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Quality assurance of calculations for ”Reference approach”

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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.

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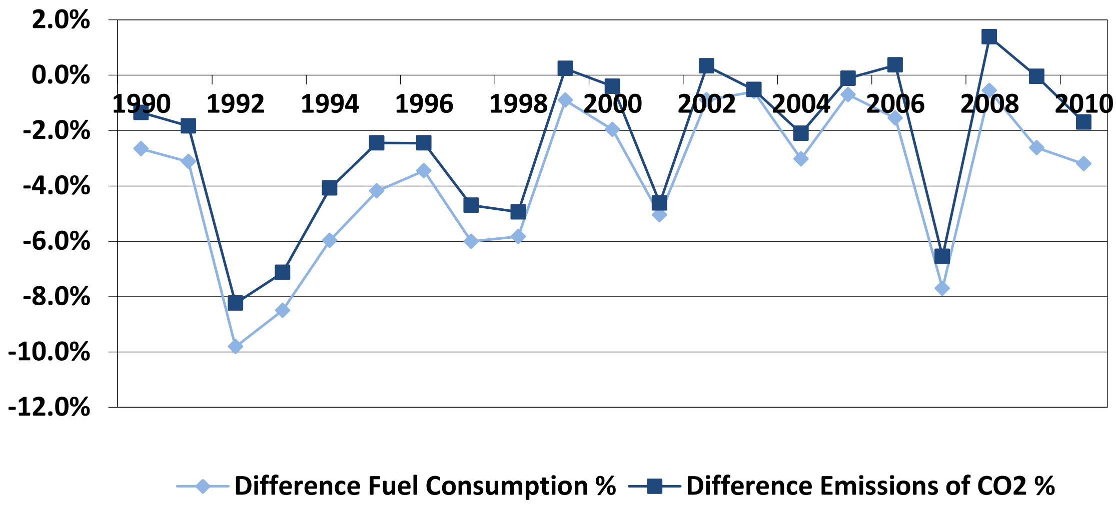
1 Background

In the Swedish greenhouse gas inventory submitted to the UNFCCC[1] in 2012, there were systematic differences between the amounts of energy and carbon dioxide calculated with the Sectoral (bottom-up) approach (SA) and Reference (top-down) approach (RA), as shown in CRF Table 1AC. For most years, fuel consumption and emissions according to RA were lower, which could indicate that the Swedish emissions reported to UNFCCC according to SA were overestimated. For several years, the difference exceeds two percent, and according to IPCC Guidelines[2] explanations are required for such large differences.

Figure 1.1. Comparison between RA and SA, total, submission 2012



Possible explanations have been investigated earlier[3] and these explanations fall into two main groups; some differences are related to the choice of calorific values and emission factors for refined and primary fuels, respectively, and others are related to the choice of activity data used in the Reference Approach. For the earliest part of the time series, the documentation on both activity data and emission factors used in RA is scarce.

The result of the comparison between RA and SA is also dependent on the amounts of fuels reported under non-energy use of fuels (CRF 1AD). At present, several data sources are used for this category and there is a need for documentation and quality check of these data as well.

2 Aim and methods

One aim of this study is to revise the calculation routines, data flows and data sources in order to ensure that data from different sources are used correctly in RA, and that no data gaps, double counting or other errors occur. This also implies improvement of the documentation and transparency. Another aim of this study is to give recommendations

[1] United Nations Framework Convention on Climate Change
[2] IPCC, 1996. IPCC= Intergovernmental Panel on Climate Change
[3] See e.g. Gustafsson 2007

on further corrections or improvements of RA data. Any remaining differences between RA and SA should be explained and the explanations should be implemented in future inventory submissions.

The presently used calculation routines will be reviewed and checked in order to ensure that the IPCC Guidelines are interpreted in the right way and that data is correctly transferred to CRF Reporter from the TPS database[4]. The improved computing programmes will be tested using the revised input data and the results will be compared to the results of the submission 2012 calculations.

The data sources used in submission 2012 are reviewed and those fuels where the difference between RA and SA is large are given particular attention. Information from earlier SMED studies will be used when appropriate. For the largest flows, i.e. fuels produced and used in refineries, chemical industry and iron and steel industry, different data sources are compared on facility level. This analysis is partly based on confidential data, and thus the findings will only be described in general terms.

If data gaps are found in the currently used sources, other energy statistics and possibly even other data sources are considered for use in future submissions in order to get complete and correct data for both the reference approach (CRF 1AB) and the non-energy use of fuels (CRF 1AD). All suspected errors in data used in submission 2012 will be documented at Statistics Sweden.

[4] Swedish EPA:s database (TPS=Technical Production Support)

3 Calculations

The top-down reference approach (CRF 1AB) is based on national fuels statistics on production, trade and stock changes as well as information on fuels used for non-energy purposes. Production of secondary or tertiary fuels is not included because that would result in double-counting of the carbon registered under production + net import of the primary fuels which are used as feedstock for production of secondary fuels. This applies to e.g. production of diesel, gasoline etc., where the carbon is counted in import of crude oil and refinery feedstock.

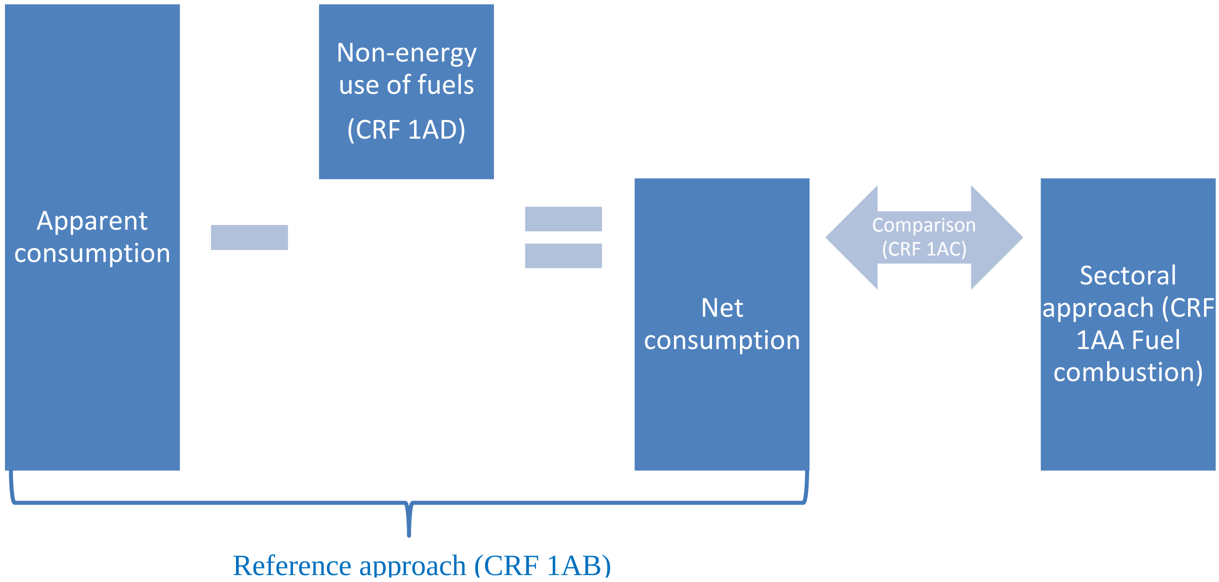
In the reference approach, net energy consumption (in TJ) and associated CO_2 emissions (in Gg) are estimated based on information on apparent consumption and non-energy use of fuels. Apparent consumption equals the sum of production of fuels, import, export, stock change and international bunkers. The carbon contents (Gg C) of the apparent consumption by fuel is estimated using carbon emission factors (t C/TJ). Some fossil fuels are used for non-energy purposes (CRF 1AD) and thus excluded in the estimations of the reference approach net consumption (TJ, Gg C)[5]. The non-energy use of fuels consists of feedstocks, non-energy products and reductants. Feedstocks are fossil fuels used as raw materials in the chemical and petrochemical industries (e.g. natural gas in production of carbon black, etc.); Non-energy products are e.g. bitumen used for asphalt or greases used for lubrication; Carbon is also used as a reducing agent (reductant) in the production of some metal and inorganic products, e.g. coke or pulverized coal in primary iron and steel production or anodes in electric arc furnaces in secondary steel production.

The reference approach CO_2 emissions (Gg CO_2) are estimated by converting (i.e. 44/12) the net carbon emissions (Gg C), taking into account the fraction of carbon oxidized at combustion.

The reference approach net energy consumption (TJ) and associated CO_2 emissions (Gg) are compared (CRF 1AC) with the bottom-up estimations of the sectoral approach (CRF 1AA).

[5] The energy contents of non-energy use of fuels are deducted from apparent energy consumption in CRF 1AC, whereas its associated carbon content is accounted as carbon stored in CRF 1AB.

Figure 3.1. Reference approach vs. sectoral approach



In order to avoid double-counting and data gaps, all data used to calculate emissions in CRF 1AB and 1AD should be delivered from the Energy Statistics Department at Statistics Sweden. In submission 2012 and earlier, data was partly gathered from other sources. This change implies some modifications of the calculation programmes. The result is simpler and more transparent calculation programmes.

The fuel group “other fuels” (this fuel group includes mixed or non-specified fuels that cannot be allocated to either of the categories liquid, solid, gaseous or biomass fuels) is not included in RA, but in SA. As this would lead to a difference on the total level when comparing CRF 1AB with 1AA in CRF 1AC, Sweden has since several years included “other fuels” in CRF 1AC and will continue to do so. There is, however, no “reference” data source for production, imports etc., and because of this, the same data source is used in RA as in SA (quarterly fuel statistics).

4 Data

Data on production, import, export, international bunkers, stock change and non energy use of fuels for all fuels are needed to calculate “apparent consumption” in the “Reference approach”. No single survey covers all essential data, and sometimes, combinations of several surveys or more complex calculations are needed to achieve completeness. In earlier submissions, the documentation on how data from various sources are compiled has been partly incomplete. The present study includes a thorough review of data sources, both those presently used and other sources that could be used to ensure completeness. Some of the data referred to in this report is published on Statistics Sweden’s website and public database,[6] whereas other data is compiled from working databases that are not accessible for public use.

4.1 Non-energy use of fuels (CRF 1AD)

In the currently used CRF tables and the IPCC guidelines of 1996[7], all types of “non-energy use” are to be reported by fuel in CRF 1AD. In the guidelines of 2006[8] , however, three sub-categories are specified under CRF 1AD: feedstock, reductant and (other) non-energy use. The feedstock category includes fuels used as feedstock that fully or partly are converted and stored in products. Reducing agents used e.g. in the metal industry are included in the reductant category and fuels used as lubricants, solvents, road paving etc. are included in non-energy use. Some fuels, e.g. bitumen, can easily be identified as belonging entirely to one of these categories, but for others, this is not obvious. In this study, we have not tried to distinguish between the three types of non-energy use. Instead, efforts have been focussed on producing a correct estimate for the aggregate CRF 1AD for each fuel. This approach reduces the risk of revealing confidential data. The survey of data sources leads to the following recommendations regarding use of data sources for different fuels in the category “non-energy use of fuels”:

Quarterly energy balances

- Bitumen
- Light virgin naphtha for production of hydrogen gas.
- LNG (liquid natural gas) for production of hydrogen gas and gas works gas. This data is gathered from the raw data used in the energy balance, as the value shown in the table is the sum of liquid and gaseous natural gas.

LNG has been used as feedstock for production of hydrogen and gas works gas since 2011. There is no data on this fuel for earlier years, as imports, exports, use etc. of LNG before 2011 is assumed to be not occurring. For 2011 (and later) data is available, but due to confidentiality reasons, it might not be possible to show data on LNG explicitly in the CRF tables. Reporting of LNG will be reviewed in future submissions.

Quarterly fuel statistics

- Coke oven coke used for carbide production
- Natural gas (gaseous). This fuel has been used as feedstock since 2004[9]. Due to confidentiality reasons, data on natural gas used in CRF 1AD can be shown only from 2009 and onwards.

[6] www.scb.se
[7] IPCC, 1996
[8] IPCC, 2006
[9] National Inventory Report, Sweden, submission 2013, section 4

- Injection coal (PCI coal)
- Ethanol

Monthly fuel statistics

- Petroleum coke (used in blast furnaces)
- LPG (in-house use in refineries)
- Ethane (used in refineries and petrochemical industry)
- LNG used as feedstock for hydrogen production in refineries (the same conditions as mentioned under *Quarterly energy balances* are applicable)
- Light virgin naphtha
- Lubricants*
- Virgin naphtha*, (the amount inserted for refining)

*these fuels are reported as an aggregate under "Other Oil"

4.2 Apparent consumption excl. non-energy use of fuels (CRF 1AB)

In this section, the data sources used for production, import, export, international bunkers and stock change are listed. If not otherwise stated, data for all these parameters originate from the data source under which the fuel is listed. Foreign trade statistics is an important data source used in the calculations of import and export reported in the energy balances. Data on non-energy use is the same as used in CRF 1AD and accounted as carbon stored in the reference approach.

Quarterly energy balances

- Bitumen (import and export)
- Petroleum coke (import and export)

Quarterly fuel statistics

- Other bituminous coal (stock change)
- Peat (import data from foreign trade statistics)

Monthly fuel statistics

- Coking coal and other bituminous coal (+ data from foreign trade statistics)
- Coke oven coke
- Crude oil
- Bitumen (stock change)
- Diesel
- Domestic fuel oil
- Residual fuel oil

- Aviation kerosene
- Aviation gasoline
- Kerosene
- Petroleum naphtha (reported under “Other Oil”)
- Petroleum coke (stock change)
- Refinery feedstock
- Ethane (import)
- LPG
- Lubricants
- Virgin naphtha (reported under “Other Oil”)
- Ethanol

Lignite has been reported as NO in previous submissions. However, imports and exports of small quantities of lignite are in fact occurring, but these quantities are included in the reported amounts of coking coal. As the relative amounts of lignite are very small compared to the amounts of coal, and data for the 1990’s are not readily available, lignite will still be included in coking coal in future submissions, but the notation key for imports and exports of lignite should be changed to IE.

4.3 Plant specific data flows

Iron and steel works, refineries and petrochemical industries account for a major part of the energy flows and, for some fuels, the differences between the reference and sectoral approach have been considerable. These data flows have been studied on facility level.

4.3.1 Solid fuels in the iron and steel industry

In the sectoral approach, data from the EU ETS and environmental reports are used for the two integrated iron and steel plants. The energy amounts allocated to CRF 1A1a, 1A1c, 1A2a, 1B1c and 2C1 are calculated from the total amounts of coking coal, coke, injection coal and scrap metal used in the process. The majority of the energy originating from coking coal in the iron and steel industry is accounted for in CRF 2C1 as heat losses and thus not accounted for in CRF 1AA. The emissions are calculated using implied emission factors based on the reported total amounts of CO_2 reported in the environmental reports.

The energy amounts in the sectoral approach should be equal to the apparent consumption based on imports, exports, stock change excluding non-energy use for the same facilities (taking into account that the original imports could be registered on another company). This does not seem to be the case, but unfortunately, original raw data from the trade statistics surveys has not been available. In addition to this, the principles for allocating energy to energy use and non-energy use in the reference approach are different from the principles for allocating energy to fuel combustion and industrial processes, respectively, in the sectoral approach. The thermal value used to calculate the energy from coking coal in the reference approach is slightly different from the plant specific thermal values used in the energy- and emission allocation model used in the sectoral approach. The impact of this difference on the overall difference between the reference and sectoral approaches for solid fuels is, however, not significant.

According to the method used in the sectoral approach, which has been developed in cooperation with the largest iron and steel producer (SSAB)[10], pulverised coal (PCI) and coke oven coke are used in the blast furnace process. Hence the blast furnace gas, which is combusted within CRF 1A1a, 1A1c and 1A2a, is reported under Solid fuels. However, according to energy statistics, petroleum coke is also used in the blast furnace. This could cause minor differences as petroleum coke is reported under liquid fuels, that is, a minor amount of coke and/or petroleum coke is allocated to solid fuels in CRF 1AA but to liquid fuels in CRF 1AB. It should be noted that these differences are very small compared to the total emissions within each of these fuel categories.

4.3.2 Petroleum coke used in refineries

Since submission 2009, combustion of petroleum coke in refineries are reported as fugitive emissions (CRF 1B2) in the Swedish inventory[11]. This allocation is based on the fact that this combustion is needed to maintain the function of the catalyst, i.e. energy production is not the primary purpose of the combustion. In the report of emissions within EU ETS to Swedish EPA and in the legal environmental report[12] this activity is not reported under fuel combustion for energy production, but separately reported as "burning off coke[13]". However, according to contacts with the refinery within the present study, the purpose of the combustion is energy production. This means that in the energy statistics, these amounts of petroleum coke are reported as fuel consumption which corresponds to CRF 1AA. Hence, the corresponding amounts of crude oil/refinery feedstock are not deducted from CRF 1AB. This causes a difference in CRF 1AC since fugitive emissions (CRF 1B) are not included in the Sectoral approach (1AA) when the difference 1AC=1AB-1AA is computed.

4.3.3 Natural gas and naphtha in chemical industries

As mentioned in section 4.1, natural gas has been used as feedstock since 2004. Due to confidentiality reasons, data on feedstock use of natural gas can only be published from 2009 and onwards. In the sectoral approach, however, environmental reports are used as a complimentary data source, and data on non-energy use (reported in CRF 2 in the sectoral approach) is reported for 2004 and onwards. This discrepancy is reflected in CRF 1AC (the comparison between RA and SA, see chapter 5). For the years prior to 2004 and after 2008, the differences are very small.

Light virgin naphtha has been used as a feedstock for hydrogen production in one of the oil refineries, and for production of gas works gas, until 2011. In the sectoral approach, light virgin naphtha used for hydrogen production is reported in CRF 1B (which means it is not included in the comparison 1AC). The data source is EU ETS data, which has shown to be consistent with data from the environmental reports[14]. Naphtha used for production of gas works gas is not reported in the sectoral approach; instead, the combustion of the produced gas works gas is reported in a number of different sub-categories in CRF 1A.

[10] Gustafsson, Gerner & Lidén, 2011
[11] National Inventory Report, Sweden, submission 2013, section 3
[12] Preem 2012, page 89
[13] In this case, "coke" means petroleum coke
[14] See e.g. Nynas 2011, page 18

4.4 Statistical differences

The energy balances describe the flow of energy commodities, such as supply, demand and final consumption of fuels and are based on statistics from different surveys, such as foreign trade statistics, quarterly fuel statistics, monthly fuel statistics, etc. Differences in energy commodity data between supply, demand and final consumption of fuels are to some extent attributed to *statistical differences*. The statistical differences may vary in size (up to ±20 per cent) depending on fuel and year. When analyzing differences between the reference and sectoral approaches it is important to take into account statistical differences presented in the national energy balances as they may explain part of the RA/SA differences. In Gustafsson (2007) it was concluded that the sectoral approach (CRF 1AA) and the final consumption in the national energy balances showed good consistency for liquid fuels and thus that remaining differences between the reference and sectoral approaches were due to the statistical differences in the energy balances. Furthermore, due to the complex commodity flows, it was concluded that statistical differences for solid fuels were more difficult to take into account when analyzing differences between the reference and sectoral approaches.

In the present study, actual analysis of statistical differences has not been prioritized. A simple comparison of statistical differences for liquid and solid fuels with the corresponding difference between RA and SA showed that statistical differences are usually at least of the same magnitude as the differences between RA and SA, which is illustrated in the figures below. Statistical differences refer to statistical differences on the supply side according to data from the annual energy balances from Statistics Sweden’s public statistical database.

Figure 4.1. Statistical differences (supply side) and RA-SA differences, PJ. Liquid fuels

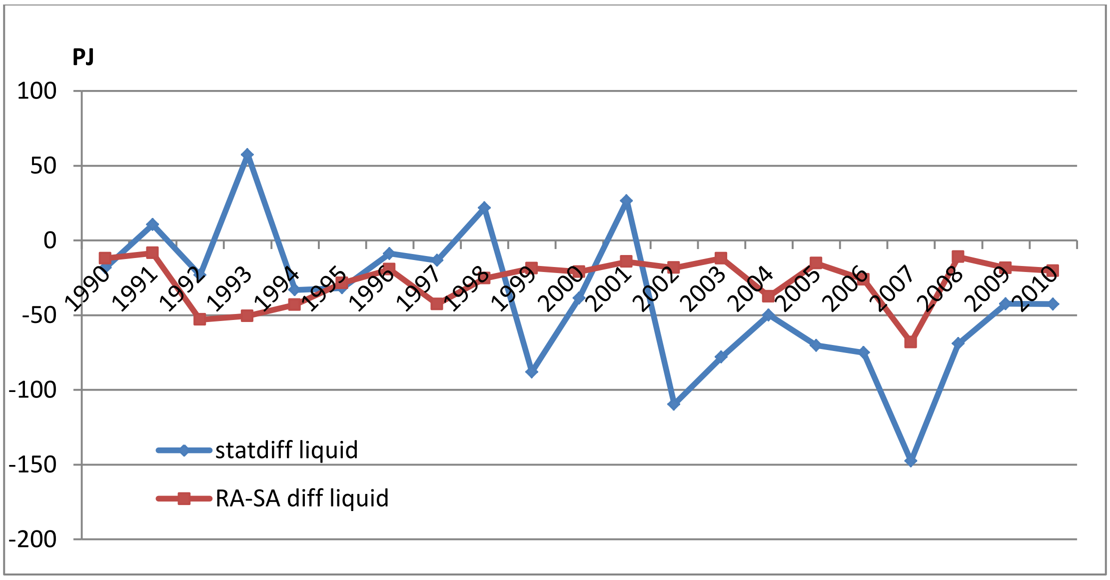
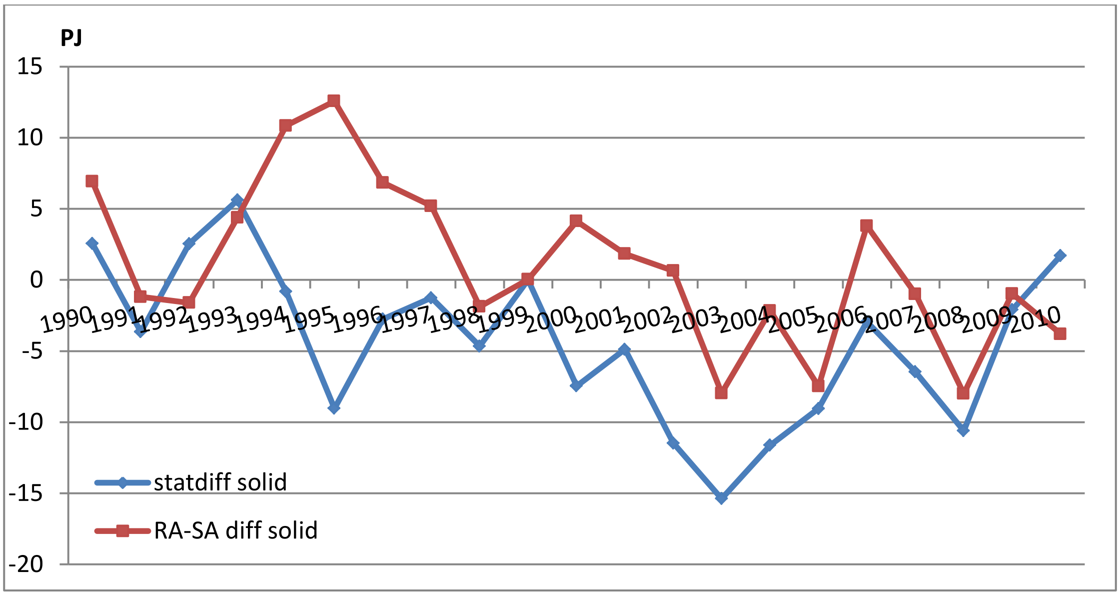


Figure 4.2. Statistical differences (supply side) and RA-SA differences, PJ. Solid fuels



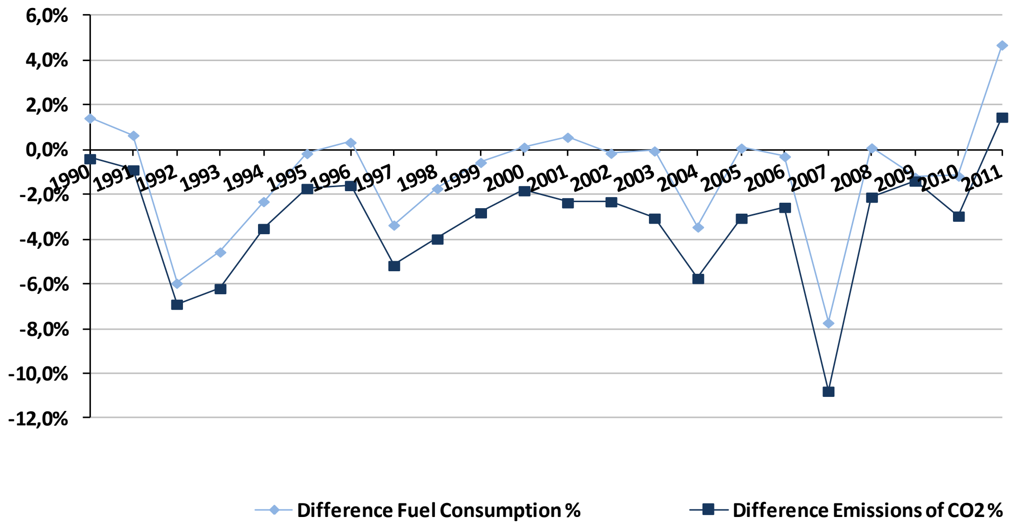
4.5 Thermal values

For all standard fuels reported both in the sectoral and reference approach, the same thermal values are used in RA and SA. Some fuels are only reported in the reference approach, i.e. primary fuels that are not combusted in its original form but transformed to secondary or tertiary fuels. The most important of these fuels is crude oil, which is not produced in Sweden but imported in large quantities. The currently used thermal value for crude oil and refinery feedstocks is 36.26 GJ/m³ for all years based on information from the Swedish Petroleum & Biofuel Institute (SPBI). The CO_2 emission factor used for these two fuels is 73.3 kg/GJ according to the emission factor database of 2006 IPCC Guidelines (EFDB). Thermal values for crude oil in this database are expressed in GJ/tonne, and these can not be compared to thermal values expressed as GJ/m³ unless the density is known. Most of the crude oil imported to Sweden in recent years comes from Russia, Norway, Denmark, Venezuela and United Kingdom. According to EFDB, thermal values for crude oil in these countries are in the range between 42.08 GJ/tonne (Russia) and 42.96 GJ/tonne (Norway). The thermal value for crude oil in Sweden according to EFDB is 42.75 GJ/tonne which is equal to 36.34 GJ/m³ if the density is assumed to be 0.85 tonne/m³. Hence, the thermal value from SPBI is considered to be accurate.

5 Results and analysis

In this section, the results of calculations based on revised data as described in section **Error! eference source not found.** are discussed. The RA/SA comparison is made between the new RA calculations and SA as reported in submission 2013 (compared to submission 2012, only minor recalculations were made in the sectoral approach). In the reference approach, large amounts of primary fuels, e.g. crude oil and coking coal, are reported. These fuels are in most cases not combusted in this form, but converted to secondary or tertiary fuels (e.g. diesel oil, gasoline, coke oven gas, blast furnace gas etc.) before they are combusted. During the transformation from primary to secondary or tertiary fuels, considerable amounts of energy are lost as heat. In Sweden, the combustion of steam coal[15] and coke for energy production is quite sparse. Instead, the main part of the coal is used in coke ovens and converted to coke, and this coke is mainly used as a reducing agent in blast furnaces. Some coke is used for carbide production. The processes are described in NIR[16] Section 4. Because the combustion of coal and coke for energy purposes is so small compared to the use in coke ovens etc., the energy losses not accounted for give rise to a huge difference between the reference and sectoral approach for solid fuels. In petroleum refineries, transformation losses of energy occur when crude oil is converted to secondary and tertiary fuels. These losses are normally about 3%.[17]

Figure 5.1. Comparison between RA and SA, submission 2013, total

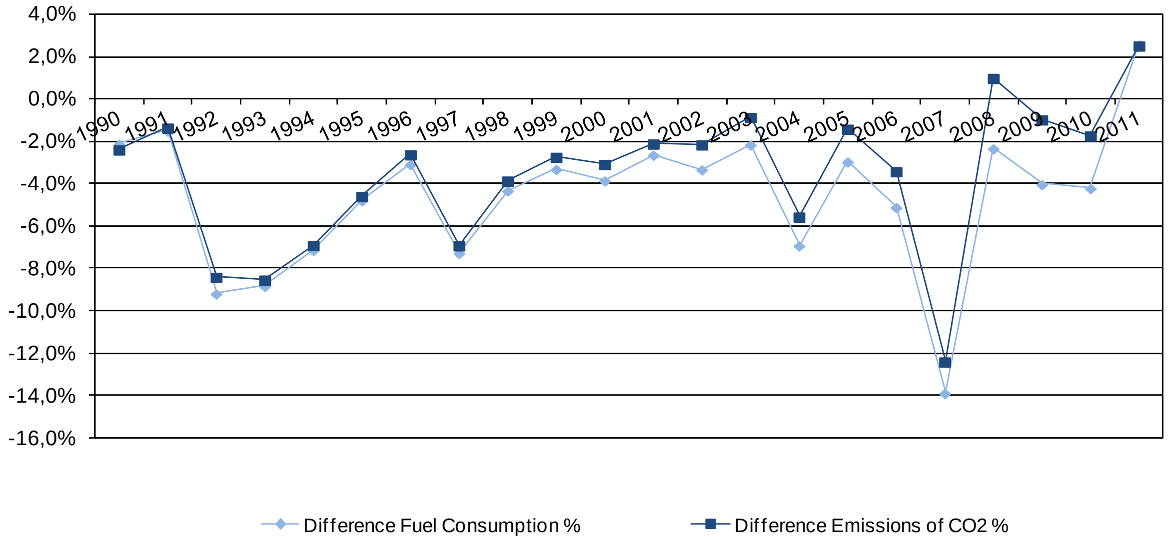


[15] The term ”Steam coal” includes all types of bituminous and sub bituminous coal used for heat production
[16] National Inventory Report, Sweden, submission 2013
[17] Telephone contact with Susanne Palm, Statistics Sweden’s energy departement, 2012-11-08

5.1 Liquid fuels

In Figure 5.2, the differences in energy consumption and CO_2 emissions, i.e. the differences to be reported in CRF 1AC, from liquid fuels calculated with the data used within this study are shown.

Figure 5.2. Comparison between RA and SA, liquid fuels



The difference between RA and SA shows quite large variation between years. There is also a systematic difference: fuel consumption and emissions according to RA are lower than SA almost every year. In addition to this, the differences in CO_2 emissions are, for later years, not entirely proportional to the corresponding differences in energy. From 2002 and onwards, the total implied emission factor (IEF) for liquid fuels is lower in SA than in RA. There are three possible main explanations to this:

In RA, a large share of liquid fuels consists of crude oil and refinery feedstock, but in the sectoral approach, refined fuels and intermediate products such as refinery gas are used. It is difficult to determine whether the default emission factor used for the primary fuel crude oil is consistent with the national or facility specific emission factors used for secondary and tertiary fuels. For later years, facility specific data are frequently used in SA. For by-products combusted in the chemical industry, technological improvements have resulted in more efficient processes which means that the by-products contain less carbon and more hydrogen[18]. This would mean that a larger share of the carbon from the feedstock is stored in products. Another explanation could be “quality transfers”. These are reported by the respondents to the monthly fuel survey and represents conversions between different fuel qualities; e.g. from domestic heating oil to diesel oil. The sum of the fuel quantities reported as “quality transfers” each month should be zero in terms of volume (cubic metres), but as different liquid fuels have different thermal values this implies that there are residuals in terms of energy (TJ). These residuals are not taken into account when the input data for CRF 1AB is compiled.

For 2005 and later, EU ETS data is the main data source in SA for refineries, and the CO_2 emissions are verified and considered to be complete and correct. In some cases, however, thermal values for refinery gas have not always been reported and thermal values from other refineries or other data sources have been used for some observations. This could possibly

[18] Gerner 2011

lead to inconsistencies in the relation between the plant specific CO_2 emission factors and thermal values used. It should however be noted that the combusted amounts of refinery gas are small compared to the two main liquid fuels reported in the sectoral approach: diesel oil and gasoline, so this issue should have only minor impact on the overall implied emission factor for liquid fuels. The thermal value used for crude oil in the reference approach calculations has been reviewed as described in section 4.5 and is not suspected to cause systematic errors.

Compared to the data reported in CRF 1AC in submission 2012, the variation between years is nearly identical when using the data compiled within this study, but the whole time series is shifted upwards, i.e. the differences generally show more positive values, and hence the coherence between energy and CO_2 is slightly better.

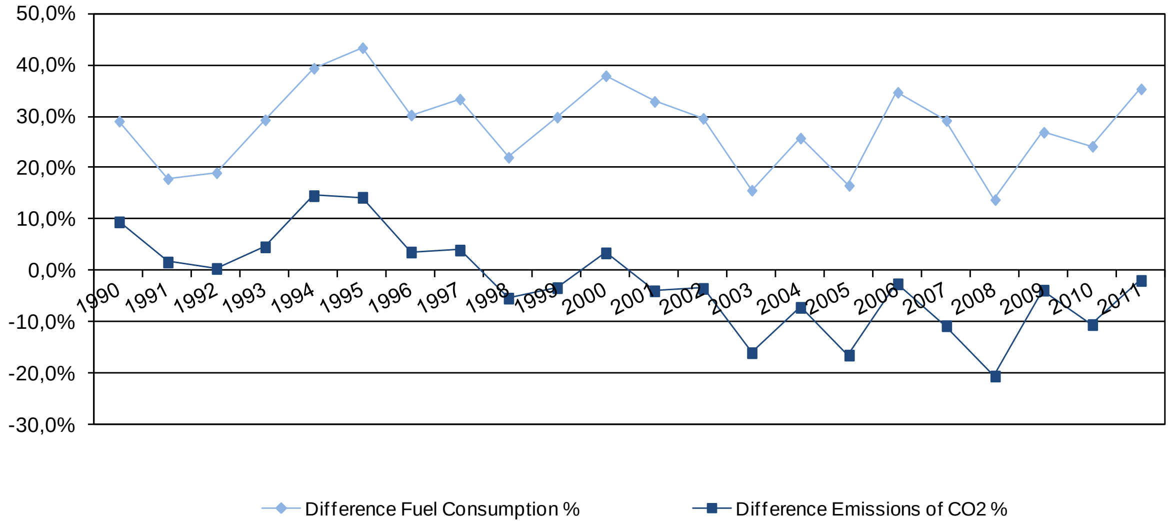
There are, however, still large differences for a number of years. The aggregate statistical differences for liquid fuels in the energy balances are also very large. In 2007, the statistical difference for liquid fuels[19] was -148 PJ on the supply side and +41 PJ on the consumption side. In the same year, the difference between the reference approach and the sectoral approach was exceptionally large for liquid fuels (-68 PJ (-13.9%) in fuel consumption and -4294 Gg (-12.4%) in emissions). A main data source for the annual energy balances, and also for reference approach, is the monthly fuel statistics. Original input data from this survey for the 1990's is no longer available, but raw data from the monthly fuel statistics 2007-2011 has been studied. This data shows that quite large amounts of fuels are reported as "product differences", i.e. unexplainable residuals reported by the respondents. These residuals are not used in the calculations of the energy balances, but they indicate that the uncertainties in input data used in the reference approach are large. According to Statistics Sweden's energy department, the accuracy of data reported to this survey 2007-2009 was suspected to be poor, but in 2010 measures were taken to improve the quality and data for 2010-2011 are considered to be more accurate.[20]

5.2 Solid fuels

For solid fuels, secondary and tertiary fuels account for a large share of the fuel consumption reported in the sectoral approach. Large amounts of primary fuels, mainly coking coal, are imported, and these amounts are used to calculate fuel consumption when applying the reference approach. A very small fraction of this coking coal is combusted. The major part is used for coke production, and the coke produced is mainly used in blast furnaces. Energy losses in coke ovens and blast furnaces are not accounted for in the sectoral approach. As shown in figure 5.3, this issue can cause substantial differences.

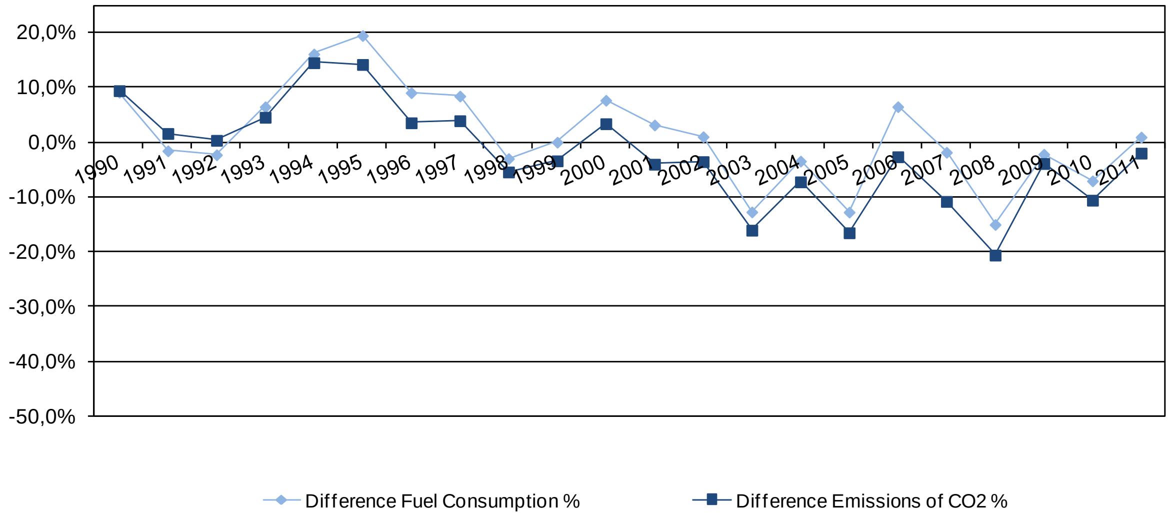
[19] Statistics Sweden's statistical database, 2012-11-16
[20] Telephone contact with Susanne Palm, Statistics Sweden's energy departement, 2012-11-08

Figure 5.3. Comparison between RA and SA, solid fuels



When analysing the differences in data used in the two approaches it is obvious that there is a large discrepancy in the total input of various coal commodities. Moreover, integrated iron and steel production processes (e.g. blast furnaces and steelworks) normally cause large energy (heat) losses that are not fully accounted for as energy consumption in the sectoral approach. In the model used to calculate emissions from the integrated iron and steel works in the sectoral approach, the energy losses are calculated in two steps; losses in the coke ovens and blast furnaces (1) and losses in the rolling mills and power plants where the steel work gases are combusted (2). When energy amounts corresponding to (1) are deducted from the energy reported for solid fuels in 1AB, the differences expressed as energy are much more in line with the emission differences as shown in figure 5.4.

Figure 5.4. Comparison between RA and SA, solid fuels, after correction for energy losses in coke ovens and blast furnaces.



This result indicates that the energy losses in coke ovens and blast furnaces are correlated with the difference between RA and SA expressed as energy. There seems to be no such correlation between the energy losses in the second step (2) and the difference between RA and SA.

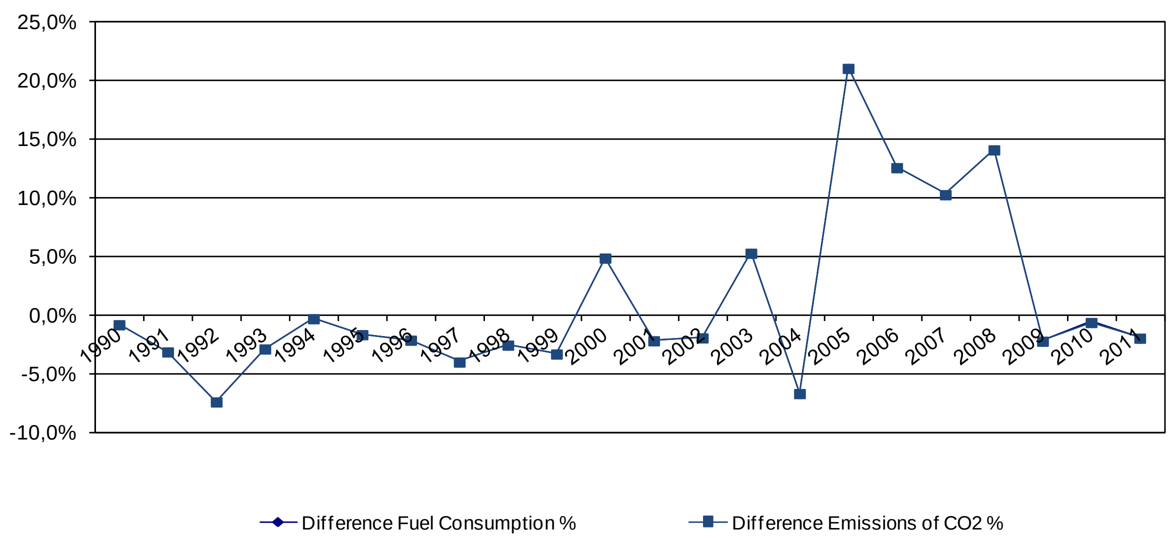
Coke used in blast furnaces is not reported in CRF 1AD because that would cause double counting of the carbon in the coking coal used in the coke ovens. This approach obviously leads to an overestimation of the energy amount, although not of CO_2 emissions, in the reference approach (1AB excluding non-energy use of fuels).

The large inter-annual variations with positive differences some years and negative differences some years do not indicate any systematical discrepancies. Input data from the monthly fuel statistics and foreign trade statistics for the 1990's are not available, and regular revisions of the annual energy balances only apply to the latest years. For the sectoral approach, a consistent time series of input data was compiled in 2010 based on data from environmental reports and a model for allocation of emissions that was developed in cooperation with the iron and steel producer SSAB.[21] These two facts indicate that at least for early years, the sectoral approach provides more correct estimates of apparent consumption of solid fuels than the reference approach.

5.3 Gaseous fuels

This fuel group consists of one single primary fuel, natural gas, and since the same emission factors and thermal values are used for the sectoral and reference approach, the relative differences in energy and CO_2 are equal. For most years, the differences are small (see Figure 5.5) but there are a few exceptions. For 2004-2008, the differences are large due to confidentiality reasons described in section 4.3.3, which means that no natural gas is reported in CRF 1AD and hence, the amount in CRF 1AB is overestimated by the corresponding amount. In submission 2012 and earlier, other data sources than energy statistics were used to solve this issue.

Figure 5.5. Comparison between RA and SA, gaseous fuels



For most years, there is no difference between these results and the ones reported in submission 2012, except for the overestimation in 2004-2008 described above. The review of input data has, unfortunately, not given any answers to the large differences in the years 1992, 2000 and 2003 as no new information on these years has become available.

[21] Gustafsson, Gerner & Lidén, 2011

5.4 Other fuels

This fuel group is included in CRF 1AC only, and since the data sources and emission factors used in the reference and sectoral approach, respectively, are identical, there are no differences (except very minor rounding errors).

6 Conclusions

The results from this study show that for liquid and solid fuels, the differences between RA and SA are large for most years in the time series. The input data for the reference approach is partly from the annual energy balances, and partly from the primary surveys which the energy balances are based on.

For liquid fuels, fuel consumption is systematically lower according to RA, although inter-annual variations are very large. Statistical differences in the annual energy balances are very large, especially for liquid fuels. The difference between RA and SA is normally smaller than the statistical difference on the supply side, but in the last 5-6 years, they follow the same pattern as the statistical differences. As the sectoral approach is calculated using data from the consumption side, this fact indicates that the differences for liquid fuels are mainly due to large uncertainties in the statistics on supply on petroleum products, most notably crude oil and refinery feedstocks.

For solid fuels, the inter-annual variations in the difference between RA and SA are also very large, but the differences are positive some years and negative other years. The large inter-annual variations are partly due to large uncertainties in the statistics on supply of primary solid fuels. The large systematic difference in fuel consumption is caused by energy losses in the transformations from coking coal to coke and coke oven gas in coke ovens and from coke to blast furnace gas in blast furnaces, as discussed in section 5.2. The input data for RA and SA, respectively, are reported by different persons, in different forms and for different purposes and this study gives no evidence that either of these data is incorrect. However, as the data for the primary iron and steel industry reported in the sectoral approach is based on the same calculation model, and the input data to this model is compiled in the same way for each year in the time series, the SA time series is considered to be consistent. The input data for early years in the RA time series is no longer available for verification, and hence the time series consistency for RA cannot be verified.

Liquid natural gas (LNG) is imported and used since 2011. However, the data on imports and non-energy use is not considered to be complete for 2011, and because of this, LNG is reported as NE for 2011 in submission 2013. The allocation and reporting of LNG in the sectoral approach as well as the reference approach needs to be reviewed, which will be done in submission 2014.

Natural gas is used as feedstock since 2004, but for 2004-2008 data is confidential, and hence non-energy use of natural gas is reported as “C” for these years, which causes a difference between RA and SA. This is of course described in the Swedish NIR, but it is not possible to prove that the differences are fully explained by this fact, as this would be equal to revealing confidential data. In earlier submissions, this problem was solved by using the same data source as in the sectoral approach for non-energy use of natural gas, but such an approach is somewhat contradictory to the purpose with the reference approach, e.g. to get a reference data source for comparison in order to ensure that the data used in the sectoral approach is accurate. The general conclusion for gaseous fuels is, however, that apart from a few early years with large differences where there is no possibility to review primary input data, the fuel consumption and emissions according to RA ad SA respectively are sufficiently coherent.

All changes in data and methodology compared to submission 2012 made within this study have been implemented in submission 2013.

7 References

Data from Statistics Sweden's surveys/databases:

- Annual energy balances
- Quarterly energy balances
- Monthly fuel-, gas-, and inventory statistics.
- Quarterly fuel statistics

Data and documentation are available at: http://www.scb.se/Pages/SubjectArea____6059.aspx

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