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Quality control of emitted NO_X and SO_2 in Swedish industries

Reported to the UNFCCC, EU Monitoring Mechanism and CLRTAP

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Sammanfattning

I föreliggande studie har utsläpp av NO_x och SO_2 från vissa industrier som rapporteras av Sverige till EU Monitoring Mechanism, EU:s takdirektiv, UNFCCC och CLRTAP studerats. Anledningen till studien är att misstankar finns att de rapporterade utsläppen inte alltid är korrekta. Inom studien har utsläpp från följande industrisektorer inkluderats; raffinaderi-, cement-, järn och stål-, övrig metall- samt skogsindustrin.

Data som rapporterats av Sverige för dessa sektorer har jämförts med data på anläggnings- eller sektorsnivå med data från andra källor (miljörapporter och branschorganisationer) och skillnader har noterats. Ett antal brister har påträffats i inventeringsdata som rapporterats internationellt och förslag på förbättringar ges vilket innebär att kvalitén kommer att höjas i internationellt rapporterade utsläpp i framtiden, om de implementeras. Bland dessa förslag kan nämnas nya emissionsfaktorer för brännolja och raffinaderigas i raffinaderiindustrin, eliminering av dubbelrapporterade utsläpp inom t.ex. skogindustrin, tillägg av saknade utsläpp inom t.ex. järn- och stålindustrin, samt utbyte av aktivitetsdata/utsläpp inom cementindustrin. Slutligen föreligger ett behov av en översyn av vissa emissionsfaktorer inom järn och stål- och skogsindustrin.

Summary

Emissions of SO_2 and NO_x from certain industries reported by Sweden to the EU Monitoring Mechanism, EU:s NEC directive, UNFCCC and CLRTAP have been investigated in this study. The motive for this investigation was that there have been reasons to believe that reported emissions are not always correct. Within the study emissions from the following industrial sectors were included; refinery, cement, iron and steel, non-ferrous metals, and pulp, paper and print industry.

Data reported by Sweden for these sectors have been compared on a plant or sector level with data from other data sources (companies' environmental reports and trade organisations) and discrepancies have been noted. Several shortcomings have been found in the internationally reported inventory data and suggestions on improvements have been made which will increase the quality in coming submissions if they are implemented. These improvements involve for instance use of new emission factors for refinery oil and gas, exclusion of emissions that are double reported in e.g. the pulp, paper and print industry, inclusion of missing emissions in for instance the iron and steel industry and exchange of activity data/emissions in the cement industry. Finally there is a need of a review of emission factors in the iron and steel and pulp, paper and print industry.

1 Background

Sweden yearly reports air emissions to the EU Monitoring Mechanism, EU:s NEC directive, UNFCCC and CLRTAP. The reported emissions to these reporting bodies are coded in different CRF/NFR sectors based on data from different sources, to make as accurate calculations as possible. Since these data sources are not connected there might be a risk that they are not covering all emission or that overlapping occurs. In these cases emissions reported to the international conventions from some sectors might be under- or overestimated. In the energy sector, national emission factors (EF) are used to estimate emissions from fuel consumption. These factors are not always adjusted for specific fuels such as unconventional fuels produced and used in refineries, and this might also result in under- or overestimated emissions.

Under-/ overestimations of emissions are suspected to be a problem especially for NO_X and SO_2 within some Swedish industries, which might affect Sweden's obligation in the EU NEC directive. To secure the quality of Swedish emission inventories these emissions need to be investigated, and if needed improved by recalculations of the time series.

1.1 Aim of the study

The aim of this study is to make an assessment of the quality in reported emissions of NO_X and SO_2 within refineries, cement industry, iron and steel industries, non-ferrous metal industries, and the pulp, paper and print industry. The reason why these industries are chosen is that previous work has indicated that these might be the most problematic ones. The study aims at comparing data reported in the Swedish inventory and data reported by single plants in environmental reports (ER) submitted annually, with one exception; the pulp and paper industry where inventory data were compared with data reported by the plants to the trade organisation Swedish Forest Industries Federation. The study will result in recommendations on how to improve the internationally reported emissions in future submissions.

2 Plant studies

In this chapter plant studies for a number of plants in five different sectors are investigated and described. In the inventories to EU Monitoring Mechanism, EU:s NEC directive, UNFCCC and CLRTAP, emissions from these plants are reported in various CRF/NFR codes. These codes and the emissions of NO_X and SO_2 are shown in Table 2.1 to give an overview of how much each sector contribute to the national total emissions, which were 197 kton of NO_X and 47 kton of SO_2 in 2004.

Table 2.1. Emissions for 2004 of NO_X and SO_2 reported in the different sectors studied in this project.

CRF/NFR sector	NO_X kton	SO_2 kton
1 A 1 b Petroleum refining	3.87	5.81
1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	0.15	0.43
1 A 2 a Iron and Steel	1.15	0.89
1 A 2 b Non-ferrous Metals	0.09	0.08
1 A 2 d Pulp, Paper and Print	5.60	3.66
1 A 2 f Other	33.71	2.44
1 B 1 b Solid fuel transformation	NA	0.13
1 B 1 c Other	0.11	0.02
1 B 2 a iv Refining / Storage	0.08	0.92
1 B 2 c Venting and flaring	0.08	0.11
2 A 1 Cement Production	NA	0.07
2 B 5	1.26	0.58
2 C Metal production	1.08	3.90
2 D 1 Pulp and Paper	10.59	6.95
National Total	**197.37**	**47.22**

2.1 Refineries

Emissions and emission factors for the five oil refineries were investigated in the study; Preemraff Lysekil, Preemraff Göteborg, Shell, Nynäs Nynäshamn and Nynäs Göteborg.

Emissions from the refineries are reported in CRF/NFR 1A1b (fuel combustion, energy industries, petroleum refining), 1B2a iv (fugitive emissions from fuels, oil, refining and storage) and 1B2c (fugitive emissions from fuels, venting and flaring). Emissions reported in CRF/NFR 1A1b and 1B2c are based on activity data (fuel consumption) from Statistics Sweden, Energy Statistic (ES), thermal values and emission factors (EF). Emissions reported in CRF/NFR 1B2a iv (including emissions of NO_X and SO_2 from catalytic cracking and sulphur recovery) are based on measured and calculated data reported in the companies' environmental reports (ER).

Compared to the total reported level for 2004, refineries contribute to about 1% and 3.5% respectively for NO_X and SO_2 according to ER data as show in Table 2.2.

Table 2.2. Emissions from refineries for 2004 reported in the inventories in different CRF/NFR codes, emissions reported in the ER for refineries and totally reported emission for Sweden.*

Data source	**NO_X kton**	**SO_2 kton**
Environmental reports, total refineries**	1.5	1.7
1 A 1 b Petroleum refining	3.87	5.81
1 B 2 a iv Refining / Storage	0.08	0.92
1 B 2 c Venting and flaring	0.08	0.11
National total	**197.37**	**47.22**

* Note that the information in the table should not be directly compared with each other. The information is only given in order to show the proportion of the reported emissions.

** Note that data from one minor refinery is lacking for 2004 and the same value as for 2003 is reported here for that refinery

2.1.1 SO_2 and NO_X emissions

In Table 2.3 and Table 2.4 it can be seen that the emissions of SO_2 and NO_X are heavily overestimated on a total level for the five plants when comparing the total reported emissions on plant level in CRF/NFR 1A1b, 1B2a iv and 1B2c with the total reported emissions in the environmental reports.

Table 2.3 Comparison between total reported emissions of SO_2 to UNFCCC/CLRTAP (CRF/NFR) and reported emissions according to environmental reports (ER).

Year	**CRF/ NFR ton**	**ER ton**	**Difference CRF/ NFR and ER ton**	**Difference CRF/ NFR and ER (%)**
2000	6 657	1 482	5 175	449%
2001	6 732	1 617	5 115	416%
2003	6 789	1 656	5 134	410%
2004	6 805	1 679	5 127	405%

Table 2.4 Comparison between total reported emissions of NO_X to UNFCCC/CLRTAP (CRF/NFR) and reported emissions according to environmental reports (ER).

Year	**CRF/ NFR ton**	**ER ton**	**Difference CRF/ NFR and ER ton**	**Difference CRF/ NFR and ER (%)**
2000	3723	1670	2053	223%
2001	3867	1653	2214	234%
2003	4034	1637	2397	246%
2004	3979	1513	2466	263%

It has been discovered that emissions resulting from use of petroleum coke are reported both in CRF/NFR 1A1b and 1B2a iv. Petroleum coke is reported as a fuel used for combustion in CRF/NFR 1A1b, but is used in the catalytic cracker and emissions from catalytic cracking are to be reported in 1B2a iv according to the guidelines[1]. All emissions reported in CRF/NFR 1B2a iv originating from catalytic cracking (SO_2, NO_X, CO, TSP, PM_{10} and $PM_{2.5}$) are taken directly from the ER and there is no risk for double counting for any other emission than those. The double counting of petroleum coke does not explain the huge over-reporting for the refineries. The bad coherence must be due the incorrect activity data or the use of to incorrect emission factors.

2.1.2 Activity data

Most emissions from fuel combustion at refineries are reported in CRF/NFR 1A1b (as shown in Table 2.2), and to make sure that these activity data is correct, the energy amount in CRF/NFR 1A1b (in TJ) was compared with reported energy amounts in the ER. Table 2.5 shows that almost the same energy amounts are reported in both data sets, and the difference in percent is lower than the uncertainty factor (10%) set for activity data reported in CRF/NFR 1A1b. Hence there is no need for revision of activity data.

Table 2.5. Total energy consumption from fuel combustion at five refineries, and the difference in percent between the data sources.

Year	Energy statistic TJ	Environmental Report TJ	ES/ER %
1990	31 237	31 514	-1%
1995	33 172	32 537	2%
1998	35 941	36 127	-1%
2000	36 183	37 579	-4%
2001	37 714	36 731	3%
2003	39 193	37 233	5%
2004	39 665	37 844	5%

2.1.3 Emission factors (EF) for SO_2 and NO_X

Since activity data is considered good enough, the discrepancies in emission levels must be due to incorrect use of EF in the Swedish inventory. The most important fuels used within the refineries are refinery gas and refinery oil. The emission factors used for SO_2 and NO_X in submission 2006 for refinery gas were developed by the Swedish Environmental Protection Agency in 1995. These factors have not been updated since 1995 and there is no available documentation on how these factors have been developed, but they are most likely not developed specifically for refinery gas. Due to lack of specific EF for refinery gas the same values as for "Other petroleum fuels" have been used. Also for refinery oils, there has been a lack of information and hence the emission factors used in submission

[1] EEA (2004). EMEP/CORINAIR Emission Inventory Guidebook - 2005. EEA Technical report No 30. http://reports.eea.eu.int/EMEPCORINAIR4/en/B411vs2.2.pdf

2006 was the same as for “Residual fuel oil, other consumption” developed by SMED in 2004. These emission factors are not adjusted to refinery oil, but to conventional residual fuel oil.

To make better estimations of NO_X and SO_2 from refineries new emission factors for refinery gas and refinery oil was developed for the whole time series, 1990-2004, within this project.

2.1.3.1 METHOD

The newly developed emission factors for SO_2 and NO_X are based on information on fuel consumption (Mg), sulphur content (%), thermal values (GJ/Mg) and energy content (TJ) for each fuel and plant. For some plants the nitrogen content (%) for each fuel are also known. For the years 2000, 2001, 2003 and 2004 the information was collected from the companies environmental reports. For 1990, 1995, 1998 no environmental reports were available for SMED within this project, and therefore data were taken from plant specific material from the Swedish EPA used for reporting to CLRTAP.

Based on information in ER, plant specific EF (kg/GJ) were calculated for each fuel and year. These EF were then used to estimate average national EF for each fuel and year. This was made by multiplying the calculated specific EF for each plant per year and fuel with the respectively energy amounts for each plant per fuel and year, and divide with the total energy amount for all five refineries per fuel and year, resulting in an average national EF for a specific fuel and year.

The average national EF per year and specific fuel were calculated as:

∑(Specific EF per plant (kg/GJ)* energy amount per plant (TJ)) / Total energy amount for all refineries (TJ)

Developed emission factors are described in more detail in the coming chapters and the exact EF are presented in Appendix 1.

2.1.3.1.1 Refinery gas

Refinery gas is used as a fuel at all five refineries in various amounts and the plant specific EF varies for NO_X and SO_2 depending on combustion procedures and the exact fuel contents.

2.1.3.1.1.1 SO_2

In Figure 2.1 the average EF based on information in environmental reports (Env. Report EF) and newly developed EF (New EF) are presented. As shown in the figure average EF from environmental reports decreased sharply from 1990-1995, but from 1995-2004 it was varying from one year to another. This variation might be caused by differences in combustion, which refinery that used the largest amount of refinery gas, which kind of refinery gas, incorrect reporting in the environmental reports etc.

A trend line was at first drawn including all years from 1990-2004, but if using the equation from that trend to estimate EF for each year, the emissions in the middle of the time series will be overestimated. Instead, based on the estimated average EF for 1990-1995, a trend line was drawn and the equation for this trend was used to estimate EF for each year in 1990-1995. For the remaining years the same EF has been used, since the variation in the average ER emission factors are too high.

The number of decimals has been set to three, with one or two significant digits, which is the same number as for the EF used in submission 2006.

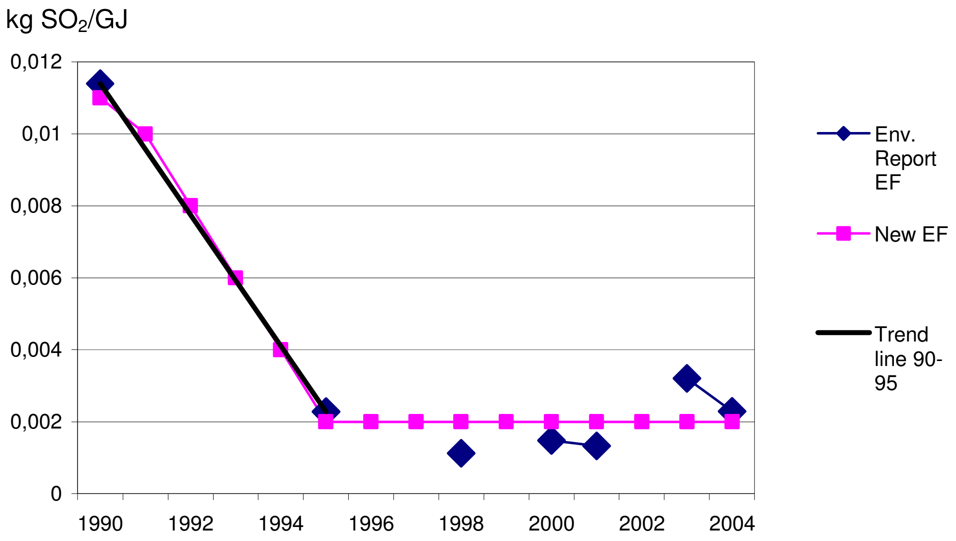

Figure 2.1. Emission factors for refinery gas (SO_2) in 1990-2004 based on data from environmental reports and newly developed EF.

2.1.3.1.1.2 NO_X

For NO_X a trend line was drawn including all years from 1990-2004 and the equation from this trend line was used to estimate specific emission factors for all years in 1990-2004. Also for NO_X the new EF consist of three decimals with two significant digits, just as the EF used in submission 2006. In Figure 2.2 the average emission factors based on environmental reports and newly developed EF can be seen.

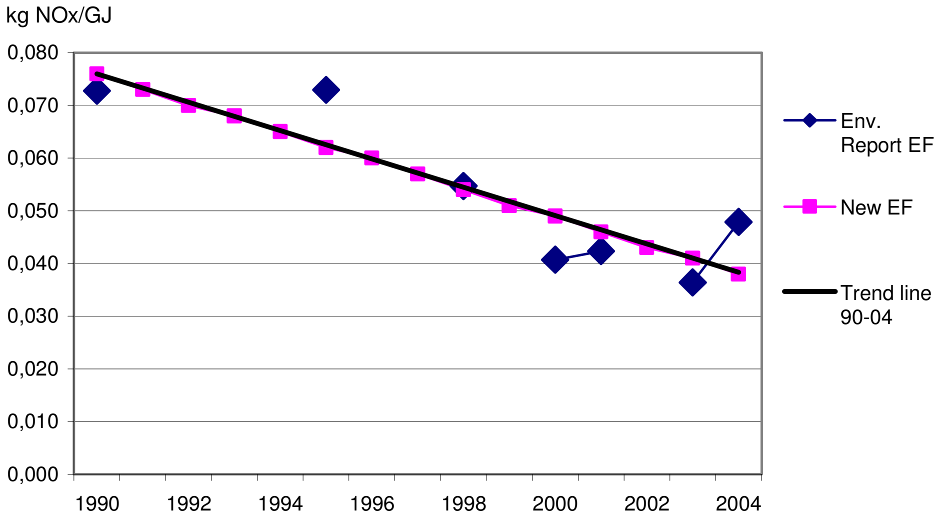

Figure 2.2. Emission factors for refinery gas (NO_X) in 1990-2004 based on data from environmental reports and newly developed EF.

2.1.3.1.2 Refinery oil

Refinery oil, earlier reported as Residual fuel oil, is used by all five refineries but in much lower amounts (in TJ) than refinery gas.

2.1.3.1.2.1 SO_2

Two trend lines have been drawn based on the average EF from the environmental reports; 1990-1995 and 1995-2004. The reason to why two lines were drawn and not one, is due to the great difference in the average EF between 1990-95 compared to 1995-2004. If the same trend line is used when estimation new EF, the emissions for the years in the middle of the time series would be overestimated.

The equations from the two trend lines were used to estimate new EF for all years in 1990-2004. These new EF are shown in Figure 2.3 together with the trend lines drawn and the average EF from environmental reports.

The numbers of decimals for the new EF are two, with two significant digits, just as the ones used in submission 2006.

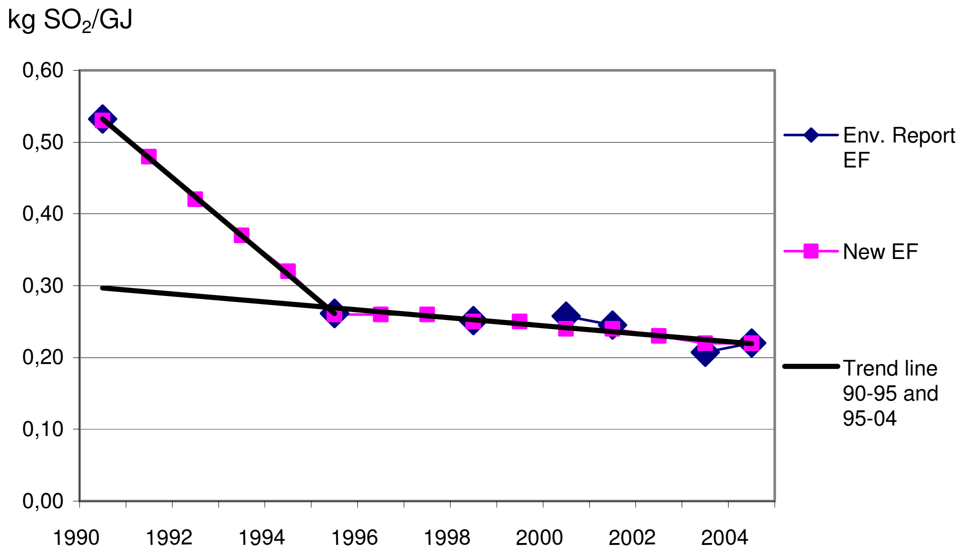

Figure 2.3. Emission factors for refinery oil (SO_2) in 1990-2004 based on data from environmental reports and newly developed EF.

2.1.3.1.2.2 NO_X

A trend line was drawn from 1990-2004, but as shown in Figure 2.4 this trend line will result in increasing EF from 1990-2004 if used to estimate new EF, which is not likely to be true. Due to this trend line and lack of other data sources, the same emission factor has been assigned for the whole time series. In Figure 2.4 average EF in environmental reports and newly developed EF are presented. The number of decimals is two and only one significant digit is used, due the high uncertainty in this new factor caused by the variation in the yearly emission factors from the ER.

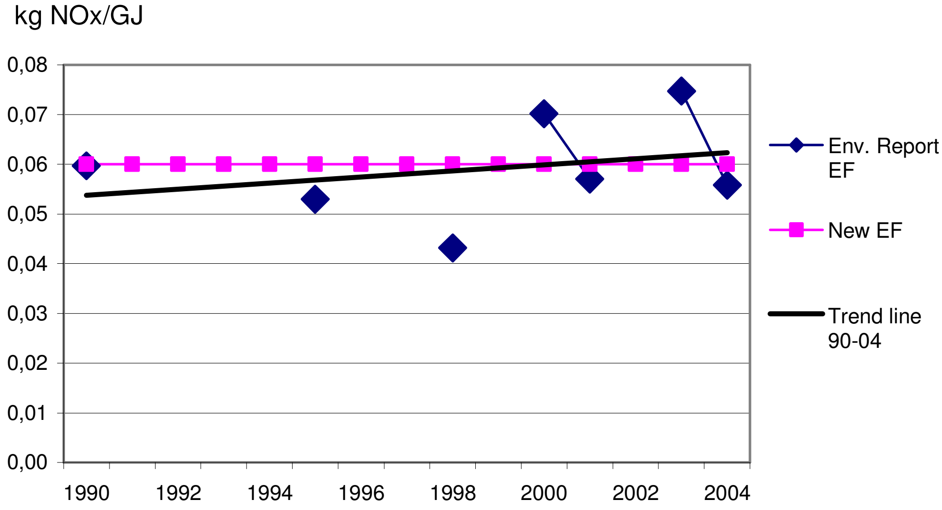

Figure 2.4. Emission factors for refinery oil (NO_X) in 1990-2004 based on data from environmental reports and newly developed EF.

2.1.3.2 RESULTS

In this chapter the resulting emission levels when using the new emission factors will be presented. Note that the presented emissions are results from both revision of EF, but also from other revisions presented as recommendations in chapter 2.1.4.

2.1.3.2.1 SO_2

In Figure 2.5 the total emissions of SO_2 from fuel combustion (CRF/NFR 1A1b) reported in submission 2006, environmental reports, and the emissions calculated with the new developed emission factors are presented. The difference between calculated emissions using the new developed emission factors and the reported emissions in the environmental reports, is in the interval -5% to 3% for SO_2.

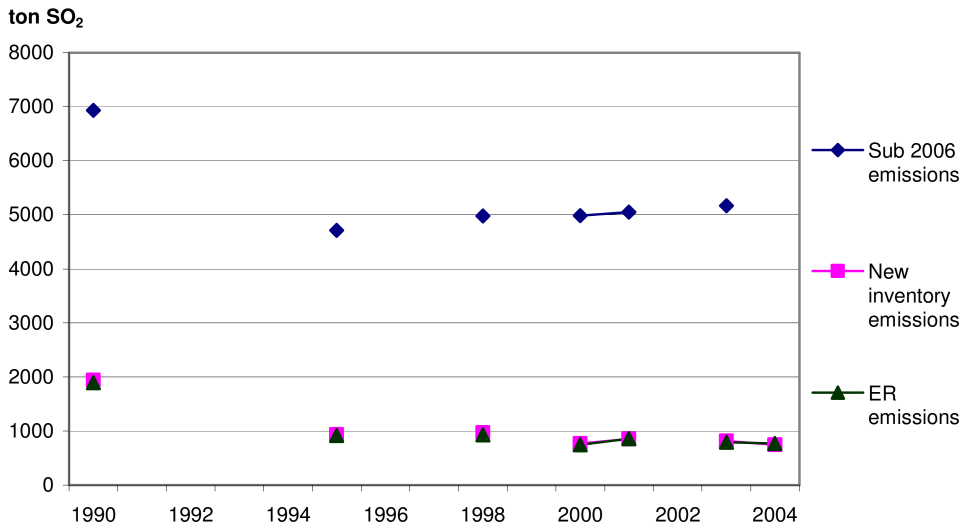

Figure 2.5. Total fuel combustion emission of SO_2 (ton) from five refineries reported in submission 2006 (CRF/NFR 1A1b), reported in environmental reports, and possible emissions in submission 2007 (CRF/NFR 1A1b) if revisions of EF for refinery gas and oil are made.

2.1.3.2.2 NO_X

In Figure 2.6 the total emissions of NO_X for refinery gas and refinery oil reported in submission 2006, environmental reports, and the emissions calculated with the new developed emission factors are shown. The difference between calculated emission, using the new emission factors, and reported emissions in the environmental reports are in the interval -11% - 11%.

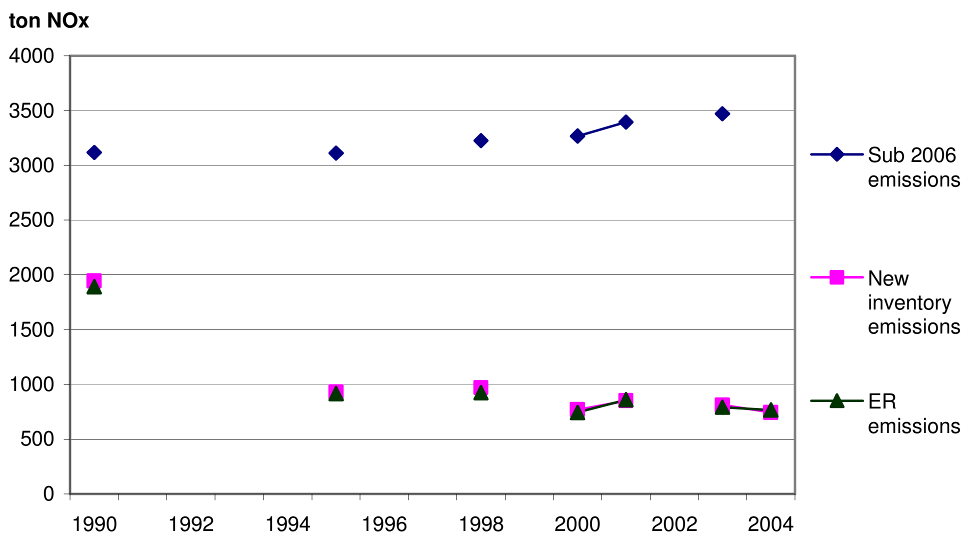

Figure 2.6. Total fuel combustion emission of NO_X (ton) from five refineries reported in submission 2006 (CRF/NFR 1A1b), reported in environmental reports, and possible emissions in submission 2007 (CRF/NFR 1A1b) if revisions of EF for refinery gas and oil are made.

2.1.4 Recommendations for refineries

- Emissions (SO_2, NO_X, CO, TSP, PM_{10} and $PM_{2,5}$) resulting from petroleum coke should be excluded in the inventory in CRF/NFR 1A1b all years.
- The newly developed emission factors for refinery gas and refinery oil will result in a more correct reporting for the refineries on a national level.

  It is important to note that the developed national emission factors cannot be used on plant level and expect that the calculated emissions will agree exactly with the reported emissions in the environmental reports. This will affect the geographical distribution of emissions reported to CLRTAP every fifth year.
- In order to follow-up the developed emission factors it is recommended that data on fuel consumption (Mg), sulphur content (%), nitrogen content (%), thermal values (GJ/Mg) and energy content (TJ) for each fuel and plant are collected from the ER when compiling the inventory for refineries in the future.
- For two refineries, errors in activity data have been found. For one plant in 2001 incorrect data for one fuel is used, and for the other plant errors have been made in the calculations for the year 2004 for one fuel.
- Residual fuel oil is reported as Gas oil for one refinery in 2003-2004, that fuel shall instead be named refinary oil and the new EF will be used.
- It is recommended that other pollutants than SO_2 and NO_X are investigated as well, since it is likely that they are also overestimated in inventory data.

2.2 Cement industries

Emissions from the three Swedish cement plants were investigated in the study; Cementa in Degerhamn, Slite and Skövde.

Emissions from cement industry are reported in CRF/NFR 1A2f (fuel combustion/ manufacturing industry/other) and 2A1 (mineral products/ cement production). Emissions reported in CRF/NFR 1A2f are based on activity data (fuel consumption) from Statisitcs Sweden, Energy Statistic (ES), thermal values, and emission factors. Emissions reported in CRF/NFR 2A1 are based on data reported in the companies' environmental reports (ER).

Table 2.6 presents emissions of NO_X and SO_2 in 2004 in environmental reports from cement industries, reported emissions in CRF/NFR 1A2f and 2A1, and the reported national total level in the inventory. Compared to the total reported emissions, cement industries contribute to about 1% and 0.1% respectively for NO_X and SO_2 according to ER data.

Table 2.6. Emissions of NO_X and SO_2 in 2004 in environmental reports from Cement industries, reported emission on different levels in CRF/NFR tables and totally reported emission for Sweden.*

Data source	NO_X kton	SO_2 kton
Environmental report, total Cement	1.9	0.07
1 A 2 f Other**	33.71	2.44
2 A 1 Cement Production	NA	0.07
National Total	**197.37**	**47.22**

* Note that the information in the table should not be directly compared with each other. The information is only given in order to show the proportion of the reported emissions.

** Note that other industries than cement industries are included in the CRF/NFR code.

2.2.1 Activity data

The fuels used by the three cement plants are very diverse since not only conventional fossil fuels such as coal and petroleum coke are used, but also a number of fossil and non-fossil fuels such as tyres, waste oils, plastics, paper, cartons and animal meal. Activity data from the plants were investigated in the Energy statistics in a SMED project in 2005, by collecting new data from the plants and revisions were then made for most years in the time series 1990-2003.[2]

Within this project activity data in the revised Energy statistics and in the ER were compared, but this was not easily done since the fuels were differently named and grouped in the two data sets.

2.2.2 SO_2 emissions

Most SO_2 emissions from the plants are process-related, and since it is very hard to identify what SO_2 emissions that are not process related in the ER, it has earlier been decided to report all SO_2 emissions in CRF/NFR 2A1, and no emissions in CRF/NFR 1A2f[3]. No emissions from energy combustion are reported in CRF/NFR 1A2f, and hence no emissions are double-accounted or missing in the inventory.

[2] Nyström, A-K & Cooper, D. Use of data from the EU emission trading scheme for reporting to EU Monitoring Mechanism, UNFCCC and CLRTAP. SMED report 2005.

[3] Manual for SMED:s Quality System in the Swedish Air Emission Inventories, Appendix 3: Arbetsdokumentation för CRF/NFR 2A1.

2.2.3 NO_X emissions

All emissions of NO_X are reported in CRF/NFR 1A2f and are based on the fuel consumption described above (chapter 2.2.1). This is the most detailed way to estimate NO_X emissions according to the EMEP Guidelines[4].

The comparison of inventory data and data according to the environmental reports showed more or less large discrepancies in the amount (ton) of NO_X emitted for several years, as shown in Table 2.7. The overestimation of emissions is 2-31% for the years 2000-2004. Only in 2001 emissions are underestimated in the inventory data. When studying the NO_X emissions on a plant level the differences are even larger; for two plants data in the environmental reports are lower and for one plant data is higher.

Table 2.7. Total emitted NO_X according to reported emission to the UNFCCC/CLRTAP from Energy statistics compared with data from environmental reports, and the differences between the two data sources.

Year	Energy Statistics ton	Environmental report Ton	Difference ES/ER ton	Difference ES/ER %
2000	1901	1856	45	2%
2001	1963	2150	-187	-9%
2002	1833	1684	149	9%
2003	1813	1389	424	31%
2004	2058	1947	111	6%

The reason for the discrepancies lies in the activity data and/or the emission factors. As described above it was hard to compare activity data between the data sets, but much data has been revised in submission 2006, and the new data used was send to Statistics Sweden with specific thermal values. It is hence reasonable to believe that activity data are more or less correct, or at least that no better data are available in any data source.

The other explanation to discrepancies is the emission factors, which are most likely not adjusted for the special fuels used by the cement industry. The unconventional fuels are classified as either “Other biomass”, “Other petroleum fuels” and “Other solid fuels” and the emission factors are default values developed by the Swedish EPA in 1995, without any documentation.

The EMEP Guidelines[5] claims that if not sufficient detailed data on energy consumption is available, cement clinker production data can be used to estimate NO_X emissions instead. The default value is 0.6 ton NO_X /kton clinker produced.

[4] EEA (2004). EMEP/CORINAIR Emission Inventory Guidebook - 2005. EEA Technical report No 30. http://reports.eea.eu.int/EMEPCORINAIR4/en/B3311vs2.4.pdf

[5] EEA (2004). EMEP/CORINAIR Emission Inventory Guidebook - 2005. EEA Technical report No 30. http://reports.eea.eu.int/EMEPCORINAIR4/en/B3311vs2.4.pdf

To estimate emissions of process-related CO_2-emissions in Sweden, clinker production is used as activity data and hence these data is available for all years since 1990. Based on data on clinker production, and NO_X emissions reported in the environmental reports, national emission factors were estimated (Table 2.8). These are higher for most years than the default values, probably due to the special fuels used in Sweden.

Table 2.8. National emission factors for NO_X based on clinker production and estimated NO_X emission based on default EF.

	Clinker production	NO_X emissions (Env. Report)	NO_X emissions based on EMEP EF	National EF	EMEP Default EF
	kton	**ton**	**ton**	**ton/kton**	**ton/kton**
2000	2389	1856	1434	0.8	0.6
2001	2472	2150	1483	0.9	0.6
2002	2372	1684	1423	0.7	0.6
2003	2235	1389	1341	0.6	0.6
2004	2386	1947	1431	0.8	0.6

If national EF values are to be used these must be developed since 1990. Data on clinker production is known and also emission data for several years, so this should be possible.

2.2.4 Recommendations for cement industries

No adjustments are needed for the SO_2 emissions, but for NO_X emissions revisions are recommended. To report as accurate NO_X emissions as possible, we recommend that emissions measured and reported in the environmental reports should be used, and that these shall be verified by estimating national emission factors. This method is described as approach 1) below together with three alternative approaches to improve the quality in NO_X data from cement industries:

Approach 1) Report the same emissions as reported by the plants in the environmental reports for 1990-2004 and coming years, in the same way as made for SO_2. To verify these data national emission factors (ton NO_X / kton clinker) need to be calculated. If this method is to be used, revisions can be made no earlier than in submission 2008, since plant specific data since 1990 needs to be collected.

Approach 2) Report emissions already available and develop national emission factors for NO_X 1990-2005 based on available information on NO_X from some plants and years, and the clinker production for all years. The emission factors should be used when no emission data is available. If this method is being chosen it is possible to make revisions of the whole time series 1990-2005 already in submission 2007.

The disadvantage by using the two first methods is that activity data reported in the CRF tables (TJ fuels consumed) would not be the same as the activity data used in the inventory (no activity data or clinker production). But since activity data and NO_X emissions are not reported on the same disaggregation level in the CRF, this should not be a problem. Especially not if the method used is clearly described in the NIR and the IIR.

Approach 3) Use the EMEP default value and data on clinker produced to estimate emissions. The disadvantage by doing so is that default values are never adjusted for national circumstances, and it would underestimate the Swedish emissions. Besides, since there is only one value, it will not reflect the possible improvements made to reduce emissions since 1990.

Approach 4) Develop national emission factors for the fuels used by the cement industry. The biggest problem would be that even not the plants know the specific EF for each fuel, since they always uses fuel mixes. So even if the plants are measuring the emissions, often the EF estimated will never reflect the emissions for one specific fuel used.

The problem would also be that emissions of NO_X from for instance combustion of tyres could vary for the different plants depending on combustion temperature etc.

Finally, the disadvantage by developing new EF for NO_X for the different fuels used since 1990, is that it is not known which fuels will be used in the future. There might be a risk that other special fuels will be used and then it is hard to know which EF to use.

It is recommended that other pollutants than SO_2 and NO_X are investigated as well, since it is likely that they are also overestimated in inventory data.

2.3 Iron and steel industries

Emissions from the three Swedish primary iron and steel plants were investigated in the study; Höganäs in Höganäs and SSAB in Luleå and Oxelösund. Besides, one secondary plant were investigated; Sandvik AB.

Emissions from iron and steel industry are reported in CRF/NFR 1A2a (fuel combustion/ manufacturing industry/ iron and steel), 1B1b (fugitive emissions from solid fuels/ solid fuel transformation), 1B1c (fugitive emissions from solid fuels/ other) and 2C1/2C (metal production/ iron and steel). Emissions from the four plants studied contribute with 0.7 and 3% respectively of the total national NO_X and SO_2 emissions according to ER data as shown in Table 2.9.

Table 2.9. Emissions of NO_X and SO_2 in 2004 reported in the environmental reports, in the different CRF/NFR sectors for iron and steel and totally reported emission for Sweden.*

Data source	NO_X kton	SO_2 kton
Environmental report, SSAB Oxelösund	0.5	0.4
Environmental report, SSAB Luleå	0.5	0.8
Environmental report, SANDVIK	0.3	0.05
Environmental report, HÖGANÄS	0.06	0.03
1 A 1c Manufacture of Solid Fuels	0.15	0.43
1 A 2 a Iron and Steel	1.15	0.89
1 B 1 b Solid fuel transformation	NA	0.13
1 B 1 c Other	0.11	0.02
2 C Metal production	1.08	3.90
National Total	**197.37**	**47.22**

* Note that the information in the table should not be directly compared with each other. The information is only given in order to show the proportion of the reported emissions.

Emissions reported in CRF/NFR 1A2a and 1B1c are based on activity data (fuel consumption) from Statistics Sweden, energy statistic (ES), thermal values and emission factors. Emissions reported in CRF/NFR 1B1b and 2C1 are mainly based on data reported in the companies' environmental reports (ER).

In CRF/NFR 1A2a, emissions from fuel combustion is reported and activity data is the fuel consumed. For all four plants process emissions are occurring and reported in CRF/NFR 2C1. According to the IPCC Guidelines[6] use of fuels as reducing agents (for example coke and anthracite) in the iron and steel sector should be reported as process emissions. For SSAB emissions are also reported in CRF/NFR 1A1c (coke production), 1B1b (quenching and extinction at coke ovens) and in 1B1c (flaring of gases).

Comments regarding the coherence in activity data are given below where necessary.

2.3.1 SSAB in Luleå and Oxelösund

2.3.1.1 SO_2 AND NO_X EMISSIONS

For the inventories, SMED has earlier made great efforts to allocate emissions from SSAB in correct CRF/NFR codes. Of course SSAB has not made the same allocation of emissions in their environmental reports, and it also differs significantly in the ER for Luleå and Oxelösund. Hence it is hard to compare emissions at any other level than the total level. Total emissions are higher in the inventory data most years (all years for Oxelösund) and lower in a few years for Luleå, and the reasons for the differences were further investigated.

[6] Revised 1996 IPCC Guideliens for National Greenhouse Gas Inventories, Reference Manual chapter 2.13.

It was noticed that emissions of SO_2 from the blast furnace are much higher in the ER than in the inventory data (CRF/NFR 2C1). This is probably due to that SSAB emission are based on the use of injection coal and coke used as reducing agents in the blast furnaces, and these agents have high sulphur contents, whereas in the inventory emissions from blast furnaces are based on the use of blast furnace gas used as fuel for combustion. The method used to estimate NO_X and SO_2 emissions is correct according to a study made by SMED in year 2003[7], but the EF are most likely not adjusted to the method used. In the inventory, emissions of SO_2 from steel converters based on energy statistics (CRF/NFR 1A2a), are generally higher than the reported ER data. This is probably due to the EF for coke oven gas, which seems to be overestimated.

Emissions of NO_X are for both plants generally lower in inventory data than in ER data on a total level, and for a few years as much as 50% lower. Emissions are particularly low for the coke ovens, where mainly coke oven gas, but also blast furnace gas, is used as fuels.

In 2004 a SMED project was carried out and the emission factors for SO_2 and NO_X for blast furnace gas and coke oven gas were revised.[8] In the SMED report a new common thermal value (3.36 GJ/1000 m3) for coke oven gas, blast furnace gas and steel converter gas (LD-gas) was suggested to be used in combination with the new EF. However, since specific thermal values are used in the inventory for each fuel and year (varying from 2.8-18 GJ/1000 m3 for the different fuels) based on direct information from SSAB, the new thermal value was not used.

Hence, the suggested EF could not be directly implemented either, but had to be adjusted to fit with the thermal values actually used. Unfortunately the documentation on how the EF were developed and then implemented in the inventory is very scarce, and it has not been possible to find out whether or not appropriate decisions have been made. Another thing that complicates what EF that are used is that in the IIR submission 2006 appendix 26 it is stated that the source for the EF for NO_X for these gases are the Swedish EPA, 1995 and not SMED, 2004. Only for SO_2, SMED 2004 is stated as the source for the EF.

Uncertainties for the EF for SO_2 and NO_X for blast furnace gas and coke oven gas was set to 10-30% in the SMED 2004 project, which can explain the great differences between inventory data and ER data if these EF are correctly used.

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[7] Ivarsson, A-K and Skårman, T, Energy Statistics versus Environmental Reports, SMED report 2003.
[8] Boström, C-Å, Flodström, E and Cooper, D, Emissionsfaktorer för stationär förbränning, SMED report 2004.

2.3.1.2 RECOMMENDATIONS FOR SSAB

- Investigate the results from the 2004 SMED study and consider revisions of the EF for SO_2 and NO_X for coke oven gas and blast furnace gas used in the inventory, based on the SMED report and new information from ER and make contacts with both plants.
- Emission data from the ER could not be used generally for the whole times series 1990-2004, since no allocation in the different CRF/NFR codes are made, data is lacking for many years, and emissions are differently reported at SSAB in Luleå and Oxelösund.

2.3.2 Höganäs

2.3.2.1 SO_2 EMISSIONS

Most SO_2 emissions are reported in CRF/NFR 2C1 (over 95%). Inventory data reported in 1A2a on SO_2 are generally a few tons lower than in the ER, due to that the Swedish EF used for LPG and natural gas is zero (developed by the Swedish EPA in 1995). Another reason for the lower inventory data is that emissions from production of manganese-sulphate (MnS-E) (ca 1.3-3.3 ton) have not been accounted for in 2C1 in the Swedish inventory earlier.

2.3.2.2 NO_X EMISSIONS

The company reports in their environmental report ca 55-70 ton of NOX-emissions and inventory data is about 20% lower than ER data for all years. Emissions resulting from use of coke and anthracite are considered as process emissions in the inventory and therefore the emissions are not included in 1A2a. However in the ER, emissions resulting from the use of reducing agents of coke and anthracite are not accounted for separately, therefore the emissions are not reported in 2C1 either. The emissions resulting from the use of coke and anthracite needs to be investigated further and contact has been taken with the plant to receive more information.[9]

2.3.2.3 RECOMMENDATIONS FOR HÖGANÄS

- Include SO_2 emissions from production of MnS-E in 2C1.
- Investigate the amount of NO_X and SO_2 emissions resulting from use of coke and anthracite further and include them in NFR/CRF 2C1 if they are missing.

2.3.3 SANDVIK

2.3.3.1 SO_2 EMISSIONS

Most emissions reported from combustion in CRF/NFR 1A2a are from the use of residual fuel oils and gas oils. The energy amount reported in the environmental reports and in the Energy statistic has been compared and correlates well. Still, emissions are much lower in the inventory data (based on energy statistics) due to lower EF for the fuels. For Sandvik, the used EF in the inventory for residual fuel

[9] Contact at Höganäs AB: Pernilla Nydahl: pernilla.nydahl@hoganas.com.

oil is the one for “Other consumption”. The EF for “Gas turbine/diesel power generation” is higher and seems to be more appropriate for this plant when comparing with the reported data in the ER.

Emissions reported in CRF/NFR 2C1 are those reported as emissions from the steel converter in the ER. The emissions resulting from reducing agents (coal-powder, coal briquettes, charge-chrome, electrodes and Scandust material) are not included in the companies’ reported emissions in the ER from the steel converter, instead they are included in the reported combustion emissions. In inventory data these emissions are lacking, as they do for NO_X emission for Höganäs. The reason to this is that they are not included in neither the CRF/NFR 1A2a, since they are considered as process related, nor in CRF/NFR 2C1, since they are not reported as process related in the ER. The proportion of the emissions resulting from the use of reducing agents needs to be investigated further in cooperation with the company.

2.3.3.2 NO_X

Emissions reported in CRF/NFR 1A2a and 2C1 are lower than data in the environmental reports all years, except in 2001 when inventory data is slightly higher. Emissions reported in CRF/NFR 2C1 are based on emissions from the steel converter and from steeping reported in the ER. As for SO_2, emissions from reducing agents are probably lacking. The comparison of data also shows that emissions from fuel combustion are lower in inventory data (15-50 ton/year), due to lower EF for residual fuel oils and LPG.

Reported data from the steel converter were incorrectly reported in submission 2006 for CRF/NFR 2C1 year 2000. Instead of 173 tonnes 144 tonnes were reported.

2.3.3.3 RECOMMENDATIONS FOR SANDVIK

- Revisions will be made in submission 2007 for NO_X for year 2000 in CRF/NFR 2C1 due to incorrect reporting in submission 2006.
- Emissions of NO_X and SO_2 from the use of reducing agents should be further investigated and included in the inventory. This is a general recommendation for all secondary iron and steel works, since emissions are likely to be lacking for all of them. The easiest way to include these emissions is to add the part missing by using data from the ER for the years 1990-2004 and use the following equation for each plant and years: 2C1 (sub 2008) = ER data - 2C1 (sub 2007).

  In 2005, SMED has been involved in a project for recommendations of what data that shall be reported by the plants when the emissions and other plant specific data will be reported via a web based survey and stored in a common data base (SMP). SMED then recommended that emissions from reducing agents shall be reported separately as process emissions. If this recommendation is implemented there will be no problems with emissions of NO_X and SO_2 from the use of reducing agents in the future (from submission 2008).

- One possibility is, though not recommended, that if it is not possible to get coherence between the data sets in any other way, some EF for both SO_2 and NO_X should be considered to be revised. For instance the emission factor for LPG for NO_X, which has not been revised since 1995. The EF used for residual fuel oil is the one for "Other industries, power plants and district heating". If the EF for "Other consumption" were to be used, the emissions would increase in the inventory data, and be more in line with ER data. However, this EF exchange would only affect the total emission levels from Sandvik very scarcely, and is hence not considered as motivated.

2.4 Non- ferrous metal industry

Emissions from three metal industries were investigated in the study; Kubal (aluminium production), Rönnskär (other metal production) and Vargöns Alloys (ferro alloy production).

Combustion emissions for all three metal industries are reported in CRF/NFR 1A2b (fuel combustion/ manufacturing industry/ non-ferrous metals). The reported emissions are based on activity data (fuel consumption) from Statistics Sweden, energy statistic (ES), thermal values and emission factors. Process emissions for Kubal are reported in CRF 2C4 (metal production/ aluminium production), Rönnskär 2C5 (metal production/ other production) and 2B5 (sulphuric acid industry) and Vargön Alloys in 2C2 (metal production/ ferroalloys production). Reported process emissions are based on data reported in the companies' environmental reports (ER).

Emissions from the three plants studied contribute with 0.2 and 8% respectively of the total NO_X and SO_2 emissions according to ER data as shown in Table 2.10.

Table 2.10. Emissions of NO_X and SO_2 in the environmental reports, the different CRF/NFR sectors for non- ferrous metal sectors and totally reported emission for Sweden.*

Data source	NO_X kton	SO_2 kton
Environmental report, Kubal	0	0.23
Environmental report, Rönnskär	0.20	3.5
Environmental report, Vargön Alloys	0.25	0.32
1 A 2 b Non-ferrous Metals	0.9	0.8
2 B 5 Other	1.26	0.58
2 C Metal production	1.8	3.9
National Total	**197.7**	**47.2**

* Note that the information in the table should not be directly compared with each other. The information is only given in order to show the proportion of the reported emissions.

2.4.1 Activity data, SO_2 and NO_X emissions

2.4.1.1 KUBAL

Emissions are reported in CRF/NFR 1A2b and 2C3, based on fuel consumption and ER data respectively. There are two different production units within the facility. The emissions reported in CRF/NFR 2C3 are calculated with EF and activity data (amount aluminium produced in tons).

The emissions of SO_2 are about 300 ton in the ER and the coherence with emission data in the ER and inventory data is very good for SO_2, except for the year 2004 when incorrect data is reported in CRF 2C3. The company reports EF for SO_2 in the ER for each production unit separately. The EF for plant 1 was not included in the inventory in submission 2006, and hence emissions for plant 1 are missing in 2004.

Kubal does not report emissions of NO_X in the ER, probably due to that NO_X is not regulated in their permit, and hence no comprehensive study could be performed. According to the work-documentation for 2C3[10], the company will make an overhaul of this in the future. Since no NO_X emissions are reported in the ER, emissions reported in 2C3 are calculated with activity data (produced amount of aluminum) reported in the ER and EF from Swedish EPA[11].

2.4.1.1.1 Recommendations for KUBAL

- Revisions will be made in submission 2007 for SO_2 in CRF/NFR 2C3 due to incorrect reporting for one of the two units in submission 2006.
- Contact needs to be taken with the company to discuss the emissions of NO_X further to make sure that correct emissions are reported in the inventory.

2.4.1.2 RÖNNSKÄR

Emissions are reported in CRF/NFR 1A2b based on fuel consumption, but the main parts of the emissions are reported in CRF/NFR 2B5 and 2C5 based on data in ER. The emission levels are about 4 000 ton SO_2 and 200 ton NO_X, and the coherence with emissions of both SO_2 and NO_X are very good between inventory data and ER data. This coherence is most likely true also for other plants in the Other metal sector (CRF/NFR 2C5).

2.4.1.2.1 Recommendations for Rönnskär

- No revisions needed.

2.4.1.3 VARGÖN ALLOYS

As for Rönnskär, most emissions from Vargön Alloys are reported as process emissions (CRF/NFR 2C2), based on data in ER. Less than one ton of NO_X and SO_2 are also reported in CRF/NFR 1A2a based on fuel consumption. Totally

[10] Manual for SMED:s Quality System in the Swedish Air Emission Inventories, Appendix 3: Arbets-dokumentation för CRF/NFR 2C3.

[11] Developed by Husamuddin Ahmadzai at the Swedish EPA.

Vargön reports about 300 ton SO_2 and 230-280 ton NO_X in the ER, and on a total level the coherence of inventory data and ER data is very good.

2.4.1.3.1 Recommendations for Vargön Alloys

- No revisions needed.

2.5 Pulp, paper and print industry

Emissions from industries classified as NACE-code 21 were investigated in the study. The emissions reported in CRF/NFR 1A2d (fuel combustion/ manufacturing industry/ pulp, paper and print are based on activity data (fuel consumption) from Statistics Sweden, energy statistic (ES), thermal values and emission factors. Process emissions reported in CRF/NFR 2 D1 (Other production/ pulp and paper) are based on reported emissions from the trade organisation Swedish Forest Industries Federation[12]. The reported emissions from Swedish Forest Industries Federation are based on measured and calculated data reported in the companies' environmental reports (ER). Emissions from pulp, paper and print industry contribute with 7.1 and 18.5% respectively of the total NO_X and SO_2 emissions according to Swedish Forest Industries Federation data as shown in Table 2.11

Table 2.11 Emissions of NO_X and SO_2 reported by Swedish Forest Industries Federation, the reported inventory data for pulp, paper and print industry and totally reported emission for Sweden.*

Data source	NO_X kton	SO_2 kton
Swedish Forest Industries Federation	13.94	8.73
1 A 2 d Pulp, Paper and Print	5.58	3.66
2 D 1 Pulp and Paper	10.59	6.95
National Total	**197.7**	**47.2**

* Note that the information in the table should not be directly compared with each other. The information is only given in order to show the proportion of the reported emissions.

Inventory data was compared with total reported emissions by the Swedish Forest Industries Federation. To make detailed comparisons of the data sets, data on energy amounts (TJ), SO_2 and NO_X was divided on as detailed level as possible within NACE 21. The result on this level was however not possible to evaluate, since only three codes (NACE 21111, 21112 and 21113) are reported in the Swedish Forest Industries Federation data, compared to 14 different NACE codes in the Energy statistics.

Before the study started it was unclear if emissions from printing were included in CRF/NFR 1A2d. However in NACE 21 reported in CRF/NFR 1A2d no NACE

[12] Swedish Forest Industries Federation
http://miljodatabas.skogsindustrierna.org/si/main/main.aspx?l1=home

code includes printing, and it is hence not included in CRF/NFR 1A2d. It might though be that industries producing for instance pulp are doing some printing as well, and those emissions are then included in both CRF/NFR 1A2d, and in data from the Swedish Forest Industries Federation.

According to the work-documentation for 2D1 emissions from bark- and oil furnaces are to be reported as CRF/NFR 1A2d and emissions from recycling- (lye combustion), mesa and destruction furnaces are to be reported as 2D1[13]. A recommendation according to the CORINAIR guidelines is to report emissions from fuels used in mesa and destruction furnaces as SNAP-category 03 (i.e. 1A2d), but since it is hard to separate which emissions that originate from the fuels and the raw material, Sweden has earlier chosen to report all emissions from mesa- and destruction furnaces in 2D1.

2.5.1 Activity data

The industries report fuel consumption to Statistic Sweden as well as to the Swedish Forest Industries Federation. The most frequently used fuel in the industry is residual fuel oils, wood waste and tall oil. In **Table 2.12** it can be seen that the reported energy amounts (in TJ) correlates well for both data sources.

Table 2.12. Total energy amounts (TJ) reported in CRF/NFR 1A2d and reported by the Swedish Forest Industries Federation.

Year	Energy statistics	Forest industries	Difference Statistics Sweden and Forest industries	Difference Energy statistics and Forest industries
	TJ	TJ	TJ	%
2001	216 267	204 608	11 659	6%
2002	219 888	213 745	6 143	3%
2003	207 527	201 871	5 656	3%
2004	222 574	215 852	6 722	3%

2.5.2 SO_2 and NO_X

In

Table 2.13 and Table 2.14 it can be seen that Sweden totally reports about 20% more SO_2 and 15% more NO_x than the Swedish Forest Industries Federation. In 2D1 emissions from recycling-, mesa- and destruction furnaces, plus other gaseous sulphur emissions (weak gases) are reported. When comparing data on total NACE 21 level it was noted that emissions from mesa- and destruction furnaces are accounted for both in CRF/NFR 1A2d and 2D1, at least partly.

[13] Manual for SMED:s Quality System in the Swedish Air Emission Inventories, Appendix 3: Arbetsdokumentation för CRF/NFR 2D1, 2G1.

When comparing the reported emissions in 1A2d with emissions from fuel combustion that the Swedish Forest Industries Federation accounts for, it was noticed that the emissions in 1A2d are overestimated. This indicates that the emission factors are too high since the energy amounts are almost the same as mentioned in chapter 0.

Table 2.13. Reported emissions of SO_2 in CRF/NFR 1A2d and 2D1 compared with reported emissions by the Swedish Forest Industries Federation.

Year	CRF/NFR 1A2d	CRF/NFR 2D1	Forest industries	Difference CRF/NFR and Forest industries	Difference CRF/NFR and Forest industries
	kton	kton	kton	kton	%
2001	4.59	7.00	9.61	1.98	21%
2002	4.23	6.65	8.94	1.94	22%
2003	3.82	7.09	9.55	1.36	14%
2004	3.66	6.95	8.73	1.88	22%

Table 2.14 Reported emissions of NO_X in CRF/NFR 1A2d and 2D1 compared with reported emissions by the Swedish Forest Industries Federation.

Year	CRF/NFR 1A2d	CRF/NFR 2D1	Forest industries	Difference CRF/NFR and Forest industries	Difference CRF/NFR and Forest industries
	kton	kton	kton	kton	%
2001	6.73	10.31	14.35	2.69	19%
2002	6.11	10.20	14.49	1.82	13%
2003	5.67	10.39	14.63	1.43	10%
2004	5.58	10.59	13.94	2.23	16%

2.5.3 Recommendations for pulp, paper and print industry

The investigation has shown that emissions of both SO_2 and NO_X are overestimated in the inventory. One reason is the use of incorrect emission factors and the other reason is that emissions from fuel consumption in mesa and destruction furnaces are reported both in 1A2d and 2D1. Below recommendations for SO_2 and NO_X respectively are made. It is likely to believe that other emissions than SO_2 and NO_X are overestimated in inventory data as well but this needs to be further investigated.

2.5.3.1 SO_2 and NO_X

It is known that some emissions are double-accounted for, but if excluding all emissions of SO_2 and NO_x reported in CRF/NFR 2C1 from CRF/NFR1A2d, the emission levels would be below zero. It is hence recommended to start by investigate the emission factors for the main fuels used. Biomass fuels accounts for about 20% of the reported SO_2 emissions in CRF/NFR 1A2d, but biomass fuels are often combusted together with fossil fuels, which will make it more difficult to develop emission factors. The possibility to divide the fuel group named

“Wood, wood waste” further in the energy statistics should be investigated, since this fuel group is likely to be quite diverse.

When new EF are developed and implemented in the inventory a new comparison should be made between inventory data and data from the Swedish Forest Industries Federation, to see if any double-accountings of emissions in CRF/NFR 1A2d and 2D1 occur.

3 Recommended improvements

Within this project a number of recommendations have been made that, if implemented, will improve the quality of reported NO_X and SO_2 emissions in future inventories to the UNFCCC, CLRTAP and the EU NEC directive. In Table 3.1 a suggestion is made on priorities for when the different recommendations could be implemented.

Table 3.1 Summary of recommended revisions and time plan.

CRF/ NFR	Sector/ plant	What	When Sub	Included in inventory work
1A1b, 1B2c	All refineries	Use new EF for refinery oil and gas for SO_2 and NO_X	2007	No
1A1b	Preem, Lysekil	Exclude emissions of SO_2, NO_X, CO, TSP, PM_{10} and $PM_{2.5}$ from CRF/NFR 1A1b.	2007	No
1A1b	3 plants	Revise activity data in 2001, 2003-2004	2007	Yes
1A1b	All refineries	Investigate if other emissions than SO_2 and NO_X are incorrect reported in the inventory.	2008	No
1A1b	All refineries	Follow-up the developed national emission factors when compiling the ER data	2007	No
1A2f-App. 1	Cement industries	Report emissions of NO_X based on emissions data from environmental reports.	2008	No
1A2f-App. 2	Cement industries	Report emissions of NO_X based on emissions data from environmental reports 1995-2005 and based on clinker production and national EF 1990-1994.	2007	No
1A2f	Cement industries	Investigate if other emissions than SO_2 and NO_X are over estimated in the inventory.	2008	No
1A1c,1A2a, 1B1c, 2C1	SSAB, 2 plants	Study the EF for SO_2 and NO_X for coke oven gas and blast furnace gas and revise and implement them if necessary	2008	No
2C1	Höganäs	Include SO_2 emissions from production of MnS-E	2007	Yes
2C1	Höganäs	Investigate and include the amount of NO_X emissions resulting from use of coke and anthracite.	2008	No
2C1	Sandvik	Revision of NO_X for 2000	2007	Yes
2C1	Sandvik + other secondary steel works	Investigate and include emissions of NO_X and SO_2 from the use of reducing agents.	2008	No
1A2a etc.	Sandvik etc.	Revise the NO_X EF for LPG and consider using the residual fuel oil EF for “Other consumption” for Sandvik, if necessary after including emissions from reducing agents.	2009	No
2C3	Kubal	Include missing SO_2 data for one unit at one plant for 2004.	2007	Yes
2C3	Kubal	Investigate and consider revision of NO_X emissions.	2008	No
1A2d	Pulp, paper and print	Develop new more detailed SO_2 and NO_X EF for the main fuels used	2008	No
1A2d, 2D1	Pulp, paper and print	Investigate possible over estimations of other emissions than NO_X and SO_2	2008	No

Appendix 1. New emission factors for refinery oil and gas

SO_2 Stationary combustion

	Fuel group	Bränsleslag	Fuel type	Area of consump-tion	kg SO_2/GJ per year																Source
					1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	
New EF	Liquid	Brännolja	Refinary oil	All con-sumption	0,53	0,48	0,42	0,37	0,32	0,26	0,26	0,26	0,25	0,25	0,24	0,24	0,23	0,22	0,22	0,22	SMED 2006
Sub 2006	Liquid	Eldnings-olja 2-5	Residual fuel oil	Other consump-tion	0,24	0,24	0,24	0,22	0,2	0,18	0,15	0,14	0,13	0,12	0,12	0,11	0,1	0,09	0,09		SMED 2004
New EF	Liquid	Raffinaderi-gaser	Refinery gases	All con-sumption	0,011	0,010	0,008	0,006	0,004	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	SMED 2006
Sub 2006	Liquid	Raffinaderi-gaser	Refinery gases	All con-sumption	0,24	0,24	0,24	0,24	0,24	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15		SEPA 1995

NO_X Stationary combustion

	Fuel group	Bränsleslag	Fuel type	Area of consump-tion	kg NO_X /GJ per year																
					1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Source
New EF	Liquid	Eldnings-olja 2-5	Refinary oil	Other consump-tion	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,06	SMED 2006
Sub 2006	Liquid	Eldnings-olja 2-5	Residual fuel oil	Other consump-tion	0,17	0,17	0,15	0,15	0,12	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1		SMED 2004
New EF	Liquid	Raffinaderi-gaser	Refinery gases	All con-sumption	0,076	0,073	0,07	0,068	0,065	0,062	0,06	0,057	0,054	0,051	0,049	0,046	0,043	0,041	0,038	0,038	SMED 2006
Sub 2006	Liquid	Raffinaderi-gaser	Refinery gases	All con-sumption	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1		SEPA 1995