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Swedish Environmental Emissions Data

Use of data from the EU emission trading scheme for reporting to EU Monitoring Mechanism, UNFCCC and CLRTAP

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SMED is short for Swedish Environmental Emissions Data, which is a collaboration between IVL Swedish Environmental Research Institute, SCB Statistics Sweden, SLU Swedish University of Agricultural Sciences, and SMHI Swedish Meteorological and Hydrological Institute. The work co-operation within SMED commenced during 2001 with the long-term aim of acquiring and developing expertise within emission statistics. Through a long-term contract for the Swedish Environmental Protection Agency extending until 2014, SMED is heavily involved in all work related to Sweden's international reporting obligations on emissions to air and water, waste and hazardous substances. A central objective of the SMED collaboration is to develop and operate national emission databases and offer related services to clients such as national, regional and local governmental authorities, air and water quality management districts, as well as industry. For more information visit SMED's website www.smed.se.

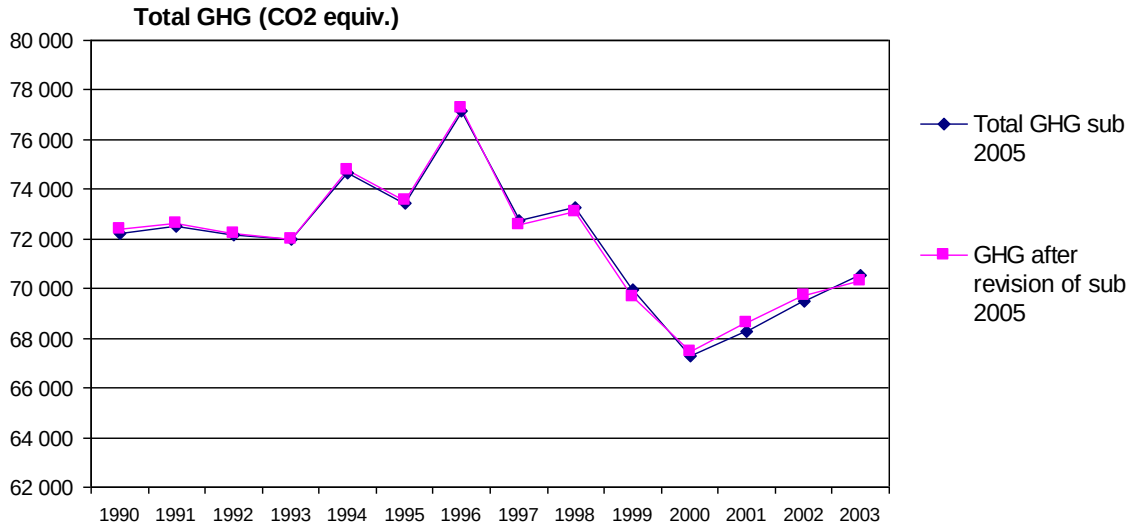
Summary

In order to provide more accurate data for Sweden's reporting to the EU Monitoring Mechanism, UNFCCC and CLRTAP, the potential of using emission trading data submitted by individual companies in a trading survey in 2004 has been investigated. In 2004 this work involved a quality check by comparing national Swedish data with data on fuel consumption and CO_2 emissions reported in the trading survey on plant level for the yeas 1998-2004. In several cases, significant discrepancies were observed which warranted a closer investigation and an eventual revision of activity data and a few emission factors

This present study covers an investigation of 46 plants with discrepancies in activity data and five plants with discrepancies in emission factors, discovered during the work in 2004. After consultation with the appropriate personnel at each company explanations to the observed differences were found. The results indicated a revision of the activity data, which have been performed for 35 plants. The investigation of emission factors also resulted in revision according to the table below.

	Previous CO_2 factor used in submission 2005 **ton CO_2/TJ**	**New CO_2 factor that will be used in submission 2006** **ton CO_2/TJ**
Carbide furnace gas	60	145
Refinery gas	66.7	59.3
Petroleum coke	103	100

The revisions of activity data and emission factors resulted in a total of 0.2% higher emissions of greenhouse gas (GHG) emissions in 1990 and 0.3% lower GHG emissions in 2003, as shown in the below diagram. These changes resulted in 2.8% lower emissions of total GHG in Sweden in 2003 than 1990. In submission 2005, before the revision in this project, Sweden reported a decrease with 2.3% from 1990 to 2003 to the UNFCCC.[1]



[1] Sweden National Inventory Report to the UNFCCC submission 2005: *http://www.naturvardsverket.se/dokument/fororen/utslapp/fcccdata/NIR.pdf*

1 Introduction

The European Union trading scheme for carbon dioxide was launched on the 1st of January 2005. In Sweden about 700 plants are included, of which energy production plants makes up the majority, but industrial production plants are also included.

SMED has been involved in the preparatory work to build up the Swedish system for the EU trading scheme. In 2004 this work involved data collection on fuel consumption and CO_2 emissions from about 500 Swedish plants for the years 1998-2002. These data were used to prepare the Swedish national allocation plan. To assure the quality of the plant specific data these were compared with fuel consumption data collected by the energy department at Statistics Sweden and the corresponding CO_2 emissions calculated by using national thermal values and emissions factors, for the years 2000 and 2001. Data from Statistics Sweden and the corresponding emissions for different substances are used for the Swedish inventories to the EU Monitoring Mechanism, UNFCCC and CLRTAP.

In the comparison of the two data sets, significant discrepancies were observed in several cases. The discrepancies might be caused by over estimated data/emissions from the plants in the trading survey, but it could also be caused by errors in data from Statistics Sweden since these are not primarily produced to calculate emissions and some emission factors used are not adjusted to national conditions and circumstances. The alternative that trading survey data is more accurate warranted a closer investigation and an eventual revision of activity data and emission factors to improve emission data reported to the EU Monitoring Mechanism, UNFCCC and CLRTAP. In this project, 48 plants with a difference of 10% or more in CO_2 emission between the two data sets for a single year were selected and further investigated.

Among the 48 plants, 43 were investigated due to discrepancies in activity data. Those plants were contacted and asked to provide information about their fuel consumption and their way to report fuel consumption and emissions in the trading survey. They were also asked to provide fuel data for the fuels with differences in the data sets for the remaining years, i.e. 1990-1997 and 2003-2004, which were the years not included in the trading survey. In chapter 2 a description of the results from the investigation of each plant is presented.

Five plants have been investigated regarding the CO_2 emissions factors used for carbide furnace gas, petroleum coke and refinery gas which differed from the conventional factors used to calculate emission to the EU Monitoring Mechanism and the UNFCCC. Chapter 3 describes each fuel and contacts for each plant.

1.1 Aim

The aim of this project was to improve and assure the quality of the Swedish emission data reported to the EU Monitoring Mechanism, UNFCCC and CLRTAP. This improvement should be based on information from the SMED-project in 2004[2] when plant specific data was collected in a mail survey (herewith called the trading survey) and compared with data

[2] Ivarsson, Kumlin, Lidén, Olsson. 2004. Dataunderlag för Sveriges nationella fördelningsplan i EU:s system för handel med utsläppsrätter. SMED- report.

used for the Swedish air emission inventory. Plants with suspected errors in data was investigated regarding their fuel consumption or the emission factors used for specific fuels. For those plants where new information on activity data or emission factors was received and this data was considered to have higher quality than old data, new time series were calculated for all relevant years since 1990. The new time series will be used in submission 2006 to the EU Monitoring Mechanism, UNFCCC and CLRTAP.

2 Study on activity data

In the SMED project carried out in 2004, data from about 500 plants was reported for the years 1998-2002. Data from Statistics Sweden (herewith called SMED-data) for 1990-2003 have been collected in different mail surveys, mainly the quarterly fuel statistics and the industrial energy statistics. These two data sets were compared in the former SMED-project for the years 2000 and 2001. This study was based on that comparison to investigate what the differences were likely to be caused by.

The differences were either caused by missing data in SMED-data or that SMED-data was too high or too low. The difference could also be caused by double-counting of trading survey data. In the trading survey the plants should decide whether the combustion was conventional resulting in production of electricity, steam or heat used in or outside the plant (definition A), or if the heat in the combustion process was used directly in the industrial production (definition B). The differences between these two definitions were obviously quite vague, since it was partly used in different ways for different plants, and most important, some plants included combustion from A in combustion B and the opposite. This inclusion led to an overestimation of the emissions when summarizing them, which was sometimes the reason to why trading emission data were higher than emissions according to SMED-data.

In the present study new activity data was collected for 1990-1997 and 2003-2004, for all fuels or fuels with the greatest discrepancies. The data collection was focused on fossil fuels since only fossil CO_2 is included in the trading survey, but biomass fuels were also collected where necessary. The plants sometimes had problems to find data from the early 1990's, especially for in-house produced fuels such as wood waste.

The differences between the fuel consumption in the data sets were often quite low, and a revision of data sometimes only caused very small changes in total emissions. But a revision was still made in order to receive good coherence between the data sets.

In this chapter a description is made for each CRF/NFR code and each plant included in the study. The description includes what information and what data that has been received, and how it has been used to improve the quality of reported emissions to the EU Monitoring Mechanism, UNFCCC and CLRTAP.

2.1 Iron and steel, CRF 1A2a

The two primary iron and steel plants: SSAB in Luleå and Oxelösund, and industrial process emissions from secondary iron and steel works have been studied by SMED earlier, and data in the time series has been revised. The quality of the time series in CRF

1A2a was already considered to be high, but some revisions were despite of this made for a few plants in the present study.

2.1.1 Fundia special bar AB, Smedjebacken

In the earlier comparison with SMED-data and trading scheme data in 2004, LPG was missing for some years in the SMED-data. Data on LPG was collected and a new time series was calculated in submission 2005. Data on some oils was though still not correct or was missing, and therefore data was collected in the present study from the company and the whole time series was revised[3].

2.1.2 LKAB, Kiruna

Despite several attempts to contact the plant by e-mail and telephone, no data was received in time to be included in this study. Hopefully they will provide data in time to be included in submission 2006.[4] Until then no revision will be made since that will result in poor consistency in the time series.

2.1.3 Outokumpu Stainless AB, Avesta

Data from Outokumpo was higher compared to SMED-data for the years 2000-2001. In a SMED project performed in 2004[5] data on fuel consumptions was collected for all years and could be used within the present study[6]. In the trading survey some data was reported as both fuel combustion A and B witch caused some double-counting, explaining some of the differences between the data sets. However, in data from the SMED project regarding iron and steel plants, data was not double-counted, and that data has been used to recalculate the whole time series by exchanging current data on residual fuel oil and LPG.

2.1.4 SSAB Tunnplåt

The fuel consumption of SSAB plants in Borlänge and Finspång are minor compared to those from the SSAB plants in Oxelösund and Luleå, but has still been investigated in this study since they were included in the trading survey.

2.1.4.1 Borlänge

Data on residual fuel oil and LPG was collected for the whole time series.[7] The data sets were quite similar, but SMED-data was still exchanged for 1990, 1998, 2000-2002 (residual fuel oil) and for 1991, 1993-1994, 1996-1997 and 1999 (LPG).

2.1.4.2 Finspång

The Finspång plant was included in this study since they reported much lower fuel consumption of LPG in the trading survey then according to SMED-data. The plant was contacted and informed that in the trading survey, only LPG consumption for heat

[3] Örtlund, Tommy, Environmental Coordinator: tommy.ortlund@ruukki.com, 0240 -668 116. 2005-01-24.
[4] Nordström, Kenneth: kenneth.nordstrom@lkab.com, 0980-71083, 2005-04-05.
[5] Kumlin & Nyström. 2004. SMED-project: Improved Statistics on Process Emissions and Flaring.
[6] Christer Manngård, Co-ordinator Environmental Protection-Process: Christer.Manngard@outokumpu.com, 0226- 816 71. 2005-05-10.
[7, 8] Jonas Larsson: jonas.larsson@ssab.com, 0243-72648. 2005-04-06.

production was reported since only that part should be included in the trading scheme. But except from heat, LPG is also used to combust solvents and that shall be included to get the total consumptions, as it already is in SMED-data.[8] No revision was hence needed.

2.2 Chemicals, CRF/NFR 1A2c

There was only one plant included in the study, and the reason to this is most likely that there are not many chemical industry plants included in the trading scheme. Another reason is also that several chemical industry plants were investigated and their emissions was revised in a SMED project carried out in 2003.[9]

2.2.1 Kemira Kemi AB

Despite that this plant was included in the SMED study on chemical industries in 2003, data on natural gas in the trading survey slightly differed from the data collected in the former SMED-project for some years. To get coherency with data in the trading survey data was exchanged in 1999-2002, but for earlier years it was not considered necessary to revise the data.

2.3 Pulp, Paper and Print, CRF/NFR 1A2d

The pulp and paper sector was the most problematic sector with totally 29 plants included in the study. A problem that was suspected before this study started was that the plants had reported the same fuel consumption for both A and B combustion in the trading survey, causing double-counting of the emissions. It was shown that this was the case for several plants, but not for all.

2.3.1 Arctic Paper Munkedals AB

The fuel consumption on residual fuel oil differed in the first comparison of the data sets and new data was provided from the plant for all years[10]. It was noticed that the consumption differed in 1991, 1994 and in 2001, hence the time series was revised for those years.

2.3.2 Assi Domän, Frövi

In the trading survey data was reported from both A and B combustion which should be summarized to get the total combustion. In the survey the emissions were much higher than in the SMED-data, partly due to that emissions from calcium carbonate ($CaCO_3$) was included, which is reported separately in SMED-data CRF 2A2 (lime production). Other discrepancies were due to that from 1990-2002 LPG was used to dry the produced pulp and this LPG was lacking in the SMED-data in some years. Data on LPG, coke and oils were collected within the present study, and was added where they where lacking and exchanged where they where inaccurate, [11] and finally new time series were calculated.

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[9] Ivarsson, A-K. SMED-report: Analyse and improvement of calculated emissions from chemical industries. 2003.
[10] Josefsson, Lennart: Lennart.Josefsson@arcticpaper.com, 0524-17 000. 2005-02-15.
[11] Lundin, Bengt: bengt.lundin@frovi.com, 0581-371 22. 2005-02-24.

2.3.3 Billerud

All plants from Billerud reported fuel consumption from A as a part of the consumption in B in the trading survey causing twice as high emissions when summarizing A and B.[12,13,14]

2.3.3.1 Gruvön

Besides the double-counting of data in the trading survey, the fuel consumption still differed and hence data on residual fuel oil was collected within this project and SCB- data was exchanged for 1990-1996 and 2001-2003, and the time series were revised.

2.3.3.2 Karlsborg

Besides the double-counting of data in the trading survey, the fuel consumption still differed and hence data on residual fuel oil and gas oil was collected within this project, data was exchanged for 1990-1995 and 2000-2002 and time series were revised.

2.3.3.3 Skärblacka

When taking into account that data was double-counted in the trading survey the coherence between the datasets was good and no data revision was needed.

2.3.4 Bäckhammar bruk

Data on residual fuel oil was collected for all years and was generally higher compared to SMED-data, especially in the beginning of 1990's.[15] SMED-data was thus exchanged for all years except 1997-1997 and 2003.

2.3.5 Frantschach Pulp & Paper

Despite several attempts to contact the plant by e-mail and telephone, no data was received in time to be included in this study. Hopefully they will provide data in time to be included in submission 2006.[16] Until then no revision will be made for the years (1998-2002) where data exists since this would result in poor consistency in the time series.

2.3.6 Holmen Paper

2.3.6.1 Braviken

Braviken reported consumption on residual fuel oil in the trading survey that differed from SMED-data. The company was contacted,[17] but they had data available only for 2003 and 2004 and not for years before 1998. SMED-data was revised for the years 2000-2002.

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[12] Ganrot, Mats, Gruvön: mats.ganrot@billerud.com, 0555-410 00. 2005-02-23.
[13] Hoffner, Nils, Karlsborg : nils.hoffner@billerud.com, Tel:0923-66 133. 2005-03-23 .
[14] Reuterhage, Åke: ake.reuterhage@billerud.com, Tel:011-24 53 00. 2005-02-28.
[15] Svensson, Alf: alf.svensson@backhammarsbruk.com, Tel: 0550-345 00. 2004-04-06.
[16] Edvall, Peter: peter.edvall@mondipackaging.com, Tel: 0612-83000. 2005-04-05.
[17] Andersson, Hans-Göte, Finance and Purchasing: hans-gote.andersson@holmenpaper.com, Tel: 011-23 63 74. 2005-03-18.

2.3.6.2 Hallsta

Data on residual fuel oil was collected from Hallsta for all years.[18] In the beginning of the 1990's, data was missing and was now added to SMED-data. From 1997 an onwards data existed but was too low and was hence exchanged and the SMED time series was revised.

2.3.7 Iggesund Paperboard, Iggesund

The emissions of CO_2 was twice as high in data in the trading survey compared to SMED-data in 2001 and it was suspected that the plant had double reported fuel consumption on residual fuel oil as both A and B combustion, however that turned out not to be the case. Instead SMED-data was exchanged with data collected from the plant[19] for residual fuel oil for some years and data on wood waste and tall oil was also exchanged for some years. The data exchange has caused revised time series for all years but 1997-1999 and 2003.

2.3.8 Kappa Holdings Kraftliner, Piteå

In the trading survey the plant reported higher consumption on residual fuel oil than they had reported to SMED in 2000 and 2001. Data on residual fuel oil and domestic heating oil was collected for the whole time period,[20] and data was exchanged for one or both fuels all years except 1997-1998 and 2003.

2.3.9 Korsnäs

In the trading survey combustion from A was a part of B, causing double-counting when summarizing A and B. One difference between the two data sets was that in the trading survey Korsnäs reported consumption of black oil and in SMED-data tall oil was reported. By contacting Korsnäs, SMED was informed that black oil is produced when refining tall oil and is therefore treated as tall oil in the SMED calculations. Data on residual fuel oil, black oil and methanol (Other biomass) was collected for all years,[21] and those data was added to or exchanged with SMED-data in several years.

2.3.10 Metsä Tissue, Katrinefors

Data on LPG residual fuel oil was collected for the whole time series since data on residual fuel oil differed between trading survey data and SMED-data.[22] When comparing the whole time series it was noted that data was in coherence in 1990-1997. For the remaining years until 2003 there were however some differences and data was exchanged.

2.3.11 M-Real, Husum

It was suspected that data was double-counted as A and B combustion, but it turned out that A was reported from steam combustion and B from process combustion. In the years

[18] Sundblom, Tage: tage.sundblom@holmenpaper.com, Tel: 011-23 50 00. 2005-03-16.
[19] Söderberg, Christer: Christer.Soderberg@iggesundpaperboard.com, 0650-280 00. 2005-03-16.
[20] Lundstrom, Ingemar: ingemar.lundstrom@kappapackaging.com, 0911-970 00. 2005-02-28.
[21] Skaringer, Johan, Environmental System Manager: Johan.Skaringer@korsnas.se, Tel: 026-15 14 66. 2005-03-16.
[22] Mikael Käll: Mikael.Kall@metsatissue.com, 0501-64 000. 2005-03-01.

1990-1992 and 2001-2002 SMED-data was to low and was exchanged with new data from the plant to submit correct time series.[23]

2.3.12 Nordic Paper, Seffle

The plant was contacted and the response on why SMED-data was higher was that in the trading survey the plant reported data only from the part of the combustion that is owned by the plant. Another part of the plant is owned by Fortum but SMED-data is correct since it includes the total fuel consumption at the facility. [24] No revision was hence needed.

2.3.13 Rottneros

2.3.13.1 Utansjö

In the trading survey data on residual fuel oil was higher than according to SMED-data, so within this project data on both residual fuel oil and wood waste was collected for all years from 1990.[25] Data was exchanged for one or both of the fuels all years and the time series was revised.

2.3.13.2 Vallstavik

Data on residual fuel oil, domestic heating oil and tall oil was collected for all years except 1990, when no data was available. SMED-data from 1990 seemed to to be in line with data for the next coming years except for tall oil which was missing and since tall oil was used all other years the same value as for 1991 was added.

Some fossil fuel and wood waste data (from the trading survey) was exchanged for a few years. In the trading survey the plant reported consumption of methanol condensate which in the Swedish inventory has been classified as "Other not specified fuels". Since methanol is a rest product from the pulp production, the classification has been changed to the biomass fuel: Other biomass.

2.3.14 SCA

All SCA plants reported combustion as for both the A and B definition, and by contacting them it was found out that the consumption came from different parts of the production, and should be summarized to achieve the total consumption.

2.3.14.1 Munksund

In the trading survey data on residual fuel oil was higher from SCA Packing in Munksund than according to SMED-data, so data on both residual fuel oil and wood waste was collected for the whole time series.[26] Data was exchanged for wood waste in 1993-2003 and for residual fuel oil in 1990-2003, and the whole time series was revised.

[23] Sondell, Kent: Kent.Sondell@m-real.com, 0663-186 14. 2005-03-04.
[24] Thor, Kristian: kristian.thor@nordic-paper.com, 0533-820 00. 2005-03-07.
[25] Johansson, Lennart: lennart.johansson@rottneros.com, 0612-716215. 2005-04-01.
[26] Adolfsson, Berith: berith.adolfsson@sca.com, 0911-98 214. 2005-03-16.

2.3.14.2 Ortviken

When SCA Graphic in Ortviken was contacted they emphasised that fuel data reported to SMED are not meant to be used for emission calculations, since they are reported from the energy department and the quality has not been assured. The plant was contacted,[27] but they could only provide data on residual fuel oil from 1998. SMED-data was exchanged in 2001 and was added in 1998. The time series was revised for these years.

2.3.14.3 Östrand

Data was reported from combustion from steam production and from the process separately from SCA Graphic in Östrand. The plant was contacted, but they could only provide data on residual fuel oil from 1998.[28] SMED-data was exchanged in 1998, 2001-2003 and the time series was revised for these years.

2.3.15 Stora Enso

2.3.15.1 Hylte

Despite several attempts to contact the plant by e-mail and telephone, no data was received in time to be included in this study. Hopefully though they will provide data in time to be included in submission 2006.[29] Until then no revision will be made since that will result in poor consistency in the time series.

2.3.15.2 Fors

Data was collected on residual fuel oil, coal and on wood waste[30] from Stora Enso in Fors and was then compared with SMED-data. The time series was revised by exchanging one or several fuels for all years except 1991, 1993 and 1999. Since 2001 coal is no longer used, instead they have purchased wood waste for combustion.

2.3.15.3 Kvarnsveden

Data on residual fuel oil, coal and wood waste was collected for all years from Stora Enso in Kvarnsveden and all fuel data have been exchanged for all years.[31]

2.3.15.4 Norrsundet

In the trading survey Stora Enso in Norrsundet reported fuel combustion from the soda lye plant (A) and the pulp plant (B) separately. In this project data was collected[32] on residual fuel oil and SMED-data was exchanged for the years 1991-1997 and 2000-2002 since SMED-data was too low.

2.3.15.5 Skutskär

In the trading survey Stora Enso in Skutskär reported higher consumption of residual fuel oil. The plant was contacted but could only provide data from 1998.[33] Based on the

[27] Ljungberg, Catarina, environmental engineer: catarina.ljungberg@sca.com, 060-16 40 00. 2005-04-07.
[28] Ljungberg, Catarina, environmental engineer: catarina.ljungberg@sca.com, 060-16 40 00. 2005-04-07.
[29] Svensson, Marie: marie.svensson@storaenso.com, Tel: 0345-19327. 2005-03-02.
[30] Sjöberg, Ronny: Ronny.Sjoberg@storaenso.com, 0226-350 00. 2005-03-10.
[31] Stangmyr, Jakob: Jakob.Stangmyr@storaenso.com, 0243-650 00. 2005-03-08.
[32] Östling, Per-Olov: Per-Olov.Ostling@storaenso.com. 026-855 00. 2005-03-16.
[33] Leijon, Torsten: Torsten.Leijon@storaenso.com, 026-850 00. 2005-04-06.

received data and data from the trading survey SMED-data was exchanged for residual fuel oil in 1998 and 2000-2002, wood waste in 1998 and tall oil in 2000. Besides that, data on wood waste was added in 2000-2002 and tall oil in 1998-1999 and 2003. The time series was revised for 1998-2003.

2.3.15.6 Skoghall

Stora Enso in Skoghall divided the fuel combustion on A and B in the same way as Stora Enso in Norrsundet in the trading survey, and they have hence not double reported emissions as was suspected. Data was collected on residual fuel oil for all years from the plant[34], but they only had data on wood waste available for 1998-2002 as was received in the trading survey. Data on residual fuel oil was exchanged in 1990-1993, 1998-1999 and 200-2003, since SMED-data was generally to low. Small amounts of domestic heating oil were also added for the years 1998-2002.

2.3.16 Södra Cell

All plants reported fuel combustion divided in A and B and these two should be summarized to achieve the total fuel combustion.

2.3.16.1 Mönsterås

Data on residual fuel oil and domestic heating oil was collected for all years.[35] The plant reported no consumption on domestic heating oil and hence the low amounts of domestic heating oil in SMED-data was excluded for the years data existed (1990-1991, 1997 and 2000- 2001). Data on residual fuel oil was exchanged with SMED-data for the years 1994, 2000- 2001.

2.3.16.2 Mörrum

Data on residual fuel oil was collected for all years and SMED-data was exchanged in 1994-1999 and 2000-2002.[35]

2.3.16.3 Värö

Data on residual fuel oil was collected for all years and data was added in 1990-1993 and 1995-1996 and SMED-data was exchanged in 2001-2002. Data on domestic heating oil was also collected and SMED-data was exchanged in 2001.[35]

2.4 Food Processing, Beverages and Tobacco, CRF/NFR 1A2e

Plants in this sector is only included in the trading survey if the have an energy plant that is large enough to be included. In this study only one plant was investigated.

2.4.1 Arla Foods, Götene

Data was collected from Arla on residual fuel oil and SMED-data was exchanged all years except 1994, 2000 and 2002-2003.[36]

[34] Reiner, Eva, production engineer: Eva.Reiner@storaenso.com, 054-155306. 2005-03-17.
[35] Malmström, Jan: jan.malmstrom@sodra.com. 0454-550 00. 2005-03-31.
[36] Kent Johansson: 0511-34 51 00. 2004-03-01.

2.5 Off Road Vehicles and Working Machinery, Construction, CRF/NFR 1A2f

2.5.1 Cementa AB

Cementa uses a number of fuels for combustion in the cement ovens when producing the cement. Coal, anthracite and petroleum coke are three of them, and they shall be considered as fuels and not raw materials in the production according to the company, [37] just as SMED has done.

Data was only available for 1990, 1995, and 1997 and onwards.

2.5.1.1 Degerhamn

When data from Degerhamn was compared with SMED-data it was noticed that there was a lack of data on waste oils for all years and it was instead reported as residual fuel oils in SMED-data. Hence data on waste oils were added in the SMED-data for all years and data on residual fuel oil was excluded. For years when data from Cementa was not available, the fuel consumption was estimated based on data from existing years.

2.5.1.2 Skövde

The whole time series was revised since there was a lack of data on coal and fossil waste, or data was incorrect for some years in the SMED-data.

2.5.1.3 Slite

The whole time series was revised since there was a lack of data on coal and fossil and biomass waste for some years in the SMED-data, or data was incorrect.

2.5.2 Gyproc AB

Data on domestic heating oil and residual fuel oil was collected for all years and SMED-data was exchanged for one or both fuels for the years 1992-1993, 1995 and 1999- 2000.[38]

2.5.3 Kalkproduktion Storugns AB

Data on LPG, coal and residual fuel oil was collected for the whole time series and SMED-data was revised by adding data in 1990-1992 and 1999, and exchanging data in 2001-2003.[39]

2.5.4 Nordkalk, Sjötullen

Data was collected on residual fuel oil and coal from 1993-2003, earlier data was not available. In the trading survey data the fuel ”Other petroleum” was reported instead of residual fuel oil resulting in higher emissions due to higher emission factors. The plant had

[37] Anders Lyberg: anders.lyberg@cementa.se. 0498-28 10 00. 2005-02-24.
[38] Wallen, Rune: rune.wallen@gyproc.com, 0171-41 54 00. 2005-03-17.
[39] Flood, Åke: ake.flood@kalkproduktion.se, 0498- 22 70 40. 2005-03-15.

also used a high emission factor for coal. When comparing fuel consumption data from the plant from 1993-2003 on residual fuel oil and coal, the coherence was good with SMED-data and no revisions were necessary.[40]

2.5.5 Paroc AB, Hällekis

In the trading survey, Paroc reported emissions from coke as process-related since the coke makes up a bed which the produced glass wool flows through.[41] It was considered to report the emissions from coke as process emissions (CRF/NFR 2A3), but the other major mineral/glass wool producer Isover said that the coke is indeed used for the wool to go through, but the main reason to why coke is used and not any other material is that there is the high temperature that is achieved by combustion of coke. Hence emissions from coke will be reported as conventional Energy emissions and not as Industrial process emissions.

Data on coke and residual fuel oil was provided for the years 1993-2003, since earlier years were not available. SMED-data was exchanged all years from 1994 and onwards for one or both fuels.

2.5.6 Pilkington, Halmstad

Data on residual fuel oil, LPG and coal were collected for all years,[42] and the coherence was good for all years except in 2000, where data on residual fuel oil was exchanged. Pilkington reported the use of coal as both energy and process emissions in the trading survey, but since the emissions are very small (about 100 Gg) per year, and no information on how the coal was used has been available, emissions from coal will continuously be reported as energy emissions in the reporting to the EU Monitoring Mechanism, UNFCCC and CLRTAP.

2.5.7 Saint-Gobain Isover AB, Vrena

As mentioned in chapter 2.5.5, Isover has reported that coke is used as a conventional fuel. Besides this information Isover provided data on coke and LPG consumption from 1990-2003. LPG data was in good coherence but data on coke had to be added to SMED-data in 1990 and exchanged with existing data in 1991, 1994, 1994 and 1998.[43]

2.5.8 SMA Svenska Mineral AB, Boda

In the trading survey fuel data was divided on residual fuel oil and ”Other petroleum”, but in SMED –data only fuel consumption on residual fuel oil is reported. Since both fuels was reported to have the same carbon content the emission will be the same no matter what the fuel was called in the survey and in data provided within this project (2003-2004) all consumption was reported as residual fuel oil, just as in SMED-data and the coherence was good for 2003. Unfortunately no data on plant level was available from 1990-1997, but the SMED-data showed a time series that seemed to be in line with the years from 1998 and

[40] Lundström, Fredrik: fredrik.lundstrom@nordkalk.com, 040 - 43 89 00. 2005-02-08.
[41] Jansson, Styrbjörn: Styrbjorn.Jansson@paroc.com, 0451- 38 56 00. 2005-03-08.
[42] Andersson, Lars: lars.andersson@pilkington.se, 035- 15 30 00, 2005-02-16.
[43] Lindvall, Per: per.lindvall@saint-gobain.com. 042-840 00. 2005-04-05.

was hence not revised. For the years 1998-2002 however, a revision of SMED-data was made since trading scheme data was somewhat lower.[44]

3 Study on emission factors of CO_2

This chapter outlines five cases where differences in CO_2 emission factors were noted. In each example, the discrepancy is illustrated and rectified.

3.1 Carbide furnace gas

The emission factor used for CO_2 for carbide furnace gas in submission 2005 to the EU Monitoring Mechanism and the UNFCCC was the same as for other petroleum fuels without a specific value, called "Other petroleum".

3.1.1 Akzo Nobel Surface Chemistry AB

The data presented in Table 3.1 was reported by Akzo Nobel Surface Chemistry AB regarding annual consumption of carbide furnace gas for their combustion utilities ("A type") at Expancel, Carbide oven and "Steam central".[45]

Table 3.1. Emission data reported by Akzo Nobel Surface Chemistry AB for use in the CO_2 emission-trading scheme.

Year	1998	1999	2000	2001	2002
CO_2 emission, ton/year	19 500	19 300	17 200	16 800	18 000
Carbide furnace gas consumed, knm^3 / year	18 123	17 976	16 002	15 666	16 758
Heating value of fuel, GJ/nm^3	10.01	10.01	10.01	10.01	10.01

By multiplying the fuel heating value by the consumption quantities, an energy flow (TJ per year) can be obtained, which can then be used with the reported CO_2 emissions to derive an energy-based emission factor. In this way, an emission factor of 0.107 ton CO_2/TJ can be derived from Table 3.1. This value differs significantly from the CO_2 emission factor previously used for reporting to the EU Monitoring Mechanism and UNFCCC, i.e. 60 ton CO_2/TJ[46].

In light of this discrepancy, contact was taken with the appropriate personnel at Akzo Nobel Surface Chemistry AB[47] with the aim of explaining and rectifying the problem. It turned out that the heating value had been reported with incorrect units i.e. as GJ/nm^3 instead of GJ/knm^3. Since the composition of carbide furnace gas varies with different

[44] Öman, Magnus, production manager: magnus.oman@svenska-mineral.se. 0248- 510 65 2005-02-08.
[45] Ivarsson, Kumlin, Lidén, Olsson. 2004. Results from previous project presented in Excel file: "Förbrukningsfil bränsle och råvaror_Master.xls", worksheet "A bränslen". SMED-project. 2004-02-14.
[46] This factor was derived by the Swedish Environmental Protection Agency as a generic value for "other petroluem related fuels". There are no specific citations or references to its origin and it is therefore likely to carry considerable uncertainty.
[47] Holmgren, Madeleine Akzo Nobel Surface Chemistry AB. Personal communication. Email Madeleine.Holmgren@expancel.com Tel. 060 – 134494. 2005

operating conditions, there is considerable uncertainty with a representative value for its carbon content. The heating value of 10.01 GJ/knm^3 was based on a gas analysis undertaken in 1991 [48] that showed a composition outlined in Table 3.2.

Table 3.2. Composition (vol-%) of Carbide furnace gas as measured by Akzo Nobel Surface Chemistry AB.

Carbide furnace gas, composition	Vol-%
CO	70
H_2	20
CO_2	3
CH_4	1
N_2	6

By converting to a wt-% analysis (using standard gas densities), the carbon fraction in the fuel can be calculated as 38.5 %, density 1.03 kg/m^3 and molecular weight 28.4 kg/kmol. In turn this implies a CO_2 emission factor of 1.41 kg CO_2/kg fuel or 145 ton CO_2/TJ.
In conclusion, two errors explain the discrepancy. Firstly, the heating value unit was incorrectly reported and secondly the "standard" CO_2 emission factor previously used for international reporting purposes is in error and should be revised to 145 ton CO_2 /TJ[49].

3.2 Refinery gas

In submission 2003 and earlier, refinery gas was classified as "Other petroleum" (as carbide furnace gas), with the same emission factors. In submission 2004 however, refinery gas was separated from "Other petroleum" and the IPCC Guidelines default values for refinery gas was used for CO_2[50]. In this study it was investigated whether or not this default value was valid for Swedish conditions.

3.2.1 Preem Raffinaderi AB

Preem Raffinaderi AB reported the data presented in Table 3.3 regarding annual consumption of refinery gas. [51]

Table 3.3. Emission data reported by Preem Raffinaderi AB for use in the CO_2 emission-trading scheme.

Year	1998	1999	2000	2001	2002
CO_2 emission, ton/year	50 300	87 200	93 200	90 150	107 200
Refinery gas consumed, toe [a)] / year	32 100	37 750	40 500	39 100	46 400
Heating value of fuel, GJ/toe [a)]	41,76	41,76	41,76	41,76	41,76

[a)] Toe corresponds to ton oil equivalents.

[48] Akzo Nobel Surface Chemistry AB are planning to undertake a new gas analysis during Spring 2005.
[49] This value is in close agreement (143 ton/TJ) in a check made by Akzo Nobel Surafce Chemistry AB.
[50] Ivarsson, A-K, Improved statistics for SSAB, refineries and lime producers, SMED-report. 2003-09-22.

By multiplying the fuel heating value by the consumption quantities, an energy flow (TJ per year) can be obtained which can then be used with the reported CO_2 emission to derive an emission factor. From Table 3.3, emission factors of 37.54 ton CO_2/TJ (1998) and 55.3 ton CO_2/TJ (1999 to 2002) can be derived. Both these values differ from the CO_2 emission factor previously used for reporting to the EU Monitoring Mechanism and UNFCCC , 66.73 ton CO_2/TJ [52]. In light of this discrepancy, contact was taken with the appropriate personnel at Preem Raffinaderi AB[53] with the aim of rectifying the problem.

On first inspection, a small error lies in the reported heating value by Preem Raffinaderi AB, 41.76 GJ/toe. This should be the standard as assigned by the International Energy Agency i.e. 41.868 GJ/ton oil equivalent. Secondly, the ratio between the CO_2 emission and the consumed gas given in ton oil equivalents should be the same for each year assuming a similar gas composition (and emission factor). This indicates that the original data (probably for 1998) reported is in error.

Preem Raffinaderi AB commented that one of the refinery gas flow meters had been in error and thus the previously reported flows were adjusted upwards to make a correction.
The composition of the fuel and an indication of the variation, as reported by Preem Raffinaderi AB, is shown in Table 3.4.

Table 3.4. Composition (mol-%) of Refinery gas as measured by Preem Raffinaderi AB.

	Min	Max	Mean
H_2	32	70	45
CH_4	8	36	21
C_2H_6	6	17	11
C_3H_8	4	31	13
C_4H_{10}	3	20	9
C_5H_{12}	0.3	2	1
C_6H_{14}	0.1	0.6	0.2

By converting to a wt-% analysis (i.e. by assuming mol-% as equivalent to vol-%[54] and using standard gas densities), the carbon fraction of the “mean fuel” can be calculated as 80.5 % (density 1.08 kg/m^3 and molecular weight as 34.6 kg/kmol). This implies a CO_2 emission factor of 2.95 kg CO_2/kg fuel. From a heating value as a polynomial function of density provided by Preem Raffinaderi AB, the heating value at a density of 1.08 kg/m^3 can be calculated as 49.14 GJ/ton refinery gas. Thus the energy-based CO_2 emission factor becomes 60.0 ton CO_2 /TJ.

In conclusion, three errors explain the original discrepancy. Firstly, the heating value unit was incorrectly reported, secondly the data for 1998 was incorrect and thirdly the “standard” CO_2 emission factor used for reporting to the EU Monitoring Mechanism and UNFCCC appears to be slightly high.

[51] Ivarsson, Kumlin, Lidén, Olsson. 2004. Results from previous project presented in Excel file: ”Förbrukningsfil bränsle och råvaror_Master.xls”, worksheet ”A bränslen”. SMED-project. 2004-02-14.
[52] Default value assigned by IPCC Guidelines Workbook, Chapter 1.6
[53] Wennerberg, Thomas, Preem Raffinaderi AB: Personal communication thomas.wennerberg@preemraff.se Tel. 031-646151. 2005-02-21.
[54] Assumes that the compressibility factors of the gases are 1.0 (factors for most common gases lie between 0.995 and 1.005).

3.2.2 Shell Raffinaderi AB

Shell Raffinaderi AB reported the data presented in Table 3.5 regarding annual consumption of refinery gas[55].

Table 3.5. Emission data reported by Shell Raffinaderi AB for use in the CO_2 emission-trading scheme.

Year	1998	1999	2000	2001	2002
CO_2 emission, ton/year	513 508	506 305	499 315	491 246	478 279
Refinery gas consumed, ton/year	175 859	172 511	171 586	168 581	163 869
Heating value of fuel, GJ/ton	47.38	47.38	47.38	47.38	47.38

By multiplying the fuel heating value by the consumption quantities, an energy flow (TJ per year) can be obtained which can then be used with the reported CO_2 emission to derive an emission factor. From Table 3.5, an emission factor of 61.6 ton CO_2/TJ can be derived. This differs slightly from the CO_2 emission factor previously used for international reporting purposes, i.e. 66.73 ton CO_2 /TJ. In light of this discrepancy, contact was taken with the appropriate personnel at Shell Raffinaderi AB[56] with the aim of clarifying the difference.

According to Shell Raffinaderi AB, they do no longer calculate via the heating value but simply measure the mass flow and determine the carbon content of the refinery gas periodically. As indicated by Preem Raffinaderi AB, even Shell's refinery gas can vary considerably in composition and properties. In general, Shell calculate on average a molecular weight of ca. 27 for their refinery gas that has a carbon content slightly lower than that used previously for reporting to the EU Monitoring Mechanism and UNFCCC. Their CO_2 factor has thus been determined as 61.6 ton CO_2/TJ. One can note that the emission factor and heating value of the refinery gas determined at Preem Raffinaderi AB and Shell Raffinaderi AB are in good agreement, when considering composition variations.

As an additional check, an enquiry was made even to the Preem Refinery at Lysekil (earlier Scanraff AB) who also consume refinery gas[57]. They carry out monthly determinations of the quality of the refinery gas and report a CO_2 emission factor of ca. 56.3 ton CO_2/TJ (heating value 47.99 MJ/kg).

In conclusion, the original anomaly noted when comparing CO_2 emissions from emission-trading and conventional methods can be explained by a slight inaccuracy in the default CO_2 emission factor. Based on the results from all three refineries, the average CO_2 factor of 59.3 ton CO_2/TJ would be a more suitable choice of emission factor.

[55] Ivarsson, Kumlin, Lidén, Olsson. 2004. Results from previous project presented in Excel file: "Förbrukningsfil bränsle och råvaror_Master.xls", worksheet "A bränslen". SMED-project. 2004-02-14.
[56] Mares, Ivan, Shell AB. Personal communication: ivan.mares@shell.com, Tel. 031 – 744 6261. 2005-01-25.
[57] Karlsson, Kurt, Preem Raffinaderi AB, Lysekil: Personal communication. kurt.karlsson@preem.se, Tel. 0523-669197. 2005-04-08.

3.3 Petroleum coke

In earlier submissions to the EU Monitoring Mechanism and UNFCCC, emissions of CO_2 from petroleum coke have been derived by using the same emission factor as for conventional coke.

3.3.1 Cementa AB, Slite

Cementa AB reported the data presented in Table 3.6 regarding annual consumption of petroleum coke for their calcination oven at the Slite factory site[58].

Table 3.6. Emission data reported by Cementa AB (Slite factory site) for use in the CO_2 emission-trading scheme.

Year	1998	1999	2000	2001	2002
CO_2 emission, ton/year	91 222	114 534	76 272	64 186	93 186
Petroleum coke consumed, ton/year	28 507	35 792	25 424	20 704	30 060
Heating value of fuel, GJ/ton	32.0	32.0	30.02	31.03	31.03

By multiplying the fuel thermal value by the consumption quantities, an energy flow (TJ per year) can be obtained which can then be used with the reported CO_2 emission to derive an emission factor. From Table 3.6, an emission factor of 100 ton CO_2/TJ can be derived[59]. This differs only slightly from the CO_2 emission factor previously used for reporting to the EU Monitoring Mechanism and UNFCCC; 103 ton CO_2/TJ.

Regarding choice of CO_2 emission factor for petroleum coke, Cementa used values assigned by the company group head i.e. HeidelbergCement Group[60]. The value was based on several representative samples used within the group, and therefore considered more accurate than previous factor used for the Swedish inventory to the EU Monitoring Mechanism and UNFCCC. In the future Cement AB plan to take samples of the exact petroleum coke used specifically by their plant to further improve accuracy in the reported emissions.

3.3.2 Cementa AB, Skövde

Cementa AB reported the data presented in Table 3.7 regarding annual consumption of coal / petroleum coke for their calcination oven at the Slite factory site[61].

[58] Ivarsson, Kumlin, Lidén, Olsson. 2004. Results from previous project presented in Excel file: ”Förbrukningsfil bränsle och råvaror_Master.xls”, worksheet ”A bränslen”. SMED-project. 2004-02-14.
[59] This factor is in good agreement with data reported by Höganäs AB for use of petroleoum coke as a raw material. For 2002 and the LB-oven, they report a CO_2 emission of 1246 tons for a consumption of 402 tons petroleum coke. This corresponds to a CO_2 factor of 3,099 ton CO_2 /ton fuel or 99,1 ton CO_2 /TJ (using 32.0 GJ/ton heating value).
[60] Nyberg, Kerstin Cementa AB. Personal communication: kerstin.nyberg@cementa.se Tel. 0498– 281144. 2005-03-21.
[61] Ivarsson, Kumlin, Lidén, Olsson. 2004. Results from previous project presented in Excel file: ”Förbrukningsfil bränsle och råvaror_Master.xls”, worksheet ”A bränslen”. SMED-project. 2004-02-14.

Table 3.7. Emission data reported by Cementa AB (Skövde factory site) for use in the CO_2 emission-trading scheme.

Year	1998	1999	2000	2001	2002
CO_2 emission, ton/year	113 206	94 171	108 838	101 641	98 292
Coal / petroleum coke consumed, ton/year	38 537	32 057	39 094	34 600	33 460
Heating value of fuel, GJ/ton	26.02	26.02	26.02	26.02	26.02

By multiplying the fuel heating value by the consumption quantities, an energy flow (TJ per year) can be obtained which can then be used with the reported CO_2 emission to derive an emission factor. From Table 3.7, an emission factor of 112.9 ton CO_2/TJ can be derived. Since the fraction of coal to petroleum coal is unknown it is difficult to compare with the standard values used for reporting to the EU Monitoring Mechanism and UNFCCC , i.e. for coal 90.7 ton CO_2/TJ and for coke/petroleum coke, 103.0 ton CO_2/TJ. In any case the value used by Cementa appears to be too high which may partly be due to the heating value used (which also differs from standard values).

A combined factor for coal/petroleum coke was used at the Skövde site following guidelines from a CO_2 protocol sent out by company group head i.e. HeidelbergCement Group, based on the GHG protocol from the WRI for the WBCSD (Working Group Cement CO_2 Emissions Inventory Protocol, Version 1.6.)[62,63]. Rather than a separate declaration for each fuel (as done for the Slite site), Cementa at Skövde chose to combine the fuels. Although this option was not, strictly speaking, permitted in the CO_2 questionnaire sent out for recording emission trading data, it was the only data available at that time. A detailed split of the fuel use for the 1998 to 2002 period has thus not been compiled, but from 2003 and onwards the fuels will be reported separately (as at Slite).

In light of the investigation above it seems reasonable to use the standard value recommended by HeidelbergCement Group, i.e. 100 ton CO_2/TJ as the most suitable emission factor at present to Swedish emissions from petroleum coke.

3.4 Revised emission factors

The investigation on emission factors of CO_2 resulted in revisions for all three fuels; carbide furnace gas, refinery gas and petroleum coke, as presented in Table 3.8. In chapter 4, revised time series for CO_2 emissions due to new emissions factors is shown.

[62] WRI- World Resource Institute, WBCSD- World Business Council for Sustainable Development.
[63] Leif Wahn: leif.wahn@cementa.se, Tel. 0500 – 424 704. 2005.

Table 3.8. Emission factors on CO_2 for carbide furnace gas, refinery gas and petroleum coke used in submissions 2005 and revised factors for use in submission 2006.

	Previous CO_2 factor used in submission 2005 ton CO_2/TJ	New CO_2 factor that will be used in submission 2006 ton CO_2/TJ
Carbide furnace gas	60	145
Refinery gas	66.7	59.3
Petroleum coke	103	100

4 Results

The revision of activity data and emission factors has resulted in new time series for all emissions and years. In submission 2005 the total Swedish green-house gas (GHG) emissions was 2.3% lower in 2003 than in 1990. After the revision in the present study the emissions are 2.8% lower in 2003 than in 1990.

In diagram 1 the whole time series of GHG emissions from 1990-2003 is shown. The revision has caused slight changes in emissions for all years, but it resulted in higher emissions in 1990 (0.2%) and lower in 2003 (-0.3%), hence causing greater emission decrease since 1990 than reported in submission 2005. Among the plants that was contacted to report activity data, 11 of them could not provide data for 1990, which implies that emissions for base year is not completely certain.

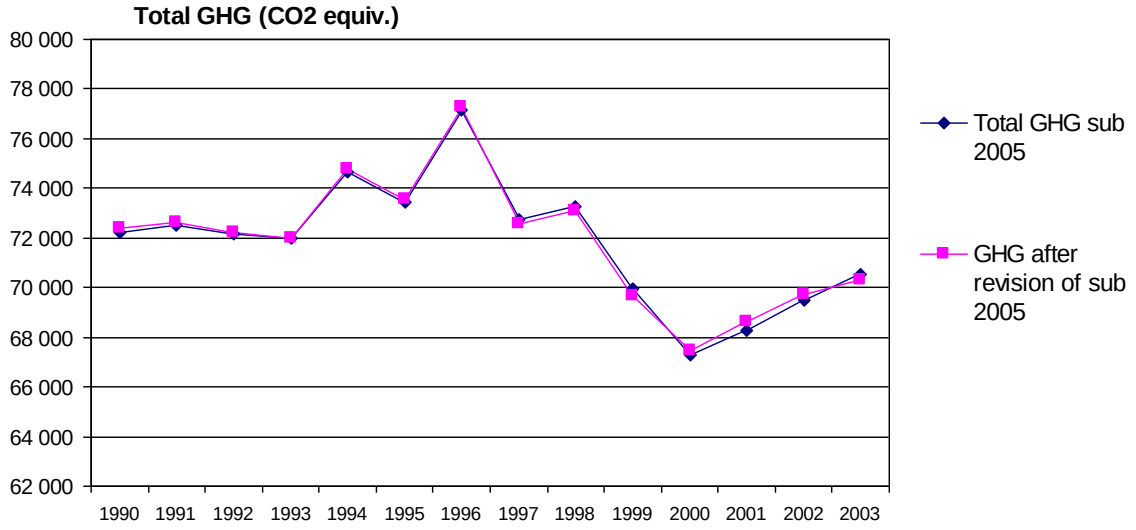

Diagram 1. Total emissions of Swedish green-house gases in submission 2005 and after the revision of activity data and emissions factors in this study (Gg CO_2-equivalents).

In all, time series for 39 plants were revised in this study due to new activity data and a number of plants were revised due to new emission factors. The changes have involved several CRF-codes and in Table 4.1 the difference in percent between revised emissions of fossil CO_2 and fuel consumption as activity data. In Appendix 1, a more detailed table is

presented showing for instance changes also per fuel type for each CRF code. For each CRF code explanations to the main reason of the changes is made based on Table 4.1.

Table 4.1. Changes (in %) in fossil CO_2 emissions and in activity data in revised data due to new emissions factors and new activity data compared to reported data in submissions 2005.

CRF	Parameter	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1A1a	Fossil CO2 (%)	0	0	0	0	0	0	-0.2	0	0	0	0	0	0	0
	Fuel consumption (%)	0	0	0	0	0	0	-1	0	0	0	0	0	0	0
1A1b	Fossil CO2 (%)	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9
	Fuel consumption (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1A2a	Fossil CO2 (%)	13	1	1	0	-1	1	0	-1	1	1	4	1	5	2
	Fuel consumption (%)	11	0	1	0	-1	1	0	-1	1	1	3	1	5	2
1A2c	Fossil CO2 (%)	1	0	0	0	0	0	0	0	0	2	1	1	0	0
	Fuel consumption (%)	0	0	0	0	0	0	0	0	0	2	0	1	0	0
1A2d	Fossil CO2 (%)	9	14	13	8	10	10	13	1	-2	-6	12	23	15	-1
	Fuel consumption (%)	4	8	5	6	6	7	8	3	3	2	7	12	12	4
1A2e	Fossil CO2 (%)	0	0	0	0	0	0	0	0	0	0	0	-2	0	0
	Fuel consumption (%)	0	0	0	0	0	0	0	0	0	0	0	-1	0	0
1A2f	Fossil CO2 (%)	1	1	1	1	0	1	0	1	2	3	4	4	4	0
	Fuel consumption (%)	1	0	1	0	0	1	0	1	1	2	3	2	3	1
1B2c	Fossil CO2 (%)	-10	-9	-8	-9	-9	-9	-9	-8	-10	-10	-8	-9	-10	-10
	Fuel consumption (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The reason to why emissions and activity data decreased in 1996 in Public Electricity and Heat Production (**CRF 1A1a)** is that fuels have been reallocated from this sector to CRF 1A2d (Pulp, Paper and Print) due to incorrect allocation earlier.

Fossil CO_2 from refineries (**CRF 1A1b**) has decreased for all years due to new emission factors for refinery gas and petroleum coke.

For Iron and steel production **(CRF 1A2a)** changes have been made for several years mainly in activity data of liquid fuels.

The chemical industry sector **(CRF 1A2c)** was slightly revised due to new emission factors and revised activity data for a few plants.

The changed emission levels on CO_2 for iron and steel production and chemical industries are shown in Diagram 2.

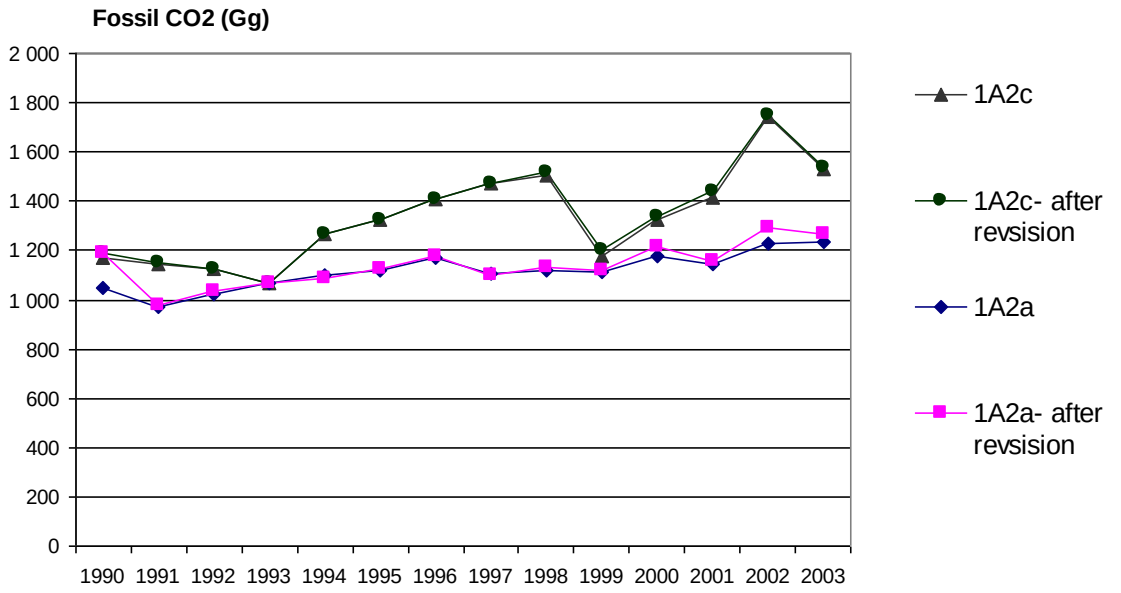

Diagram 2. Fossil emissions of CO_2 in iron and steel production (CRF 1A2a) and chemical industries (CRF 1A2c) in submission 2005 and after the revision.

The Pulp Paper and Print sector **(CRF 1A2d)** was the sector with the greatest revisions due to new activity data. Fuel consumption data and emission of CO_2 from both fossil and biomass fuels has been revised.

In the sectors Food Processing, Beverages and Tobacco **(CRF 1A2e)** and Off Road Vehicles and Working Machinery, Construction, **(CRF 1A2f)** there has been revisions of activity data, especially for solid fuels such as coal and coke, and liquid fuels.

The changed emission levels on CO_2 for Food Processing, Beverages and Tobacco and Off Road Vehicles and Working Machinery and Construction are shown in Diagram 3.

Finally emissions from flaring **(CRF 1B2C)** at refineries has been revised and emissions has decreased just as emission from refineries, due to a new emission factor for refinery gas. No revisions of activity data have been made.

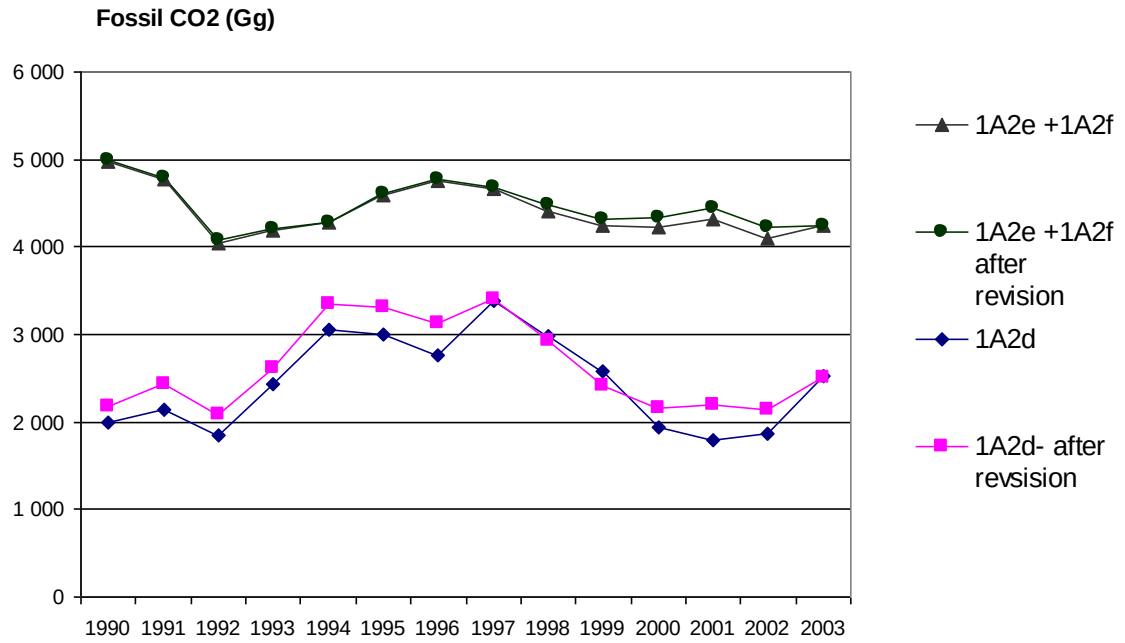

Diagram 3. Fossil emissions of CO_2 in Food Processing, Beverages and Tobacco and Off Road Vehicles (CRF 1A2e) and Working Machinery, Construction, (CRF 1A2f) in submission 2005 and after the revision.

If only the emissions factors would have been revised in this project the total GHG emissions would have decreased with 2.4% from 1990 to 2003. As can be seen in Table 4.2 the changes in emission factors are mainly caused by the decreased emission factor of refinery gas, which is the most used fuel at Swedish refineries.

Table 4.2. Changes (in %) in fossil CO_2 emissions and in activity data in revised data due to new emissions factors compared to reported data in submissions 2005.

CRF		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1A1b	Liquid fuels	-9,1	-9,2	-9,5	-9,4	-9,4	-9,1	-9,2	-9,2	-9,3	-9,4	-9,5	-9,5	-9,4	-9,0
1A1b	Total fuels	-9,1	-9,2	-9,5	-9,4	-9,4	-9,1	-9,2	-9,2	-9,3	-9,4	-9,5	-9,3	-9,2	-8,9
1A2c	Liquid fuels	3,2	1,2	0,0	0,0	0,0	0,0	0,0	0,7	1,1	0,0	1,1	1,1	0,2	0,9
1A2c Totalt	Total fuels	1,4	0,5	0,0	0,0	0,0	0,0	0,0	0,3	0,5	0,0	0,6	0,6	0,1	0,4
1A2d	Liquid fuels	0,0	0,0	0,0	0,0*	0,0*	0,0*	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
1A2d Totalt	Total fuels	0,0	0,0	0,0	0,0*	0,0*	0,0*	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
1B2c	Liquid fuels	-9,7	-9,0	-7,8	-9,1	-9,2	-9,2	-9,0	-7,7	-9,5	-9,7	-7,8	-9,1	-9,7	-10,2
1B2c	Total fuels	-9,7	-9,0	-7,8	-9,1	-9,2	-9,2	-9,0	-7,7	-9,5	-9,7	-7,8	-9,1	-9,7	-10,2

* In 1993-1995 petroleum coke was reported from the pulp and paper industry resulting in slightly decreased emissions these years.

5 Activity data in future submissions

The activity data used by SMED is fuel consumption data collected by the energy department at Statistics Sweden. The primary purpose of this data is not and has never been to calculate emission. However, the energy statistics data has improved over the years by for instance collecting data on flaring of fuels and in-house produced fuels, and the quality of the data has thereby increased. This improves SMED:s possibilities to use this data for calculation of emissions from the energy sector. Still in this study fuel consumption data was revised for 17 plants for the last year reported; 2003. This indicates that special care must be taken by SMED when data for 2004 and the coming years are used. In 2005 the time series for especially these 17 plants, but of course also for other plants, will be carefully studied and data for 2004 will be compared with earlier years. If data are suspected to be incorrect it will be compared with data reported by the plants in the present study, or the plants will be contacted to receive correct data.

In 2006 the plants included in the EU trading scheme will report emissions for the emission year 2005. If SMED states that data for 2004 from several plants were inaccurate, plant specific data from the trading scheme should be compared with SMED-data, and if trading data is found more accurate it should be used instead of SMED-data for the plants and fuels where relevant.

6 Discussion

In this project, activity data has been revised for a number of plants due to incorrect data in the energy statistics. There are several possible reasons for this incorrectness. One explanation that SMED were told during this project is that data to the energy statistics is reported from another department at the company than that which was involved in the trading survey. These departments might have different information, depending on whether the fuels are measured, calculated based on storage of fuels, or based on how much fuels that have been bought in the specific period.

In the trading survey, the companies were extremely motivated to report every single TJ of fuels consumed, since that data should be used when deciding how much CO_2 this plant would be allowed to emit without paying. In other words the higher fuel consumption they reported, the more emissions trading units was likely to be allocated to the plant. It must however be mentioned that the companies that reported data in the trading survey seemed to be as honest as possible at least when it comes to historical data, and that is why SMED has chosen to use data from the survey. In surveys to Statistics Sweden on the other hand, the plants are obliged to report data, but they do not have the same incitement as in the trading survey to report absolutely correct data. Lack of motivation might also be a reason why correct data is not reported, for instance if the plants have problems to understand what data they are asked to report in the survey.

A final reason for differences in data is that Statistics Sweden has changed the surveys since 1990, for instance in-house fuels have not been included all years. The last years however the surveys have been more stable.

Despite of all these possible reasons for differences between data from Statistics Sweden and data from the trading survey, we consider the quality of the activity data from Statistics Sweden to be fairly high. This is for instance stated when fuel consumption data, (called the sectoral approach) reported to the UNFCCC is compared with total fuels delivered in Sweden (called the reference approach).[64]

SMED has performed several studies during recent years within the energy sector for emissions from stationary combustion, and the quality of activity data and emission factors for CO_2 can now be considered to be high. It will always be possible to improve the quality on data, but Sweden has focused on sources with high emissions as the IPCC Good Practice Gudiance advocates. Time series in iron and steel plants, chemical industries and refineries has been revised in earlier studies by SMED, and by the present study the Swedish inventory of green-house gases reported to the UNFCCC CLRTAP has been further improved.

[64] Swedens National Inventory report submission 2005, Appendix 15:
http://www.naturvardsverket.se/dokument/fororen/utslapp/fcccdata/app15.pdf

Appendix 1. Results of revised time series

In the submitted table changes in % in activity data and emissions of fossil CO_2 after revision of activity data and emission factors compared with activity data and emission in submission 2005. Only the CRF-codes and the fuel-types where changes have occurred are presented in the table. To be able to see how big the changes are compared to the to the total emissions row are included showing how great part of the total CO_2 emissions that respectively CRF-codes contributes to.

CRF	Fuel type	Data	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1A1a	Liquid	Fossil CO2 (Gg)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-0,3%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
		TJ	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-0,3%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	b-solid	Fossil CO2 (Gg)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-0,3%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
		TJ	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-0,3%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	d-biomass	Fossil CO2 (Gg)														
		TJ	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-1,9%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
% of total CO2 emissions after revision			13,5%	15,4%	16,4%	16,1%	16,2%	15,0%	20,4%	15,1%	16,6%	14,8%	12,8%	14,8%	16,5%	17,4%
1A1a Total CO2 fossil			**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**-0,2%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**
1A1a Total TJ			**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**-0,7%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**
1A1b	a-liquid	Fossil CO2 (Gg)	-9,1%	-9,2%	-9,5%	-9,4%	-9,4%	-9,1%	-9,2%	-9,2%	-9,3%	-9,4%	-9,5%	-9,5%	-9,4%	-9,0%
		TJ	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
% of total CO2 emissions after revision			3,5%	3,5%	3,7%	3,8%	3,6%	3,6%	3,6%	3,8%	3,9%	4,1%	4,3%	4,4%	4,6%	4,3%
1A1b Total CO2 fossil			**-9,1%**	**-9,2%**	**-9,5%**	**-9,4%**	**-9,4%**	**-9,1%**	**-9,2%**	**-9,2%**	**-9,3%**	**-9,4%**	**-9,5%**	**-9,3%**	**-9,2%**	**-8,9%**
1A1b Total TJ			**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**
1A2a	a-liquid	Fossil CO2 (Gg)	16,3%	0,7%	1,5%	0,0%	-1,0%	0,9%	0,5%	-0,9%	1,1%	1,2%	4,5%	1,4%	6,5%	3,0%
		TJ	15,1%	0,5%	1,4%	-0,1%	-1,2%	0,9%	0,5%	-1,0%	1,1%	1,2%	4,4%	1,3%	6,5%	3,2%
% of total CO2 emissions after revision			2,1%	1,7%	1,8%	1,9%	1,9%	2,0%	1,9%	1,9%	2,0%	2,1%	2,3%	2,2%	2,4%	2,3%
1A2a Total CO2 fossil			**13,1%**	**0,5%**	**1,2%**	**0,0%**	**-0,8%**	**0,7%**	**0,4%**	**-0,7%**	**0,9%**	**1,0%**	**3,6%**	**1,1%**	**5,2%**	**2,5%**
1A2a Total TJ			**11,2%**	**0,3%**	**1,0%**	**-0,1%**	**-0,9%**	**0,7%**	**0,3%**	**-0,7%**	**0,9%**	**0,9%**	**3,2%**	**1,0%**	**4,8%**	**2,4%**
1A2c	a-liquid	Fossil CO2 (Gg)	3,2%	1,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,7%	1,1%	0,0%	1,1%	1,1%	0,2%	0,9%
		TJ	1,4%	0,5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,3%	0,5%	0,0%	0,5%	0,5%	0,1%	0,4%
	c-gaseous	Fossil CO2 (Gg)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	23,0%	1,5%	9,9%	1,5%	0,0%
		TJ	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	23,0%	1,5%	9,9%	1,5%	0,0%
	e-other	Fossil CO2 (Gg)	-10,5%	-4,4%	0,0%	0,0%	0,0%	0,0%	0,0%	-1,6%	-2,6%	0,0%	-10,2%	-5,0%	-1,9%	-1,3%
		TJ	-10,5%	-4,4%	0,0%	0,0%	0,0%	0,0%	0,0%	-1,6%	-2,6%	0,0%	-10,2%	-5,0%	-1,9%	-1,3%
% of total CO2 emissions after revision			2,1%	2,0%	2,0%	1,9%	2,2%	2,3%	2,3%	2,6%	2,6%	2,2%	2,5%	2,7%	3,2%	2,7%
1A2c Total CO2 fossil			**1,4%**	**0,5%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,3%**	**0,5%**	**2,3%**	**0,7%**	**1,5%**	**0,3%**	**0,4%**
1A2c Total TJ			**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**2,5%**	**0,2%**	**1,0%**	**0,2%**	**0,0%**

CRF	Fuel type	Data	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1A2d	a-liquid	Fossil CO2 (Gg)	12,3%	20,8%	18,0%	10,9%	13,4%	12,4%	16,7%	1,7%	-1,4%	-6,6%	11,1%	23,8%	13,8%	-1,5%
		TJ	12,0%	20,5%	17,8%	11,0%	13,5%	12,5%	16,7%	1,7%	-1,4%	-6,7%	11,0%	23,5%	13,6%	-1,5%
	b-solid	Fossil CO2 (Gg)	-5,8%	-7,0%	-11,2%	-6,5%	-11,7%	-3,7%	-8,2%	-12,8%	-6,8%	-5,2%	60,1%	42,8%	198,1%	7,1%
		TJ	-5,9%	-7,1%	-11,3%	-6,6%	-11,7%	-3,8%	-8,2%	-12,8%	-6,8%	-5,2%	61,1%	43,4%	198,1%	7,1%
	d-biomass	Fossil CO2 (Gg)														
		TJ	1,4%	4,0%	1,4%	5,4%	2,1%	4,1%	3,1%	6,4%	7,4%	12,2%	3,6%	7,6%	10,7%	8,8%
	e-other	Fossil CO2 (Gg)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-1,6%	0,0%	-1,5%	-3,0%	0,0%	0,0%	0,0%	-3,0%
		TJ	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-1,6%	0,0%	-1,4%	-2,8%	0,0%	0,0%	0,0%	-2,4%
% of total CO2 emissions after revision			3,9%	4,3%	3,7%	4,7%	5,7%	5,8%	5,1%	6,0%	5,1%	4,4%	4,1%	4,1%	3,9%	4,5%
1A2d Total CO2 fossil			**9,0%**	**13,8%**	**12,8%**	**7,7%**	**9,8%**	**10,3%**	**13,3%**	**0,8%**	**-1,6%**	**-6,2%**	**11,6%**	**22,8%**	**14,6%**	**-1,3%**
1A2d Total TJ			**4,4%**	**7,9%**	**5,5%**	**6,4%**	**5,8%**	**7,1%**	**8,2%**	**3,3%**	**2,7%**	**2,5%**	**6,7%**	**12,4%**	**12,0%**	**4,0%**
1A2e	a-liquid	Fossil CO2 (Gg)	-0,5%	0,5%	-0,4%	0,7%	0,0%	-0,4%	0,5%	-0,4%	-0,3%	-0,3%	0,0%	-2,7%	0,0%	0,0%
		TJ	-0,5%	0,5%	-0,3%	0,7%	0,0%	-0,4%	0,5%	-0,4%	-0,3%	-0,3%	0,0%	-2,6%	0,0%	0,0%
% of total CO2 emissions after revision			1,6%	1,6%	1,5%	1,6%	1,5%	1,6%	1,5%	1,7%	1,6%	1,6%	1,4%	1,2%	1,3%	1,5%
1A2e Total CO2 fossil			**-0,3%**	**0,3%**	**-0,2%**	**0,5%**	**0,0%**	**-0,3%**	**0,3%**	**-0,2%**	**-0,2%**	**-0,2%**	**0,0%**	**-1,7%**	**0,0%**	**0,0%**
1A2e Total TJ			**-0,3%**	**0,3%**	**-0,2%**	**0,4%**	**0,0%**	**-0,3%**	**0,3%**	**-0,2%**	**-0,2%**	**-0,2%**	**0,0%**	**-1,4%**	**0,0%**	**0,0%**
1A2f	a-liquid	Fossil CO2 (Gg)	0,3%	0,4%	1,4%	0,8%	-0,3%	0,8%	0,4%	0,1%	-0,5%	0,5%	2,1%	2,4%	-1,0%	0,7%
		TJ	0,5%	0,5%	1,5%	1,2%	0,1%	1,3%	0,8%	0,6%	0,5%	1,6%	3,0%	2,4%	-0,3%	1,5%
	b-solid	Fossil CO2 (Gg)	1,9%	1,4%	0,4%	0,0%	0,7%	1,4%	0,4%	2,1%	13,8%	16,2%	14,8%	14,9%	16,0%	6,3%
		TJ	1,7%	1,7%	0,4%	0,0%	1,0%	1,7%	1,3%	3,2%	17,3%	20,9%	18,9%	19,3%	21,5%	11,1%
	c-gaseous	Fossil CO2 (Gg)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-7,9%	0,0%	0,0%	0,0%
		TJ	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	-7,9%	0,0%	0,0%	0,0%
% of total CO2 emissions after revision			7,2%	6,8%	5,7%	5,9%	5,8%	6,4%	6,3%	6,6%	6,2%	6,3%	6,8%	7,1%	6,4%	6,1%
1A2f Total CO2 fossil			**0,8%**	**0,5%**	**1,0%**	**0,5%**	**0,0%**	**0,9%**	**0,4%**	**0,7%**	**2,4%**	**2,6%**	**3,6%**	**3,7%**	**3,8%**	**0,2%**
1A2f Total TJ			**0,5%**	**0,4%**	**0,6%**	**0,5%**	**0,1%**	**0,7%**	**0,5%**	**0,7%**	**1,5%**	**1,7%**	**2,6%**	**2,3%**	**3,2%**	**0,6%**
																-
1B2c	a-liquid	Fossil CO2 (Gg)	-9,8%	-9,2%	-8,0%	-9,2%	-9,3%	-9,4%	-9,3%	-7,9%	-9,6%	-9,8%	-7,9%	-9,2%	-9,8%	10,3%
		TJ	-0,1%	-0,1%	-0,1%	-0,1%	-0,1%	-0,1%	-0,2%	-0,1%	-0,1%	-0,1%	-0,1%	-0,1%	-0,1%	-0,1%
% of total CO2 emissions after revision			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%
																-
1B2c Total CO2 fossil			**-9,8%**	**-9,2%**	**-8,0%**	**-9,2%**	**-9,3%**	**-9,4%**	**-9,3%**	**-7,9%**	**-9,6%**	**-9,8%**	**-7,9%**	**-9,2%**	**-9,8%**	**10,3%**
1B2c Total TJ			**-0,1%**	**-0,1%**	**-0,1%**	**-0,1%**	**-0,1%**	**-0,1%**	**-0,2%**	**-0,1%**	**-0,1%**	**-0,1%**	**-0,1%**	**-0,1%**	**-0,1%**	**-0,1%**