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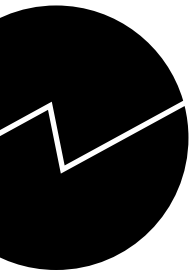

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CO_2 Emission Estimates for Norway. Methodological Difficulties

Abstract

It is important for the control of greenhouse gas emissions in Europe that countries report accurate and timely statistics on CO_2 emissions and that the same data are reported to different international organisations. Norway, as a non-EU member does not report emissions under the EU monitoring mechanism. Norway reports consistent data to the UNFCCC (United Nation Framework Convention on Climate Change) and Eurostat/OECD.

However, data reported using the Reference Approach, based on energy inflow, gives very different results from the Sectorial Approach, based on end use of energy. This report reveals that Norway's reporting using the Reference Approach has been based on other energy data than reported by Norway to the IEA (International Energy Agency). In this work the IEA data are used as an input to the Reference Approach. Also key input parameters have been reviewed. After these changes the difference in CO_2 estimates between the Reference and Sectorial Approach is reduced, but is still large.

Norway has a large upstream oil and gas industry, and small errors in input parameters may have a large effect on the CO_2 emission estimates using the Reference Approach. Also the statistical error in the energy balance is rather large for Norway. On the other hand, the statistics on end use of energy is considered to be of high quality, so the confidence in CO_2 emissions estimated using the Sectorial Approach is high.

Live Tanum Pasnin and Trond Sandmo at Statistics Norway have contributed to this report. The work has been initiated and funded by Eurostat.

Contents

1. Introduction

High quality emission data is important for the implementation of the Kyoto protocol and monitoring of emissions in general. CO_2 is the most important greenhouse gas. In Norway it accounts for about 75 per cent of the total GWP weighted emissions. Also the growth is high compared to other gases, 20 per cent from 1990 to 1999 (Statistics Norway 2000a).

The aim of this report is to demonstrate the consistency of official Norwegian reporting, to explain possible differences and suggest improvements in the statistical system.

This report is based on official data reported by Norway in 2000 for the years 1990, 1995 and 1998. Reporting in 2001 is slightly different due to some minor methodological improvements. This does, however, not alter the conclusions made in this report.

This report has been prepared as a request from Eurostat.

2. Methodology used in Norway

2.1. Administrative system

The national emission inventory is prepared in collaboration between the Norwegian Pollution Control Authority (SFT) and Statistics Norway. Statistics Norway is responsible for the emission inventory system and activity data, while SFT is responsible for emission factors, reported emissions from large plants and inventory improvements in general.

The national emission inventory is a multi-pollutant system used for estimating emissions of greenhouse gases, acidifying pollutants and toxic substances. The system is documented in Flugsrud et al. (2000). This system forms the basis for reporting of emissions to air to all international organisations.

Statistics Norway has the formal responsibility for reporting to the OECD/Eurostat Joint questionnaire. Statistics Norway also has the responsibility for reporting energy data to Eurostat and the International Energy Agency (IEA). The Ministry of Environment has the responsibility for reporting to the UNFCCC (United Nations Framework Convention on Climate Change). However, Statistics Norway is filling in the CRF (Common Reporting Format). This system ensures that the same data are reported to all international organisations.

Norway, as a non-EU member, does not report to the EU Monitoring Mechanism Decision.

Differences in published emission data may, however, still occur. This is because reported data often are recalculated at a later stage, due to improvements in data and methodologies. For example is the total CO_2 emission estimate for 1998 as reported in 2001 41.4 Gg, compared to 41.7 reported in 2000. The difference is due to methodological improvements. This means that discrepancies between emission figures apparently can be present when data from different publications are compared.

The basic methodology used in the national inventory system equals the IPCC Sectorial Approach (IPCC = Intergovernmental Panel on Climate Change). The methodology is described below (Section 2.2). Countries are in addition required to use the Reference Approach for reporting to UNFCCC. This methodology is explained in Section 2.3.

2.2. Sectorial Approach

2.2.1. Methodology

The Sectorial Approach is recommended in IPCC (1997) for estimating emissions of CO_2. The Norwegian national methodology is in accordance with this methodology at level 2/level 3.

The starting point is the total consumption of various types of energy commodities. This consumption is distributed between sectors (end users) and appliances. Note that this distribution is not actually necessary for estimating emissions of CO_2. Such distribution is, however, necessary for estimating emissions of other pollutants. It is also crucial in order to analyse emissions (e.g. why they are changing and possible measures). Consumption of fuels where carbon is stored is subtracted. The most important example is fractions of gas used as a feedstock in the production of plastic and methanol.

Emissions are estimated by multiplying the fuel use with appropriate emission factors reflecting the carbon content. Also indirect emissions of CO_2 are estimated. These are from oxidation of NMVOCs and methane (CH_4). This is also according to the Revised 1996 Guidelines which state that gross emissions should be counted, not "end of pipe". Net CO_2 emissions from use of biomass are not counted (according to the Revised 1996 Guidelines).

Norway has a large metallurgical industry. Emissions from use of coal and coke as reducing agents are accounted for as process emissions and not energy. This is according to IPCC Good Practice (IPCC 2000).

CO_2 emissions from non-energy sources are added. Most important is CO_2 from cement production. This estimate is based on the production of clinker and national emission factors. Again this is according to the Revised 1996 Guidelines. Also emissions from use of lime in agriculture and industry are estimated.

2.2.2. Data sources for energy related emissions

The data sources used to determine the consumption differs between the various energy commodities. The data are shown in Table 1 and the CO_2 emission factors (with source of information) in Table 2.

Natural gas
Consumption of natural gas as a fuel gas in the extraction sector is reported from the Norwegian Petroleum Directorate. These data are based on reports from each field operator and is reviewed in detail as the CO_2 taxation is based on the same data. Consumption in the manufacturing industries is reported to Statistics Norway by the plants. In addition some minor figures for use outside the manufacturing industries are reported from a distributor.

Petroleum products
Statistics Norway, in co-operation with the Norwegian Petroleum Industry Association, produces an annual sales statistics for petroleum products, based on reports from the oil companies. The statistics is corrected for direct import by consumers. Due to the rather small market in Norway, the statistics is considered accurate.

Coal and coke
Coal and coke in Norway are almost entirely used by large industrial plants, and mostly as reducing agents. The total consumption is based on reports to Statistics Norway from the plants using coal and coke. Consumption in residences and agriculture (a small amount only) is based on information from importers, users and sales figures from Norway's only coal producing company.

As the main consumers are well identified and report high quality data, the final consumption is considered to be rather accurately determined.

Table 1. Energy used in emission calculations and in the energy accounts in 1998. PJ. Explanation of discrepancies

	Total		Combustion		Non-energy use	
	Emission calculations	Energy accounts	Emission calculations	Energy accounts	Emission calculations	Energy accounts
Total	1194.4	1301.4	548.8	554.0	645.6	747.5
Coal/coke	47.2	60.5	7.5	8.2	39.7	52.3
Wood, waste etc.	53.6	54.0	53.6	54.0	-	0.0
Petroleum products 1)	281.6	329.1	281.6	286.6	-	42.6
Gas 2)	213.8	259.6	206.1	205.2	7.7	54.4
Crude oil	598.2	598.2	-	-	598.2	598.2

1) Gasoline, kerosene, middle distillates, heavy fuel oil, waste oil
2) Including LPG
COMMENTS:
Combustion:
Coal/coke: Deviation because coal coke used at one metal plant has been registered as non-energy use in the emission calculations
Wood, waste etc.: Deviation because of different figures for waste in district heating production
Petroleum products: Deviation because of different figures for air transport (differences in definition of what is included)
Gas: Deviation because flaring at one plant is not included in the energy accounts
Non-energy use:
Coal/coke: In addition comes 175002 tons prebaked anodes and 313420 tons coal electrodes used for the emission calculations.

Table 2. CO_2 emission factors used in the national emission inventory

Energy commodity	Emission factor (tonne CO_2/tonne energy)	Emission factor (tonne CO_2/TJ energy)	Source of information
Coal[1]	2.42[2]	86.1	Contact with main consumers
Coke	3.19	111.9	Based on typical carbon content
Petrol coke	3.59	102.6	Based on typical carbon content
Wood	0.0	0.0	Renewable
Gasoline	3.13	71.3	Information from oil distribution companies on typical carbon content
Kerosene	3.15	73.1	Information from oil distribution companies on typical carbon content
Diesel	3.17	73.5	Information from oil distribution companies on typical carbon content
Light fuel oil	3.17	73.5	Information from oil distribution companies on typical carbon content
Heavy distillates	3.17	73.5	Information from oil distribution companies on typical carbon content
Heavy fuel oil	3.20	78.8	Information from oil distribution companies on typical carbon content
Waste oil	3.20	78.8	Assumed equal to heavy fuel oil
LPG	3.00	65.1	Information from oil distribution companies on typical carbon content
Natural gas/LNG	2.75[3]	57.3[4]	Based on typical carbon content

[1] Hard coal only is in use in Norway
[2] Emission factor is revised to 2.52 tonnes/tonne for use in the 2002 reporting. Individual factors for use in the cement industry.
[3] 2.34 tonnes/kSm^3
[4] Value is updated annually according to annual average energy content.

2.3. Reference Approach

2.3.1. Methodology

The Sectorial Approach is based on the end use of energy. The Reference Approach is, on the other hand, based on primary use of energy (import and export of all energy and production of primary energy). If energy statistics were without errors, the corresponding CO_2 estimates would have been equal. The Reference Approach does not follow the fuels to the actual end use and makes general assumptions about storage etc.

The Reference Approach is based on the *apparent consumption* of fuels (IPCC 1997). The apparent consumption is defined as *import-export + production (primary energy only)* of all fuels that may generate CO_2 emissions. The fuels to consider are specified in the methodology. The calculation is based on energy data in PJ, while the

national Sectorial Approach is using consumption data in tonnes[1]. The methodology takes into account the carbon content of the fuels and fraction oxidised. The long-term storage is taken into account by using general factors.

2.3.2. Sources of data

The Reference Approach is designed to use data reported to the IEA. While Norway formerly has used other sources of data, the IEA data are described here. The IEA data are, however, national data reported by Norway. The data sources used when reporting to IEA differs between the types of energy commodities. For use in the energy balance there is a slightly different grouping.

Crude oil and NGL
Production data are data collected by Statistics Norway, except for the fields Teesside and Murchison, where data collected by the Norwegian Petroleum Directorate are used.

Export data for crude oil are data produced by Statistics Norway. They are based on the amount of oil loaded from each field. For Teesside, Murchison and the gas terminal at Kårstø[2], data from the Norwegian Petroleum Directorate are used. For NGL export data are collected from the Norwegian Petroleum Directorate.

Import data are collected from the refineries.

Stock change data are estimated from data on production, export, consumption and import. This makes the statistical difference zero by definition[3].

Natural gas
Production data are based on data collected by Statistics Norway. The production reported to IEA is the saleable amount. Fuel gas is included, but gas flared, injected and vented (and losses) excluded. Dry gas and NGL are excluded.

Export data are from the Norwegian Petroleum Directorate.

Other petroleum products
Production data are reported to Statistics Norway from the refineries.

Export data are data reported to Statistics Norway. Export of LPG from the gas terminal at Kårstø is subtracted as this is accounted for as NGL. It is difficult to identify the correct amount to subtract, and this is a potential source of error. Export of naphtha from the gas terminal at Kårstø is also subtracted, as this is accounted for as crude oil.

Import data are taken form the foreign trade statistics. Import of LPG is corrected for export of NGL from Teesside to Norway.

Stock change is reported monthly to Statistics Norway from the most important stock holders (refineries and oil companies with terminals for storage).

Coal and coal coke
Production of coal is reported from the only producer at Spitsbergen. Coking coal is not produced in Norway. Import and export data of coal and coking coal are taken from the foreign trade statistics in Statistics Norway (based on data from the customs authorities).

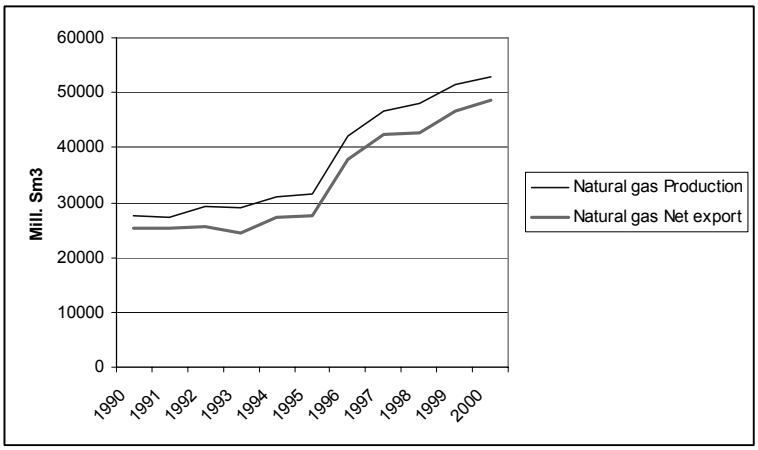
Stock change is based on data reported from the main consumers and the only producer at Spitsbergen.

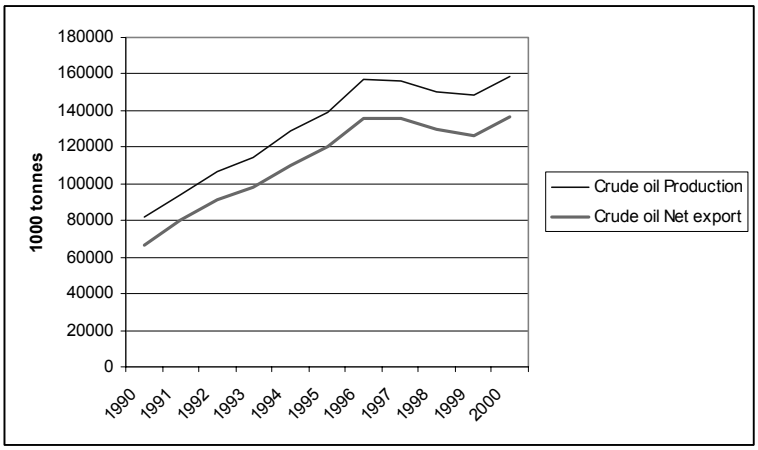
[1] IPCC (1997) recommends using data in PJ also here, but we consider data in physical units to be more accurate.

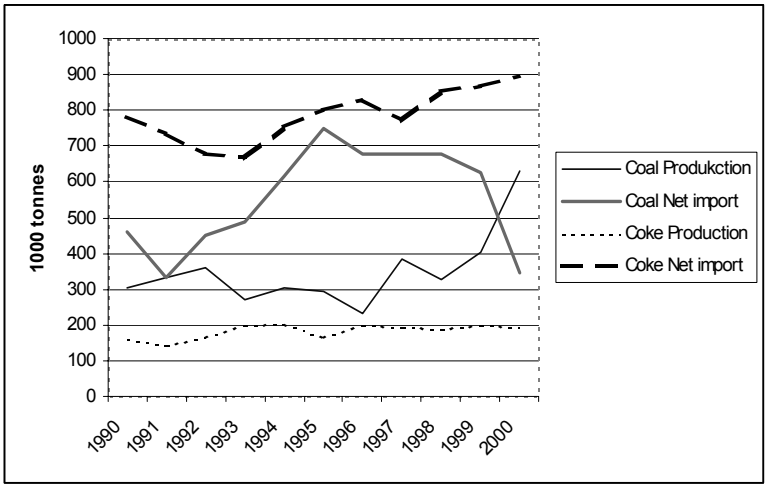
[2] Kårstø exports condensate in addition to natural gas liquids.

[3] Other data are used in the energy balance, giving a quite large statistical error.

Figure 1. Production and net export/import of crude oil, natural gas, coal and coke for selected years







Feedstock data

Some data are reported to IEA, but the quality of these data can be poor. Consequently, we have used the data from the energy balance (also used in the emission inventory) in the CRF.

Other
Data on aircraft bunkers reported to IEA is not correct, as it covers the total sales, not sales to international air transport as supposed. The correct data is estimated as total sale subtracted the amount used for domestic air transport (based on surveys).

3. Comparison of various CO_2 estimates

Various estimates reported from Norway in 2000 are shown in Table 3. As a comparison also data estimated by the IEA are shown.

Table 3. CO_2 emissions in Norway reported to various international organisations for 1990. Total energy Sectorial Approach and Reference Approach. Million tonnes (Gg).

	1990	1995	1998	Change 1990-1998 %
Total emissions				
CRF	35.1	38.2	41.7	18.6
JQ	35.1	38.2	41.7	18.6
Total energy[1]				
CRF	34.1	36.9	40.4	18.5
JQ	34.1	36.9	40.4	18.5
IEA	28.5	32.7	36.9	29.4
Reference Approach				
CRF[2]	24.3 (28.7)	..	32.4 (37.6)	33 (31)
IEA	28.5	30.4	34.3	20.6

[1] Includes emissions from coal and coke used as reducing agents and fraction of gas used as feedstock that is oxidised during the process.
[2] Figures in brackets include emissions from metallurgical industry. These were originally subtracted from the Reference Approach to make the output comparable with fuel combustion in the Sectorial Approach.

The reported figures of total emissions to UNFCCC (CRF) and Eurostat/OECD (JQ) are exactly the same.

The IEA figures for energy are systematically lower than the national figures officially reported. The difference was about 5.6 Gg in 1990 and 3.5 in 1998. This is a quite large discrepancy (about 10 per cent of total emissions). The difference can be explained by items not included in the IEA central estimate (waste combustion (0.1 Gg), indirect emissions from oil and gas (1.9 Gg in 1998) and, perhaps, also the fact that IEA has made general assumptions about the storage that are less exact than those that can be made with exact knowledge.

There are also large differences between the Reference Approach and Sectorial Approach for energy. These differences seem to have increased from 1990 to 1998 and may have different explanations as reviewed below.

Statistical errors
The statistical errors in the energy balance show the difference between the import, export and production (including transformation) and final consumption. There will in practice always be a statistical error. However, it should be random. If not, it indicates a systematic error in one or more parts of the energy balance. The statistical errors in the Norwegian energy balance (excluding electricity and biomass) are shown in table 4.

Table 4. Statistical errors in the Norwegian energy balance. 1990, 1995 and 1998

	1990	1995	1998
Total (TJ)	-11	34	61
Total (ktonnes) (excluding natural gas)	-449	578	498
Coal and coke (ktonnes)	-16	1	9
Petroleum products (ktonnes)	-11	750	-88
LPG and other gas (ktonnes)	4	85	417
Crude oil (ktonnes)	-426	-259	149
Natural gas (mill. Sm^3)	225	191	924

* A negative statistical error indicates that the final consumption is larger than the input and vice versa.

The statistical error in 1998 is high, corresponding to more than 3.5 million tonnes of CO_2. This difference will remain as a difference between the Reference Approach and Sectorial Approach.

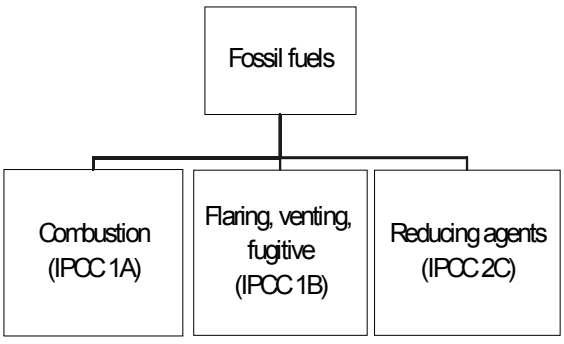
Note that in the CO_2 emissions data from IEA, the statistical error has been distributed between the approaches. That makes them more comparable, but such a distribution is not according to the IPCC 1996 Revised Guidelines (IPCC 1997).

Level of comparison

The Reference Approach gives an estimate of CO_2 emissions that is not straightforward to compare with the Sectorial Approach. Use of fossil fuels in Norway will end up as CO_2 emissions in three main source categories: Combustion (IPCC 1A) fugitive, venting and flaring (IPCC 1B) and reducing agents (IPCC 2C) as illustrated in figure 2. This is in principle the case in all countries, but is more important for Norway than for other countries, due to the large oil and gas sector and the many metal producing plants. For this reason, the amount of gas vented and flared and coal used as a reducing agent is subtracted from the Reference Approach. IEA data includes coal used as a reducing agent, but does that also in the Sectorial Approach.

There are some fuels not directly included in the Reference Approach. One is municipal waste combustion (fossil part) emitting about 0.16 million tonnes CO_2. Another is use of special types of waste, where waste oil is most important (0.2 million tonnes of CO_2). These are accounted for in the energy sector as they are used as fuels.

Figure 2. Overview of reporting of emissions from use of fossil fuels



Estimation of storage

The Reference Approach methodology has a module where amount of fuels used as a feedstock is entered. The fraction stored is estimated by using factors. These factors as proposed in IPCC (1997) are quite general and may for some products vary from year to year. In Table 5 we have made proposals for changes in "fractions stored" based on the actual use of these products in Norway. Note that for natural gas and LPG these factors are not applicable to the total amount used, but to the fractions used as feedstock. This way of book-keeping is necessary in order to increase the comparability with the Sectorial Approach.

Also note that in order to make the Reference Approach comparable to the Sectorial Approach as they are compared in the CRF, fuels oxidised during industrial processes are assumed "stored". Due to the industrial structure of Norway these are large amounts of coal, coke and gas. The new values in Table 5 are, consequently, not directly comparable with those initially used, as the latter values are applicable to the total consumption. Due to the large amount of fuel used for industrial processes in Norway, use of such general factors gives misleading results.

Table 5. Fractions stored

	Initially assumed stored	New value
Naphta	0.8	1.00
Lubricants	0.5	1.00
Bitumen	1.00	1.00
Natural gas	1.00	1.00
LPG	0.77	1.00
Other bituminous coal	1.00	1.00
Coke oven coke	1.00	1.00
Petroleum coke	1.00	1.00

Crude oil emission factor
The apparent consumption of crude oil was more than 44 Gg in 1998, this is more than the total emissions. The corresponding emission factor is however of poor quality as it does not enter the estimation in the Sectorial Approach.

We have now reviewed this factor by contacting the main refinery in Norway. The refineries do not monitor the carbon content of crude oil, but they have some literature values. The carbon content can vary from 83 to 87 %, a typical value for North Sea oil can be about 86 %[4]. With a lower heating value of 42.3 MJ/kg this gives a carbon emission factor of 20.33 tonnes C/TJ oil. This is only 1.6 % different from the IPCC default, but with the high apparent consumption of crude oil in Norway this corresponds to about 0.7 million tonnes of CO_2.

The energy data used
In general we have more confidence in the energy data used for the Sectorial Approach. The data on production, import and export are probably of high quality, but obviously small uncertainties in these data can have large effects in a country exporting most of its production of oil and gas. The complexity of the oil and gas industry in Norway also indicates a high risk of some double counting of products.

Other
There may be confusion whether the natural gas figures given are based on net or gross calorific values. We have used the gross calorific value, while IEA is using the net. However, as long as the national emission factors is converted from its original unit using the same reference value for energy content, this should not be problematic.

4. Suggestions for improvements

Improvements can mainly be found concerning the Reference Approach. It is a goal to identify discrepancies both with the IEA data and the Reference Approach.

4.1. Data

Statistics Norway has recently worked to improve the reporting of energy data to IEA. Revisions have mainly been made for the primary petroleum products (crude oil, NGL and natural gas).

[4] Kjartan Sletten, Statoil, personal communication based on J.G. Speight: "The Chemistry and Technology of Petroleum").

Crude oil and NGL
Production data will from 2001 be based on data collected by the Norwegian Petroleum Directorate. These are accurate data based on the amount sold from each field, corrected for stock change.

Stock change data are from 2000 based on data from the Norwegian Petroleum Directorate. The stock is measured at the terminals each month. This means that the statistical difference can be estimated independently. This difference will occur due to delay in loading to ships, re-loading at the terminals at the end of the month and uncertainties in the stock estimates. It should, however, be averaged to zero from year to year.

Natural gas
From 2001 production data are taken from the Norwegian Petroleum Directorate. Fuel gas consumption is added to the net production, and is also based on reports from each field.

4.2. Reference Approach

Some suggested changes in the Reference Approach were mentioned in chapter 3.

These include
- changes in crude oil emission factor
- consequent use of IEA energy data
- use of the same feedstock data as in the Sectorial Approach, rather then using the IPCC (1996) default fractions for storage

The changes suggested in this report have lead to changes in the national implementation of the Reference Approach, and consequently also the results. The new results are displayed in Table 6. The Reference Approach has also been updated to 1999. The difference between the national Sectorial and Reference Approaches is still rather high, especially in 1999. However, the estimates are based on a consistent methodology and assumptions. The large difference in 1999 can have been caused by revisions in statistics as explained above.

Table 6. Comparison between various approaches. Updated Reference Approach. 1990, 1998 and 1999. Gg. Change in %. Deviation in %

	1990	1998	1999	90-98	90-99
National Sectorial Approach	26.4	31.6	31.7	20	20
National Reference Approach	25.9	31.7	34.1	22	32
Deviation (%)	-3	+0.3	+7.6	-4 pp	-13 pp
IEA Sectorial Approach	28.5	36.9	38.2	29	34
IEA Reference Approach	28.5	34.3	37.1	21	30
Deviation	-	-7	-3	8 pp	4 pp

4.3. Final conclusions

The Reference Approach is proposed as verification of national estimates based on the Sectorial Approach. Norway meets larger difficulties using the Reference Approach than most other countries. The main reason for this is the large oil and gas sector. Small errors in data and conversion factors may have large effects on the output. Norway also has large amounts of fuel used for industrial processes. This causes problems for comparisons with the Sectorial Approach.

There are also notable differences between CO_2 estimates made by IEA and Statistics Norway. This can be explained by the fact that IEA is using the default IPCC emission factors and assumptions about carbon stored while Statistics Norway is utilising more actual information. IEA is also distributing the statistical error between the Sectorial and Reference Approach. Also estimated growth rates differ between the approaches. This can be

due to the fact that energy data have been revised throughout the period. In the national Sectorial Approach such changes are always made back to 1990 for the reason of consistency.

This project has allowed us to harmonise energy data used in the Reference Approach with those used by the IEA. However, the large statistical error in the energy data reported by Norway indicates that there are still potential for improvements.

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Appendix A. CO_2 estimates by the Reference approach 1990, 1998 and 1999.

Feedstock and non-energy use of fuels

1990

FUEL TYPE	ACTIVITY DATA AND RELATED INFORMATION		IMPLIED EMISSION FACTOR	ESTIMATE
	Fuel quantity (TJ)	Fraction of carbon stored	Carbon emission factor (t C/TJ)	of carbon stored in non-energy use of fuels (Gg C)
Naphtha [2]	5 794,80	1,00	20,00	115,90
Lubricants	4 404,74	1,00	20,00	88,09
Bitumen	14 815,20	1,00	22,00	325,93
Coal Oils and Tars	0,00		0,00	
Natural Gas[2]	0,00	1,00	0,00	0,00
Gas/Diesel Oil [2]	0,00	0,00	0,00	0,00
LPG [2]	47 114,20	1,00	12,94	609,55
Butane [2]	0,00		0,00	
Ethane [2]	0,00		0,00	
Other *(please specify)**				
Other bit. coal	16 713,60	1,00	23,49	392,56
Coke Oven	13 875,40	1,00	30,53	423,57
Petroleum Coke	14 122,43	1,00	27,97	395,06
Gasoline	0,00	1,00	0,00	0,00

1998

FUEL TYPE	ACTIVITY DATA AND RELATED INFORMATION		IMPLIED EMISSION FACTOR	ESTIMATE
	Fuel quantity	**Fraction of carbon stored**	**Carbon emission factor**	**of carbon stored in non-energy use of fuels**
	(TJ)		**(t C/TJ)**	**(Gg C)**
Naphtha [2]	0,00	1,00	0,00	0,00
Lubricants	3 295,58	1,00	20,00	65,91
Bitumen	15 633,91	1,00	22,00	343,95
Coal Oils and Tars	0,00		0,00	
Natural Gas[2]	16 957,00	1,00	15,76	267,20
Gas/Diesel Oil [2]	125,00	1,00	0,00	0,00
LPG [2]	36 345,00	1,00	17,75	645,09
Butane [2]	0,00		0,00	
Ethane [2]	148,00	1,00	0,00	0,00
Other *(please specify)**				
white spirit	20,00		0,00	0,00
Other bit. coal	22 701,00	1,00	23,49	533,18
Coke Oven	15 826,00	1,00	30,53	483,11
Petroleum Coke	13 723,00	1,00	27,97	383,88
Residual Fuel Oil	650,00	1,00	21,50	13,97263636
Kerosene	283,00	1,00	19,93	5,64
Gasoline	4,00	1,00	19,45	0,08

1999

FUEL TYPE	ACTIVITY DATA AND RELATED INFORMATION		IMPLIED EMISSION FACTOR	ESTIMATE
	Fuel quantity (TJ)	Fraction of carbon stored	Carbon emission factor (t C/TJ)	of carbon stored in non-energy use of fuels (Gg C)
Naphtha [2]	0,00	1,00	0,00	0,00
Lubricants	3 295,58	1,00	20,00	65,91
Bitumen	14 508,59	1,00	22,00	319,19
Coal Oils and Tars	0,00		0,00	
Natural Gas[2]	18 711,00	1,00	15,76	294,84
Gas/Diesel Oil [2]	125,00	1,00	20,06	2,51
LPG [2]	33 560,80	1,00	17,75	595,67
Butane [2]	0,00		0,00	
Ethane [2]	111,00	1,00	0,00	0,00
Other *(please specify)**				
Residual fuel oil	650,00	1,00	21,50	13,97
Kerosene	272,00	1,00	19,93	5,42
White spirit	19,00	1,00	0,00	0,00
Other bit. coal	22 227,00	1,00	23,49	522,05
Coke Oven	14 718,00	1,00	30,53	449,29
Petroleum Coke	13 880,00	1,00	27,97	388,27
Gasoline	13,00	1,00	19,45	0,25

Estimates of CO_2 emissions

1990

FUEL TYPES			Unit	Prod-uction	Imports	Exports	Inter-national bunkers	Stock change	Apparent consumption	Conversion factor (TJ/Unit)	Apparent consumption (TJ)	Carbon emission factor (t C/TJ)	Carbon content (Gg C)	Carbon stored (Gg C)	Net carbon emissions (Gg C)	Actual CO_2 emissions (Gg CO_2)
Liquid	Primary	Crude Oil	kton	79 663,00	1 444,00	66 602,00		1 786,00	12 719,00	42,30	538 013,70	20,44	10 997,00		10 997,00	40 322,33
Fossil	Fuels	Orimulsion							0,00		0,00		0,00		0,00	0,00
		Natural Gas Liquids	kton	2 425,00		1 464,00		38,00	923,00	44,00	40 612,00	17,20	698,53		698,53	2 561,26
	Secondary	Gasoline	kton		501,00	1 717,00		20,00	-1 236,00	43,90	-54 260,40	19,45	-1 055,12	0,00	-1 055,12	-3 868,77
	Fuels	Jet Kerosene	kton		86,00	412,00	192,00	8,00	-526,00	43,10	-22 670,60	19,93	-451,91		-451,91	-1 656,99
		Other Kerosene	kton		15,00	0,00		4,00	11,00	43,10	474,10	19,93	9,45		9,45	34,65
		Shale Oil							0,00		0,00		0,00		0,00	0,00
		Gas / Diesel Oil	kton		827,00	3 609,00	218,00	4,00	-3 004,00	43,10	-129 472,40	20,06	-2 597,10	0,00	-2 597,10	-9 522,70
		Residual Fuel Oil	kton		592,00	972,00	232,00	-39,00	-573,00	40,60	-23 263,80	21,50	-500,09		-500,09	-1 833,65
		LPG	kton		129,00	226,00		-6,00	-91,00	46,10	-4 195,10	17,75	-74,46	609,55	-684,00	-2 508,02
		Ethane							0,00		0,00		0,00	0,00	0,00	0,00
		Naphtha	kton		132,00	677,00		-32,00	-513,00	45,01	-23 090,13	20,00	-461,80	115,90	-577,70	-2 118,23
		Bitumen	kton		228,00	9,00		20,00	199,00	40,19	7 997,81	22,00	175,95	325,93	-149,98	-549,94
		Lubricants	kton		75,00	3,00		7,00	65,00	40,19	2 612,35	20,00	52,25	88,09	-35,85	-131,44
		Petroleum Coke	kton		366,00	114,00		3,00	249,00	35,00	8 715,00	27,97	243,79	395,06	-151,27	-554,64
		Refinery Feedstocks							0,00		0,00		0,00		0,00	0,00
		Other Oil			37,00	13,00		-3,00	27,00		0,00		0,00		0,00	0,00
Liquid Fossil Totals											341 472,53		7 036,49	1 534,53	5 501,97	20 173,88
Solid	Primary	Anthracite [2]							0,00		0,00		0,00		0,00	0,00
Fossil	Fuels	Coking Coal							0,00		0,00		0,00	0,00	0,00	0,00
		Other Bit. Coal	kton	303,00	713,00	254,00		13,00	749,00	28,10	21 046,90	23,49	494,33	392,56	101,78	373,18
		Sub-bit. Coal							0,00		0,00		0,00		0,00	0,00
		Lignite							0,00		0,00		0,00		0,00	0,00
		Oil Shale							0,00		0,00		0,00		0,00	0,00
		Peat							0,00		0,00		0,00		0,00	0,00
	Secondary	BKB & Patent Fuel							0,00		0,00		0,00		0,00	0,00
	Fuels	Coke Oven/Gas Coke	kton		534,00	5,00		15,00	514,00	28,50	14 649,00	30,53	447,18	423,57	23,62	86,59
Solid Fuel Totals											35 695,90		941,51	816,12	125,39	459,77
Gaseous Fossil		Natural Gas (Dry)	MSm3	27 642,00		25 380,00		0,00	2 262,00	40,50	91 611,00	15,76	1 443,57	0,00	1 443,57	5 293,08
Total											**468 779,43**		**9 421,58**	**2 350,65**	**7 070,93**	**25 926,73**

1998

FUEL TYPES			Unit	Production	Imports	Exports	Inter-national bunkers	Stock change	Apparent con-sumption	Conversion factor (TJ/Unit)	Apparent con-sumption (TJ)	Carbon emission factor (t C/TJ)	Carbon content (Gg C)	Carbon stored (Gg C)	Net carbon emissions (Gg C)	Actual CO_2 emissions (Gg CO_2)
Liquid	Primary	Crude Oil	kton	146 166,00	2 071,00	134 399,00		-306,00	14 144,00	42,30	598 291,20	20,33	12 163,26		12 163,26	44 598,62
Fossil	Fuels	Orimulsion							0,00		0,00		0,00		0,00	0,00
		Natural Gas Liquids	kton	3 660,00		2 694,00		56,00	910,00	44,00	40 040,00	17,20	688,69		688,69	2 525,19
	Secondary	Gasoline	kton		472,00	1 885,00		-33,00	-1 380,00	43,90	-60 582,00	19,45	-1 178,04	0,08	-1 178,12	-4 319,78
	Fuels	Jet Kerosene	kton		190,30	226,00	310,00	-42,00	-303,70	43,10	-13 089,58	19,93	-260,92		-260,92	-956,72
		Other Kerosene	kton		55,00			12,00	43,00	43,10	1 853,30	19,93	36,94		36,94	135,46
		Shale Oil							0,00		0,00		0,00		0,00	0,00
		Gas / Diesel Oil	kton		491,00	3 760,00	469,00	1,00	-3 739,00	43,10	-161 150,90	20,06	-3 232,54	0,00	-3 232,54	-11 852,65
		Residual Fuel Oil	kton		988,00	1 428,00	429,00	-49,00	-820,00	40,60	-33 292,00	21,50	-715,66		-715,66	-2 624,08
		LPG	kton		171,00	327,00		0,00	-156,00	46,10	-7 191,60	17,75	-127,64	645,09	-772,74	-2 833,36
		Ethane							0,00		0,00		0,00	0,00	0,00	0,00
		Naphtha	kton		8,00	1 283,00		-17,00	-1 258,00	45,01	-56 622,58	20,00	-1 132,45	0,00	-1 132,45	-4 152,32
		Bitumen	kton		346,00	7,00			339,00	40,19	13 624,41	22,00	299,74	343,95	-44,21	-162,10
		Lubricants	kton		72,00	7,00			65,00	40,19	2 612,35	20,00	52,25	65,91	-13,66	-50,10
		Petroleum Coke	kton		373,00	86,00		-2,00	289,00	35,00	10 115,00	27,97	282,95	383,88	-100,93	-370,07
		Refinery Feedstocks							0,00		0,00		0,00		0,00	0,00
		Other Oil							0,00		0,00		0,00		0,00	0,00
Liquid Fossil Totals											334 607,60		6 876,57	1 438,91	5 437,66	19 938,08
Solid	Primary	Anthracite [2]							0,00		0,00		0,00		0,00	0,00
Fossil	Fuels	Coking Coal							0,00		0,00		0,00	0,00	0,00	0,00
		Other Bit. Coal	kton	328,17	967,28	291,40		-18,67	1 022,71	28,10	28 738,27	23,49	674,98	533,18	141,80	519,93
		Sub-bit. Coal							0,00		0,00		0,00		0,00	0,00
		Lignite							0,00		0,00		0,00		0,00	0,00
		Oil Shale							0,00		0,00		0,00		0,00	0,00
		Peat							0,00		0,00		0,00		0,00	0,00
	Secondary	BKB & Patent Fuel							0,00		0,00		0,00		0,00	0,00
	Fuels	Coke Oven/Gas Coke	kton		576,47	10,41		1,29	564,78	28,50	16 096,17	30,53	491,36	483,11	8,25	30,24
Solid Fuel Totals											44 834,44		1 166,34	1 016,29	150,05	550,17
Gaseous Fossil		Natural Gas (Dry)	MSm3	47 855,00	0,00	42 645,00		0,00	5 210,00	40,50	211 005,00	15,76	3 324,93	267,20	3 057,73	11 211,66
Total											**590 447,04**		**11 367,84**	**2 722,40**	**8 645,43**	**31 699,92**

1999

FUEL TYPES			Unit	Production	Imports	Exports	Inter-national bunkers	Stock change	Apparent con-sumption	Conversion factor (TJ/Unit)	Apparent consumption (TJ)	Carbon emission factor (t C/TJ)	Carbon content (Gg C)	Carbon stored (Gg C)	Net carbon emissions (Gg C)	Actual CO_2 emissions (Gg CO_2)
Liquid	Primary	Crude Oil	kton	145 843,00	2 085,00	133 520,00		80,00	14 328,00	42,30	606 074,40	20,33	12 321,49		12 321,49	45 178,81
Fossil	Fuels	Orimulsion							0,00		0,00		0,00		0,00	0,00
		Natural Gas Liquids	kton	3 507,00		2 803,00		-25,00	729,00	44,00	32 076,00	17,20	551,71		551,71	2 022,93
	Secondary	Gasoline	kton		341,00	1 840,00		15,00	-1 514,00	43,90	-66 464,60	19,45	-1 292,43	0,25	-1 292,69	-4 739,85
	Fuels	Jet Kerosene	kton		216,00	200,00	310,00	18,00	-312,00	43,10	-13 447,20	19,93	-268,05		-268,05	-982,86
		Other Kerosene	kton		67,00			15,00	52,00	43,10	2 241,20	19,93	44,68		44,68	163,81
		Shale Oil							0,00		0,00		0,00		0,00	0,00
		Gas / Diesel Oil	kton		389,00	3 484,00	467,00	-153,00	-3 409,00	43,10	-146 927,90	20,06	-2 947,24	2,51	-2 949,75	-10 815,74
		Residual Fuel Oil	kton		1 164,00	1 638,00	391,00	26,00	-891,00	40,60	-36 174,60	21,50	-777,62		-777,62	-2 851,28
		LPG	kton		108,00	324,00		2,00	-218,00	46,10	-10 049,80	17,75	-178,37	595,67	-774,05	-2 838,18
		Ethane							0,00	46,00	0,00	20,00	0,00	0,00	0,00	0,00
		Naphtha	kton		63,00	892,00		38,00	-867,00	45,01	-39 023,67	20,00	-780,47	0,00	-780,47	-2 861,74
		Bitumen	kton		307,00				307,00	40,19	12 338,33	22,00	271,44	319,19	-47,75	-175,07
		Lubricants	kton		80,00	12,00			68,00	40,19	2 732,92	20,00	54,66	65,91	-11,25	-41,26
		Petroleum Coke	kton		391,00	43,00		-7,00	355,00	35,00	12 425,00	27,97	347,57	388,27	-40,70	-149,24
		Refinery Feedstocks							0,00		0,00		0,00		0,00	0,00
		Other Oil			84,00	4,00			80,00		0,00		0,00		0,00	0,00
Liquid Fossil Totals											355 800,08		7 347,35	1 371,81	5 975,54	21 910,33
Solid	Primary	Anthracite [2]							0,00		0,00		0,00		0,00	0,00
Fossil	Fuels	Coking Coal							0,00		0,00		0,00	0,00	0,00	0,00
		Other Bit. Coal	kton	398,56	914,44	287,71		-18,70	1 043,98	28,10	29 335,72	23,49	689,02	522,05	166,96	612,20
		Sub-bit. Coal							0,00		0,00		0,00		0,00	0,00
		Lignite							0,00		0,00		0,00		0,00	0,00
		Oil Shale							0,00		0,00		0,00		0,00	0,00
		Peat							0,00		0,00		0,00		0,00	0,00
	Secondary	BKB & Patent Fuel							0,00		0,00		0,00		0,00	0,00
	Fuels	Coke Oven/Gas Coke	kton		524,31	6,31		-7,48	525,47	28,50	14 976,01	30,53	457,16	449,29	7,88	28,88
Solid Fuel Totals											44 311,73		1 146,18	971,34	174,84	641,08
Gaseous Fossil		Natural Gas (Dry)	MSm3	50 904,00	0,00	45 499,00		0,00	5 405,00	40,30	217 821,50	15,84	3 449,37	294,84	3 154,53	11 566,62
Total											**617 933,31**		**11 942,90**	**2 637,99**	**9 304,92**	**34 118,03**

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