4 B 6	(a)	4 B 6 Horses		IE	IE	IE
4 B 7	(a)	4 B 7 Mules and Asses		IE	IE	IE
4 B 8	(a)	4 B 8 Swine		3211,0	3211,0	642,2
4 B 9	(a)	4 B 9 Poultry		4756,0	4756,0	951,2
4 B 13	(a)	4 B 13 Other		0,0	0,0	0,0
4 C	(a)	4 C RICE CULTIVATION		NO	NO	NO

NFR sectors to be reported to CLRTAP			A = Allowable Aggregation	Particulate matter TSP Mg	 PM10 Mg	 PM2.5 Mg
4 D	(a)	**4 D AGRICULTURAL SOILS**	**A**	NO	NO	NO
4 D 1	(a)	4 D 1 Direct Soil Emission				
4 F	(a)	4 F FIELD BURNING OF AGRICULTURAL WASTES		NO	NO	NO
4 G	(a)	4 G OTHER (d)		377,0	377,0	75,4
5 B	(a)	5 B FOREST AND GRASSLAND CONVERSION		NO	NO	NO
6 A	(a)	6 A SOLID WASTE DISPOSAL ON LAND		0,0	0,0	0,0
6 B	(a)	6 B WASTE-WATER HANDLING		6,5	6,5	6,5
6 C	(a)	6 C WASTE INCINERATION (e)		6,6	6,6	6,6
6 D	(a)	6 D OTHER WASTE (f)		102,1	76,3	76,3
7,0	(a)	7 OTHER		1770,0	1770,0	1770,0
		National Total		73945,4	59836,3	37243,9

Memo Items						
1 A 3 a i (i)	(a)	International Aviation (LTO)				
1 A 3 a i (ii)	(a)	International Aviation (Cruise)				
1 A 3 d i	(a)	International Navigation		1551,4	1551,4	1551,4
5 E	(a)	5 E Other				
X		X (11 08 Volcanoes)				

(a) Sectors already reported to UNFCCC for NOx, CO, NMVOC, SO_2.
(b) Including Product handling.
(c) Including NH_3 from Enteric Fermentation.
(d) Including PM sources.
(e) Excludes waste incineration for energy (this is included in 1 A 1).
(f) Includes accidental fires.

Note 1: Main Pollutants should cover the timespan from 1980 to latest year.
HM should cover the timespan from 1990 to latest year.
PM should cover the timespan from 2000 to latest year.

Note 2: The A=Allowable Aggregation illustrates the level of aggregation that can be used if more detailed information is not available. Grey cells show which sectors can be aggregated into the sector marked A. Black cells occur when two possible levels of aggregation are possible.

IE:	Included Elsewhere
NO:	Not Occurring
NA:	Not Applicable
NE:	Not estimated
C:	Confidential

Appendix C. Simple error propagation

If emissions from two independently measured sources 1 and 2 are being added, the sum of emissions has the following absolute confidence interval:

$$C_{Total} = \sqrt{C_1^{\,2} + C_2^{\,2}}$$

Here the result of two sources with absolute confidence intervals of 10 ton is an overall confidence interval of 14 ton for the sum of the emissions from both sources. If the number of sources is 100, the overall confidence interval is (100 x 100 ton^2) = 100 ton, which is on average per source 1 ton. This illustrates that summation of a large number of independent sources in general increases the overall confidence of the sum. This is only true when the errors in the individual emissions are (to a great extent) non-systematic. If for example in all emission inventories sources are neglected that have a contribution of 10% to the total emission of a plant, the sum of all these plants will have a systematic error of 10% (the real sum is 10% higher).

If an emission is calculated by multiplication of an activity and an Emission Factor (EF), the confidence interval of the emissions can be calculated by using the relative confidence interval in % of the activity and the EF. For example, if the latter are both 10%, the confidence interval of the emissions is 14%. Here, the multiplication of two categories of data with their confidence intervals leads to an overall confidence smaller than the confidence in the individual components.

The reader should bear in mind these messages in order to understand the approach taken in this report. First, a large number of relatively small, independent sources in the inventory may have a large uncertainty and still result in an accurate national emission estimation. Here, independence of the measurement of the sources should be a relevant issue to address, as well as the relation to enforcement of standards. From a point-of-view of enforcement, emission assessment might be too uncertain while it is accurate enough for the estimation of national emissions.

Second, collective emission estimation methods using the famous relation between activity and EF ‘preserve’ uncertainty up to the national level. Here, the focus should be on representativeness of measurements of EF and the accuracy of activity data.

Appendix D. Branch descriptions

This appendix gives an overview of available information by branch, which served as a background for the assessment made in the report. It provides useful background information on the fine dust situation in the different industrial branches.

Before describing the branch situations, table D.1 provides a data overview per branch on PM_{10} and $PM_{2.5}$ emissions and concentrations in 1998 and presently installed abatement technologies (1998). The technology related figures are indicative and the concentration ranges can vary substantially, since the underlying sources can involve a large variety of processes and companies.

This information is also presented by branch in the branch descriptions. There, a short overview is given of the branch in terms of types of processes and the companies registered individually in the year 1995. These companies are obliged to publish an annual Environmental report or are selected for registration on the basis of criteria to complete a representative branch selection. Here ‘representative’ is defined as being representative from the angle of ‘environment’, expressed as a large number of pollutants. This means that the selection of companies is not necessarily covering the majority of the PM_{10} and $PM_{2.5}$ emissions in the branch, nor that these companies are necessarily representative for the PM emissions in the branch. The companies are not explicitly presented with their name if companies have a very large or a very tiny contribution to the sector emissions.

The information of these companies has been used to make a sector assessment of the ‘present’ technological situation, e.g. the type and dimensions of the process equipment installed and the de-dust technology in use. The share in sector production of the individually registered companies can be viewed as a first estimate of the representativeness of the emission and technology data; the higher the share, the more representative are the data. A higher representativeness does not necessarily mean that the data are more accurate. Sometimes, more general estimates on the basis of an accurate emission factor can be more precise. Information on this subject is not available in the framework of the present project.

Besides the individual pollutant emission register of the year 1995, a report [ref. 19] by Haskoning on diffuse Particulate Matter emission sources has been the basis for the technological branch assessment.

The emissions of PM_{10} and $PM_{2.5}$ of the branch are reported in three categories of emission sources, viz. process emissions, diffuse emissions and combustion emissions. Diffuse emissions are defined as fugitive emissions by (un)abated building ventilation and (material handling) activities in open air. Combustion emissions are emissions from combustion processes to generate power or heat. All other emissions are due to production related industrial activities, the so-called process emissions.

These emission estimates are based upon the pollutant emission register of the year 1998.

Furthermore, the branch description includes a comparison of the present National Emission Regulation (NeR) and the EU guidelines on best available technology (BREF documents) for as far as these exist at the moment of study. If not stated otherwise, the general requirements of the NeR with respect to dust emissions are an emission concentration of 20 mg/m^3 in general and 5 mg/m^3 if fabric filters can be used.

Finally, the scope of technologies to reduce sector emissions further in the future is discussed briefly.

Table D.1 Overview per branch of PM emissions and concentrations in 1998, presently installed abatement technologies (1998) and possible future measures (up to 350 /kg) and the resulting concentrations and specific costs (technology related figures are indicative).

Source	*Present situation (1998)*					*Additional measures*			
Sector / process	PM_{10} share industry	PM_{10}	$PM_{2.5}$	Presently installed abatement technology	PM_{10} concentration	Additional abatement technology	PM_{10} concentration	Reduc-tion	Specific costs
	[%]	[ton/y]	[ton/y]		[mg/Nm^3]		[mg/Nm^3]	[%]	[€/kg PM_{10}]
Aluminium (274)	**8,9**	**1600**	**692**					**10%**	
Process	8,5	1541	686	diverse	2-30	none / fabric filter	0,5-2	10%	20-100
Diffuse	0,3	59	6	none / fabric filter		material handling		80%	5-50
Combustion									
Cement (2651)	**1,2**	**220**	**96**					**60%**	
Process	1,2	215	95	Fabric filter / ESP	35-65	Fabric filter	2	60%	20-50
Diffuse	0,0	5	1						
Combustion									
Chemicals (24)	**13,1**	**2370**	**1294**					**70%**	
Process	11,8	2129	1131	none / diverse	10-200	diverse	2-5	70%	5-250
Diffuse	0,5	85	7			material handling		80%	5-50
Combustion	0,9	156	156		30	Incineration	5	70%	
Construction (45 excl. 4531)	**5,9**	**1062**	**106**					**90%**	
Process									
Diffuse	5,9	1062	106	none	1	collection + fabric filter	2 *	90%	190
Combustion									
Food (15, 16)	**12,8**	**2300**	**386**					**90%**	
Process	10,2	1841	340	none / diverse	10-400	scrubbers / fabric filters	2-5	90%	2-150
Diffuse	2,5	459	46			mat. handling / collect +FF		80%	7-350
Combustion									
Glass (261-3)	**2,8**	**510**	**316**					**80%**	
Process	2,0	353	298	none / scrubber	30-220	Fabric filter / Wet ESP	2-5	80%	15-130
Diffuse	0,9	154	15			collection + fabric filter	2 *	70%	
Combustion	0,0	3	2	none	1				340
Iron & Steel (231, 27 excl. 274)	**16,7**	**3006**	**1803**					**80%**	
Process	7,9	1432	1289	diverse	10-100		0,1-5	80%	70-270
Diffuse	8,3	1499	448	diverse	5-10	mat. handling / collect +FF	0,1	80%	4-350
Combustion	0,4	75	66	none / ESP	10-20	ESP	2-5	70%	40
Metal working (28-35, 4531)	**3,0**	**543**	**337**					**70%**	
Process	1,6	286	286	none	1	collection + fabric filter	2 *	60%	350
Diffuse	1,4	257	51	none	1-2	collection + fabric filter	2 *	80%	350
Combustion									
Other Build M. (264-8 excl. 2651)	**6,2**	**1112**	**257**					**90%**	
Process	1,1	194	93	none	1-30	Wet ESP	2	90%	100-200
Diffuse	5,1	918	164	none	1-2	collection + fabric filter	2 *	90%	45-350
Combustion									
Paper (21)	**2,1**	**384**	**38**					**80%**	
Process									
Diffuse	2,1	384	38	none	1	collection + fabric filter	2 *	80%	150
Combustion									
Power (40001)	**3,0**	**539**	**346**					**70%**	
Process									
Diffuse	0,8	142	14			materials handling		80%	5-50
Combustion	2,2	397	332	ESP-scrubber-FF	1-10	none / fabric filter	2	70%	100
Refineries (232)	**18,8**	**3390**	**2787**					**90%**	
Process	9,5	1721	1291	none	50	ESP	5	90%	40
Diffuse									
Combustion	9,3	1669	1496	none	75-750	ESP	5	100%	25
Rubber & Plastics (25)	**0,4**	**66**	**6**					**60%**	
Process									
Diffuse	0,4	66	6	none	0,5	collection + fabric filter	2 *	60%	> 350
Combustion									
Textile (17,18)	**0,7**	**121**	**12**					**80%**	
Process									
Diffuse	0,7	121	12	none	1	collection + fabric filter	2 *	80%	280
Combustion									
Waste (9000)	**0,2**	**35**	**34**					**40%**	
Process									
Diffuse									
Combustion	0,2	35	34	ESP-scrubber-FF	3	Fabric filter	2	40%	200
Wood (20, 361)	**2,3**	**406**	**41**					**90%**	
Process									
Diffuse	2,3	406	41	none	1,5	collection + fabric filter	2 *	90%	250
Combustion									
Other industry	**2,0**	**367**	**220**						
Process									
Diffuse	2,0	367	220						
Combustion									
TOTAL INDUSTRY	**100,0**	**18000**	**8800**					**80%**	
Process	53,9	9700	5500					70%	
Diffuse	33,2	6000	1200					90%	
Combustion	12,9	2300	2100					90%	

Notes: see next page

Notes with table C1 (previous page):

- Diffuse: Fugitive emissions by (un)abated building ventilation and (material handling) activities in open air.
- FF = fabric filter; ESP = Electrostatic Precipitator;
- Materials handling: Measures that reduce dust emission at activities in the open air by about 50 to 80%.

* Collection + fabric filter: collection by local extraction in 10% of present building ventilation air; the dust concentration in the cleaned air is presented (which is a factor 10 higher than the overall average concentration).

Contents

1. Aluminium (sbi 274)

2742: primary and secondary aluminium, aluminium oxide (anode, electrolyses, smelting, founding, diffuse)

2743/4: zinc/copper (smelting, founding, diffuse, combustion)

1.1 Branch description

Aluminium is produced in two ways, depending on the origin of the raw material. Primary aluminium is prepared from bauxite and secondary aluminium from recycled aluminium. Only the first stage of the production process is different for the two kinds of aluminium. The final stages of the production process are the same for both primary and secondary aluminium.
The total production of aluminium in the Netherlands is about 420,000 tons per year. About 45% of this is secondary aluminium.
The other non-ferrous metal production (zinc, copper) hardly contributes to the fine dust emissions.

The production of the individually registered companies in the branch.

Aluminium		
Company name	**Annual production Sector 1998 [ton]**	**% of production by individual companies 1998**
Aldel		
Pechiney		
Aluminium Hardenberg B.V.	~ 850,000	~ 80%
Alcoa Botlek		
Aluchemie		

The representativeness of the branch data seems rather high since the share of individually registered companies is approximately 80% in terms of production.

1.2 Description of processes and sources of fine dust

Primary aluminium: Bauxite is treated with caustic soda to extract the aluminium at elevated temperatures. The aluminate solution is cooled and seeded with alumina to crystallise hydrated alumina. The crystals are washed and calcined in rotary kilns. The alumina is electrolytically reduced in a bath of molten sodium aluminium fluoride at approximately 1000°C. This electrolytic process is the main source of fine dust emission, both as process emissions and building emissions. At present time, fabric filter are used to reduce the process emissions, and washers to reduce building emissions.

Secondary aluminium: In the production of secondary aluminium, recycled aluminium parts are melted in an oven. This melting is the main source of fine dust emission in secondary aluminium production. The emissions can both be fugitive or stack emissions. Fugitive emission can be much greater than captured and abated emissions. Handling of materials is particularly important.

1.3 Emission of fine dust and abatement techniques

The emissions of the aluminium industry contribute with almost 10% substantially to the total of industrial emissions. The vast majority of emissions consists of process emissions.

Source	***Situation 1998***				
Sector / process	**PM_{10} share industry**	**PM_{10}**	**$PM_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Aluminium (274)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process	8.5	1541	686	Diverse	2-30
Diffuse	0.3	59	6	none / fabric filter	
Combustion					
Total	**8.9**	**1600**	**692**		

<u>BREF (Non ferrous)</u>:

- Primary measures (a lot).
- Secondary measures:
  Point sources: fabric filter, hot ESP, cyclone (pre-treatment) ⇒ 1 - 100 mg/Nm^3.
  Fugitive emissions:
  - dry dust: capture + wear resistant fabric filter or ceramic filter (1-5 mg/Nm^3).
  - sticky and abrasive dust: capture + wet ESP or Scrubber (1-5 mg/Nm^3).
  - roofline collection of fume is very energy consuming and should be a last resort.

Comparison between guidelines NeR and BREF (new installations)					
Sector	**Process**	**Reduction Techniques**	**Dust concentration / emission**		
			NeR	**BREF**	
			[mg/m^3]	**[mg/m^3]**	**[kg/ton pr.]**
Non Ferrous	Electrode baking	dry alumina + FF	5	1 - 5	
	Other sources	collection + FF	5	1 - 5	

1.4 Further emission reduction

On the process emissions, being the bulk of the emissions in the branch, further emission reduction with fabric filters will have a limited effect in the order of 10% since most plants already are being equipped with severe reduction measures and consequently have low dust concentrations, down to 2 mg/m^3. Material handling emissions can be reduced up to 80%, but form only a very limited part of the emissions.

Primary aluminium: Use of electrodes that are inert at the used conditions and give better energy efficiency can lead to less indirect dust emissions.
Secondary aluminium: Reuse of filter dust to increase the overall efficiency of the production unit.

2. Cement (sbi 2651)

2.1 Branch description

For the cement industry, emission data from two companies in the Netherlands are used. Together they produce 2,500,000 tons of cement (70% of the annual production) and 186 tons of fine dust (65% of the total annual fine dust emission in this branch).

2.2 Description of processes and sources of fine dust

The production of cements begins with the calcinations of calcium carbonate ($CaCO_3$) at 900°C to produce calcium oxide (CaO). This calcium oxide is reacted at high temperatures (1400-1500°C) with silica, alumina and ferrous oxide to produce clinkers. These clinkers are finally grounded and milled with gypsum to produce cement. The main sources of dust emission are the kilns, raw mills, clinker coolers and cement mills. Emission of fine dust is reduced by applying fabric filters and ESP's resulting in emission levels of 15 mg/m^3 for kilns and 10 mg/m^3 for clinker coolers.
Fugitive emission sources are storage and handling of materials and solid fuels.

The production of the individually registered companies in the branch.

Cement		
Company Name	**Annual production Sector 1998 [ton]**	**% of production by individual companies 1998**
ENCI Maastricht B.V.		
ENCI-Rotterdam B.V.	~ 3,500,000	100%
Cementfabriek IJmuiden Bv		

The representativeness of the branch data is high since all companies have been included in the individual registration.

2.3 Emission of fine dust and abatement techniques

The emissions of the cement industry contribute a little bit over 1% to the total of industrial emissions. The vast majority of emissions consists of process emissions.

Source	***Situation 1998***				
Sector / process	**PM_{10} share industry**	**PM_{10}**	**$PM_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Cement (2651)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process	1.2	215	95	Fabric filter / ESP	35-65
Diffuse	0.0	5	1		
Combustion					
Total	**1.2**	**220**	**96**		

<u>BREF Emission reduction</u> (after BAT: 0.03-0.3 kg/ton clinker):
Primary measures: no
Secondary measures:

- Point sources (kiln systems, clinker coolers and cement mills):
  - ESP or fabric filter: ⇒ 10 – 50 mg/Nm^3 (20 – 50 mg/Nm^3 on a daily basis).
- Fugitive emission reduction by Good Housekeeping:
  - open pile wind protection.
  - water spray and chemical dust suppressors.
  - paving, road wetting.
  - mobile and stationary vacuum cleaning.
  - ventilation and collection in fabric filters.
  - closed storage with automatic handling system.

Comparison between guidelines NeR and BREF (new installations)					
Sector	**Process**	**Reduction technique**	**Dust concentration / emission**		
			NeR *	**BREF**	
			[mg/m^3]	**[mg/m^3]**	**[kg/ton pr.]**
Cement	Cement production	FF (ESP)	5	10 - 50	
	. Kiln systems	FF (ESP)	5	10 - 50	
	. Clinker cooler	FF (ESP)	5	10 - 50	
	. Cement mills	FF (ESP)	5	10 - 50	

* If application of fabric filter is not possible, 20 mg is required

2.4 Further emission reduction

Additional fabric filters can lead to 60% emission reduction.

3. Chemicals (sbi 24)

Sbi 2413:	Other inorganic chemicals
Sbi 2414:	Organic and inorganic chemicals
Sbi 2415:	Fertiliser
Sbi 2416:	Plastic production
Sbi 2417:	Rubber production
Sbi 242:	Agricultural pesticides
Sbi 243:	Paint
Sbi 244:	Pharmaceuticals
Sbi 245:	Detergents and cosmetics
Sbi 246:	Other chemicals
Sbi 247:	Synthetic fibres

3.1 Branch description

A large number of companies with a large variety belong to the chemical industry. Most important companies included in the individual pollutant emission register with substantial emissions of fine dust are summarised below. These companies produce products that belong in the statistical category or sbi code 24.13 (inorganic chemicals), 24.14 (organic chemicals) and 24.15 (fertilisers). Approximately 95% of the individually registered PM_{10} emissions is being covered by the companies presented in the table.

These individually registered companies are the main source of information on applied technologies. The emissions of the total sector are estimated on the basis of the companies. This means that the emissions are not available for the (other) detailed sbi codes.

Chemicals	
Company Name	**Sbi code**
Carbon Black Nederland Bv	2413
Cabot Bv	2413
Norit Nv	2413
Hoechst Holland Nv (Vlissingen)	2413
Norit Nederland B.V.(Klazinaveen)	2413
Nedmag Industries Bv	2413
Elektroschmelzwerk Delfzijl Bv	2413
Shell Nederland Chemie Bv	2414
Nova Chemicals Netherlands Bv	2414
Dsm Limburg Bv	2414
Akzo Nobel Chemicals Bv	2414

Chemicals	
Company Name	**Sbi code**
Kemira Agro Pernis Bv	2415
Hydro Agri Rotterdam Bv	2415
Kemira Agro Rozenburg Bv	2415
Dsm Agro B.V. (IJmuiden)	2415
Zuid-Chemie Bv	2415
Hydro Agri Sluiskil Bv	2415

The representativeness of the branch data seems reasonable since the share of individually registered companies is approximately 70% in terms of PM_{10} emissions. However, scope for improvement exists since not all processes and sbi codes have been included systematically.

3.2 Description of processes and sources of fine dust

Carbon Black (inorganic, SPIN 130):
The production is based on dissection of an organic compound (oil) by partial combustion and thermal cracking (furnace process) in a horizontal reactor at temperatures of 1500 °C. Part of the tail gasses are burned in furnaces for drying of the wet carbon black granules. Emission of dust is reduced by suction and cleaning of the waste gases (fabric filters).

Silica carbide (inorganic, SPIN 141):
The production is based on chemical reduction of very pure quartz sand (SiO_2) and petroleum coke (C) in ovens at temperatures of about 2500 °C. Tail gasses are burned and energy is recovered. Dust emission during cutting of the product in the ovens and handling and storage is reduced by water spraying and good housekeeping measures.

PVC (organic, SPIN 139):
Production is based on polymerisation (chemical reaction of vinyl chloride and other reactants in an oxygen free reactor). Sources of emission of PVC-dust are the drying and handling of PVC-powder. Waste gasses are cleaned in fabric filters.

Fertiliser (fertilisers, Netherlands BAT-Fertilisers; SPIN 102, 147):
Fertilisers are produced on the basis of ores of phosphates and dolomite (and intermediate products like phosphor and sulphur acids) and basic compounds like ammonia and nitric acid. Sources of dust emissions are the handling and grinding of base materials (ores) and waste products and the drying (prilling) and handling of granules.
NeR: 5 mg/m^3 if a fabric filter can be applied, in other cases 20 mg/m^3
BAT: Urea plant: 100-150 g dust/ton after cleaning of granulation/cooling sections.

Salts (inorganic and organic, SPIN 166, 167):
During the production in the Solvay-process waste gases from calcining (drying) and transport are cleaned (fabric filters). Emissions of fine dust can be reduced by installation of fabric filters with higher efficiency.

3.3 Emission of fine dust and used abatement techniques

The emissions of the chemical industry contribute with more than 10% substantially to the total of industrial emissions. The vast majority of emissions consists of process emissions.

Source	***Situation 1998***				
Sector / process	**PM_{10} share industry**	**PM_{10}**	**$PM_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Chemicals (24)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process	11.8	2129	1131	none / diverse	10-200
Diffuse	0.5	85	7		
Combustion	0.9	156	156		30
Total	**13.1**	**2370**	**1294**		

The following table illustrates that the fertiliser industry is responsible for a large portion of the emissions, followed by the inorganic chemical production (including silica carbide, active carbon and carbon black).

Chemical subsector	**PM_{10} emission [ton/y]**
fertiliser	745
other organic	190
inorganic	1158
other chemicals	277
Total	**2370**

3.4 Further emission reduction

A large diversity of reduction measures can reach up to 70% emission reduction.

4. Construction (sbi 45 excl. 4531)

4.1 Branch description

This branch deals with the erection of new buildings and the dismantling of old buildings. Sbi 4531 involves welding in construction and is included in Metal working.

4.2 Description of processes and sources of fine dust

Activities that generate dust are the preparation of the site (handling of soil), the dismantling of old buildings and activities related to reuse of old building materials (breaking of used bricks). The dust generating activities take place in the open air.

The emission estimate is not based upon individual registered companies but on a collective estimate. The total sector concerns over 25,000 companies. The representativeness of the emission estimation is not known.

4.3 Emission of fine dust and abatement techniques

The emissions of the construction sector contribute more than 5% to the total of industrial emissions. The vast majority of emissions consists of diffuse emissions (material handling).

Source	***Situation 1998***				
Sector / process	**PM_{10} share industry**	**PM_{10}**	**$PM_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Construction (45 excl. 4531)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process					
Diffuse	5.9	1062	106	None	1
Combustion					
Total	**5.9**	**1062**	**106**		

Emission reduction can be accomplished by wetting the surfaces or working in (temporary) closed compartments with extracting and cleaning of dust-laden air.

4.4 Further emission reduction

Measures to reduce dust emission concern the collection of dust (herewith increasing the concentration of the waste gas flow) and dedusting it with fabric filters. This relatively expensive measure can reach up to 90% emission reduction.

5. Food (sbi 15, 16)

5.1 Branch description

There are a lot of companies belonging to the food industry (foods for humans and animals).

Most important food categories with emissions of fine dust are summarised below, with the specific product produces and the relevant dust sources between brackets.

154: Oils/fats
155: Dairy (spray dryers)
156: Meal: Flour (dryers); Starch (dryers: potato/wheat)
157: Cattle food (dryer: pulp/grass)
158: Sugar (dryer: sugar/pulp), Cacao (roasting/crushing), Coffee (roasting/crushing), Bakery
159: Beverages
160: Tobacco.

The production of the individually registered companies in the branch.

Food		
Company Name	**Annual production Sector [ton]**	**% of production by individual companies**
Oils and fats		
Speelman'S Oliefabrieken B.V.		
A.D.M. Europoort B.V.	~ 4,500,000	~ 70 %
Cereol Benelux B.V.	*(1995)*	
Cargill B.V. (Coenhavenweg)		
Starch		
Amylum Nederland B.V.	~ 1,200,000	~ 50 %
Cargill B.V.	*(1991)*	
Cerestar Benelux B.V.		
Latenstein Zetmeel B.V.		
Avebe Loc. Gasselternijveen		
Avebe Ba Loc. D.W.M. Veendam		
Avebe Ter Apelkanaal		
Avebe Ba Lokatie Foxhol		
Sugar		
Suiker Unie	~ 1,000,000	~ 70 %
CSM Suiker BV Fab.’Wittouck’	*(1988)*	
Coop.Vereniging Suikerunie U.A		
Sensus Operations CV		
Suiker Unie Vest.Groningen		
CSM Suiker BV ‘Vierverlaten’		

Food		
Company Name	**Annual production Sector [ton]**	**% of production by individual companies**
Cattle food		
Cc Landbouwbelang Maasbracht		
Cc Landbouwbelang Ua (Wanssum)		
Kon. Mengv. Ind. Meulemans B.V.		
Cehave N.V.		
Nutrifeed		
Schouten Industries B.V.		
Coop. Grasdrogerij Ruinerwold	*	*
Coop.Grasdrogerij Opeinde E.O.		
Coop.Groenv.Drog. Gaasterland		
Coop Grasdrogerij Pasveer		
Coop. Groenv.Drog. Oosterwolde		
Sloten Jongveevoeders		
B.V.’Oldambt’		
Groenvoerdrogerij Flevoland B.V.		

*Total sector unknown

The representativeness of the branch data seems reasonable since the share of individually registered companies is varying from 50% to 70% in terms of production for a number of important subsectors. However, scope for improvement exists since not all subsectors (sbi codes) and processes have been included systematically.

5.2 Description of processes and sources of fine dust

Oils and fats (SPIN 175, BREF):
Dust emissions in this branch are almost completely caused by processing of seeds and (soy)beans (4,400,000 ton/year) to vegetable oils. Processing consists of cleaning (dust emission), husk/hull cracking (dust emission), conditioning, pressing, crushing (dust emission) and extraction of oil with hexane. Waste products (soy scrap) is dried and transferred (dust emission).

Dairy (SPIN 157):
In the dairy industry about 480 companies process raw milk (11,400,000 ton/year) to produce milk and milk products. In ERI 6 companies are mentioned that produce milk powder in spray dryers. To separate the powder from the air product cyclones are installed behind the dryers. These cyclones are the most important sources of dust emission. Most of the dryers are equipped with end of pipe emission reduction techniques (fabric filters and/or scrubbers). Other dust sources are combustion installations for heating purposes.

Starch (SPIN 165, BREF):

Most important base materials for production of starch are potatoes, wheat and wheat flour. One company (Avebe) with several production locations produces starch (465,000 ton/year) from potatoes. Processing consists of: cleaning/washing potatoes, milling, extraction/refining of starch, drying and storage ((starch)dust emission) in silos.

About 5 companies (Meneba, Amylum, Cargill, Cerestar, Latenstein) are in ERI that produce starch from wheat and wheat flour (branch capacity: 3,000,000 ton/year). Handling, separation and drying of products (starch and waste) are sources of dust emission.

Cattle food (BREF):

Most emissions of dust take place at direct dryers for grass and pulp together with combustion particles. Most dryers are equipped with cyclones to separate course particles from the emitted waste gasses. At all of the other processes (reception of food basic materials, weighing, grinding, blending/pressing, cooling and storage/packaging) emissions of dust are relevant. If these emissions are not reduced by locally extraction and cleaning they are emitted to the atmosphere by ventilation of the buildings.

Sugar (SPIN 110, BREF):

There are two main producers (Suiker Unie and CSM) of sugar (1,000,000 ton/year) from sugar beets. The production process consists of 6 primary processes (cleaning of beets, winning of juice, juice purification, juice concentration/crystallization, separation of crystals, drying/cooling/storage of sugar) and some secondary processes (direct drying of beet pulp with combustion gasses, calcination, combustion for heating purposes).

The main sources of dust emission are the sugar dryers and the dryers for beet pulp with emission of combustion and pulp particles.

NeR: pulp dryer: - with multi-cyclones: < 75 mg/m^3.
- new installations with steam drying: negligible.

Cacao (SPIN 118):

In this branch raw imported cacao beans (300,000 ton/year) are processed to semi-finished products like cacao mass, cacao butter and cacao powder. Cacao beans are supplied in bags and are cleaned before processing (dust emission). The beans are broken and the shells are separated from the nibs in winnowers (dust emission). After preparation the nibs are roasted to temperatures of 100 to 140 °C by direct or indirect heating with waste gases from natural gas burners (aerosol emissions are extracted by suction). After crushing (dust emission) and pressing to separate cacao cake from cacao butter the cake is cooled and milled to cacao powder, transported and sacked (dust emission). Air from locations with emission of dry dusts is extracted and cleaned in fabric filters. Waste gases from roasting and milling cacao cake contain fatty aerosols that cannot be cleaned by fabric filters.

Tobacco:
Dust emissions during the production of tobacco occur at several stages. All emissions are released in the production building and emitted to the atmosphere by ventilation.

Coffee (SPIN 121, BREF):
In this branch raw imported coffee beans (137,000 ton/year) are supplied in bags and are cleaned before processing (dust emission). The beans are roasted in roasters by hot air with temperatures of 300 to 500 °C (dust emission). After cooling and grinding (dust emission) the coffee is dried (dust emission), transported and packed under vacuum.
Roaster gasses are cleaned in cyclones (separation of skins) and partly recycled.
Crushing rooms are vented and extracted air is cleaned by cyclones and/or fabric filters.
BREF: emitted roaster gases: < 20 mg/m^3.

Bakery (BREF):
Dust emissions during the production of bread and pastry occur at several stages related to cleaning/milling of grain and handling/mixing of flour. All emissions are released in the production building and emitted to the atmosphere by ventilation.

5.3 Emission of fine dust and abatement techniques

The emissions of the food industry contribute with more than 10% substantially to the total of industrial emissions. The vast majority of emissions consists of process emissions.

Source	***Situation 1998***				
Sector / process	**PM_{10} share industry**	**PM_{10}**	**$PM_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Food (15, 16)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process	11.7	2116	340	none / diverse	10-400
Diffuse	1.0	184	46		
Combustion					
Total	**12.8**	**2300**	**386**		

The next table presents the contributions of the different subsectors, illustrating the importance of starch and cattle food.

Subsector Food	PM_{10} emission [ton/y]
Oil and fats	185
Dairy	198
Flour	39
Starch	728
Cattle food	1004
Cacao	87
Sugar	32
Bakery	12
Other	15
Total	**2300**

5.4 Further emission reduction

Measures to reduce dust emission concern the collection of dust (herewith increasing the concentration of the waste gas flow) and dedusting it with fabric filters. This relatively expensive measure can reach up to 80% emission reduction.

6. Glass (sbi 261-3)

Sbi 261: Glass production
Sbi 262-3: Fine ceramics

6.1 Branch description

To investigate the possibilities for fine dust emission reduction, emission data from the Individual Emission Registration (ERI) of 1998 for 6 companies/establishments are used:

- Glaverbel (former Maasglas BV) (Float glass)
- Glasspack (former Verenigde glasfabrieken) (3 establishments, Container glass)
- Isover B.V. (Glass wool)
- PPG Industries Fiber Glass B.V. (Fiber Glass)

The total annual production of these companies is close to 90% of the total production of glass (980,000 ton).

Fine ceramics (Sbi 262-3): There are about 20 companies producing fine ceramics (pottery, wall tiles, sanitary). Almost 75% of fine ceramics is produced by two companies.

It can be concluded that the representativeness of the branch data seems satisfactory.

6.2 Description of processes and sources of fine dust

General:
In the production of glass, a mixture of sand, intermediate/modifying materials (e.g. soda ash, limestone to avoid bubbles, feldspar) and colouring/decolouring agents (e.g. iron chromite, iron oxide) is molten at high temperature (1400-1550°C) to form a molten glass. The main sources of fine dust emission are the melter ovens. Additional to the conventional combustion products, the main emission products are Sodium sulphate (Na_2SO_4) and borates.

Float glass production:
The basic principle of the float process is to pour the molten glass onto a bath of molten tin, and to form a ribbon with the upper and lower surfaces becoming parallel under the influence of gravity and surface tension.

Container glass production:
The molten glass flows from the furnace along a fore hearth to a gathering bowl (spout) at the end. These glass streams are cut into accurate lengths by a shear mechanism to form primitive, sausage shaped, glass ‘gobs’. The initial forming of the blank may be made either by pressing with a plunger, or by blowing with compressed air, according to the type of container. The final moulding operation is always by blowing to obtain the finished hollow shape.

Glass fibre production:
The molten glass flows from the front end of the furnace through a series of refractory lined, gas-heated canals to the fore hearths. Bushings are complex box-like structures with a perforated metal plate (bushing plate) at the base, with several hundred calibrated holes (bushing tips). The glass flowing through the bushing tips is drawn out and attenuated by the action of a high speed winding device to form continuous filaments.

Glass wool production:
A stream of molten glass flows from the furnace along a heated refractory lined fore hearth and pours through a number (usually one to ten) of single orifice bushings into specially designed rotary centrifugal spinners. Primary fiberising is by centrifugal action of the rotating spinner with further attenuation by hot flame gases from a circular burner.

Fine ceramics:
The manufacture of pottery, wall tiles, sanitary and related products involves the preparation of the raw materials, followed by the forming, cutting or shaping, and firing of the final product. In contrary with coarse ceramics the fine ceramics are almost always glazed before firing. The raw materials (clay, water and additives) are mixed (dust emission) and the products are formed into the shape of the final product. The products are then heated. Three stages of heating are involved: the initial drying period with high volumes of hot air of 30 – 110 °C, the oxidation preheating period and the finishing period in a kiln at final temperatures of 900 – 1250 °C (dust emission).

6.3 Emission sources and reduction

Glass

The main sources of fine dust emissions from glass production are the melting ovens. The oven producing glass wool is equipped with a wet scrubber or ESP, resulting in relative low PM_{10} emission levels (ca 30 mg/m^3) the other ovens use no reduction techniques and have higher PM_{10} emission levels (100-250 mg/m^3).

Dust sources:

- handling fine materials;
- melting: condensation of volatiles, entrainment of fine material, combustion of fuel;
- forming: mineral wool or ceramic fibre;
- downstream processing: cutting/polishing;
- packaging.

Part of the fine dust is released to the atmosphere as diffuse emissions.

The emissions of glass industry contribute less than 3% to the total of industrial emissions. The majority of emissions consists of process emissions and to a lesser extent diffuse emissions.

Source	***Situation 1998***				
Sector / process	**PM_{10} share industry**	**PM_{10}**	**$PM_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Glass (261-3)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process	2.0	353	298	none / scrubber / ESP / fabric filter	30-220
Diffuse	0.9	154	15		
Combustion	0.0	3	2	none	1
Total	**2.8**	**510**	**316**		

Emission reduction (BAT):

Primary measures (not as effective as secondary):

- changes in raw materials
- furnace/firing modification

Secondary measures (BAT) for Container/flat/fibre/wool glass: ⇒ 0.1 – 0.15 kg/ton glass

- ESP (2/3 stage): 95-99% for 0,1-10μm ⇒ < 20 mg/Nm^3
- Fabric filters: 95-99% for 0,1-10μm ⇒ < 10 mg/Nm^3

Comparison between guidelines NeR and BREF (new installations)					
Sector	**Process**	**Reduction technique**	**Dust concentration / emission**		
			NeR	**BREF**	
			[mg/m^3]	**[mg/m^3]**	**[kg/ton pr.]**
Glass	Melting	FF or ESP	5 / 20	< 10 - 20	< 0.1
	. Container/Flat glass	FF or ESP	5 / 20	5 - 30	< 0.1
	. Fibre glass	FF or ESP	5 / 20	5 - 30	< 0.14
	. Glass wool	FF or ESP	5 / 20	5 - 30	< 0.1

Fine ceramics:
Most flue gas cleaning systems currently in operation are dry absorption based processes: packed bed filters and cloth filters.
In packed bed filters the flue gas passes through a filter bed of granular limestone for absorption of gaseous pollutants and deposition of dust.
At cloth filter systems lime or hydrated lime is injected into the gas stream to absorb the gaseous pollutants followed by a fabric filter to separate polluted lime and dust from the waste gasses.
Both systems are able to reach dust concentrations in the treated waste gasses of < 50 mg/m^3.
Other dust emissions are reduced by local extraction and venting systems. The extracted air is mostly passed through fabric filters before discharge.

6.4 Further emission reduction

Primary control techniques are based mainly on raw material changes and furnace/firing modifications. In most applications primary techniques cannot yet achieve emission levels comparable with FF and ESP's.

Secondary control techniques are focused on better fabric filters (or electrostatic filters) to reduce emission levels of smelter ovens to 5 (or 20) mg/Nm^3. In this way, emission of fine dust can be reduced by 85% to less than 0.15 kg dust per ton glass(fibre).

Measures to reduce diffuse dust emission concern the collection of dust (herewith increasing the concentration of the waste gas flow) and dedusting it with fabric filters. This relatively expensive measure can reach up to 70% emission reduction.

7. Iron & steel (sbi 231, 27 excl. 274)

Sbi 231: Coke oven
Sbi 271: Iron & steel
Sbi 272: Pipe production
Sbi 273: Rolling mill
Sbi 275: Iron/steel foundries (casting)

7.1 Branch description

The iron and steel industry is a highly material and energy intensive industry. More than half of the total amount of starting materials is converted to waste gases and by-products.
Steel is produced from pig iron, scrap and additives. The Basic Oxygen Furnace (BOF) is world-wide the most predominant process to produce primary steel. Sinter plants and pelletisation plants are both used to prepare starting material for primary iron and steel making. In the Netherlands, steel making is only performed by Corus and Nedstaal (primary steel production).
Iron/steel foundries produce steel castings (carbon steel, low-alloy steel or high-alloy steel) from molten steel that are used in machinery, transportation, and other industries requiring parts that are strong and reliable (secondary steel production). The other Dutch companies fall in this category.

Coke ovens are included in the iron and steel sector, since the coke production is closely related to the steel production.

The production of the individually registered companies in the branch.

Iron & Steel		
Company Name	**Annual production Sector 1998 [ton]**	**% of production by individual companies 1998**
Corus		
Nedstaal B.V.		
De Globe B.V.		
Gieterij Doesburg B.V.	~ 27,000,000	100%
Ned.IJzergiet.Vulcanus B.V. (Dt)		
Lovink Terborg B.V.		
Rademakers Gieterij B.V.		

The representativeness of the branch data is high since all companies have been included in the individual registration.

7.2 Description of processes and sources of fine dust

Iron and Steel: Iron and steel plants can be separated in several processes, which will all be described briefly here. Sinter plants and pelletisation plants are both used to prepare starting material for primary iron and steel making. Local conditions such as the availability and type of raw materials govern the choice for one of these techniques.

Sinter

In sinter plants, raw materials are blended and burned to produce sinter. Fine dust emissions are a result of burning the raw materials.

Pelletisation

In pelletisation plants, raw material is grinded to small crystallized balls of iron size are produced by as starting material for primary iron and steel making. The main emission source of pelletisation plants is grinding of the raw material.

Coke oven

In coke oven plants coal is pyrolised by heating the coal to 1000-1100°C in an oxidation free atmosphere. The products of coke oven plants are gases, liquids char and coke. The main sources of fine dust from coke oven plants are coal handling, coke handling and coke oven gas.

Blast furnace

Blast furnaces are used to produce pig iron. In a closed system, iron bearing materials (iron ore, sinter and/or pellets), additives and reducing agents (coke) are heated to continuously reduce iron to form metal iron. Main sources of fine dust are the cast house, and BF-gas released in the process.

Basic oxygen steel

Basic oxygen steel making uses oxygen instead of air for the production of steel. In basic oxygen steel making, undesirable impurities in the metal feedstock are burnt to the corresponding oxides. Undesirable impurities are among other things, carbon, silicon, manganese, phosphorous and sulphur. Main source of fine dust is BOF gas.

Electric steel making

In electric steel making, iron-containing materials are melted in an electric arc furnace. These iron-containing materials can be ferrous scrap, cut-offs from steel producers and recycled iron. Fine dust emissions arise from the furnace, and from building evacuation.

Iron/steel foundries

The major processing operations of a typical steel foundry are the raw materials handling (receiving, unloading, storing and conveying), the metal melting process (scrap preparation, furnace charging, closed melting, back charging, oxygen lancing and tapping), mould and core production, and casting and finishing. At almost all of the mentioned activities there are emissions of fine particulates.

7.3 Emission of fine dust and abatement techniques

The emissions of the iron and steel sector contribute with more than 15% substantially to the total of industrial emissions. The vast majority of emissions consists of process emissions and diffuse emissions (building ventilation and material handling).

Source	***Situation 1998***				
Sector / process	**PM_{10} share industry**	**PM_{10}**	**$PM_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Iron & Steel (231, 27 excl. 274)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process	7.9	1432	1289	diverse	10-100
Diffuse	8.3	1499	448	diverse	5-10
Combustion	0.4	75	66	none / ESP	10-20
Total	**16.7**	**3006**	**1803**		

Comparison between guidelines NeR and BREF (new installations)

Sector	Process	Reduction technique	Dust concentration / emission		
			NeR	BREF	
			[mg/m^3]	[mg/m^3]	[kg/ton pr.]
Iron and Steel	Sinter strand	Advanced ESP	100	< 50	
	. idem	ESP + HES*	100	< 50	
	. idem	ESP + (lime) + FF	5	10 - 20	
	Pelletisation				< 0.1
	. Induration strand	FF (or wet scrubber)	5 (20)	< 10	
	. Dry grinding mills	ESP	5	< 50	
	. Drying	FF (wet scrubber)	5 (20)	< 20	
	Coke oven plant				
	. Charging	collection + FF	5	< 30	< 0.005
	. Pushing	Collect.+ FF+ quenching	5	< 30	< 0.005
	. Quenching	wet quenching	<0.06 kg/t		< 0.05
	Blast furnace				
	. Furnace gases	wet scrubber or wet ESP	20	< 10	
	. Cast house	collection + (FF or ESP)	effic. >99%	1 - 15	
	Basic Oxygen Steel				
	. Hot metal pre-treatment	collection + FF	5	5 - 15	
	. idem	collection + ESP	5	20 - 30	
	. Fugitive		< 5 g/ton		5 - 15 g/ton
	Electric Steel making	collection (>98%) + FF	5	5 -15	

* It concerns a high pressure wet scrubber

Sinter Plant (BREF - sinter strand):

- Primary measures: Waste gas minimisation by re-circulation
- Secondary measures at point sources:
  - Advanced ESP: ⇒ 50 mg/Nm^3:
  - ESP + lime/fabric filter: ⇒ 10-20 mg/Nm^3;
  - Pre-dedusting (ESP or cycl.) + high pressure wet scrubbing: ⇒ 50 mg/Nm^3.

Pelletisation plant (BREF):

- Secondary measures at point sources:
- Grinding mills: ESP ⇒ < 50 mg/Nm^3
- Drying and induration zone: Scrubber (η>95%) ⇒ < 20 mg/Nm^3

Coke oven plant (BREF):

- Secondary measures at battery operation:
  - charging: collection + fabric filter ⇒ < 5g/ton coke
  - pushing: collection + fabric filter ⇒ < 5g/ton coke (< 30 mg/ Nm^3)
  - quenching: wet scrubber (η=90%) ⇒ < 50g/ton coke
- Fugitive: Good housekeeping (e.g. sealing)

Blast furnace (BREF):

- Primary measures: gas recovery, direct injection of reduction agents, tar-free runner linings, covering runners with movable lids, fume suppression with inert gas
- Secondary measures:
- Blast furnace gases: scrubber or wet ESP or other ⇒ <10 mg/Nm^3
- Cast house (tap-holes, runners, skimmers, etc.):
- collection +fabric or ESP ⇒ 1-15 mg/Nm^3
- fugitive emission (others) ⇒ 5-15g/ton pig iron

Basic Oxygen Steel making and Casting (BREF):

- Primary measures:
- Basis Oxygen Furnace (BOF)-gas recovery: suppressed combustion
  - hot metal handling: fume suppression with inert gas
- Secondary measures: evacuation
  + fabric or ESP ⇒ 10-15 or 20-30 mg/Nm^3
- BOF gas recovery: after suppressed combustion
  - pig iron pre-treatment, charging and tapping, hot metal handling, ventilation system

Electric Steel making and casting (BREF):

- Primary measures: Electric Arc Furnace (EAF) dust recycling
- Secondary measures: Dust collection (>98%)
  + fabric filter: ⇒ 5-15 mg/Nm^3
- direct EAF gas extraction and hood systems or
- dog-house and hood system or
- total building evacuation

Metals working:

Capture and collection systems during welding may be used to catch the fumes at the source and to remove the fumes with a collector (high efficiency filters, ESP, Scrubbers and Active carbon). Not captured fumes will be emitted to the atmosphere by building ventilation.

Iron/steel foundries:

Controls for emissions during melting and refining operations focus on venting the furnace gasses and fumes directly to an emission collection and control system (bag filters, cyclones and venturi scrubbers). Other fugitive emissions are emitted to the atmosphere by building ventilation.

7.4 Further emission reduction

For sinter plants, emerging techniques are mainly concerned in reducing the amount of halogenated organic compounds released from the process.
Emerging techniques for pelletisation plants are focused on reducing emission of NO_x and SO_2.
Several new processes are developed to improve the performance of coke oven plants. These new processes will use less fuel and will reduce the total emissions from the coke oven plant.
Blast furnaces use coke as the main fuel, which results in high emission levels. New techniques are being developed to use coal as fuel.
In basic oxygen steel making, new developments are not focused on reducing dust emission, but on zinc recovery and desulphurisation.
For electric arc furnaces, new furnace types are being developed which reduce energy consumption and dust emission.

Measures to reduce diffuse dust emission concern the collection of dust (herewith increasing the concentration of the waste gas flow) and dedusting it with fabric filters. This relatively expensive measure can reach up to 90% emission reduction.

8. Metal working (sbi 28-35, 4531)

Sbi 28:	metal products
Sbi 29-35:	metal/electro
Sbi 4531:	welding in construction

8.1 Branch description

The metal working industry can be divided in different industries that manufacture metal products like flats, bars, wires, pipes, formed parts, transmission elements and machinery/appliances.

The estimation of emissions is based upon a collective emission estimate per process, not on individually registered companies. The representativeness is not known.

8.2 Description of processes and sources of fine dust

In the metal working industry the processes with dust emissions are foundries, hot and cold forming, metal removal operations, connecting techniques (welding) and surface treatment [SPIN 101, 125, 129, 134, 159, 176].

Forming:
The hot and cold forming processing comprises different manufacturing methods, such as hot rolling, cold rolling and drawing of steel. In hot rolling the size, shape and metallurgical properties of steel are changed by repeatedly compressing the hot metal between rollers. In cold rolling the properties of the hot rolled strip products are changed without heating. Dust emissions arise from product handling and hot rolling.

Welding:
Welding is the process by which 2 metal parts are joined by melting the parts at the points of contact and simultaneously forming a connection with molten metal from these same parts or from a consumable electrode. In welding, the most frequently used methods for generating heat employ either an electric arc or a gas-oxygen flame. Other operations include brazing, soldering, thermal cutting, and gauging operations. During welding operations emission aerosols occur (particulate matter and particulate-phase hazardous air pollutants). Electric arc welding has the greatest emission potential (particulate matter and particulate-phase hazardous air pollutants). All particulate emissions are PM_{10} and contain hazardous metals (Mg, Ni, Cr, Co, and Pb).

Surface treatment:

Surface treatment processes that generate dust emissions are (sand) blasting and dry sanding. The air extracted from the blasting cabin or compartment is the source of dust emission.

8.3 Emission of fine dust and abatement techniques

The emissions of the metal working contribute with 3% to the total of industrial emissions. The vast majority of emissions consists of both process emissions and diffuse emissions (building ventilation).

Source	***Situation 1998***				
Sector / process	**PM_{10} share industry**	**PM_{10}**	**$PM_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Metal working (28-35, 4531)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process	1.6	286	286	None	1
Diffuse	1.4	257	51	None	1-2
Combustion					
Total	**3.0**	**543**	**337**		

Welding:

Capture and collection systems may be used to catch the fumes at the source and to remove the fumes with a collector (high efficiency filters, ESP, Scrubbers and Active carbon). Not captured fumes will be emitted to the atmosphere by building ventilation.

Surface treatment:

Generated dust particles can be captures locally by extracting air and dedusting in fabric filters. All blasting cabins and compartments are equipped with dedusting installations.

Comparison between guidelines NeR and BREF (new installations)					
Sector	**Process**	**Reduction technique**	**Dust concentration / emission**		
			NeR	**BREF**	
			[mg/m^3]	**[mg/m^3]**	**[kg/ton pr.]**
Ferrous Metals	Hot rolling				
	. Dry dust	enclosure + FF	5	< 5 - 20	
	. Wet fumes	enclosure + ESP	20	< 10 - 50	
	Cold rolling				
	. Decoiling / levelling/ welding	collection + FF	5	< 5 - 20	

BREF

Cold rolling:

- Primary measures at pickling: corrosion prevention, mechanical descaling, electrolytic pre-pickling, spray or turbulence pickling, enclosed pickling tanks.
- Fugitive emission: Mechanical descaling operations: 10-20 g/ton en $< 1 – 25$ mg/Nm^3.

Hot rolling:

- Unabated fugitive emission concentrations: 5 – 100 mg/Nm^3
- Fugitive: reheating and heat treatment furnaces (no measures): $< 5 – 20$ mg/Nm^3

8.4 Further emission reduction

Measures to reduce dust emission concern the collection of dust (herewith increasing the concentration of the waste gas flow) and dedusting it with fabric filters. This relatively expensive measure can reach up to 60-80% emission reduction.

Appendix D

9. Other building materials (sbi 264-8 excl. 2651)

sbi 264 (SPIN 112, 119; UK):	Coarse ceramics (clinker/brick)
sbi 2652-3 (BREF):	Lime (chalk, gypsum, basics)
sbi 266:	Products of cement, lime etc.
sbi 267/8:	Not-metal minerals: Mineral wool (SPIN 114), natural stone

9.1 Branch description

This branch consists of all building materials except the materials in the sector glass (sbi 261-3) and cement (2651-2).

Lime:
Lime is used in a wide range of products, for example as a fluxing agent in steel refining, as a binder in building and construction, in water treatment to precipitate impurities, for neutralisation of acidic components in effluent and flue gases.

Coarse ceramics:
The three most import types of companies in the coarse ceramics branch are: brick production, roofing tile production and floor tile production.

Mineral wool:
One company (Rockwool) produces mineral wool mainly for (heat) insulation purposes.

The estimation of emissions is based upon an almost 100% coverage of individually registered companies. The representativeness is regarded to be high. The number of companies is too high to present them here.

9.2 Description of processes and sources of fine dust

Lime:
The lime making process consists of the burning in a kiln (calcining) of calcium and/or magnesium carbonates to liberate carbon dioxide and to obtain the derived oxide. Kilns are fired with solid, liquid or gaseous fuels (dust emission in flue gases). The calcium oxide product from the kiln is generally crushed, milled and/or screened (dust emission) before being conveyed to silo storage. From the silo some of the calcium oxide (quicklime) can be transferred to a hydrating plant where it is reacted with water to produce calcium hydroxide (slaked lime).

Coarse ceramics:
The manufacture of bricks and related products involves the preparation of the raw materials, followed by the forming, cutting or shaping, and firing of the final product. In contrary with coarse ceramics the fine ceramics are almost always glazed before firing. The raw materials (clay, water and additives) are mixed (dust emission) and the products are formed into the shape of the final product. The products are then heated. Three stages of heating are involved: the initial drying period with high volumes of hot air of 30 – 110 °C, the oxidation preheating period and the finishing period in a kiln at final temperatures of 900 – 1250 °C (dust emission).

Mineral wool:
The manufacture of mineral wool involves the processes: melting (dust emission), spinning (dust emission), hardening, cooling and cutting (dust emission). Raw material used is volcanic stone. In an oven a mixture of stone, blast-furnace slag, coke, natural gas and air is smelted (1500 °C).

9.3 Emission of fine dust and abatement techniques

The emissions of the other building materials contribute with more than 5% substantially to the total of industrial emissions. The vast majority of emissions consists of diffuse emissions from building ventilation.

Source	***Situation 1998***				
Sector / process	**PM_{10} share industry**	**PM_{10}**	**$PM_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Other Build M. (264-8 excl. 2651)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process	1.1	194	93	None	1-30
Diffuse	5.1	918	164	None	1-2
Combustion					
Total	**6.2**	**1112**	**257**		

Lime:
<u>BREF Emission reduction (BAT)</u>:
Primary measures: no
Point sources: fabric filter or ESP or wet scrubber: ⇒ <5 - 50 mg/Nm^3 ⇒ 0.1 – 0.3 kg/ton

- Calcining of limestone (kilns): bag filter/ESP: 0.1 –0.2 kg/ton;
- Lime hydrating: bag filter/wet scrubber: 0.02 kg/ton;
- Lime grinding/milling: bag filter: 0.03 kg/ton.
- Subsidiary operations (crushing, screening, conveying, slaking, storage and discharge):
  - Containment + extracting air + bag filters

Fugitive: Good housekeeping (see Cement)

Comparison between guidelines NeR and BREF (new installations)					
Sector	**Process**	**Reduction technique**	**Dust concentration / emission**		
			NeR	**BREF**	
			[mg/m³]	**[mg/m³]**	**[kg/ton pr.]**
Lime	Calcining of Lime	FF / ESP	5 / 20	< 5 - 20	0.1 – 0.2
	Hydrating	FF / wet	5 / 20	< 5 - 20	0.02
	Grinding and milling	FF	5		0.03

Ceramic filters are not currently used on lime kilns. They are able to remove dust very efficiently at high temperatures and it is possible that, with kilns such as rotary kilns producing dead-burned dolomite, de-dusting high temperature gases might enable certain heat recovery systems to become viable.

Coarse ceramics:
Most flue gas cleaning systems currently in operation within the brick industry are dry absorption based processes: packed bed filters and cloth filters.
In packed bed filters the flue gas passes through a filter bed of granular limestone for absorption of gaseous pollutants and deposition of dust.
At cloth filter systems lime or hydrated lime is injected into the gas stream to absorb the gaseous pollutants followed by a fabric filter to separate polluted lime and dust from the waste gasses.
Both systems are able to reach dust concentrations in the treated waste gasses of < 50 mg/m^3.
Other dust emissions are reduced by local extraction and venting systems. The extracted air is mostly passed through fabric filters before discharge.

Mineral wool:
Flue gases from the oven are incinerated and after subsequently de-dusted in flue gas filters. Waste air from the spinning room contains dust and other pollutants and is cleaned in a filter made of mineral wool blankets. Dust emission from cutting/sawing the blankets is reduced by local extraction and venting systems. The extracted air is passed through fabric filters before discharge.

9.4 Further emission reduction

Wet ESP can reduce process emissions up to 90%.

Measures to reduce diffuse dust emission concern the collection of dust (herewith increasing the concentration of the waste gas flow) and dedusting it with fabric filters. This relatively expensive measure can reach up to 90% emission reduction.

10. Paper (sbi 21)

10.1 Branch description

For the paper industry in the Netherlands, only emission data from building emissions are available, based upon a collective emission estimation. The representativeness is not known. The total sector concerns over 500 companies. The total fine dust emission from the paper industry caused by building emissions is about 384 ton/year.

10.2 Description of processes and sources of fine dust

In paper production fibres are dissolved in water in low concentrations (less than 1%) and passed through a sieve. The paper pulp remains on the sieve, producing thin sheets of paper, which are dried and cut to size. Only very low concentrations of dust arise form the production process. Another source of fine dust emission is the power generator where fuels are burnt to produce electricity or steam.

10.3 Emission sources and reduction

The emissions of the paper industry contribute 2% to the total of industrial emissions. The main emission sources in paper industry are building emissions. Because of the very low concentrations of fine dust, no reduction techniques are installed to reduce PM_{10} emission for paper production.

Source	***Situation 1998***				
Sector / process	**PM_{10} share industry**	**PM_{10}**	**$PM_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Paper (21)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process					
Diffuse	2.1	384	38	none	1
Combustion					
Total	**2.1**	**384**	**38**		

10.4 Further emission reduction

Due to the very low PM_{10} concentrations in waste gas streams from paper industry, measures to reduce dust emission concern the collection of dust (herewith increasing the concentration of the waste gas flow) and dedusting it with fabric filters. This relatively expensive measure can reach up to 90% emission reduction.

Appendix D

11. Power (sbi 40)

11.1 Branch description

Power stations generate electricity by combustion of fossil fuels (natural gas, oil or coal). Only the combustion of heavy oil (3 plants) and coal (5 plants) results in flue gasses with high concentrations of dust. All these power stations are individually registered. The representativeness is therefore regarded as high.
Coal fired power stations used about 6000 kton of coal in 1998 and are responsible for almost all emissions of dust in this branch.

The production of the individually registered companies in the branch.

Power		
Company Name	**Annual production Sector 1998 [kWh]**	**% of production by individual companies 1998**
Nv.EPZ Lok.Limburg Maascentr.		
Nv.Elek.Bed.Zuid-H.Waalhaven		
Nv Elek.Bed.Zuid-H.Maasvlakte		
Nv. UNA Centrale Hemweg		
Nv. UNA Centrale Velsen	5,774 MWh	100%
Nv. UNA Centrale Lage Weide		
Nv.EPZ Locatie Zeeland		
Nv.EPON Centrale Gelderland		
Nv EPON (Centrale Harculo)		

11.2 Description of processes and sources of fine dust

The most important sources of fine dust emission are the flue gases (concentrated emission) and the handling and storage of coal and residue diffuse emission).

11.3 Emission of fine dust and abatement techniques

The emissions of the power production contribute 3% to the total of industrial emissions.

Source	***Situation 1998***				
Sector / process	**PM$_{10}$ share industry**	**PM$_{10}$**	**PM $_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Power (40001)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process					
Diffuse	0.8	142	14		
Combustion	2.2	397	332	ESP-scrubber-FF	1-10
Total	**3.0**	**539**	**346**		

Flue gases of all oil and coal fired power stations are equipped with flue gas treatment to be able to comply with emission regulations for dust, NO$_x$, (heavy) metals, dioxins etc.
With a combination of electrostatic precipitation (ESP) and scrubbing and/or fabric filtration the concentrations of (fine) dust in the flue gases of the coal fired power plants are lower than 10 mg/m^3.
NeR/BEES: 20 mg/m^3 (coal), 100 mg/m^3 (heavy oil).

11.4 Further emission reduction

The application of measures to reduce material handling emissions and additional fabric filters to reduce combustion emissions can reduce emissions with 80% and 70% respectively.

12. Refineries (sbi 232)

12.1 Branch description

In refineries, crude oil and natural gas are converted to useful products, such as fuels and raw materials for the chemical industry. The industry is complex, due to the changing composition of feedstock and the broad range of products produced.
The refineries in the Netherlands produce 59 Million ton of product per year.

The production of the individually registered companies in the branch.

Refineries		
Company Name	**Annual production Sector 1998 [ton]**	**% of production by individual companies 1998**
Shell Ned.Raff. B.V.		
Nerefco Europoort		
Kuwait Petroleum Europoort B.V.	~ 59,000,000	100%
Esso Nederland B.V.		
Smid En Hollander Raff. B.V.		
Witco B.V.		
Total Raffinaderij Ned.NV		

The representativeness of the branch data is high since all companies have been included in the individual registration.

12.2 Description of processes and sources of fine dust

Three processes are the main sources of fine dust emission in oil refineries.

- Distillation of crude oil, primary distillation unit.
- Catalytic cracking/reforming.
- Energy production (electricity and steam).

Primary distillation unit:
In the primary distillation unit, crude oil is separated in three fractions, based on boiling point. These three fractions are further processed in the other segments of the refinery. Emissions to air are mainly caused by pressure relief valves, poor containment in overhead systems and venting during cleaning.

Catalytic cracking:
Catalytic cracking is the most widely used method to convert larger hydrocarbons to smaller (more useful) molecules. The heavy distillate stream from a distillation section is heated to 500-540°C at 1.5-2.0 bar in the presence of a zeolite catalyst. In

this process, coke is formed as a by-product which adheres to the catalysts, resulting in deactivation. The catalyst is regenerated by burning off the coke. This regeneration is the main source of fine dust.

Energy systems:
The energy system is one of the most important sources of fine dust emissions in refineries. Fuels are burnt to generate energy, and the emissions depend on the kind of fuel that is used. Heavy fuels cause much more fine dust emission than lighter fuels, because the latter contain much less metal compounds and coke. These compounds are the main source of fine dust.

12.3 Emission of fine dust and abatement techniques

The emissions of the refineries contribute almost 20% to the total of industrial emissions, being the largest PM_{10} and $PM_{2.5}$ emitting industrial sector. The emissions consist of process and combustion emissions.

Source	***Situation 1998***				
Sector / process	**PM_{10} share industry**	**PM_{10}**	**$PM_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Refineries (232)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process	9.5	1721	1291	none	50
Diffuse					
Combustion	9.3	1669	1496	none	75-750
Total	18.8	3390	2787		

Primary distillation unit:
Particulate matter abatement techniques for the distillation section of refineries are mainly focused on reduction of fuel consumption by using less energy. New developments on abatement techniques include ceramic filters and a rotating particulate separators.

Catalytic cracking:
The best technique to reduce fine dust emission during catalyst regeneration is ensuring longer lifetimes for the catalyst. By using ideal conditions, regeneration of the catalyst can be done less often, thereby reducing the amounts of fine dust emitted. In catalytic cracking, particulate emissions can be reduced by retrofitting the existing hot ceramic filters to the underflow of third stage cyclones. In niche applications, use of ceramic filters is possible.

Energy systems:
In energy systems, the main focus is on reducing the amount of energy used in the total refinery. By heat integration and more effective production, the energy de-

mand can be reduced, resulting in reduced amounts of fuels that have to be burnt for energy production.
To reduce fine dust emissions in waste gasses several techniques are generally employed:

- Maximize the use of ‘clean’ fuels such as gas and low ash content liquid fuels.
- Steam atomisation on the liquid fuels.
- Use ESP’s or FF in the flue gasses when heavy liquid fuels are used.

12.4 Further emission reduction

Due to fuel switch to natural gas, combustion emissions can be avoided almost totally. This measure has already been agreed upon for the year 2010 (also in relation with greenhouse gas measures). Process emissions can be reduced with 90% by the application of ESP.

13. Rubber & plastic (sbi: 25)

251: Rubber products
252: Plastic products

13.1 Branch description

Rubber: Natural and synthetic rubber is being used in the manufacture of rubber, plastics, carpet and cable. In the rubber processing industry it is mainly used for the manufacture of tires for the transportation sector.

Plastics: The plastics processing industry uses mainly five bulk chemicals (polyethylene, polyvinyl chloride, polypropene and polystyrene) to produce plastic products.

Only four companies are registered in the individual pollutant emission register, together with a dust emission of less than 1 ton/y. The total sector concerns over 1,500 companies. This means that the emission estimate is almost solely based on a collective emission estimate based on emission factors. The representativeness is not known.

13.2 Description of processes and sources of fine dust

Rubber:
To give virgin rubber (natural or synthetic) the desired properties (elasticity, hardness, strength) several substances are added during production. The processing of rubber can be divided in three steps: mixing (compounding), moulding and vulcanising. Most emissions of dust occur during compounding.

Plastics:
The bulk chemicals for the production of plastics are delivered as fluid, granules or powder.
Handling of powders can give rise to the emission of dust.

13.3 Emission of fine dust and abatement techniques

The emissions of the Rubber and plastics contribute less than 1% to the total of industrial emissions. It concerns diffuse emissions from building ventilation.

Source	***Situation 1998***				
Sector / process	**PM_{10} share industry**	**PM_{10}**	**$PM_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Rubber & Plastics (25)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process					
Diffuse	0.4	66	6	none	0.5
Combustion					
Total	**0.4**	**66**	**6**		

Rubber:
The emissions of dust have been reduced by compounding in closed systems and using filters (fabric filters, scrubbers and cyclones).

Plastics:
Dust emissions at handling of powders can be reduced by working with dust free concentrates and local ventilation in combination with dust filtration with fabric filters.

13.4 Further emission reduction

Measures to reduce dust emission concern the collection of dust (herewith increasing the concentration of the waste gas flow) and dedusting it with fabric filters. This relatively expensive measure can reach up to 60% emission reduction.

14. Textile (sbi 17, 18)

14.1 Branch description

The textile industry consists of a large number of companies (about 1700) with various types of materials and processing. The textile industry is divided in two sections, with SBI codes 17 and 18. SBI code17 stands for the companies who produce sheets of textile, and 18 stands for the companies who use these sheets to produce clothing.

Only three companies are registered in the individual pollutant emission register, together with a dust emission of less than 1 ton/y. This means that the emission estimate is almost solely based on a collective emission estimate based on emission factors. The representativeness is not known. The total sector concerns almost 5000 companies.

The total emission of PM_{10} for the production of textile is 121 ton per year.

14.2 Description of processes and sources of fine dust

For colouring of textiles, powdered dyes are used. These dyes are dissolved is water or organic solvents. Handling and mixing of dyes causes fine dust emissions, estimated at about 0.05-0.1% of the total use of dyes.

The dust emissions are building emissions with very low fine dust concentrations (typically 1 mg/m^3). Due to this very low concentration, no effective reduction techniques are used at present time.

In the clothing industry, the sheets of textile are used to produce clothes. No process or emissions date are available for this branch of industry.

14.3 Emission of fine dust and abatement techniques

The emissions of the textile industry contribute less than 1% to the total of industrial emissions. It concerns diffuse emissions from building ventilation.

Source	***Situation 1998***				
Sector / process	**PM_{10} share industry**	**PM_{10}**	**$PM_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Textile (17,18)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process					
Diffuse	0.7	121	12	none	1
Combustion					
Total	**0.7**	**121**	**12**		

No abatement techniques for the textile industry are used at present time. Due to the low concentrations of fine dust in waste gas streams, no BAT techniques are described.

14.4 Further emission reduction

Measures to reduce dust emission concern the collection of dust (herewith increasing the concentration of the waste gas flow) and dedusting it with fabric filters. This relatively expensive measure can reach up to 80% emission reduction.

15. Waste (sbi: 9000)

15.1 Branch description

There are 11 plants for municipal waste incineration, 2 for hazardous waste, 2 for sewage sludge and 1 for specific clinical waste. Total incinerated waste in 1999 was about 6000 kton [InfoMil BAT].

The production of the individually registered companies in the branch.

Waste		
Company Name	**Annual production Sector 1998 [ton]**	**% of production by individual companies 1998**
NV. Afvalverwerking Rijnmond		
Ruhr-Carbo Milieu B.V.		
GDA-Gem.Dienst Afvalverwerking	~ 4,500,000	~ 75%
NV Avira		
ARN BV-Afvalverw.Regio Nijmegen		

The representativeness of the branch data is considered to be high since 75% of the sector production has been included in the individual registration.

15.2 Description of processes and sources of fine dust

In the municipal waste incineration sector the grate technology is the most commonly used technology.

Dust emissions occur at the processes:

- pre-treatment, handling and storage of municipal waste (diffuse emission);
- incineration;
- handling of solid residue (diffuse emission).

The flue gasses are the most important source of dust emission. All installations are equipped with flue gas treatment to be able to comply with emission regulations for dust, NO_x, (heavy) metals, dioxins etc.

With a combination of electrostatic precipitation (ESP) and scrubbing and/or fabric filtration the concentrations of (fine) dust in the flue gases of the Dutch incineration plants are 0.5 - 3 mg/m^3 resulting in specific dust emissions of 1-10 g per ton of waste.
NeR/BVA: 5 mg/m^3

15.3 Emission of fine dust and abatement techniques

The emissions of the waste incineration contribute less than 1% to the total of industrial emissions. It concerns mainly combustion emissions.

Source	***Situation 1998***				
Sector / process	**PM_{10} share industry**	**PM_{10}**	**$PM_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Waste (9000)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process					
Diffuse					
Combustion	0.2	35	34	ESP-scrubber-FF	3
Total	**0.2**	**35**	**34**		

15.4 Further emission reduction

Measures to reduce dust emission further concern the use of additional fabric filters. This can reduce the sector emissions with 40%.

16. Wood (sbi 20, 361)

Sbi 20: wood processing, production of wooden products
Sbi 361: production of furniture

16.1 Branch description

The branch involves the production of wood (sawmills, production of fibre board, furniture production). The emission estimate is almost solely based upon a collective emission estimate of which the representativeness is not known. The total sector concerns over 3000 companies.

16.2 Description of processes and sources of fine dust

In the wood processing industry wood dust is generated by sawing, machining operations and by grinding.
It is unclear how much the emissions from combustion of waste wood in stoves contribute. These emissions could be substantial, like emissions from fire places in house holds.

16.3 Emission of fine dust and abatement techniques

The emissions of the wood processing industry contribute more than 2% to the total of industrial emissions. It concerns diffuse emissions.

Source	***Situation 1998***				
Sector / process	**PM_{10} share industry**	**PM_{10}**	**$PM_{2.5}$**	**Presently installed abatement technology**	**PM concentration**
Wood (20, 361)	**[%]**	**[ton/y]**	**[ton/y]**		**[mg/Nm^3]**
Process					
Diffuse	2.3	406	41	None	1.5
Combustion	?	?	?		
Total	**2.3**	**406**	**41**		

Dust emission is reduced by local extraction and venting systems. The extracted air is passed through fabric filters before discharge. With the vented air from the production buildings diffuse emission of dust takes place.

16.4 Further emission reduction

Measures to reduce dust emission concern the collection of dust (herewith increasing the concentration of the waste gas flow) and dedusting it with fabric filters. This relatively expensive measure can reach up to 90% emission reduction.