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Differences between Eurostat and CRF data in Swedish reporting

A comparative study of data on fuel consumption in
2005-2011 reported by Sweden to Eurostat and UNFCCC

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Sammanfattning

EU ESD review avseende submission 2012 visade på skillnader i data över bränsleförbrukning i Sveriges rapporteringar till Eurostat respektive UNFCCC. I föreliggande studie har årlig energistatistik som rapporteras till Eurostat (Eurostat-data) och Sveriges rapportering till UNFCCC, submission 2013 (UNFCCC-data), jämförts och de viktigaste skillnaderna har analyserats. Studien omfattar referensåren 2005-2011. Skillnaderna är många, men inga större felaktigheter i rapporteringen till UNFCCC har kunnat påvisas.

Generellt orsakas skillnaderna oftast av att:

- Olika allokeringsprinciper används beroende på att rapporteringarna har olika syften, och riktlinjer och manualer skiljer sig åt.
- Olika datakällor används till de respektive rapporteringarna.
- Eurostat använder andra värmevärden än de som Sverige använder i rapporteringen till UNFCCC.

I sectoral approach återfanns de största skillnaderna för fasta fossila bränslen inom järn- och stålindustrin, diesel som används till vägtrafik och i övrigsektorn, petroleumbaserade bränslen i kemisk industri samt avlutar inom industrin, som rapporteras som processutsläpp till UNFCCC.

Inga fel hittades i UNFCCC-data, sectoral approach, men allokeringen av avlutarna kommer att ses över under 2013 ifall problemet tas upp under In Country Review. En misstänkt dubbelräkning av diesel 2011 upptäcktes i Eurostat-data, vilket orsakade en mycket stor skillnad för vägtrafik det året. De stora skillnaderna i petroleumbränslen inom kemisk industri förklaras av att förbränning av biprodukter från processerna inte rapporteras i Eurostat-data på grund av att insatsvarorna rapporteras under användning för icke-energiändamål.

Inom reference approach är den vanligaste orsaken till skillnader att olika värmevärden används. Värmevärdena för kol som används i Reference approach misstänks vara för låga och kommer att ses över. Ett par mindre felaktigheter för torv 2006-2007 kommer att korrigeras. För petroleumbränslen förekommer dessutom ofta betydande skillnader i lagerförändringar, vilket också resulterar i skillnader i inhemsk konsumtion (apparent consumption). Konsumtion av biomassa är systematiskt högre i Eurostat-data, vilket bara delvis förklaras av att fossila fraktioner av avfallsbränslen inkluderats. Beräkningarna för reference approach för biomassa kommer att ses över i mån av tid.

2 Summary

The EU ESD review regarding submission 2012 revealed differences between data on fuel consumption reported from Sweden to Eurostat and UNFCCC respectively. In this study, annual energy statistics reported to Eurostat (Eurostat data) and the Swedish greenhouse gas inventory reported to UNFCCC and EU, submission 2013 (UNFCCC data) have been compared and analysed. The study covered the reference years 2005-2011. Numerous differences were found, but no obvious errors in UNFCCC data were revealed.

Generally, the major causes of differences are:

- Different allocation principles due to different purposes and guidelines.
- Different data sources
- Different calorific values

In the sectoral approach, the largest differences were found for solid fuels in the iron and steel industry, gas/diesel oil for road transports and in the other sectors, liquid fuels in the chemical industry and black liquor in the industrial sector, which is reported as process emissions in UNFCCC data.

No errors were found in UNFCCC data, but the allocation of black liquor will be reviewed during 2013, if this issue is discussed during the In Country Review . A suspected double counting of diesel in 2011 was found in Eurostat data, which caused a very large difference for road transport that year. The large difference for liquid fuels in 1A2c is explained by the fact that combustion of process by-products are not reported to Eurostat because the raw materials used are reported as non-energy use.

In the reference approach, differences are generally caused by differences in calorific values. For coking coal, the calorific value in the UNFCCC reference approach is considered to be too low and should be adjusted before submission 2014. For liquid fuels, there are often significant differences in stock change data which causes differences in apparent consumption. For biomass, apparent consumption is systematically higher in Eurostat data. This is only partly explained by the fact that non-renewable waste was coded as biomass in the EU ESD mapping. The calculations for biomass in the UNFCCC reference approach will be reviewed in future submissions.

3 Introduction

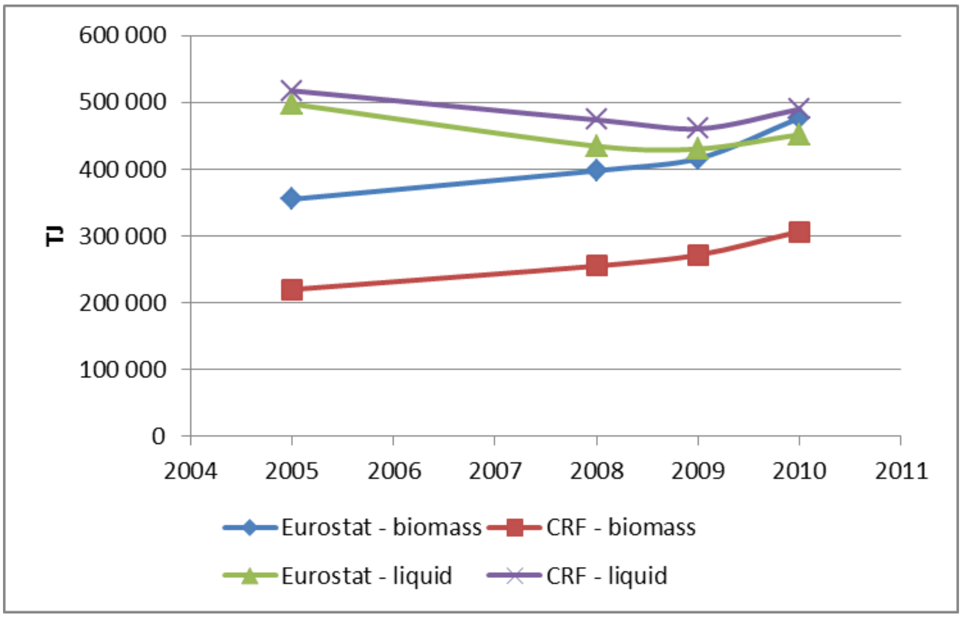
Statistics Sweden and Swedish Energy Agency report annual energy statistics in the so-called joint questionnaires to International Energy Agency (IEA) and Eurostat. Energy statistics is also included as part of the greenhouse gas emission inventory reported to the EU Monitoring Mechanism and the United Nations Framework Convention of Climate Change (UNFCCC). The different reports include data corresponding to sectoral approach (combustion of fuels within the country in different sectors) and reference approach (supply and deliveries of fuels) in the reports to UNFCCC. In this report, the data reported to Eurostat and UNFCCC are referred to as “Eurostat data” and ”UNFCCC data”, respectively.

In the EU ESD review (EU technical review of GHG inventories under the Effort Sharing Decision) of the Swedish submission 2012 to EU[1], the annual fuel consumption reported for the years 2005, 2008-2010 was compared to Eurostat data for the same years (e.g. see

[1] The Swedish data reported to the EU Monitoring Mechanism and to the UNFCCC are identical.

Figure 1 for the biomass fuel consumption and liquid fuel consumption comparisons). The comparison showed that there are some large differences, i.e. larger than a few percent on an aggregate level, between the two data sources. In additions to this, there are major differences for certain sectors due to different allocation principles, most notably for liquid fuels in the transport sector.

Figure 1. Biomass consumption and liquid fuel consumption (TJ) 2005, 2008-2010 based on Eurostat data and UNFCCC data (CRF)



The purpose of this study is to describe the differences between UNFCCC data and Eurostat data reported by Sweden. The aim is to increase the knowledge of these issues so that explanations will be readily available when the differences are discussed in various international forums, e.g. EU's and UNFCCC's annual reviews. The comparison of data includes both the sectoral approach (SA) and the reference approach (RA). The notions of SA and RA are not used in Eurostat data, but it is possible to link each of the different "Eurostat sectors" to either sectoral or reference approach according to the UNFCCC terminology.

We would like to thank Viktoria Johansson, Swedish Energy Agency, for her contribution of information on how data on liquid fuels are reported to Eurostat.

4 Method

Initially, the material from the EU ESD-review was checked against original data submitted to Eurostat in order to conclude exactly which data that was used in the EU ESD-review. Within this study, the following comparisons have been made:

1. SA according to Eurostat data ↔ SA according to UNFCCC data
2. RA according to Eurostat data ↔ RA according to UNFCCC data
3. SA according to Eurostat data ↔ RA according to Eurostat data

A comparison of sectoral approach and reference approach in UNFCCC data is already submitted to UNFCCC in 2013 (Swedish NIR, submission 2013, Andersson et al, 2012).

Although the origin of this investigation was the EU ESD review of submission 2012, data for the years 2005-2011 as reported to UNFCCC in submission 2013 has been used in the comparisons, as this is more relevant for the future. The differences between submission 2012 and 2013 are small for the sectoral approach, but in the reference approach, some significant revisions of calculations and input data were made in submission 2013.

Data for the years 2005-2011 was downloaded from Eurostat's website (Eurostat, 2013) and mapped with CRF-codes and "CRF fuels" according to the mapping principles used in EU ESD (Appendix 1A and 1B). Four datasets were compiled: Solid fuels (including derived gases), liquid fuels, gaseous fuels and renewables/wastes. These datasets were merged with corresponding datasets from the UNFCCC data per fuel and CRF code. It should be noted that in the Eurostat datasets, all fuel consumption is mapped with CRF codes starting with 1A, that is, combustion for energy purposes. In UNFCCC data, some fuel consumption is reported in other CRF codes such as 1B (e.g. flaring, hydrogen production plants) or 2 (process emissions where fuel is used as raw material), which causes some systematic differences between UNFCCC data and Eurostat data.

The causes of the most important differences have been surveyed and are described in this report. Differences and explanations are listed in Appendix 2. Minor differences, including large relative difference for fuels/sectors where the total amounts of consumed fuel are low, have not been studied in detail.

5 Description of data

5.1 Eurostat data

The reporting includes several data deliveries submitted by Statistics Sweden (SCB) and Swedish Energy Agency (EM). SCB is responsible for submitting data on solid fossil fuels and derived gases, renewables and wastes, and electricity and heat. EM reports oil and natural gas.

Data is submitted to Eurostat on a monthly and annual basis. The annual reports are more comprehensive and a preliminary report is submitted in the spring, and a definitive report is submitted in September the year after the reference year. The preliminary report is less comprehensive regarding final domestic consumption of fuels. In both cases, the data is submitted to International Energy Agency (IEA) using the web interface Energy Data Center. In addition, IEA sends an Excel worksheet for each submission, which gives the reporting parties the possibility to export data from Energy Data Center to the Excel worksheet for reporting to Eurostat and UN.

Data is reported in thousands of tonnes, except for natural gas and derived gases, which are reported in energy units (TJ or toe). In the Swedish energy statistics, liquid fuels such as heating oils are reported in m^3, which means that data has to be converted to tonnes before reporting to Eurostat. Standard conversion factors are used (Swedish Energy Agency, 2013). Prior to the publishing of data on Eurostat's website, all data is converted to the energy units toe and TJ using standard conversion factors. These calculations are made by Eurostat and not by the reporting parties.

Eurostat does not use the concepts "Sectoral approach" and "Reference approach". However, the data submitted under "Transformation sector" and "Energy sector and final consumption" corresponds to the sectoral approach, and the supply sector corresponds to reference approach, although the Eurostat data includes production of secondary fuels which should not be included in the reference approach.

5.2 UNFCCC data

5.2.1 Sectoral approach

Fuel related emissions are reported to UNFCCC in the CRF categories 1A1 (Energy industries), 1A2 (manufacturing industries[2] and construction), 1A3 (Transport), 1A4 (Other sectors), 1A5 (military transports), 1B (flaring and fugitive emissions) and 2 (industrial processes). Fuel consumption, however, is only reported in CRF 1A1-5 and not in CRF 1B or 2.
The main data sources to the fuel consumption data reported to UNFCCC, sectoral approach, are shown in

[2] Including energy related emissions in the mining industry

Table 1. For a more comprehensive description of data sources and calculation/estimation methods, see Swedish NIR submission 2013, Annex 2.

Table 1. Data sources in UNFCCC data, sectoral approach

CRF code	Main data source	Other data sources
1A1a	Quarterly fuel statistics	-
1A1b	EU ETS	Environmental reports
1A1c	Environmental reports/model calculation	Quarterly fuel statistics
1A2a	Quarterly fuel statistics, Environmental reports/model calculation	
1A2b	Quarterly fuel statistics	
1A2c	Quarterly fuel statistics	EU ETS
1A2d	Quarterly fuel statistics	
1A2e	Quarterly fuel statistics	
1A2f - Stationary	Quarterly fuel statistics	EU ETS, Energy balances (construction and small enterprises)
1A2f - Mobile	Model calculation (working machinery)	
1A3a	Monthly fuel statistics	Data from the Swedish transport agency is used for allocation o fuels for domestic and international aviation, respectively
1A3b	Monthly fuel statistics, model calculations	
1A3c	Swedish Transport Administration	
1A3d	Monthly fuel statistics, model calculations	
1A4a-c - Stationary	Energy balances	
1A4a-c - Mobile	Model calculation (working machinery)	
1A5	Armed Forces Logistics (FMLog)	

5.2.2 Reference approach

In the so called reference approach reported to UNFCCC, the parameters primary production, imports, exports, bunkers, stock change and non-energy use of fuels are reported per fuel type. Based on this data, apparent consumption (corresponding to gross inland consumption according to Eurostat data) and apparent consumption excluding non-energy use of fuels (corresponding to Final energy consumption) are calculated. The latter is then summarized by fuel group (liquid, solid, gaseous, other, biomass) and compared with the consumption of fuels for energy purposes according to the sectoral approach. The most important data sources for the reference approach are monthly fuel statistics, quarterly fuel statistics and quarterly energy balances. Foreign trade statistics is an important source for the parameters imports and exports in the energy balances. The methodology is described in detail in the Swedish NIR submission 2013, section 3 and Annex 4, and Andersson et al, 2012.

6 Comparison of data

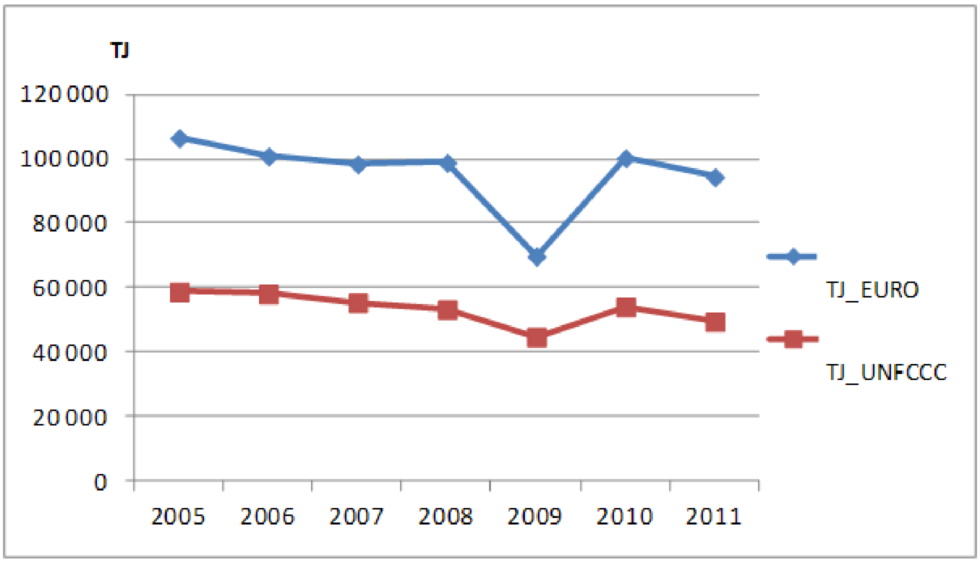
In this section, all major findings are discussed. Major differences and explanations are also listed in Appendix 2 (Excel Workbook).

6.1 Sectoral approach

6.1.1 Solid fuels

Figure 2 shows the solid fuel consumption (TJ) 2005-2011 based on Eurostat data and UNFCCC data (CRF 1A only). It is obvious that there are systematic differences between the two data sets. Eurostat data are about 70-90% larger every year compared to UNFCCC data, when only fuels reported in CRF 1A are included in the UNFCCC data. In the data compilation made in the EU ESD review, all fuel consumption according to Eurostat is allocated to CRF 1A. This is, however, not comparable with UNFCCC data, sectoral approach. The difference is around 45 000 TJ for most years and the major reason is the large quantities of fuels allocated to CRF 2 in UNFCCC data.

Figure 2. Solid fuel consumption (TJ) 2005-2011 based on Eurostat data and UNFCCC data (CRF, submission 2013, CRF 1A only)

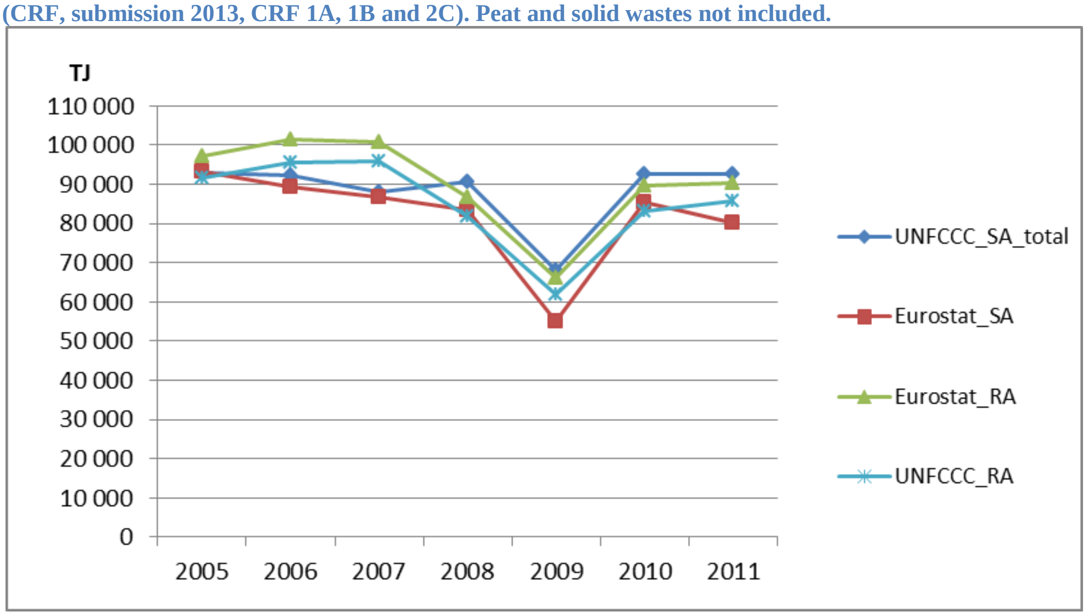


6.1.1.1 Coke ovens, blast furnaces and energy consumption in iron and steel industry (CRF 1A1c, 1A2a and 2C1)

The largest differences for solid fuels are caused by different allocation of fuels used and produced within the iron and steel industry. In UNFCCC data, the only solid fuels reported in 1A2a and 1A1c are coke oven gas and blast furnace gas.

In **Error! Reference source not found.**, the issue with allocation of fuel consumption to industrial processes in the iron and steel industry is illustrated. The graphs include consumption of coking coal, other bituminous coal, coke oven coke and derived gases (i.e. coke oven gas, blast furnace gas and oxygen steel furnace gas) in all sectors, which means that fuel quantities allocated to CRF 1B and 2, which are not reported in the CRF tables, are included in “UNFCCC_total”.

Figure 3. Solid fuel consumption (TJ) 2005-2011 based on Eurostat data and UNFCCC data (CRF, submission 2013, CRF 1A, 1B and 2C). Peat and solid wastes not included.



UNFCCC_RA= Apparent consumption (TJ), Eurostat_RA=Gross inland consumption (TJ). UNFCCC_SA_total includes also fuel use in CRF 2 and 1B.

According to the mapping of CRF codes against the Eurostat dataset, other bituminous coal (PCI-coal) used in blast furnaces reported to Eurostat is allocated to CRF 1A2a. In the data reported to UNFCCC, this is considered to be non-energy use of fuels and is not reported in CRF 1. In data reported to Eurostat, large amounts of coke oven coke are reported in the sector “Iron & Steel industry” which is linked to CRF 1A2a according to the mapping made in EU ESD review. The rest of the coke used in the Iron and steel industry is reported under final energy consumption of Iron and steel industry.

Blast furnaces are an integral part of Iron and steel industry, since the purpose of them is to reduce iron oxides to pig iron. Blast furnace gas is a side product, and because it has calorific value and is used as a source of energy it is necessary to have blast furnaces in the transformation sector, although there is not a NACE code for blast furnaces. In physical terms it is not possible to separate fuel input into the (virtual) conversion process and iron oxide reduction process. According to Eurostat methodology for energy balances the coke oven coke input into blast furnaces is calculated as blast furnace gas production divided by 28.5. In doing this it is assumed that blast furnaces have 100% conversion efficiency. The rest of the coke reported from the primary iron and steel facilities is allocated under final energy consumption of Iron and steel industry.

The differences between the datasets/graphs *UNFCCC_SA_total*, *Eurostat_SA*, *Eurostat_RA* and *UNFCCC_RA* (Figure 3) are most likely due to use of different calorific values and conversion factors between coke oven coke and derived gases. In later years, Eurostat RA and UNFCCC SA, total, are very similar. As mentioned earlier, when something is changed in the UNFCCC SA calculations, the whole time series is revised. This is not the case with Eurostat data. In Eurostat SA, some coke is reported that is calculated from produced amounts of blast furnace gas. This coke is not reported in any of the other three datasets (UNFCCC SA, UNFCCC RA or Eurostat RA). In both RA datasets, the original coking coal is reported and none of the coke oven coke or derived gases (exports, imports and stock change of coke oven coke is reported, but not the coke oven coke produced in Sweden as that would imply double counting). In UNFCCC SA, no coking coal or coke oven coke is reported but only the combustion of the resulting derived gases. A large share of these gases is allocated to CRF 2, and a very small amount to CRF 1B1c (flaring at coke oven plants).

6.1.1.2 Peat

The coherence for peat is generally quite good, however, for 2011 there are quite large differences for CRF 1A1a and CRF 1A2. The main data source in both UNFCCC and Eurostat data is quarterly fuel statistics. To UNFCCC, the amounts of energy are calculated with the individual calorific values reported to the survey by the respondents and then summarized by CRF code. In the data reported to Eurostat, data in toe is converted to tonnes with a standard factor. In addition, the quantities reported to Eurostat are sometimes adjusted with data from the annual energy statistics (Swedish Energy Agency, 2013a). Finally, Eurostat calculates toe and TJ from the quantities reported in tonnes.

6.1.1.3 Chemical industry (1A2c)

The differences for peat are quite large, but entirely caused by differences in calorific values. Eurostat uses a calorific value around 10.8 GJ/tonne, while the calorific values reported to the quarterly fuel statistics in this sector, which are used in UNFCCC data, are around 8.3 GJ/tonne. In 2009-2011, the difference for peat in the chemical industry is around 70 TJ annually.

Coke burned for carbide production is included in CRF 1A2c in UNFCCC data, but most of the coke used in the chemical industries is considered as feedstock. In Eurostat data, all coke used in the chemical industry is reported as feedstock.

6.1.1.4 Non-ferrous metal industry (1A2b)

In Eurostat data, consumption of coke is reported in this sector. In UNFCCC, the emissions from use of the corresponding amounts of coke in industrial processes are allocated to CRF 2, which means that fuel consumption is not reported.

6.1.1.5 Service and residential (1A4a and 1A4b)

In the Eurostat dataset, the amounts of fuels reported as solid in these sectors include only gas works gas. In the Swedish reporting to UNFCCC, gas works gas is allocated to liquid fuels as it is produced from naphtha or LNG. Hence, solid fuels are reported as not occurring. Gas works gas is used in quite small quantities and the differences between Eurostat data and UNFCCC data are small except for 2007. In the data reported to UNFCCC, a calorific value of 16.75 GJ/1000 m^3 is used.

6.1.1.6 Other solid fuels

In data reported to UNFCCC, some non-standard fuels such as e.g. rubber waste are coded as solid fuels. These types of fuels are used mainly in CRF 1A1a and 1A2f. No such fuels are reported to Eurostat.

6.1.2 Liquid fuels

On an aggregate level, consumption of liquid fuels is systematically lower in Eurostat data than in UNFCCC data (

Figure 4). This applies to both domestic consumption and bunkers. For the years 2006-2010, Eurostat data on domestic consumption is 6-8% lower than UNFCCC data. In 2005 and 2011, the difference is about 3%. For bunkers, the difference is around -5% except for 2007 (Eurostat data 10% lower) and 2011 (Eurostat data 13% lower). For 2011, data on marine bunkers of gas/diesel oil seems to be missing/not reported to Eurostat.

Figure 4. Liquid fuels. Total domestic and bunker fuels.

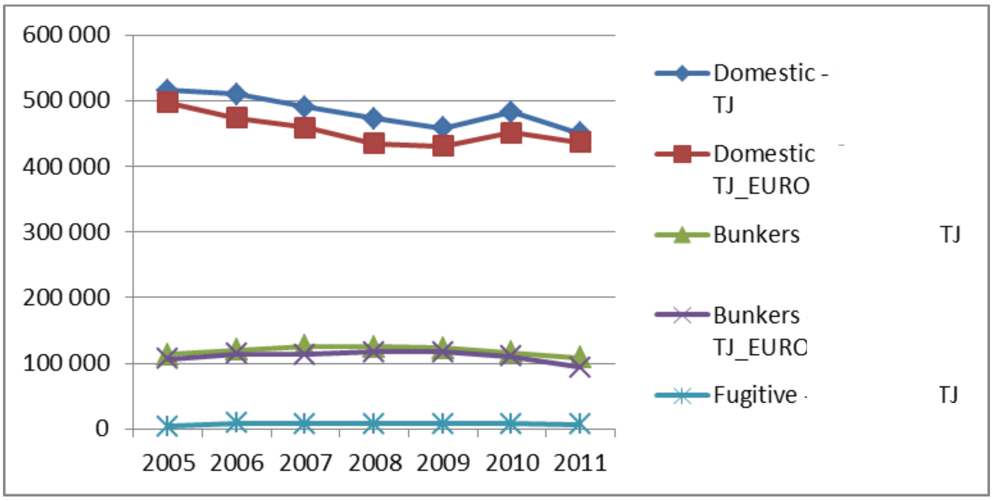


Table 2 shows the aggregate differences for domestic and bunker liquid fuels by fuel type 2011. The largest differences are found for refinery gas, gas/diesel oil, LPG, residual fuel oil and jet kerosene.

Table 2. Aggregate differences for domestic and bunker liquid fuels by fuel type 2011.

Fuel type	**UNFCCC fuel combustion (TJ)**	**Eurostat fuel combustion (TJ)**	**Difference (TJ)**
Refinery Gas (not. Liquid)	52 230	26 235	-25 995
Gas/Diesel Oil (without biodiesel) (derived product)	210 619	221 726	11 107
LPG	22 833	15 134	-7 699
Residual Fuel Oil	101 454	97 240	-4 214
Kerosene Type Jet Fuel	40 897	38 055	-2 842
Petroleum Coke	3 660	960	-2 700
Other liquid fuels	1 313		-1 313
Motor gasoline (without biogasoline) (derived product)	131 738	130 835	-903
Lubricants		84	84
Other Kerosene	16	0	-16
Aviation Gasoline	117	132	15
Total	**564 876**	**530 401**	**-34 475**

6.1.2.1 Jet kerosene

Data reported to Eurostat is generally about 7% lower than UNFCCC data (2400-2900 TJ per year). Partly, this is explained by different calorific values. According to the Swedish Energy Agency, quantities reported to the monthly fuel statistics in m^3 are multiplied by 0.8 and then reported to Eurostat in 1000 tonnes. Eurostat uses a calorific value of 43 GJ/tonne corresponding to 34.4 GJ/m^3. The calorific value used in UNFCCC data is 35.28 GJ/m^3. This discrepancy explains 2.5% of the difference in TJ. To Eurostat, only civil jet kerosene consumption is reported. The jet kerosene reported in the military sector (1A5b) to UNFCCC explains the remaining difference in m^3 between the two data sources. Table 3 shows quantities of jet kerosene for civil consumption (domestic+bunkers) in m^3.

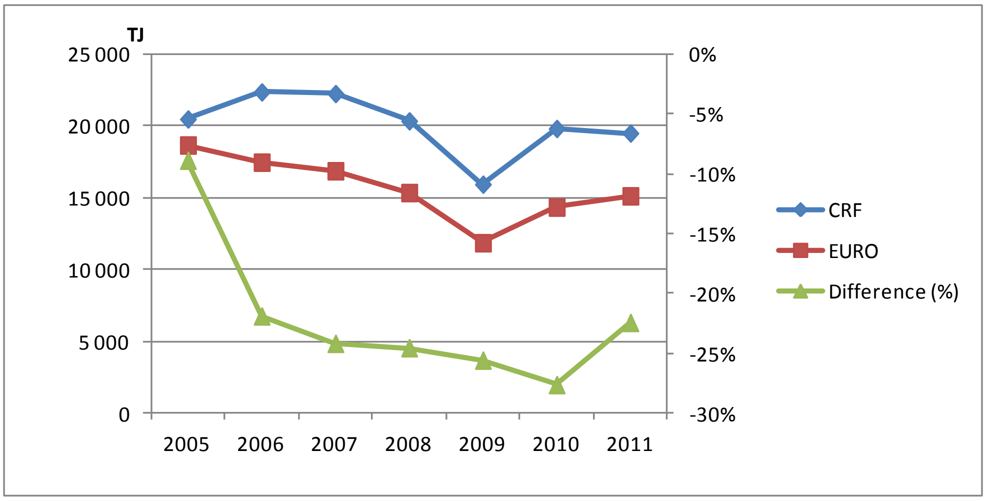
Table 3. Quantities of jet kerosene for civil consumption (domestic+bunkers)

Year	UNFCCC, m³	Eurostat, m³	Difference
2005	1 026 087	1 030 000	0.4%
2006	1 038 609	1 053 750	1.5%
2007	1 106 467	1 138 750	2.9%
2008	1 204 480	1 203 750	-0.1%
2009	1 020 094	1 040 000	2.0%
2010	1 022 708	1 022 500	0.0%
2011	1 106 490	1 106 250	0.0%

6.1.2.2 LPG

LPG, liquefied petroleum gas, includes propane and buthane. The aggregate consumption of LPG is systematically much higher in UNFCCC data than in Eurostat data, as shown in Figure 5.

Figure 5. LPG



According to Eurostat data, consumption of LPG is not occurring in the sectors 1A1b, 1A2c (until 2010) and 1A4a-c, or only used in very small quantities,. The largest absolute differences are found in CRF 1A4a, where the annual consumption of LPG is about 3000 TJ lower in Eurostat data (which explains most of the differences on the total level). The data sources for consumption used for UNFCCC data and Eurostat data, respectively are shown in

Table 4.

Table 4. Data sources for LPG

Sector	Eurostat data source	CRF data source
1A1a	Annual energy statistics (AREL)	Quarterly fuel statistics (KvBr)
1A2a-f	Quarterly fuel statistics (KvBr)	Quarterly fuel statistics (KvBr)
1A4a-b	Monthly fuel statistics: deliveries to state, municipalities, county councils, enterprises in public electricity and heat production+ deliveries to dwellings	Annual energy balances
1A4c	Monthly fuel statistics: deliveries to enterprises in agriculture, forestry and fisheries	Annual energy balances

According to Swedish energy agency, small quantities of LPG have been reported for 2011 in the categories corresponding to 1A4a and 1A4c. These quantities were not found in the datasets downloaded from Eurostat's database, which indicates an error somewhere.

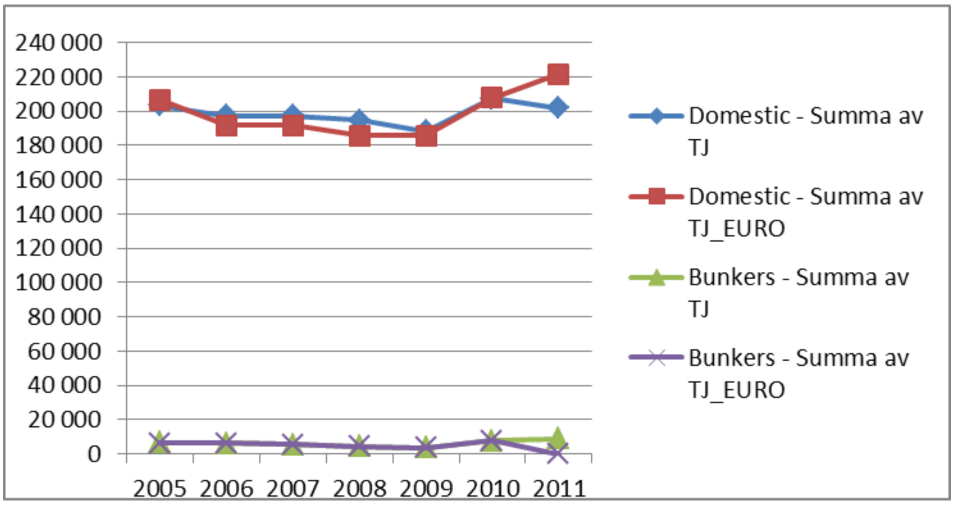
6.1.2.3 Gas/diesel oil

In Eurostat data, diesel oil and domestic heating oil are aggregated to "gas/diesel oil". In UNFCCC, these two fuels are treated separately. Consumption of diesel in different sectors is collected from various sources (model calculations, the national sectoral authorities responsible for providing data input to the Swedish greenhouse gas inventory, etc.) as described in NIR (National inventory report, Sweden, submission 2013). The amount of diesel consumed in sectors where the data is considered to be less exact is then adjusted so that the sum of diesel consumption in all sectors is equal to deliveries according to national statistics (Statistics Sweden, 2012).

On an aggregate level, the coherence between Eurostat data and UNFCCC data varies between years (

Figure 6). The difference is about the same regardless of if the amount of fuel is counted in 1000 tonnes or TJ, which means that the calorific values for gas/diesel oil used in UNFCCC and Eurostat data respectively are similar.

Figure 6. Total domestic consumption and bunkers of gas/diesel oil



For 2011, domestic consumption of diesel according to Eurostat data is 20 000 TJ higher than according to UNFCCC data, and no bunker diesel has been reported to Eurostat for 2011. As mentioned above, diesel quantities reported to UNFCCC are adjusted so that the total amount reported in the sectoral approach equals the total deliveries according to monthly fuel statistics. In the data reported to Eurostat, the monthly fuel statistics is used for some categories including road transportation, but for manufacturing industries, quarterly fuel statistics and the quarterly energy balances are used. The large difference in 2011 is most likely caused by a double counting in Eurostat data which is described below.

6.1.2.3.1 Road transportation

According to EM, data on diesel used for road transportation regarding 2011 reported to Eurostat is the sum of deliveries to own retailers, other retailers and consumers, minus deliveries to the military and the amount of FAME that is mixed in the diesel fuel. For earlier years, deliveries to agriculture, forestry and fishing, mining and manufacturing industries, public service, railways, domestic navigation, dwellings and premises were also deducted. Diesel consumption in these categories seems to have been double counted, i.e. included in both road transportation and the respective Eurostat sectors, in 2011 which explains the large differences for this year.

How consumption of diesel in road transportation is estimated in UNFCCC data is described in NIR Annex2, p.46ff. In short, data from the Swedish Transport Agency is used and then adjusted so that the total amount of diesel consumed in all sectors is consistent with total deliveries according to the monthly fuel statistics.

In the first step, the volume used for stationary combustion and the volume of FAME added is subtracted from the total deliveries. FAME is reported as biomass under CRF 1A3b.

For railways, information on diesel consumption to UNFCCC data is collected from the Swedish Transport Administration and for Military activities from the Swedish Armed Forces. This data is subtracted from the total deliveries of diesel in a second step. The consumption of diesel in off-road vehicles and other machinery (CRF 1A2f, 1A3e and 1A4b–c) is estimated by a model. This amount of diesel is also subtracted from the total deliveries in the second step. In the third and last step, the remaining amount of the total delivered diesel is allocated over subsectors where the estimated diesel consumption is more uncertain. These are fisheries, domestic navigation, and civil road transportation. The allocation is made proportionally to the estimated consumption of each subsector. The consumption estimates of each subsector are based on sources according to Table 5.

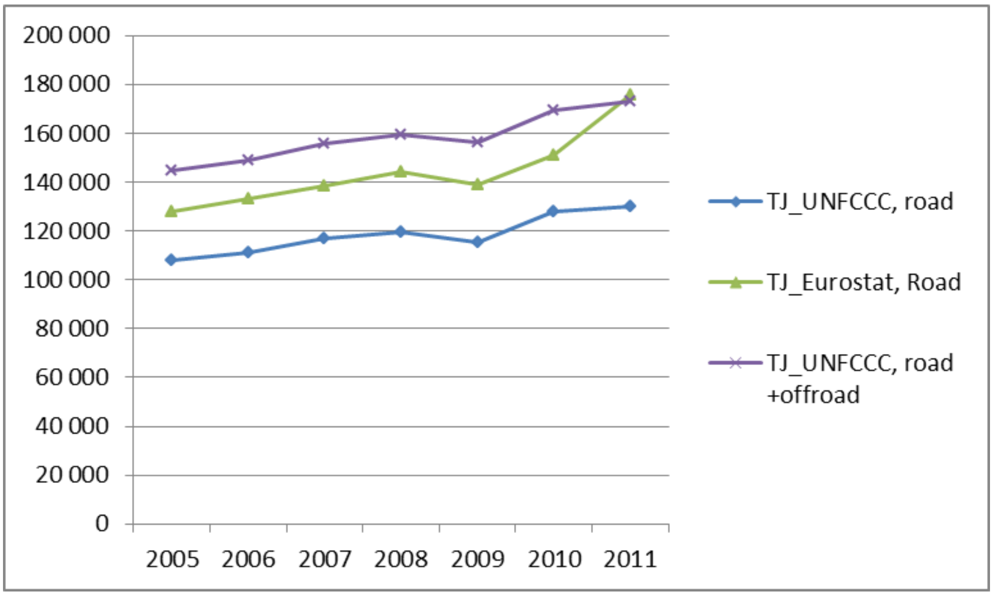
Table 5. UNFCCC, data sources for diesel consumption in “uncertain” sectors.

Sector	Data source
Fisheries (1A4c)	SMED report, 2005 & The Swedish Agency for Marine and Water Management (SwAM)
Domestic navigation (1A3d)	Statistics Sweden, EN31SM
Civil road traffic (1A3b)	HBEFA 3.1 road model provided by the Swedish Transport Administration.

In UNFCCC data used in this study, diesel consumption in road transportation is generally a few per cent higher than the estimates from HBEFA.

Diesel consumption in road transportation is about 20% higher according to Eurostat data (Except for 2011 where the double counting mentioned above causes a difference as large as 35%). The fuel consumption in off road vehicles and working machinery reported to UNFCCC is partly included in deliveries to “own retailers” and “other retailers” and partly in deliveries to agriculture and forestry and mining and manufacturing industries. In Eurostat data, fuels from “own retailers” and “other retailers” used by off-road vehicles are included in the fuel amounts reported for road transportation.

Figure 7. Diesel consumption in road transportation and offroad vehicles



6.1.2.3.2 Off-road vehicles and working machinery

In UNFCCC data, fuel consumption in off-road vehicles and working machinery is estimated by a complex model taking into account the number of vehicles, average motor effect, working hours, load, age etc. The aggregate fuel consumption is allocated over the CRF-codes 1A2f (Other industry and construction), 1A3e (Other mobile combustion), 1A4b (Households) and 1A4c (Agriculture and forestry).

In Eurostat data, fuel consumption in off-road vehicles and working machinery is included in the categories Machinery, Agriculture/Forestry and Service. However, stationary combustion of domestic heating oil and mobile combustion of diesel are not shown separately, which means that UNFCCC data and Eurostat data are not directly comparable.

6.1.2.4 Residual fuel oil

The main causes of differences are different data sources, different calorific values and sometimes different allocation principles. “Residual fuel oil” is not one specific fuel but a group of heating oils with different properties. According to EM (Swedish Energy Agency 2013), the average density for the group “Fuel oils no. 2-6” is 0.91 tonnes/m³ and the average calorific value is 38.10 GJ/m³ for this group. If UNFCCC data are converted from TJ to tonnes using these factors, the overall difference for domestic consumption excluding the “other sectors” (CRF 1A4), varies between -81 and +35 kton and is not systematic. The relative difference is between -8.5% and +3.7%. Probably, the differences are mainly caused by inter-annual variations in the relative amounts of different oils, whose properties are shown in Table 6. The data source is the Swedish Energy Agency, 2013b, which in turn refers to the Swedish Petroleum and Biofuel Institute (SPBI).

Table 6. Properties of residual fuel oils

Oil quality	Density, tonnes/m³	Calorific value, GJ/m³
Heating Oil No. 2, incl. WRD	0.88	37.44
Heating Oil No. 3	0.90	38.16
Heating Oil No. 4	0.92	38.16
Heating Oil No. 5	0.93	38.70
Heating Oil No. 6	0.98	40.50

For the “other sectors”, considerably larger quantities are reported to Eurostat than to UNFCCC, mainly in the Service sector (1A4a). In UNFCCC data, data for these sectors are from the energy balances. The main source for these items in the energy balances are the Energy statistics for dwellings and non-residential premises (Swedish Energy Agency, 2012). In Eurostat data, the monthly fuel statistics is the data source. Deliveries to one- and two-dwellings and multi dwellings are reported in the residential sector, deliveries to agriculture, forestry and fisheries are reported under Agriculture/Forestry, and deliveries to state, municipalities, county councils, companies in the electricity and heat sector and to unspecified residential dwellings are reported under Commercial and Public Services.

For domestic navigation, the coherence is very good when data in 1000 tonnes are compared, except for 2009-2010 when there is a large jump in Eurostat data. The difference in other years when data is compared in TJ, around 6-8%, is due to differences in calorific values. The same explanation is valid for bunker fuels/international navigation, where Eurostat data is systematically 7% lower when counted in TJ. The calorific value used for both domestic and international navigation in the UNFCCC data is 39.53 GJ/m³ (from Cooper & Gustafsson, 2004). This indicates that heating oils 5 and 6 are most frequently used, which would mean that the average density should be between 0.93 and 0.98. If a density of 0.95 tonnes/m³ is assumed, the calorific value of 39.53 GJ/m³ corresponds to 41.61 GJ/tonne. Eurostat uses the value 40.00 GJ/ tonne.

6.1.2.5 Motor gasoline

The difference between Eurostat and UNFCCC data on a total level is negligible (less than one percent) and seems to be caused by rounding errors in conversions between different units. In Eurostat data, all motor gasoline is allocated to road transportation. In UNFCCC data, minor amounts are allocated to 1A3d (leisure boats), 1A5a (military), and 1A2f, 1A3e, 1A4b and 1A4c (working machinery). The amount of motor gasoline allocated to road transportation is adjusted so that the sum of all categories equals total deliveries according to the monthly fuel statistics.

6.1.2.6 Refinery gas

The differences for refinery gas in CRF 1A1b, petroleum refineries, are large. The data reported to Eurostat is based on the monthly fuel statistics survey, and some of the refineries do not report production and use of refinery gas to this survey (although they are included in the survey and report consumption, production etc. of other liquid fuels). The quantities are reported in tonnes and Eurostat uses the default NCV 49.5 GJ/tonne. The data reported to UNFCCC includes all five refineries in Sweden. Plant specific calorific values are used. The fuel consumption is reported in tonnes for some plants and m³ for others. In some cases, calorific values are not reported and values from environmental reports and/or other refineries are used. Most calorific values are in the range 45-50 GJ/tonne, but some are considerably lower, around 27 GJ/tonne. The conclusion is that data reported to UNFCCC is more complete than data reported to Eurostat, and that calorific values for this fuel are very variable and sometimes difficult to obtain. If the same calorific value is used for all years in one data source (Eurostat) and facility- and year specific values are used in another, there will inevitably be differences.

6.1.2.7 Petroleum coke

Petroleum coke used in refineries is reported in CRF 1.B.2.A.iv in the Swedish GHG inventory. This means that it is not included in the mapping of UNFCCC data vs Eurostat data made in the EU ESD review. In the Eurostat dataset, petroleum coke used in refineries is allocated to CRF 1A1b in the mapping. The amounts of petroleum coke combusted in refineries reported in CRF data are from environmental reports and/or EU ETS data and are systematically higher than the amounts reported in Eurostat data.

6.1.2.8 Liquid fuels in the petrochemical industry

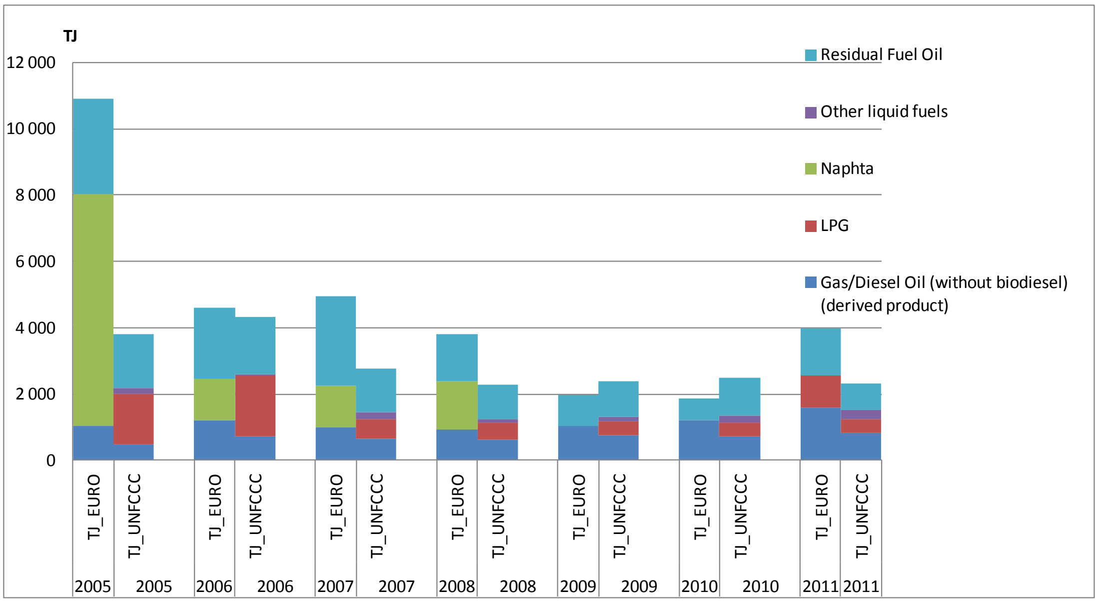
In the petrochemical industry plants, LPG, naphtha and ethane are used for production of heating oils and refinery feedstocks. The production processes also generate large amounts of gaseous by-products, which are combusted on site or used by adjacent chemical industry plants for heat production. Because of the different purposes with the Eurostat and UNFCCC data respectively, the fuels are reported in different ways. In Eurostat data, the LPG, naphtha and ethane in the petrochemical industry are reported as non-energy use of fuels. The combustion of by-products from the processes is not reported. In the sectoral approach reported to UNFCCC, combustion of fuels with the purpose of energy generation should be reported in CRF 1A. Hence, the by-products that are combusted for heat generation are reported under 1A2c, i.e. energy production within the chemical industry. These derived products are not included in the Eurostat data since the raw materials (LPG etc.) are reported as non-energy use.

The quantities are not comparable, since the by-products combusted and reported in UNFCCC data represents only a fraction of the total energy content in the feed stocks (LPG etc.) Most of the energy is transferred to the products, e.g. heating oils, which are used and thus reported in other sectors.

In both UNFCCC data and Eurostat data, the data for the chemical industry is compiled from several data sources. Apart from the issue with feed stock and by products described above, this also means that it is difficult to find the reasons behind differences per fuel type. The differences are not systematic and vary between years. In

Figure 8, all liquid fuels reported for the chemical industry are shown except the feedstocks / derived gases discussed above.

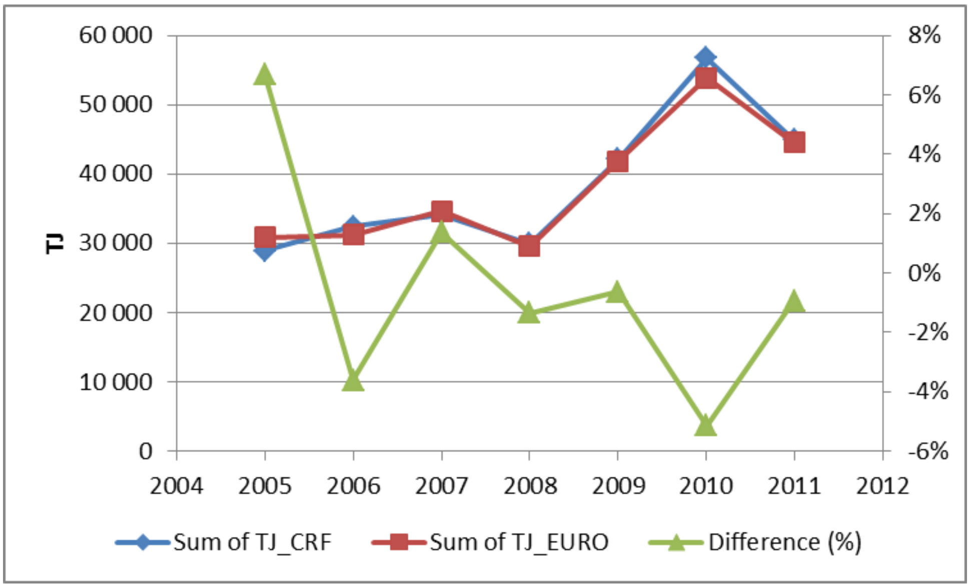
Figure 8. Liquid fuels in the chemical industry except feedstocks and derived gases.



6.1.3 Gaseous fuels

Figure 9 shows the gaseous fuel consumption (TJ) 2005-2011 based on Eurostat data and UNFCCC data (CRF), and the differences between the two data sources. The differences (green legend) are significant only for 2005 and 2010. However, detailed information by source category also shows that there are systematic and significant differences in electricity and heat production sector (CRF 1A1a), chemical industry (1A2c), other industry (1A2f) and the Other sector (CRF 1A4) for several years.

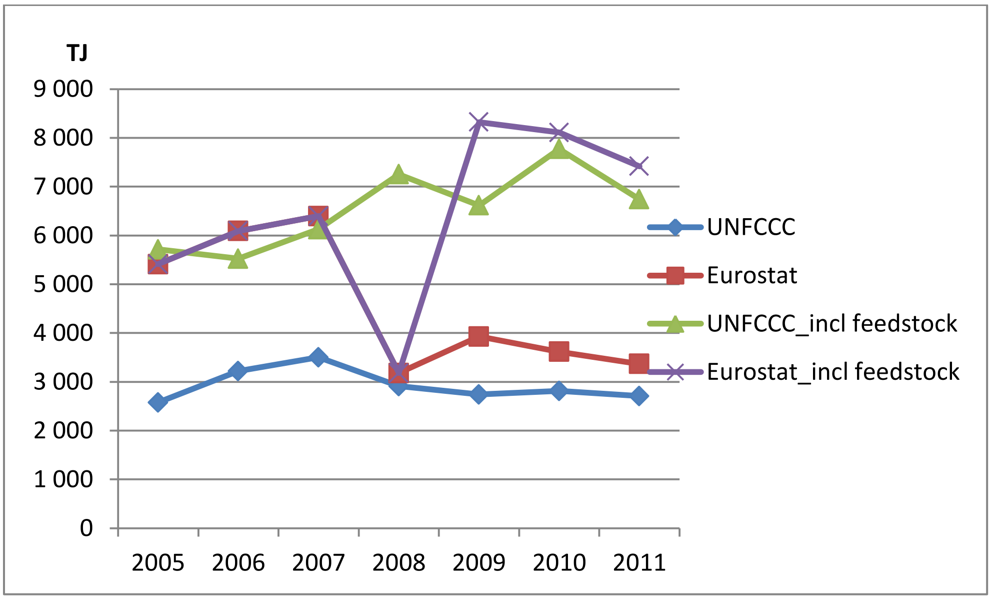
Figure 9. Gaseous fuel consumption (TJ) 2005-2011 based on Eurostat data and UNFCCC data (CRF)



In the electricity and heat production sector, 1A1a (corresponding to Eurostat sectors ”Main Activity Producer CHP Plants” and ”Main Activity Producer Heat Only Plants”), Quarterly fuel statistics (KvBr) is the data source in UNFCCC data and Annual energy balances are used in Eurostat data. The data source for this item in the annual energy balance is the annual energy statistics (Electricity supply, district heating and supply of natural and gasworks gas, “AREL”). Generally, the consumption of natural gas for electricity and heat production is higher according to KvBr than to AREL. A comparison of AREL and KvBr was made in an earlier SMED study (Eklund & Kanlén, 2011). The difference was noted, but it was not possible to determine which, if any, of the two data sources that was most accurate.

In the chemical industry (1A2c), natural gas is partly used for non-energy purposes, i.e. as feedstock. For the UNFCCC reporting, the allocation of natural gas as fuel consumption and non-energy use of fuel has been revised for two major facilities (Gustafsson et al, 2010), causing discrepancies between the two data sources.

Figure 10. Gaseous fuel consumption (TJ) 2005-2011 based on Eurostat data and UNFCCC data (CRF). Chemical industry with/without non-energy use



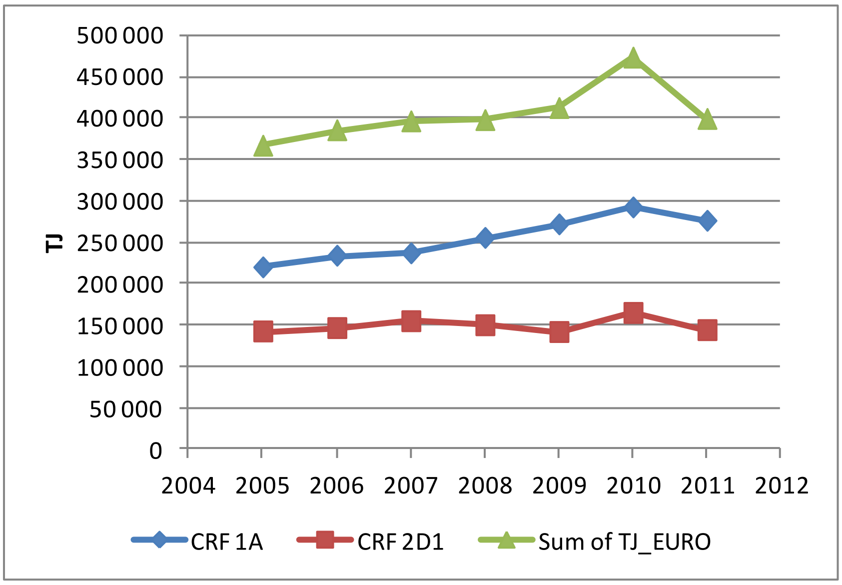
In Figure 10, all non-energy use, not only in chemical industries, is included but non-energy use in other industries than chemical is negligible. It is obvious that in Eurostat data, both energy and non-energy use was reported as energy use in 2007 and earlier. In 2008, non-energy use of natural gas seems not to have been reported to Eurostat. In 2009-2011, both energy- and non-energy use is much higher (5-10% or more) according to Eurostat. The

differences in calorific values are less than 0.5%. The cause of the difference is that in UNFCCC data, EU ETS data is used as a data source for a couple of facilities combusting by-products from the processes (see Liquid fuels in the petrochemical industry). These by-products are reported as liquid fuels. However, they may contain natural gas. This natural gas is not possible to separate from the liquid fraction, and hence there is probably a difference compared to Eurostat data. For other manufacturing industries, CRF 1A2f, the difference is not systematic. For 2010-2011, the coherence is good for most sub categories but there are a few exceptions. The Eurostat sector “Autoproducer CHP plants” was linked to CRF 1A2f in the EU ESD review, but might include plants that are reported in another sub-category of CRF 1A2 in the UNFCCC data. Another systematic difference is found in the construction sector, where about 400-500 TJ per year are reported in the annual energy balances and thus also in UNFCCC data. In Eurostat data, only about
15-18 TJ per year is reported in the construction sector.

6.1.4 Biomass

The ESD review showed that there were obvious differences between the biomass fuel consumption in Eurostat data and the UNFCCC data. Figure 11 shows the biomass fuel consumption based on Eurostat (green) and UNFCCC (blue). In Sweden, large amounts of black liquor are used in the pulp and paper industry. In the Swedish inventory reported to the UNFCCC, black liquor is considered used for non-energy purposed and thus reported under CRF 2D1 industrial processes in pulp and paper industries (red).

Figure 11. Biomass consumption.

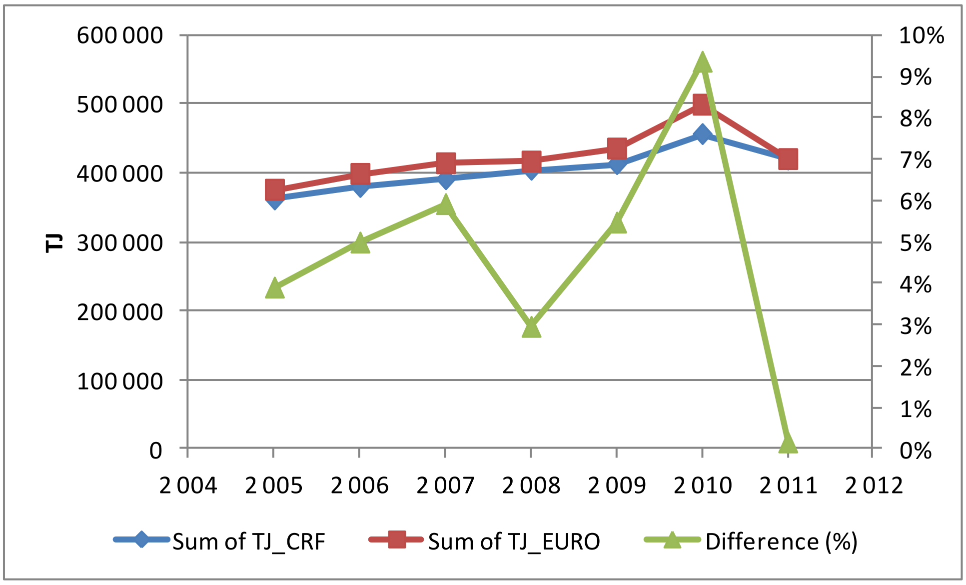


Including black liquor with biomass fuel consumed in CRF 1A (Figure 12) gives better coherence with the Eurostat data. Only for 2010, there are major discrepancies.

Per CRF code, the time series in Eurostat data are not consistent. The largest differences occur in CRF 1A1a, CRF 1A2d+1A2f (black liquor included), CRF 1A3b and CRF 1A4b. In CRF 1A1a, 1A2d and 1A2f (including black liquor in CRF 2 shown in Figure 12), the source for UNFCCC data is quarterly fuel statistics. In Eurostat data, quarterly fuel statistics (KvBr) is used for manufacturing industries (corresponding to CRF 1A2) excluding autoproducers, whereas the annual energy statistics (AREL) is used for CRF 1A1a and autoproducers. As concluded in (Eklund & Kanlén 2011), there are differences between AREL and KvBr in terms of population and scope, and thus a compilation of these two data sources is not consistent with data based solely on KvBr.

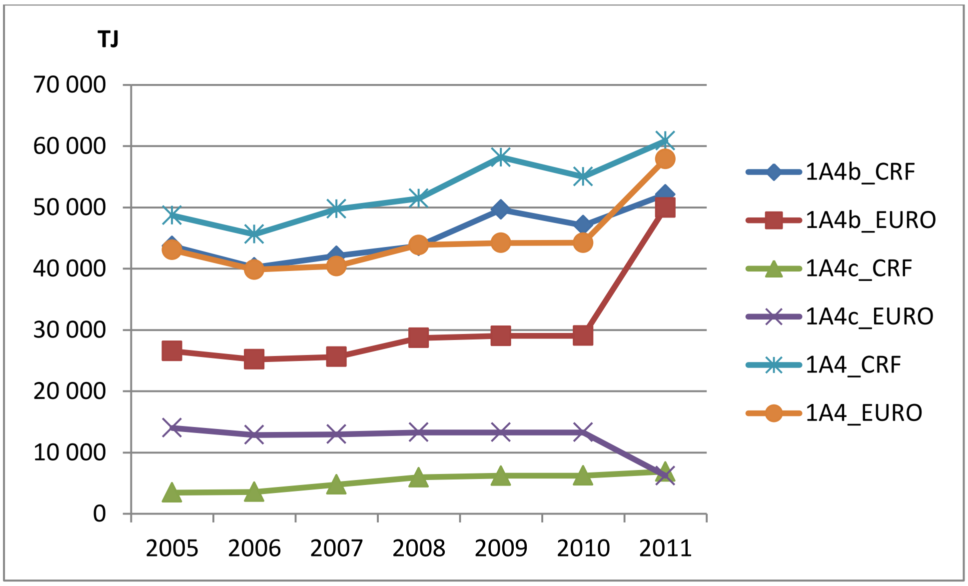
Biomass consumption in road transportation, 1A3b, is systematically slightly lower in Eurostat data, probably because of differences in calorific values. The data sources are the same; monthly fuel statistics and deliveries of motor fuel gas.

Figure 12. Biomass consumption. Black liquor reported in CRF 2 included.



Biomass consumption in the other sectors, CRF 1A4, is systematically higher in UNFCCC data than in Eurostat data. In 2011, the difference is much smaller, which indicates that the data reported to Eurostat for years prior to 2011 are not complete for these sectors. The data source for UNFCCC data is annual energy balances (For 2011, a preliminary estimate based on the trend from the quarterly balances is used). The data source for Eurostat data is energy statistics for one-and-two-dwellings, multi-dwellings and premises (Swedish Energy Agency, 2012), and an intermittent survey on fuel consumption in leisure houses (Swedish Energy Agency / Statistics Sweden, 2002). These surveys are the basis for the energy balances for these consumer categories, but complementary calculations for covering data gaps are added in the energy balances. Biomass consumption in the other sectors, CRF 1A4, is shown in figure 13. Biomass consumption in CRF 1A4a, services, is small and not shown separately but included in the aggregates 1A4.

Figure 13. Biomass consumption in other sectors (CRF 1A4).



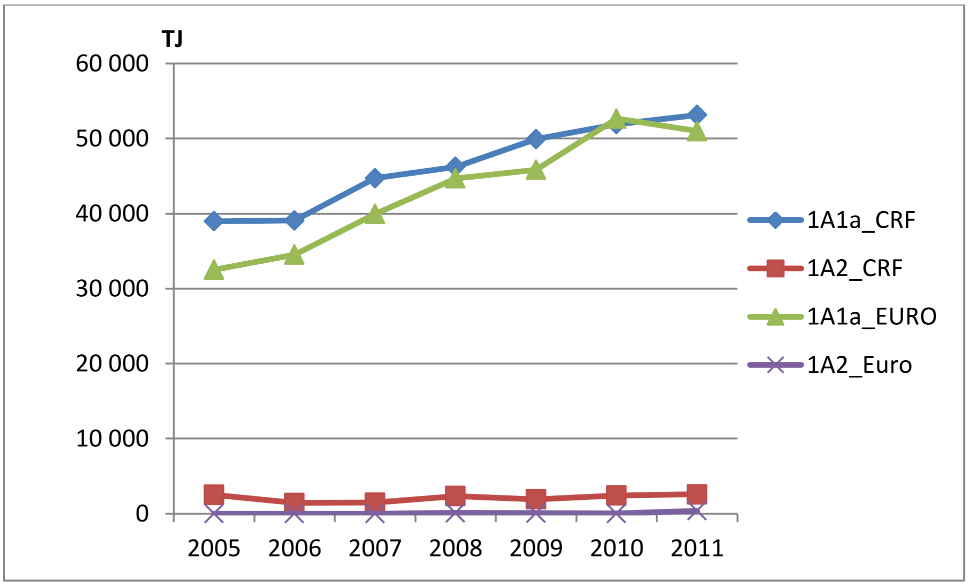
6.1.5 Other fuels

ESD showed that consumption of other fuels is systematically much higher in UNFCCC data than in Eurostat data. In UNFCCC data, quarterly fuel statistics (KvBr) is the data source. The category “other fuels” includes solid waste (municipal + industrial) and other mixed fuels such as production reject, sludge, rubber waste, mixtures of plastic and paper etc. In Eurostat data, the source is annual energy statistics (AREL). The fuels coded as “other fuels” are municipal waste (renewable), municipal waste (non-renewable), and industrial waste. Because of the different classification, there might be some differences in the allocation of fuels to “other” and biomass, respectively. Another reason is the differences between AREL and KvBr as mentioned earlier. The coherence between Eurostat and CRF data is slightly better in recent years.

Table 7. Other fuels

Year	Total CRF	Total Euro	Difference, TJ	Difference, %
2005	41 499	32 520	-8 979	-22%
2006	40 508	34 524	-5 984	-15%
2007	46 189	39 946	-6 243	-14%
2008	48 565	44 781	-3 784	-8%
2009	51 826	45 893	-5 933	-11%
2010	54 331	52 668	-1 663	-3%
2011	55 726	51 369	-4 357	-8%

Figure 14. Other fuels, CRF 1A1a and 1A2.



As shown in table 6 and figure 14, the total consumption of “other” fuels is 40-50 PJ annually and the consumption is about 3-10% higher according to UNFCCC data than Eurostat data. No obvious errors have been found in either of the data sources.

6.2 Reference approach

As mentioned above, the concepts of “sectoral” and “reference” approach are not used by Eurostat. However, the Eurostat sector “gross inland consumption” is calculated in exactly the same way as “apparent consumption” according to UNFCCC, i.e. Primary production + imports – exports - stock change.

6.2.1 Solid fuels

Table 8 shows the comparison of data for solid fuels from the EU ESD review for the UNFCCC reference approach and the gross inland consumption 2010.

Table 8. Solid fuels from the EU ESD review for the UNFCCC reference approach and the gross inland consumption 2010.

Solid fuel type	Eurostat (TJ)	UNFCCC (TJ)	Difference (TJ)
coking coal	56 040	50 828	-5 212
coke oven/gas coke	6 470	5 498	-972
other solid	766	- -	-766
peat	14 686	14 002	-684
other bituminous coal	27 153	26 969	-184
Total solid	**105 114**	**97 297**	**-7 817**

Most differences between UNFCCC data and Eurostat data in reference approach, solid fuels, are systematic and due to use of different calorific values, especially for coking coal (Table 9). The data sources are the same, but a few differences not related to calorific values were discovered. Original data was checked and a few errors in UNFCCC data regarding peat were discovered and will be corrected in submission 2014.

Another systematic difference is that in UNFCCC data, BKB and patent fuels are assumed to be reported together with peat (if occurring at all). Consumption of BKB and patent fuels in Sweden is extremely small and according to Eurostat data not occurring since 2007 (imports and exports reported for 2008).

Table 9. Calorific values used in Reference approach, solid fuels

Fuel	Calorific values, TJ/1000 tonnes	
	Eurostat	UNFCCC
Coking Coal	30.00	27.21
Other Bituminous Coal	27.41	27.21
Coke Oven Coke	28.50	28.05
BKB/PB	20.00	-
Peat	Production: 12.50 Imports: 12.94	11.48

The calorific values for Eurostat in the table above have been calculated implicitly from Eurostat data in TJ and 1000 tonnes. Mostly, they are identical to those NCV:s reported to IEA, but for coke oven coke there is a difference (28.08 GJ/tonne is reported to IEA).

Solid fuels in 1000 tonnes according to Eurostat and UNFCCC data respectively are shown in Table 8. Note that stock change is defined with opposite signs in the two data sources.

Table 10. Reference approach , solid fuels, 1000 tonnes.

Fuel	Parameter	2009		2010		2011	
		CRF	Eurostat	CRF	Eurostat	CRF	Eurostat
Coking Coal	Production	0	0	0	0	0	0
Coking Coal	Imports	1 069	1069	2 258	2258	1 616	1 616
Coking Coal	Stock change	-371	371	390	-390	-17	17
Coking Coal	Exports	0	0	0	0	0	0
Coking Coal	Apparent consumption	1 440	1440	1 868	1868	1 633	1633
Other Bituminous Coal	Production	0	0	0	0	0	0
Other Bituminous Coal	Imports	829	829	1 027	1027	1 460	1460
Other Bituminous Coal	Stock change	-170	170	35	-35	49	-49
Other Bituminous Coal	Exports	6	6	1	1	1	1
Other Bituminous Coal	Apparent consumption	993	993	991	991	1 410	1410
Coke Oven/Gas Coke	Imports	146	146	247	247	214	214
Coke Oven/Gas Coke	Stock change	19	-19	19	13	89	-89
Coke Oven/Gas Coke	Exports	274	274	32	33	24	25
Coke Oven/Gas Coke	Apparent consumption	-147	-147	196	227	101	100
Peat	Production	814	702	855	797	556	736
Peat	Imports	435	435	365	365	360	360
Peat	Stock change	0	0	0	0	0	0
Peat	Exports	0	0	0	0	0	0
Peat	Apparent consumption	1 249	1137	1 220	1162	916	1096

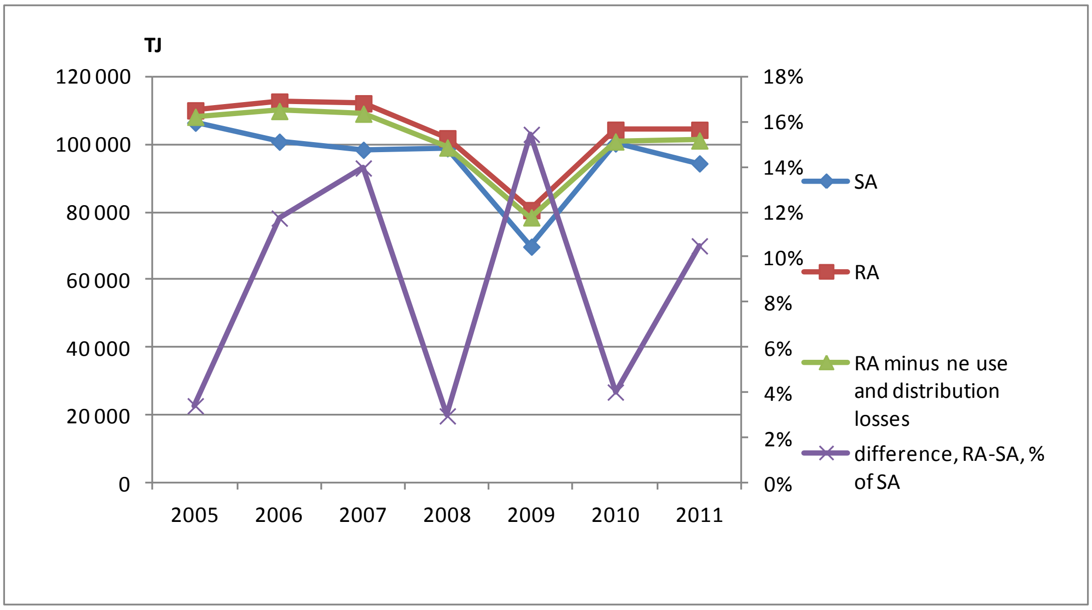
The differences for peat production are caused by the fact that data reported to Eurostat is adjusted to be coherent with the reported data on electricity production (which is not included in this study).

6.2.1.1 *Comparison with sectoral approach according to Eurostat data*

Gross inland consumption has been compared to the sum of all the Eurostat sectors that were mapped against CRF codes in the EU ESD review. Because imported fuels are transformed to e.g. derived gases before the final use, the comparison must be made on an aggregate level and in terms of energy, e.g. TJ, and not in physical units, except for peat. For peat, there is a difference because different calorific values are used for imports, production and end use in different sectors. Gas works gas has been excluded because it is produced from naphtha and natural gas and should thus not be considered as a solid fuel.

The comparison shows that the energy consumption as reported to Eurostat corresponding to the sectoral approach is systematically lower than gross inland consumption, i.e. “reference approach” (Figure 15).

Figure 15. Solid fuels according to Eurostat data, including peat



The difference in TJ excluding peat is in the range 3 000-14 000 TJ per year. Distribution losses, mainly flaring, is typically around 2 000 TJ per year. Non-energy use, which is coke oven coke used for carbide production, is around 500-800 TJ per year. As shown in Figure 3, there is still a difference for most years, sometimes large, between gross inland consumption minus transformation losses and non-energy use and “sectoral approach”. There are no obvious explanations to these differences. This indicates that there are large systematic gaps in the reporting of solid fuels to Eurostat.

6.2.2 Liquid fuels

On a total level, the differences in apparent consumption according to Eurostat data and UNFCCC data respectively are not systematic. The differences in recent years are between -5% and +5%. “Apparent consumption” in UNFCCC data corresponds to “Gross inland consumption” in Eurostat data. The largest differences in absolute quantities are found for the fuel group “other oil”, naphtha, residual fuel oil, gas/diesel oil and crude oil (Table 11). For crude oil, the relative differences are small for all parameters indicating minor differences in calorific values and/or rounding errors in conversions between different units. Data are reported to Eurostat in 1000 tonnes, while the input data for UNFCCC data is expressed in 1000 m^3. Both in Eurostat data and UNFCCC data the same calorific value for crude oil is used for all years, although the origin of the oil might change between years.

Table 11. Liquid fuels from the EU ESD review for the UNFCCC reference approach and the gross inland consumption 2010.

Liquid fuel type	Eurostat (TJ)	UNFCCC (TJ)	Difference (TJ)
other oil	44	21 987	21 944
naphta	12 408	-8 425	-20 833
residual fuel oil	-171 480	-181 069	-9 589
gas/diesel oil	-93 507	-101 664	-8 157
refinery feedstocks	-19 071	-23 858	-4 787
crude oil	842 686	845 766	3 080
petroleum coke	672	2 227	1 555
bitumen	-14 196	-12 854	1 342
lubricants	-11 718	-12 940	-1 222
gasoline	-10 604	-10 916	-312
ethane	16 533	16 834	301
jet kerosene	258	104	-154
liquefied petroleum gas (lpg)	26 634	26 709	75
other kerosene	-43	-35	9
Total liquid	**578 616**	**561 866**	**-16 749**

The fuels “other oil” and “naphtha” apparently include different fuels in Eurostat data than in UNFCCC data, but added together they represent almost the same fuels (some “naphtha” according to Eurostat is reported in “other oil” in UNFCCC data). Hence, these fuels were aggregated before the data analysis. The major findings for each fuel are listed in Table 8.

Table 12. Reference approach, liquid fuels. Comments/findings

Fuel	Comment
Bitumen	Systematically much higher imports according to UNFCCC data. This in turn leads to that non-energy consumption and apparent consumption are also higher in UNFCCC data.
Crude Oil	Generally good coherence. Differences in stock change 2006-2007. Export data for 2011 missing in UNFCCC data, which is however of minor importance since exports contribute only marginally to apparent consumption of crude oil.
Ethane	Eurostat data 2% lower due to lower calorific value (Eurostat: 49.5 TJ/tonne, UNFCCC: 50.4 TJ/tonne). Minor difference in stock change.

Gas/diesel oil	Good coherence for exports, imports and bunkers except for differences in calorific values which causes differences up to 2%. Large differences in stock change which causes considerable differences in apparent consumption.
Gasoline	Large differences in stock change which causes considerable differences in apparent consumption. Less than 1% differences for the other parameters.
Jet Kerosene	Bunkers seems to be included in ”Gross inland consumption”. Otherwise good coherence except for stock changes and the differences in calorific values described under Sectoral approach.
LPG	Good coherence.
Lubricants	Major decline in non-energy use 2009 and later according to Eurostat.
Napththa and ”Other oil”	Annual apparent consumption generally about 1000 TJ lower according to Eurostat, primarily because of higher exports and lower imports. Probably differences in calorific values, which is different to validate due to different reporting units and lack of information on conversion factors used in Eurostat data.
Other Kerosene	Negligible amounts. Relatively good coherence.
Petroleum Coke	All parameters much lower according to Eurostat.
Refinery Feedstocks	Eurostat data systematically 20% lower for all parameters. This is probably related to calorific values, but no information on conversion factors between tonnes and m³ is available so this conclusion has not been verified. It is, however, consistent with the findings of (Hedlund & Lidén, 2010).
Residual Fuel Oil	Large differences in stock change. Differences in other parameters are most likely caused by differences in calorific values as discussed under ”Sectoral approach”. Eurostat data about 5% lower.

As shown in table 8, one general cause of differences is data on stock change. These differences have not been investigated in this study due to lack of resources. However, as concluded in (Hedlund & Lidén, 2010) the data sources used for reporting to Eurostat/IEA and UNFCCC respectively are sometimes different, and some of these differences have not been harmonized since 2010.

No comparison between Eurostat RA and Eurostat SA has been made within this study due to lack of resources and the fact that the Swedish Energy Agency (EM) is responsible for all reporting of liquid fuels, which means that such a comparison should preferably be made by EM.

6.2.3 Gaseous fuels

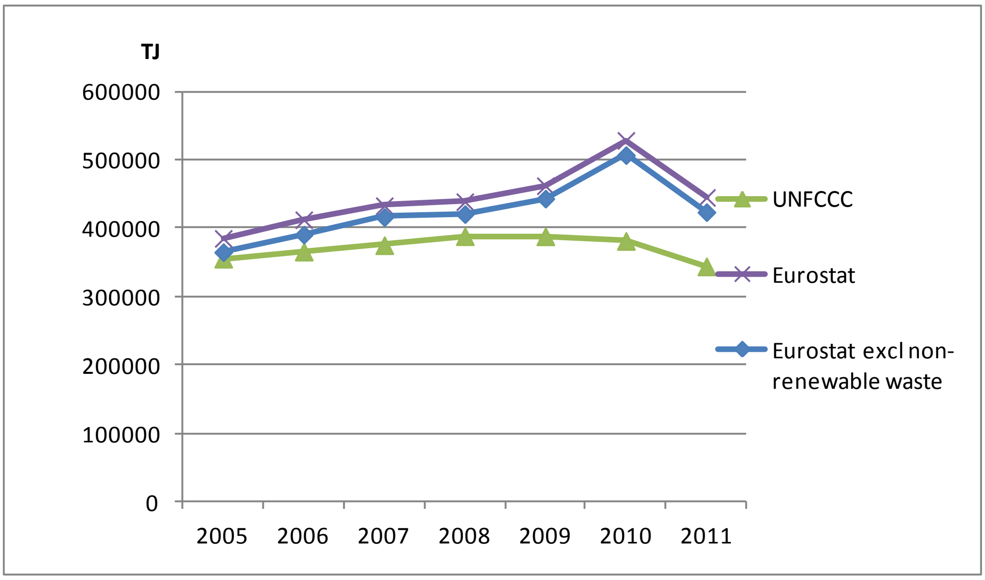
The differences are around 1% or less and are caused by slightly different calorific values. In UNFCCC data, annual average NCV:s are obtained from Swedegas. In Eurostat data, the value 39.56 TJ/Mm³ is used for all years.

6.2.4 Biomass

Apparent consumption of biomass is systematically much higher according to Eurostat than in UNFCCC data. In this study, it was noted that all of the fuel groups solid biomass, liquid biomass, gaseous biomass and other biomass showed very large differences, and thus it seems to be differences in the mapping made in the EU ESD review and the classification used in the Swedish greenhouse gas inventory. This also makes it difficult to isolate allocation differences from differences for specific fuels. It was noted that industrial wastes and non-renewable municipal waste was included in biomass in the EU ESD mapping. These fuels, however, only account for a small share of total biomass apparent consumption according to Eurostat data, reference approach.

In Eurostat data, no imports are reported, which means production equals gross inland consumption. In UNFCCC data, imports of liquid biomass are reported, which accounts for 1-2% of the consumption. Stock changes or exports are not reported in any of the datasets.

Figure 16. Biomass, reference approach. Apparent consumption.



The large jump in Eurostat data in 2010 is due to a large increase in wood and wood waste consumption. Total domestic consumption of biomass according to Eurostat RA, is systematically around 6% higher than according to Eurostat, SA. For UNFCCC data, the apparent consumption is systematically higher in SA than RA if the black liquor is included. This might indicate some problems in reporting of the RA parameters in both Eurostat and UNFCCC data.

7 Conclusions

7.1 Sectoral approach

Generally, the major causes of differences are:

- Different allocation principles due to different purposes and guidelines.
- Different data sources.
- Different calorific values.

The largest differences per fuel group are:

- Solid fuels
    - Coking coal, 1A2a
    - Coke oven coke, 1A2a
- Liquid fuels
    - Gas/diesel oil, 1A3b
    - Gas/diesel oil, 1A2f
    - Gas/diesel oil, 1A4a-c
    - Process by-products, 1A2c
    - Refinery gas, 1A1b
- Gaseous fuels
    - 1A1a
- Biomass
    - Black liquor not included in CRF 1 in UNFCCC data. Affects CRF 1A2d and 1A2f

7.1.1 Solid fuels

The major conclusion for solid fuels in the iron and steel industry is that because of the different purposes of the energy statistics reported to Eurostat and the activity data reported in the greenhouse gas inventory to UNFCCC and EU, these data are not directly comparable. This study has not revealed any errors in either Eurostat data or UNFCCC data for solid fuels in the iron and steel industry.

Another systematic difference is that different calorific values are used for peat. As the calorific values used in UNFCCC data are the ones reported by the consumers in CRF 1A1 and 1A2, UNFCCC data is concluded to be accurate in this respect.

In the EU ESD review, gas works gas used in CRF 1A4 was allocated to solid fuels which is not correct since the Swedish gas works gas, the feedstock is naphtha and natural gas (for 2011 and later only natural gas).

This study does not indicate that any corrections are needed in UNFCCC data, solid fuels, sectoral approach. No suspected errors have been found in Eurostat data.

7.1.2 Liquid fuels

The most important difference is the large discrepancy for gas/diesel oil used in road transportation. This study indicates a possible double counting in Eurostat data for 2011, which has the effect that the sum of diesel consumption in all sectors in 2011 is considerably higher according to Eurostat data. Apart from this suspected error, there are systematic differences. The reason is that off-road vehicles and working machinery are treated separately in the calculations for UNFCCC data. Hence, more diesel is allocated to CRF 1A2f, 1A4b and 1A4c, and less to 1A3b in UNFCCC data. Hence, the systematic differences for road traffic are caused by differences in reporting guidelines/manuals.

It was also noted that no marine bunkers of gas/diesel oil seems to have been reported to Eurostat for 2011.

Another large systematic difference is visible for the chemical industry, CRF 1A2c. The cause is the different principles for Eurostat and UNFCCC data, respectively. In Eurostat data, the raw materials used in the processes are reported under non-energy use of fuels, and hence not included in the mapping against sectoral approach in EU ESD. In UNFCCC data, however, the raw materials are not included in the sectoral approach. Instead, the combustion of the products (heating oils) and the gaseous by-products are reported in the respective CRF codes where they are combusted. Because of the large amounts of by-products combusted in the chemical industry, the difference for this CRF code is very large.

There are considerable differences for refinery gas in 1A1b. The reason is that refinery gas from only two of the five refineries is reported to Eurostat, while all five refineries report combustion of refinery gas to EU ETS, which is the data source for UNFCCC data.

A smaller, but still notable, systematic difference was found for jet kerosene where Eurostat uses a calorific value of 34.4 TJ/1000 m^3 which is considerably lower than the 35.28 TJ/1000m^3 used in UNFCCC data.

No errors found in UNFCCC data, liquid fuels, sectoral approach. In Eurostat data, suspected errors were found for 2011 regarding gas/diesel *oil in road transport (double counting of some consumer categories) and marine bunkers (no marine bunkers found in the Eurostat dataset 2011).*

7.1.3 Gaseous fuels

The largest differences were found in CRF 1A1a, due to different data sources used in Eurostat data and UNFCCC data, respectively. In UNFCCC data, the same data source is used for CRF 1A1a and CRF 1A2, which reduces the risk of data gaps and double counting. However, for a few plants in the chemical industry (1A2c), EU ETS data is used instead which might possibly lead to that some by-products containing natural gas are reported as 100% liquid fuel.

Another relatively large difference is found in CRF 1A2f, probably due to different allocation of autoproducers and different data sources for the construction sector (energy balances in UNFCCC data and monthly fuel statistics in Eurostat data).

No errors found in either UNFCCC data or Eurostat data.

7.1.4 Biomass

The main issue is that black liquor used in the pulp and paper industry is reported in CRF 2 in UNFCCC data. When black liquor is added to UNFCCC data for CRF 1A, the difference in biomass on an aggregate level is ± 5%. There are different allocation principles, so when the CRF categories 1A1a + 1A2d (including CRF 2) + 1A2f are aggregated, the differences in CRF 1A1 and 1A2 are relatively small. There are large differences in 1A4 in 2005-2010, but in 2011, there is a jump in Eurostat data that almost eliminates the difference for biomass, total, in 2011.

The allocation of black liquor in UNFCCC data will be reviewed in 2013. No errors found in either of the data sources, but for 1A4 the Eurostat time series seems less consistent than UNFCCC data. The coherence on total level, including black liquor, is very good 2011.

7.1.5 Other fuels

The total consumption of “other” fuels is 40-50 PJ annually and the consumption is about 3-10% higher according to UNFCCC data than Eurostat data. To define the difference between biomass and other fuels is sometimes difficult which is likely to cause differences.

No obvious errors have been found for other fuels in either of the data sources.

7.2 Reference approach

7.2.1 Solid fuels

When data in physical units (tonnes) is analysed, there are only some minor differences for peat. All other differences in energy (TJ) are caused by use of different calorific values. The accuracy of the respective calorific values has not been evaluated.

7.2.2 Liquid fuels

Generally, the largest differences are caused by different calorific values and different data on stock change. The largest differences in absolute quantities are found for “other oil”, naphtha, residual fuel oil, gas/diesel oil and crude oil. Because of the very large quantities of crude oil, even very small differences in calorific values give differences of many TJ although the relative differences, in per cent, are very small for this fuel. The accuracy of the calorific values has not been evaluated.

7.2.3 Gaseous fuels

Only minor differences due to differences in calorific values were found. The calorific values in UNFCCC data are updated annually with weighted annual mean values from the only supplier of natural gas, which means that they should be the most accurate ones.

7.2.4 Biomass

Apparent consumption of biomass is systematically higher according to Eurostat than UNFCCC. Biomass, reference approach, has not been prioritized in this study but it could be worth investigating in future studies because of the large fuel quantities and the increasing importance of biomass fuels.

7.3 Implications for the Swedish greenhouse gas inventory

No major errors in the Swedish greenhouse gas inventory were found in this study. However, the allocation of black liquor to CRF 2 will be reviewed in submission 2014 It would also be advisable to review the use of input data for biomass, reference approach, since the differences between RA and SA are large. A couple of small errors for peat 2006-2007 in the reference approach will be corrected in submission 2014.

The large discrepancy for liquid fuels used in the chemical industry (1A2c) was studied in detail and revealed no double counting. The difference is caused by the fact that the input material is reported as non-energy use in Eurostat data, and the combustion of the by-products is not reported. This does not mean that combustion of these by-products should not be reported in 1A2c. The allocation to 1A2c was thus found to be correct.

The differences for the transport sector described in this report are caused by different allocation principles and to some extent different calorific values. There are large differences for road transportation. The allocation of gas/diesel oil and motor gasoline in Eurostat data is based on data on deliveries to different consumer categories. In UNFCCC data, fuel consumption is calculated by the Swedish Transport administration and then adjusted so that the total consumption of gas/diesel oil and motor gasoline equals total deliveries according to monthly fuel statistics. Off-road vehicles and working machinery is a separate category, which is not the case in Eurostat data where some of the fuel consumption in such vehicles is most likely included in the road transport sector. The results of this study do not imply any need for change in the estimation of fuel consumption in the transport sector in UNFCCC data.

The calorific values for liquid fuels used in the Swedish inventory were revised in 2009 and are assumed to be correct.

The large differences for solid fuels in the iron and steel industry are due to different purposes and allocation principles. UNFCCC data and methods are regularly reviewed, but this study does not indicate any obvious need for corrections since data are essentially not comparable.

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Appendix 1A. List of mappings between Eurostat and CRF, Sectoral Approach

Eurostat nomenclature	**Eurostat code**	**CRF source category**	**CRF code**
Main Activity Producer Electricity Plants	B_101031	Public Electricity and Heat Production	1A1a
Main Activity Producer CHP Plants	B_101032	Public Electricity and Heat Production	1A1a
Main Activity Producer Heat Only Plants	B_101038	Public Electricity and Heat Production	1A1a
Own Use in Electricity, CHP and Heat Plants	B_101301	Public Electricity and Heat Production	1A1a
Oil refineries (Petroleum Refineries)	B_101307	Petroleum Refining	1A1b
Oil and Natural Gas extraction plants	B_101305	Manufacture of Solid Fuels and Other Energy Industries	1A1c
Coal Mines	B_101310	Manufacture of Solid Fuels and Other Energy Industries	1A1c
Patent fuel plants	B_101311	Manufacture of Solid Fuels and Other Energy Industries	1A1c
Coke Ovens	B_101312	Manufacture of Solid Fuels and Other Energy Industries	1A1c
BKB / PB Plants	B_101313	Manufacture of Solid Fuels and Other Energy Industries	1A1c
Gas works	B_101314	Manufacture of Solid Fuels and Other Energy Industries	1A1c
Coal	B_101316	Manufacture of Solid Fuels	1A1c

Liquefaction Plants		and Other Energy Industries	
Liquefaction (LNG) / regasification plants	B_101317	Manufacture of Solid Fuels and Other Energy Industries	1A1c
Gasification plants for biogas	B_101318	Manufacture of Solid Fuels and Other Energy Industries	1A1c
Gas-to-Liquids (GTL) Plants (Energy)	B_101319	Manufacture of Solid Fuels and Other Energy Industries	1A1c
Non-specified (Energy)	B_101320	Manufacture of Solid Fuels and Other Energy Industries	1A1c
Charcoal production plants (Energy)	B_101321	Manufacture of Solid Fuels and Other Energy Industries	1A1c
Blast Furnaces	B_101315	Iron and Steel	1A2a
Iron & steel industry	B_101805	Iron and Steel	1A2a
Non-ferrous metal industry	B_101810	Non-Ferrous Metals	1A2b
Chemical and Petrochemical industry	B_101815	Chemical	1A2c
Paper, Pulp and Print	B_101840	Pulp, Paper and Print	1A2d
Food and Tabasco	B_101830	Food Processing, Beverages and Tobacco	1A2e
Autoproducer Electricity Plants	B_101034	Manufacturing Industries: Other	1A2f
Autoproducer CHP Plants	B_101035	Manufacturing Industries: Other	1A2f
Autoproducer Heat Only	B_101039	Manufacturing Industries: Other	1A2f

Plants			
Non-metallic Minerals (Glass, pottery & building mat. Industry)	B_101820	Manufacturing Industries: Other	1A2f
Transport Equipment	B_101846	Manufacturing Industries: Other	1A2f
Machinery	B_101847	Manufacturing Industries: Other	1A2f
Mining and Quarrying	B_101825	Manufacturing Industries: Other	1A2f
Wood and Wood Products	B_101851	Manufacturing Industries: Other	1A2f
Construction	B_101852	Manufacturing Industries: Other	1A2f
Textile and Leather	B_101835	Manufacturing Industries: Other	1A2f
Non-specified (Industry)	B_101853	Manufacturing Industries: Other	1A2f
Domestic aviation	B_101932	Civil Aviation	1A3a
Road	B_101920	Road Transportation	1A3b
Rail	B_101910	Railways	1A3c
Domestic Navigation	B_101940	Navigation	1A3d
Pipeline transport	B_101945	Other Transportation	1A3e
Non-specified (Transport)	B_101950	Other Transportation	1A3e
Services	B_102035	Other Sectors: Commercial/Institutional	1A4a
Residential	B_102010	Other Sectors: Residential	1A4b
Agriculture / Forestry	B_102030	Other Sectors: Agriculture/Forstry/Fisheries	1A4c
Fishing	B_102020	Other Sectors: Agriculture/Forstry/Fisheries	1A4c

Non-specified (Other)	B_102040	Other	1A5
International aviation	B_101931	International bunkers: aviation	1C1a
Bunkers	B_100800	International bunkers: marine	1C1b

Appendix 1B. List of mappings between Eurostat and CRF, Reference Approach

Eurostat nomenclature	**Eurostat code**	**CRF reference approach**
Patent Fuel	2112	BKB and Patent Fuel
Anthracite	2115	Anthracite
Coking Coal	2116	Coking Coal
Other Bituminous Coal	2117	Other Bituminous Coal
Sub-bituminous Coal	2118	Sub-bituminous Coal
Coke (derived product)	2120	Coke Oven/Gas Coke
Coke Oven Coke	2121	Coke Oven/Gas Coke
Gas Coke	2122	Coke Oven/Gas Coke
Coal Tar	2130	Other Solid Fossil
Lignite/Brown Coal	2210	Lignite
BKB/PB	2230	BKB and Patent Fuel
Peat	2310	Peat
Crude Oil without NGL	3105	Crude oil
Natural Gas Liquids (NGL)	3106	Natural Gas Liquids
Refinery Feedstocks	3191	Refinery Feedstocks
Refinery Gas (not. Liquid)	3214	Other Oil
Ethane	3215	Ethane
LPG	3220	Liquefied Petroleum Gas
Motor	3234	Gasoline

gasoline (without biogasoline) (derived product)		
Aviation Gasoline	3235	Gasoline
Kerosenes & Jet fuels (derived product)	3240	Jet kerosene
Other Kerosene	3244	Jet kerosene
Gasoline Type Jet Fuel	3246	Jet kerosene
Kerosene Type Jet Fuel	3247	Jet kerosene
Naphta	3250	Naphta
Gas/Diesel Oil (without biodiesel) (derived product)	3260	Gas / Diesel Oil
Transport Diesel (derived product)	3265	Gas / Diesel Oil
Heating and other Gasoil	3266	Gas / Diesel Oil
Residual Fuel Oil	3270A	Residual Fuel Oil
White Spirit and SBP	3281	Other Oil
Lubricants	3282	Lubricants
Bitumen	3283	Bitumen
Petroleum Coke	3285	Petroleum Coke

Paraffin Waxes	3286	Other Oil
Other Oil Products	3295	Other Oil
Natural gas in TJ (GCV)	4100	Natural Gas
Wood & Wood Waste	5541	Solid Biomass
Biogas (derived product)	5542	Gas Biomass
Landfill Gas	55421	Gas Biomass
Sewage Sludge Gas	55422	Gas Biomass
Other Biogas	55423	Gas Biomass
Municipal wastes (renewable)	55431	Solid Biomass
Charcoal	5544	Solid Biomass
Liquid biofuels (derived product)	5545	Liquid Biomass
Biogasoline (derived product)	5546	Liquid Biomass
Biodiesels (derived product)	5547	Liquid Biomass
Other liquid biofuels	5548	Liquid Biomass