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Documents

Pricing of CO_2 emissions in Norway

Documentation of data and methods used in estimations of average CO_2 tax rates in Norwegian sectors in 2006

Statistics Norway/Climate and energy economics

Contents

1. Introduction

The Norwegian CO_2 taxes are highly differentiated between sectors, fossil commodity sources and use. Consequently, the average CO_2 tax vary between sectors, according to the combination of the varying taxes, the relative use of different fossil commodities and whether the sectors use the commodities for stationary, mobile or process purposes. The variation in the average CO_2 taxes is analyzed and discussed in Bruvoll and Dalen (2008). This report presents a documentation of the data, assumptions and the computation behind these figures.

The CO_2 taxes were introduced in 1991. The CO_2 taxes on mainland activities are generally levied on the use (more precisely the purchase or import) of mineral oils and petrol. The CO_2 taxes on the Norwegian offshore sector are levied on the burning of petroleum and natural gas.

In this report, we look into the 2006 CO_2 taxes, the latest numbers available when the analysis was performed. In 2005 a system for trading with CO_2 emission permits was introduced. The current system includes the offshore sector, and the CO_2 taxes are reduced equivalent to the price on permission permits. However, the quota system in 2006 was restricted to only 42 Norwegian companies. Hence, we do not consider the cost of permission permits in our calculations.

2. CO_2 taxes in Norway

The levels of the greenhouse gas taxes in Norway vary between different sources of emissions, different types of greenhouse gases and to some extent between which parts of the economy that are causing the emissions. This causes large variations in the marginal cost of reducing emissions. In 2008 the CO_2 taxes varied between zero and 354 Norwegian krone (NOK) per tonne CO_2. Broadly the CO_2 taxes are dominated by high taxes on emissions from the oil industry and transport, and tax exemptions in the process industry. The CO_2 taxes are mainly levied on the mineral oils and petrol, rather than on the emissions, as there is a fixed relationship between the use of fossil fuels and emissions, given no carbon capture.

Norwegian CO_2 taxes are regulated by two different laws (*Act concerning sales tax* and *Act relating to CO_2 tax in the petroleum activity on the continental shelf*). In addition, there are taxes on emissions of the greenhouse gases methane from waste disposal, HFC and PFC. These taxes are not included in this analysis. CO_2 emissions from incineration of waste are included and levied a tax equivalent to 200 NOK/tonne CO_2.

Table 1 summarizes the Norwegian CO_2 taxes measured in NOK/tonne CO_2, and the total emissions from different energy sources and some broadly defined sectors in 2006. This corresponds to the data used in Bruvoll and Dalen (2008).

Table 1. Norwegian CO_2 taxes and emissions in 2006. NOK/tonne CO_2 and million tonne CO_2

Sector	Energy source	Stationary combustion, NOK/tonne CO_2	Mobile combustion, NOK/tonne CO_2	Process emissions, NOK/tonne CO_2	Emissions mill. tonne CO_2
Extraction of crude oil/natural gas and pipe transport	Natural gas	338	-	-	10.5
	Light mineral oil: middle distillates	297	297	-	0.4
	Unspecified	-	-	0	0.9
Private households	Petrol	-	341	-	3.7
	Light mineral oils: paraffin	208	-	-	0.3
	Light mineral oils: middle distillates	199	199	-	1.1
	Light mineral oils: special distillates	190	-	-	0.0
	LPG/Natural gas	0	0	-	0.0
	Coal and coke	0	-	-	0.0
	Unspecified	0	-	0	0.1
Inland transport by road, domestic shipping (e.g. fishing) and domestic air service	Petrol	-	341	-	0.1
	Light mineral oils: paraffin		208		0.9
	Light mineral oils: middle distillates	-	199	-	5.7
	Light mineral oils: special distillates	-	190	-	0.2
	Heavy mineral oils	-	169	-	0.3
	LPG/Natural gas	-	0	-	0.0
	Unspecified	-	-	0	0.0
Other process emissions	Unspecified	-	-	0	7.3
Other stationary combustion		0 - 208*	-	-	7.6
Other mobile combustion		-	0 - 341**	-	4.2
Total emissions		19.1	16.5	7.6	43.3

Source: Statisics Norway and Ministry of Finance (2005a)

The latest available data at a sufficiently detailed level was from 2006. There have been some changes in the taxing of CO_2 emissions since then. For comparison, we show the CO_2 tax levels in 2008 (see table 2). The main difference between the tax system in 2006 and 2008 was the extended CO_2 quota system that reduced the taxes for some emissions, and that more emissions were priced at the margin.

Table 2. The Norwegian CO_2 taxes in 2008. NOK/tonne CO_2.

Sector	Energy source	Stationary combustion, NOK/tonne CO2	Mobile combustion, NOK/tonne CO2	Process emissions, NOK/tonne CO2
Extraction of crude oil/natural gas and pipe transport	Natural gas	192 (342)[a]	-	-
	Light mineral oil: middle distillates	169 (300) [a]	169 (300) [a]	-
	Unspecified	-	-	0
Private households	Petrol	-	354	-
	Light mineral oils: paraffin	216	-	-
	Light mineral oils: middle distillates	207	207	-
	Light mineral oils: special distillates	197	-	-
	Natural gas for heating in buildings	205	0	-
	Coal and coke, unspecified	0	0	0
Inland transport by road, domestic shipping (e.g. fishing) and domestic air service	Petrol	-	354	-
	Light mineral oils: paraffin in domestic air service	-	263	-
	Light mineral oils: middle distillates	-	207	-
	Light mineral oils: special distillates	-	197	-
	Heavy mineral oils	-	175	-
	LPG/Natural gas	-	0	-
	Unspecified	-	-	0
Other process emissions	Unspecified	-	-	0
Other stationary combustion		0 - 216 [a]	-	-
Other mobile combustion		-	0 – 354 [b]	-

Source: Statisics Norway and Ministry of Finance (2007a)

[a] The petroleum sector was included in the quota system from 2008. The level of the CO_2 tax from 2007 (shown in parenthesis in table 2) is upheld, but the tax is adjusted so that the total CO_2 cost approximately corresponds to the 2007 level (Ministry of the Environment 2007).
[b] Includes different tax rates specified in the table.

3. Data and conversion factors

3.1. Emission data

The source for the emission data is the Norwegian environmental accounts, Statistics Norway. These data have earlier been published in a more aggregated version.[1] The emission data are based on a mix of measurement and calculations and are published on a yearly basis.[2] See Hoem (2006) for a documentation of the methods used in the emission accounting in 2006 and Sandmo (2009) for a documentation of the present accounting methodology.

A total of 120 sectors are included in the analysis. The sector classification accords to the EU's Standard Industrial Classification, NACE. Only sectors with positive emissions are included (see table 4). This is a relatively detailed level, and it is methodologically challenging to calculate the emissions (and hence the average taxes) for many of the smaller sectors. Particularly, this is problematic for the service sectors. Our main presentation and interpretation of the results (Bruvoll and Dalen 2008) is based on more aggregated data. The detailed level of 120 sectors however, should be interpreted with care. This is particularly important if the data in table 4 or the tables in the Appendixes are connected to other data sources than the Norwegian environmental accounts.

Emissions from each sector were categorized in two dimensions: according to energy source, and whether the emissions were related to mobile or stationary use of energy, or process emissions. The detailed specifications of the emissions from each sector made it possible to calculate the average weighed tax rate per sector.

3.2. Conversion factors

The conversion factors used in this analysis are based on factors used by the Norwegian Pollution Control Authority (SFT) and Statistics Norway, see table 3. Tax rates, exemptions and reductions are applied to the relevant sectors according to laws and regulations (e.g. *Act concerning sales tax* (especially regulations concerning special duties) and *Act relating to CO_2 tax in the petroleum activity on the continental shelf*) and official documents describing the tax system (NOU 2007:8, NOU 2000:1, Ministry of Finance (2005a), Ministry of Finance (2005b), Ministry of Finance (2006), Ministry of Finance (2007a), Ministry of Finance (2007b) and Ministry of Finance (2008)).

[1] See http://statbank.ssb.no/statistikkbanken/Default_FR.asp?PXSid=0&nvl=true&PLanguage=0&tilside=selectvarval/define.asp&Tabellid=07207

[2] See http://www.ssb.no/klimagassn/arkiv/ for an overview of publications of Norwegian emission data on a more aggregate level.

Table 3. Conversion factors used in the calculations of the CO_2 taxes per tonne CO_2 emission and the corresponding tax rates used in the analysis measured in NOK/tonne CO_2.

	Petrol	Light mineral oils: paraffin	Light mineral oils: middle distillates	Light mineral oils: special distillates	Heavy mineral oils	Natural gas
CO_2 factor kg/kg fuel (natural gas: Sm^3)	3.13	3.15	3.17	3.17	3.20	2.34
Self weight kg/l	0.74	0.81	0.84	0.88	0.98	
CO_2 factor kg/unit for tax (liter, kg or Sm^3)	2.32	2.55	2.66	2.79	3.14	2.34
NOK/tonne CO_2 given full tax	341	208	199	190	169	338

4. CO_2 tax rates and emissions divided by sectors

The average CO_2 tax level in the 120 sectors have been calculated on the basis of detailed CO_2 emission data for each sector (see table 4 for an overview of included sectors) divided by energy source and stationary, mobile and process combustion. This division of emissions led to a 39 times 120 matrix of energy sources and sector specific emissions. For every combination of sector and energy source with a positive value we linked a CO_2 tax rate. The tax rates were chosen according to tax rate levels specified in the act relating to CO_2 tax in the petroleum activity on the continental shelf and regulation of special duties. Relevant exemptions from and reductions for sectors and energy sources were assigned the different sectors as accurate as the detail level of the data allowed (see section 4.1 and 4.2 for details).

To compare the average tax rate levels, conversion factors were used to calculate the tax levels in NOK per tonne CO_2 (see section 3.2). The conversion factors only relate to emissions from fossil energy use. Conversion factors were not used for emissions from waste. To get the average CO_2 tax level per sector i (TAX^i) we calculated the total CO_2 tax payments in each sector (i.e. the sum of tax rates multiplied by the CO_2 emissions from each tax base k) and divided by total emissions in that sector:

[1] $$TAX^i = \Sigma(TAX^i_k * CO_2{}^i_k) / CO_2{}^i$$

Conversion factors given in table 3 are included in the following way:

[2] $$TAX^i = \sum_{k=1}^{K} \left\{ \frac{\frac{(1/100) * NOK/liter}{self\ weight, kg/liter}}{CO_2\ factor, kg/kg\ fuel} * 10 * CO^i_{2k} \right\} / CO^i_2$$

4.1. Simplifying assumptions

For some sectors simplifying assumptions have been made due to tax exceptions. This mainly applies to six sectors: fishing (sector number 230510), extraction of crude petroleum and natural gas (231110), oil drilling (231120), processing and preserving of fish and fish products (231520), manufacture of refined petroleum products (232320), gas terminal (232340) and transport via pipelines (oil and gas) (236080). This information relates to the policy in 2006.

The CO_2 tax rate in the *fishing* sector is set to zero for *all* use of mineral oils except for a small amount of emissions stemming from the use of motor petrol used for other purposes than road traffic (these emissions makes up less than one percent of the total emissions from this sector). The zero CO_2 tax rate in the fishing sector follows from a tax refund scheme specified for this sector.

In the *extraction of crude petroleum and natural gas*, the general CO_2 tax rate on the use of oil and gas was higher than in other sectors and on the main land (0.79 compared to 0.53 NOK/liter in 2006). Use of oil on mobile appliances in the sector concerning extraction of crude petroleum and natural gas is partly paying the inland CO_2 tax rate of 0.53 NOK/liter. In our analysis all emissions from stationary or mobile sources within this sector have been imposed a tax of 0.79 NOK/liter or standard cubic meter.

In the *oil drilling* sector all emissions from the mobile sector were set to the standard light mineral oil tax rate (0.53 NOK/liter in 2006). Use of mineral oils in the drilling sector is in reality partly levied the higher tax rate that applies to the petroleum sector. In our data it is not possible to separate emissions from the use of oil that have a high CO_2 tax rate imposed from those with a lower tax rate within this sector. Thus all emissions from the use of oil for mobile purposes in this sector is, based on discretionary, levied a tax of 0.53 NOK/liter oil used in this analysis.

Parts of the sector concerning *processing and preserving of fish and fish products* have a reduced tax rate. This applies to the production of herring meal and fishmeal. Due to lack of details in our emission data this is not taken into consideration and the standard CO_2 tax rates have been applied to the whole sector.

Within the *manufacture of refined petroleum products* sector about half of the emissions stem from processing and the other half stems from stationary use of refinery and blast furnace gas. In our analysis we have levied no CO_2 tax on emissions from the use of gas, apart from gas used in the petroleum sector on the continental shelf. This is according to out interpretation of the design of the CO_2 tax system in 2006. Due to this we have interpreted the tax level for these emissions to be zero in this analysis.

Emissions from the *gas terminal* sector mainly stems from stationary use of natural gas. Gas terminals were included in the CO_2 quota system between 2005 and 2007. Emissions from the use of natural gas within gas terminals were, due to this, exempt from the CO_2 tax in these analysis.

There is a small amount of CO_2 emissions stemming from stationary use of natural gas in *transport of oil and gas via pipelines*. All these emissions were imposed a CO_2 tax rate of 0.79 NOK/standard cubic meter gas in this analysis. This is according to the CO_2 tax level in the petroleum sector on the continental shelf.

The emission data used in this analysis only include CO_2 emissions. This means that emissions from landfill gases are not included since this is emissions of other greenhouse gases (methane). The only emissions included from waste are emissions from waste combustion. To these emissions we have levied a tax level equivalent to 200 NOK/tonne CO_2 emission (this is according to NOU 2007:8).

4.2. Sectors with reduced or exempted CO_2 tax rates

There is a variety of partly or complete exemptions from the Norwegian CO_2 tax. This applies to some particular sectors.

There are no CO_2 taxes on emissions from *industrial processes*. In Norway these emissions made up about 18 percent of total emissions in 2006. *Foreign air and water transport* are fully exempt from CO_2 taxes. Emissions from these sectors are not included in the Norwegian emission inventory, and hence not in this analysis. *Fishing in distant and coastal waters* is also exempt from CO_2 taxes. These emissions are mainly included in this analysis.

The *wood processing industry* has a reduced tax level of 50 percent on. This is mainly taken into consideration in our data material. The *herring meal and fishmeal industries* also have a reduced CO_2 tax level by 50 percent. Due to lacking details in our data, this is not taken into consideration in our analysis.

A number of exemptions are not related to specific sectors. All use of gas on the main land was exempted in 2006, while the use of gas from activities within the petroleum sector on the continental shelf was subject to a CO_2 tax. This is taken into consideration. We have not corrected for other exemptions for specific kinds of fuels or ranges of use of mineral products. A description of the different subsidies and exemptions can be found in the relevant laws (*Act concerning sales tax* (1933), see regulations concerning special duties, and *Act relating to CO_2 tax in the petroleum activity on the continental shelf* (1990)).

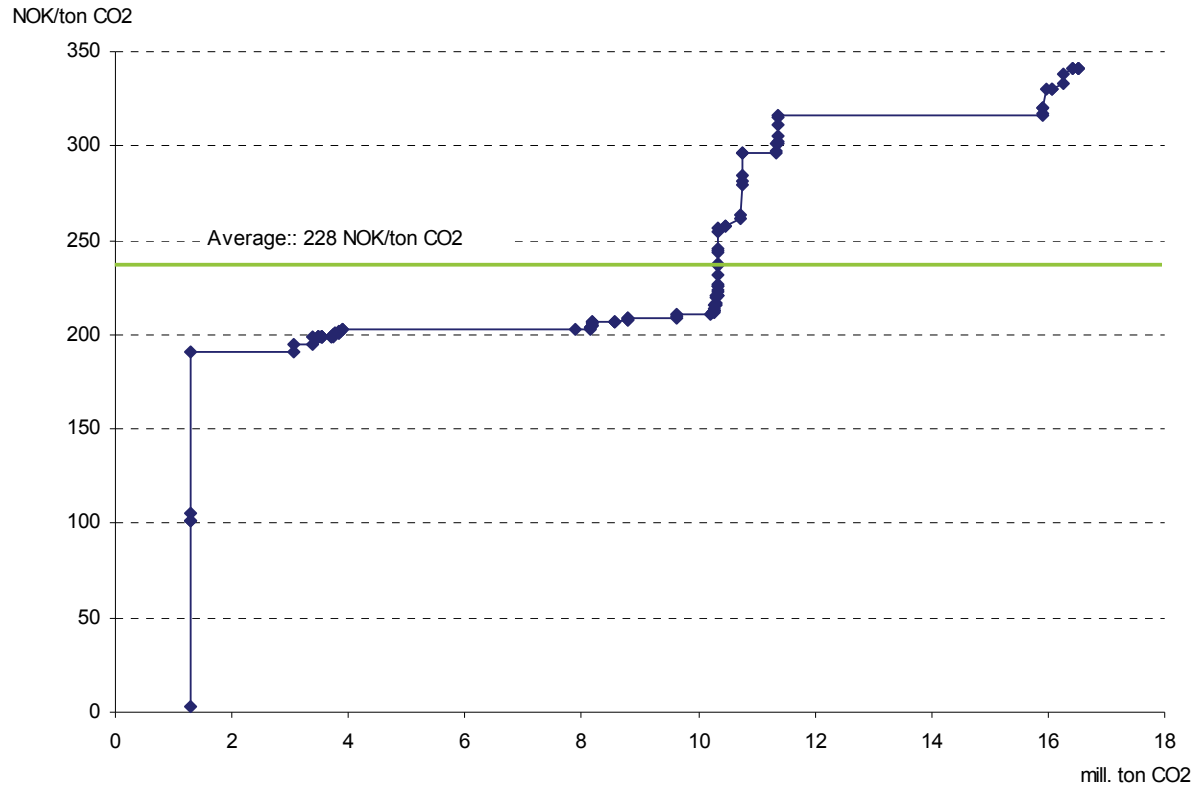
5. Average CO_2 tax per sector

Total Norwegian emissions in 2006 were 43 million tonnes CO_2 (not including foreign sea and air transport). 16.5 million tonnes CO_2 were mobile emissions, 19.1 million tonnes CO_2 were stationary emissions and 7.6 million tonnes CO_2 were emissions from industrial processes.

5.1. Mobile emissions

According to our calculations, the average CO_2 tax rate for mobile emissions varies between 2.50 NOK/tonne CO_2 and 341 NOK/tonne CO_2 in 2006 (see figure 1). Sectors with average tax levels below 190 NOK/tonne CO_2 are sectors with reduced tax (e.g. the wood processing industry) or tax exemptions (e.g. fishing). About 20 percent of the mobile emissions were levied a tax that was lower than 200 NOK/tonne and 20 percent were levied a tax higher than 300 NOK/tonne.

Figure 1 Average CO_2 tax for emissions from mobile sources divided by sector. Tax rates and emissions from 2006.[3]



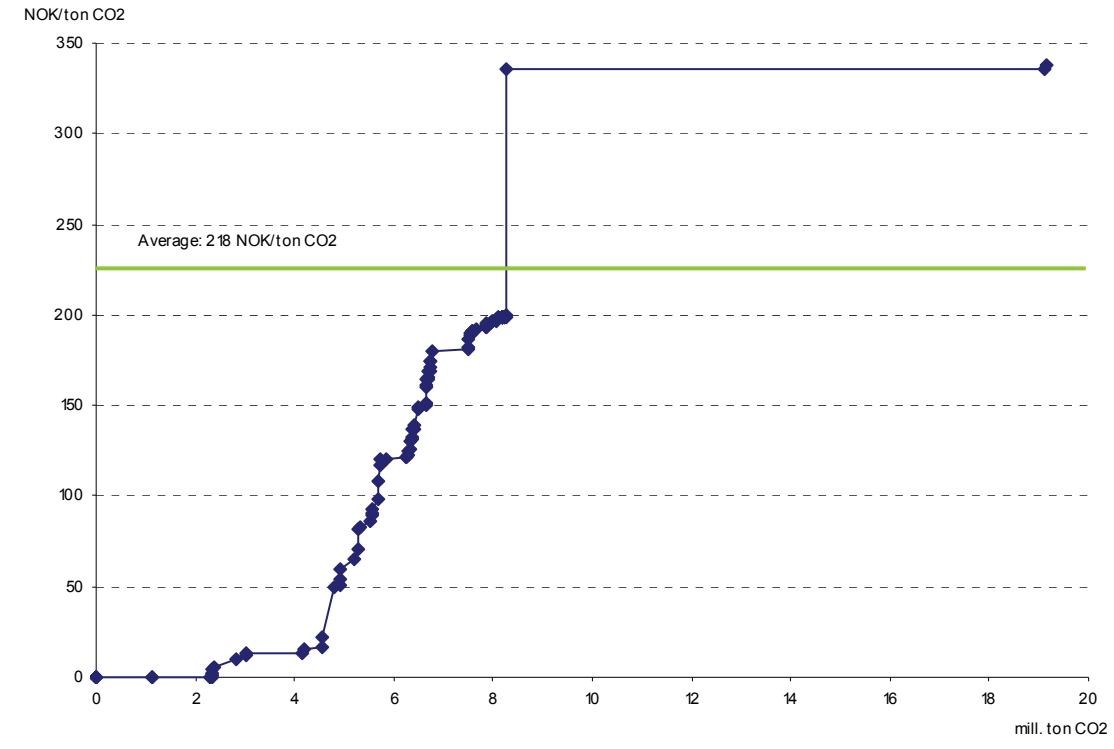
[3] Only sectors with positive emissions from mobile sources are included in the figure.

The main differences come from differences in the composition of petrol and auto diesel oil use across sectors. Emissions from petrol is levied a tax of 341 NOK/tonne CO_2 and emissions from auto diesel are taxed 199 NOK/tonne CO_2. Sectors with high shares of mobile emissions from petrol have high average tax levels. Details concerning figure 1 are given in table A.1. in the appendix.

5.2. Stationary emissions

From stationary sources about half of the emissions were levied a tax of 200 NOK or less per tonne CO_2, and half of the emissions had a tax equal to 340 NOK/tonne CO_2 (this only includes emissions from the extraction of crude petroleum and natural gas). Sectors with particularly low average tax level generally have a large share of emissions from the use of gas. The average tax rate for stationary emissions (218 NOK/tonne CO_2) were somewhat lower than for mobile emissions (228 NOK/tonne CO_2), see figure 2.

Figure 2 Average CO_2 tax for emissions from stationary sources divided by sector. Tax rates and emissions from 2006.[4]



[4] Only sectors with positive emissions from stationary sources are included in the figure.

Extraction of crude petroleum and natural gas leads to more than half of the emissions from stationary energy use. This sector also has the highest average CO_2 tax level. Except sectors with reduced tax or tax exemption the main cause for the differences in the average tax levels is the amount of emissions within the sector from the use of gas. Sectors dominated by emissions from the use of gas have a very low average CO_2 tax rate for emissions from stationary sources. In our analysis we have applied a zero tax rate on all emissions from use of gas on the mainland. Details concerning figure 2 are given in table A.2. in the appendix.

5.3. All emissions

The variations in the mean CO_2 tax rate is mainly caused by the zero tax rate on processing emissions and hence the varying shares of emissions from processing relative to mobile or stationary sources. Other tax reductions and exemptions on petroleum products explain the rest of the variation. For example, petrol has a high tax rate (341 NOK/tonne CO_2 in 2006) compared to diesel oil (199 NOK/tonne CO_2).

Light mineral oils used on the continental shelf had a higher tax rate than on the mainland. In 2006 this tax rate was almost 300 NOK/tonne CO_2. The petroleum sector also had a high tax rate on the use of natural gas on the continental shelf (338 NOK/tonne CO_2). Natural gas on the mainland was exempt from the CO_2 tax in 2006.

Table 4 shows the total emissions and average price per tonne CO_2 emissions for each sector included in the analysis. Many sectors with a high share of the emissions pay a very low average CO_2 tax rate. This especially applies to sectors within the processing industry like e.g. the manufacture of basic iron, steel, cement, plaster and aluminum. Refining of oil products and fishing also have large emissions and low average CO_2 taxes according to our analysis. The extraction of crude petroleum and natural gas and private household have large shares of the emissions with high average CO_2 tax relative to other sectors. The highest average taxes are in the sectors whose emissions are mainly (or only, cf "computer and related activities") related to transport.

As mentioned in 3.1, the detailing level in table 4 implies that the figures within each sector should be interpreted with care. Particularly this is true for the service sectors within the sector-numbers 235000-259200. The interpretation issues are particularly problematic if the data in the table 4 are connected to other data sources than the Norwegian environmental accounts.

Table 4. Sectors included in the analysis, emissions and average NOK/tonne CO_2 in 2006. Sorted by average CO_2 taxes. [a,b]

Sector number	Sector	Emissions, tonne	Average NOK/tonne CO_2
247300	Research and development	2334	0
232340	Gas terminal	1175339	0
232320	Manufacture of refined petroleum products	2142769	1
230510	Fishing	1282183	2
232730	Aluminum production	2388313	2
232650	Manufacture of cement, lime and plaster	1373837	3
232710	Manufacture of basic iron and steel	1825915	4
232415	Manufacture of fertilizers, nitrogen compounds and pesticides	721210	8
232620	Manufacture of ceramic goods	10892	9
232610	Manufacture of glass and glass products	31401	10
233540	Manufacture and repair of aircraft and spacecraft	1563	13
232416	Manufacture of plastics and synthetic rubber in primary forms, manufacture of other organic basic chemicals	1181839	14
231930	Manufacture of footwear	1037	15
248500	Health and social work	19538	15
232412	Manufacture of dyes and pigments and other inorganic basic chemicals	606863	20
259000	Sewage and refuse disposal, sanitation and similar activities	22518	28
232220	Printing and service activities related to printing	28984	28
231590	Manufacture of beverages	228195	28
233210	Manufacture of electronic components and television and radio transmitters	446	29
232640	Manufacture of other mineral products	416891	57
232740	Other non-ferrous metal production	23062	63
232120	Manufacture of paper and paperboard	288970	66
231000	Coal mining	6878	70
232450	Manufacture of soap and detergents and toilet preparations	9944	77
233110	Manufacture of electric motors, generators and transformers, manufacture of electricity distribution and control apparatus	6159	80
232020	Manufacture of particle board, fiber board and other panels and boards	47702	81
232110	Manufacture of pulp	211327	81
233630	Other manufacturing	4683	86
231570	Manufacture of prepared animal feeds	59241	86
232130	Manufacture of articles of paper and paperboard	17496	88
249200	Other service activities	571	91
233520	Building and repair of oil platforms	22861	92
239000	Sewage and refuse disposal, sanitation and similar activities	15178	100
233710	Recycling of metal waste and scrap	20648	104
231120	Oil drilling	149040	104
232750	Casting of metals	6552	105
231300	Mining of metal ores	25907	106
231530	Processing and preserving of fruit and vegetables	17175	115

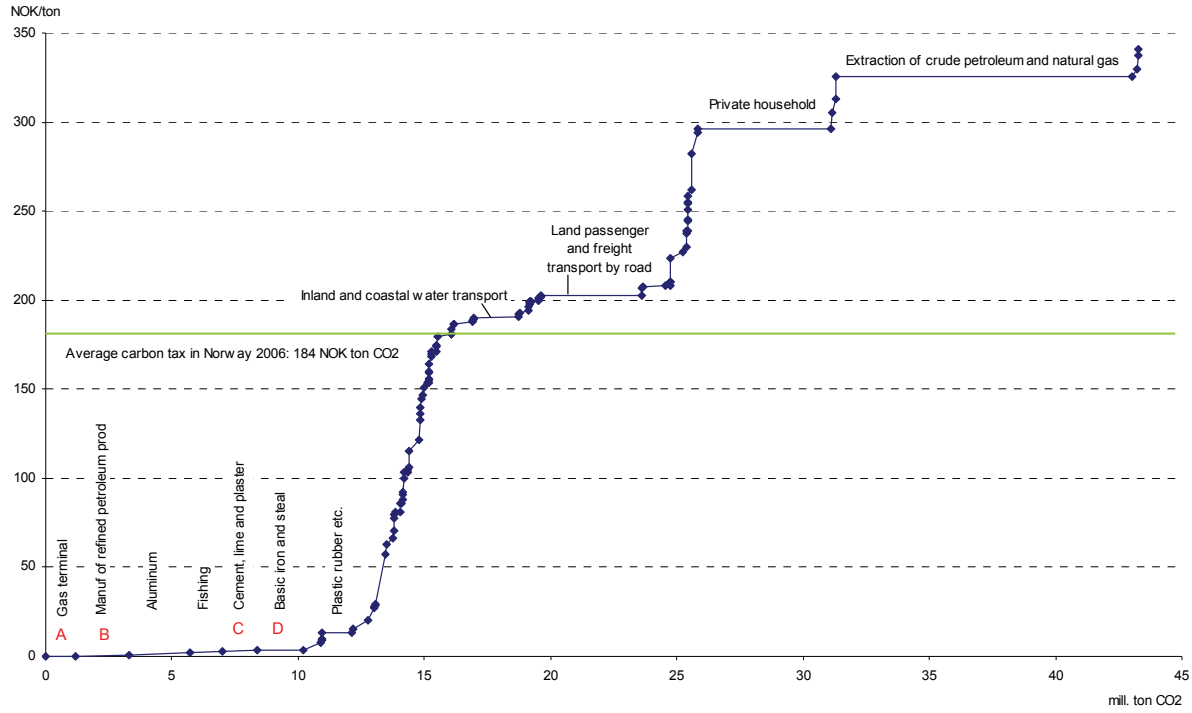
234040	Steam and hot water supply	386910	122
232500	Manufacture of rubber and plastic products	34951	133
231700	Manufacture of textiles and textile products	16574	136
232440	Manufacture of basic pharmaceutical products and pharmaceutical preparations	19719	140
231550	Manufacture of dairy products	48333	144
231540	Manufacture of vegetable and animal oils and fats	17859	146
231510	Production, processing and preserving of meat and meat products	56160	151
231520	Processing and preserving of fish and fish products	144428	153
232870	Manufacture of other metal products	6960	154
232910	Manufacture of general purpose machinery	29127	154
232970	Manufacture of domestic appliances	3971	155
232930	Manufacture of special purpose machinery	16833	156
233620	Manufacture of jewellery and related articles	997	159
248000	Education	3073	160
231560	Manufacture of grain mill products, starches and starch products	7904	164
235500	Hotels and restaurants	69231	168
232411	Manufacture of industrial gases	353	170
233510	Building and repair of ships and boats	26185	171
231400	Other mining and quarrying	174559	171
232810	Manufacture of fabricated metal products, except machinery and equipment	40014	174
233140	Manufacture of other electrical apparatus and equipment	1481	175
231580	Manufacture of other food products	48977	179
232430	Manufacture of paints and varnishes, printing ink and mastics	6506	181
230100	Agriculture	493581	181
233400	Manufacture of motor vehicles and parts and accessories for motor vehicles	14917	184
258500	Health and social work	88223	186
232460	Manufacture of other chemical products	10808	187
257510	Public administration	14489	188
234500	Construction	733939	188
259200	Other service activities	1688	190
237000	Real estate activities	28662	190
236130	Inland and coastal water transport	1767157	190
233530	Manufacture and repair of railway and tramway locomotives and rolling stock	130	192
258000	Education	76673	192
236020	Tramway and suburban transport, other scheduled passenger land transport	338574	194
239100	Activities of membership organizations	22990	196
233130	Manufacture of insulated wire and cable	2290	197
239200	Recreational, cultural and sporting activities	22107	198
231810	Manufacture of leather clothes	4	199
233000	Manufacture of office machinery and computers	25	199
232322	Manufacture of asphalt	1468	199
231910	Tanning and dressing of leather, manufacture of luggage, handbags,	1732	199

	saddlery and harness		
234100	Collection, purification and distribution of water	5097	199
246300	Supporting and auxiliary transport activities	5259	199
233720	Recycling of non-metal waste and scrap	8003	199
236010	Transport via railways	43778	199
232010	Sawmilling and planing of wood, impregnation of wood	22592	200
247520	Defense	279460	200
231830	Dressing and dyeing of fur, manufacture of articles of fur	738	201
232860	Manufacture of cutlery, tools and general hardware	2219	201
231820	Manufacture of other wearing apparel and accessories	811	202
230200	Forestry and logging	51856	202
236040	Other land passenger transport, freight transport by road	4005657	203
232040	Manufacture of other products of wood	2793	207
233610	Manufacture of furniture	9608	207
234010	Production of electricity	47899	207
236030	Taxi operation	194715	208
236202	Domestic air transport	863206	208
237100	Renting of machinery and equipment	31388	210
232030	Manufacture of builders' carpentry and joinery	5288	211
235000	Wholesale and retail trade, repair of motor vehicles and personal and household goods	463998	227
236300	Supporting and auxiliary transport activities	166351	230
232230	Reproduction of recorded media	246	238
233550	Manufacture of other transport equipment	177	239
238000	Education	26951	239
232960	Manufacture of weapons and ammunition	288	244
233310	Manufacture of medical and precision instruments	975	245
233340	Manufacture of optical instruments, photographic equipment, watches and clocks	47	251
233230	Manufacture of television and radio receivers, sound or video recording apparatus	48	254
230520	Operation of fish farms	10675	255
247510	Public administration	3001	259
239300	Other service activities	159775	262
232210	Publishing	5152	282
238500	Health and social work	205777	294
330000	Private household	5280050	296
237400	Other business activities	75026	305
236500	Financial intermediation, insurance	121304	313
231110	Extraction of crude petroleum and natural gas	11750345	326
236400	Post, telecommunications	219171	330
236080	Transport via pipelines	13548	338
237200	Computer and related activities	15562	341
	Total	43277907	184

[a] Some sectors with the same name appear more than once in the table, e.g. health and social work, for these sectors the leading two digits indicate as follows; 23=private sector, 24=central government and 25=local government.
[b] One sector is removed from the table due to confidentiality concerns

Figure 3 shows the average CO_2 tax rates and emissions in all sectors included in the analysis in 2006, as shown in table 4. Sectors with high shares of total emissions are labeled in the figure.

Figure 3 Average CO_2 tax divided by sector. Tax rates and emissions from 2006.



Source: Dalen and Bruvoll (2008)

6. The CO_2 quota system between 2005 and 2007

Between 2005 and 2007 a limited quota system was introduced in Norway, including 42 Norwegian companies. Companies that were involved in the CO_2 quota system engaged in district heating, wood processing, processing of fish and fish products, petro chemistry, gas processing, steel and mineral production, and other businesses running refineries, gas terminals, gasworks and other energy plants. Most quotas were freely distributed.

Between 2005 and 2007 a total of 19.2 million emission permits were allocated between different businesses. One emission permit corresponds to one tonne of CO_2. Emissions included in the quota system were a total of 17.8 million tonnes of CO_2. These emissions were approved by the Norwegian Pollution Control Authority (SFT). Of the 42 businesses included in the quota system 16 had higher emissions, in total, during the three year period than the amount of emission permits that they had been assigned. Accordingly they had to buy emission permits. Companies that had to buy emission permits were mainly refineries, but also gas terminals and companies involved in mineral production. Companies bought emission permits from the EU market to market prices, but could not sell permits into the same system. Details concerning the CO_2 quota system between 2005 and 2007 are found in The Norwegian Pollution Control Authority (1) and (2).

Many of sectors with the lowest average CO_2 tax rate per tonne CO_2 (shown in table 4 and figure 3) were completely or partly incorporated into the quota system in 2006. This applies, among others, to emissions from gas terminals (emissions market A in figure 3), manufacture of refined petroleum products (B), manufacture of cement, lime and plaster (C) and manufacture of basic iron and steel (D) in table 4 and figure 3. The emitters within these sectors consequently had a *marginal* cost corresponding to the price of emission permits. Due to the free allocations of quotas they did *not pay* for their emissions. [5]

[5] From 2008 is the Norwegian quota system for carbon emissions expanded and connected to EU quota system.

7. Summary and uncertainties

In this analysis we have combined detailed emission data for different sectors in the Norwegian economy with relevant CO_2 tax rates for different emission sources (both energy source and sector) documented in various official documents. Based on this information, we have estimated the variations in the average CO_2 tax rate across 120 Norwegian sectors. We find large variations in the CO_2 taxes across both sectors and fossil sources. The variations are mainly caused by the zero tax rate on processing emissions and hence the varying shares of emissions from processing relative to mobile or stationary sources. Other tax reductions and exemptions on petroleum products explain the rest of the variation. For example, petrol has a high tax rate (341 NOK/tonne CO_2 in 2006) compared to diesel oil (199 NOK/tonne CO_2).

Many of sectors with the lowest average CO_2 taxes were completely or partly incorporated into the quota system in 2006. The emitters within these sectors consequently had a *marginal* cost corresponding to the price of emission permits. Still, due to the free allocations of quotas they did *not pay* for their emissions.

A number of factors can potentially lead to inaccuracies and uncertainty in this analysis. The interpretation of the relevant laws and official documents are not always straightforward with respect to tax levels per sector and fossil source. Our interpretations are described in this document. In the categorization of emissions between sectors and energy sources or industrial processes some simplifying assumptions were necessary. These are documented in section 4.1. We have used the same conversion factors for all emissions from different energy sources to link the tax rates measured in NOK/energy input unit to tax rates measured in NOK/tonne of CO_2. The relationship between energy use and emissions are therefore assumed to be constant.

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Appendix

Table A.1. Average CO_2 tax rate and emissions from mobile sources by sector. NOK/tonne CO_2 and tonne[a,b,c]

Sector number	Sector	Average NOK/ tonne CO_2	Emissions from mobile sources, tonne
230100	Agriculture	207	378962
230200	Forestry and logging	202	51856
230510	Fishing	2	1282183
230520	Operation of fish farms	279	7415
231000	Coal mining	320	1513
231110	Extraction of crude petroleum and natural gas	297	596677
231120	Oil drilling	199	77621
231300	Mining of metal ores	199	13722
231400	Other mining and quarrying	199	139808
231510	Production, processing and preserving of meat and meat products	212	13752
231520	Processing and preserving of fish and fish products	204	7818
231530	Processing and preserving of fruit and vegetables	215	1081
231540	Manufacture of vegetable and animal oils and fats	207	3324
231550	Manufacture of dairy products	204	15293
231560	Manufacture of grain mill products, starches and starch products	200	556
231570	Manufacture of prepared animal feeds	220	6230
231580	Manufacture of other food products	213	11077
231590	Manufacture of beverages	202	11668
231700	Manufacture of textiles and textile products	223	2605
231810	Manufacture of leather clothes	199	4
231820	Manufacture of other wearing apparel and accessories	255	279
231830	Dressing and dyeing of fur, manufacture of articles of fur	225	59
231910	Tanning and dressing of leather, manufacture of luggage, handbags, saddlery and harness	201	42
231930	Manufacture of footwear	316	7
232010	Sawmilling and planing of wood, impregnation of wood	201	20579
232020	Manufacture of particle board, fibre board and other panels and boards	101	1330
232030	Manufacture of builders' carpentry and joinery	220	3389
232040	Manufacture of other products of wood	208	2400
232110	Manufacture of pulp	101	3041
232120	Manufacture of paper and paperboard	105	3473
232130	Manufacture of articles of paper and paperboard	226	722
232210	Publishing	301	4603
232220	Printing and service activities related to printing	244	2464
232230	Reproduction of recorded media	238	246
232320	Manufacture of refined petroleum products	200	6272
232322	Manufacture of asphalt		0
232340	Gas terminal		0

232411	Manufacture of industrial gases	199	52
232412	Manufacture of dyes and pigments and other inorganic basic chemicals	205	4325
232415	Manufacture of fertilisers, nitrogen compounds and pesticides	199	239
232416	Manufacture of plastics and synthetic rubber in primary forms, manufacture of other organic basic chemicals	200	2765
232430	Manufacture of paints and varnishes, printing ink and mastics	297	900
232440	Manufacture of basic pharmaceutical products and pharmaceutical preparations	257	90
232450	Manufacture of soap and detergents and toilet preparations	199	99
232460	Manufacture of other chemical products	217	165
232500	Manufacture of rubber and plastic products	212	3931
232610	Manufacture of glass and glass products	207	620
232620	Manufacture of ceramic goods	210	267
232640	Manufacture of other mineral products	201	60353
232650	Manufacture of cement, lime and plaster	199	2113
232710	Manufacture of basic iron and steel	201	3563
232730	Aluminium production	199	14738
232740	Other non-ferrous metal production	206	526
232750	Casting of metals	221	619
232810	Manufacture of fabricated metal products, except machinery and equipment	221	12151
232860	Manufacture of cutlery, tools and general hardware	244	130
232870	Manufacture of other metal products	258	1482
232910	Manufacture of general purpose machinery	207	11545
232930	Manufacture of special purpose machinery	213	3776
232960	Manufacture of weapons and ammunition	285	152
232970	Manufacture of domestic appliances	305	87
233000	Manufacture of office machinery and computers	199	25
233110	Manufacture of electric motors, generators and transformers, manufacture of electricity distribution and control apparatus	224	745
233130	Manufacture of insulated wire and cable	199	865
233140	Manufacture of other electrical apparatus and equipment	231	853
233210	Manufacture of electronic components and television and radio transmitters	220	59
233230	Manufacture of television and radio receivers, sound or video recording apparatus	281	33
233310	Manufacture of medical and precision instruments	264	735
233340	Manufacture of optical instruments, photographic equipment, watches and clocks	311	22
233400	Manufacture of motor vehicles and parts and accessories for motor vehicles	208	1967
233510	Building and repair of ships and boats	206	16292
233520	Building and repair of oil platforms	204	5821
233530	Manufacture and repair of railway and tramway locomotives and rolling stock	225	111
233540	Manufacture and repair of aircraft and spacecraft	297	68
233550	Manufacture of other transport equipment	246	151
233610	Manufacture of furniture	237	2181
233620	Manufacture of jewellery and related articles	302	66
233630	Other manufacturing	212	1087
233710	Recycling of metal waste and scrap	201	10629
233720	Recycling of non-metal waste and scrap	199	7981

234010	Production of electricity	216	22819
234040	Steam and hot water supply	320	429
234100	Collection, purification and distribution of water	199	2615
234500	Construction	211	583273
235000	Wholesale and retail trade, repair of motor vehicles and personal and household goods	261	262866
235500	Hotels and restaurants	301	17679
236010	Transport via railways	199	41514
236020	Tramway and suburban transport, other scheduled passenger land transport	195	336661
236030	Taxi operation	208	194715
236040	Other land passenger transport, freight transport by road	203	4005657
236080	Transport via pipelines		0
236130	Inland and coastal water transport	191	1765792
236202	Domestic air transport	209	860283
236300	Supporting and auxiliary transport activities	257	128092
236400	Post, telecommunications	333	214296
236500	Financial intermediation, insurance	341	97130
237000	Real estate activities	199	19001
237100	Renting of machinery and equipment	212	29559
237200	Computer and related activities	341	15562
237400	Other business activities	330	62967
238000	Education	338	7752
238500	Health and social work	341	138205
239000	Sewage and refuse disposal, sanitation and similar activities	317	4683
239100	Activities of membership organisations		0
239200	Recreational, cultural and sporting activities	199	2041
239300	Other service activities	330	79272
246300	Supporting and auxiliary transport activities	199	5259
247300	Research and development		0
247510	Public administration	341	1559
247520	Defence	203	238888
248000	Education		0
248500	Health and social work		0
249200	Other service activities		0
257510	Public administration	341	166
258000	Education		0
258500	Health and social work		0
259000	Sewage and refuse disposal, sanitation and similar activities	199	3170
259200	Other service activities		0
330000	Private household	316	4538557
	Total emissions		16527480

[a] As mentioned in 3.1, the detailing level implies that the figures within each sector should be interpreted with care. Particularly this is true for the service sectors, i.e. the service sectors within the sectors 235000-259200. The interpretation issues are particularly problematic if the data in the table are connected to other data sources than the Norwegian environmental accounts.

[b] One sector is removed from the table due to confidentiality concerns

[c] Some sectors with the same name appear more than once in the table, e.g. health and social work, for these sectors the leading two digits indicate as follows; 23=private sector, 24=central government and 25=local government.

Table A.2. Average CO_2 tax rate and emissions from stationary sources by sector. NOK/tonne CO_2 and tonne.[a,b,c]

Sector number	Sector	Average NOK/tonne CO_2	Emissions from stationary sources, tonne
230100	Agriculture	98	110764
230200	Forestry and logging		0
230510	Fishing		0
230520	Operation of fish farms	200	3260
231000	Coal mining		0
231110	Extraction of crude petroleum and natural gas	336	10864766
231120	Oil drilling		0
231300	Mining of metal ores	1	12185
231400	Other mining and quarrying	82	24131
231510	Production, processing and preserving of meat and meat products	131	42408
231520	Processing and preserving of fish and fish products	151	136610
231530	Processing and preserving of fruit and vegetables	108	16094
231540	Manufacture of vegetable and animal oils and fats	133	14505
231550	Manufacture of dairy products	117	33040
231560	Manufacture of grain mill products, starches and starch products	162	7348
231570	Manufacture of prepared animal feeds	70	53011
231580	Manufacture of other food products	169	37900
231590	Manufacture of beverages	191	20526
231700	Manufacture of textiles and textile products	120	13969
231810	Manufacture of leather clothes		0
231820	Manufacture of other wearing apparel and accessories	174	532
231830	Dressing and dyeing of fur, manufacture of articles of fur	199	678
231910	Tanning and dressing of leather, manufacture of luggage, handbags, saddlery and harness	199	1690
231930	Manufacture of footwear	199	70
232010	Sawmilling and planing of wood, impregnation of wood	195	2014
232020	Manufacture of particle board, fibre board and other panels and boards	89	41797
232030	Manufacture of builders' carpentry and joinery	194	1899
232040	Manufacture of other products of wood	199	393
232110	Manufacture of pulp	87	193986
232120	Manufacture of paper and paperboard	66	285360
232130	Manufacture of articles of paper and paperboard	82	16775
232210	Publishing	125	550
232220	Printing and service activities related to printing	23	8870
232230	Reproduction of recorded media		0
232320	Manufacture of refined petroleum products	0	1129538
232322	Manufacture of asphalt	199	1468
232340	Gas terminal	0	1161960
232411	Manufacture of industrial gases	165	301
232412	Manufacture of dyes and pigments and other inorganic basic chemicals	148	78145

232415	Manufacture of fertilisers, nitrogen compounds and pesticides	16	350996
232416	Manufacture of plastics and synthetic rubber in primary forms, manufacture of other organic basic chemicals	13	1156254
232430	Manufacture of paints and varnishes, printing ink and mastics	199	4581
232440	Manufacture of basic pharmaceutical products and pharmaceutical preparations	166	16520
232450	Manufacture of soap and detergents and toilet preparations	199	3763
232460	Manufacture of other chemical products	191	10360
232500	Manufacture of rubber and plastic products	137	27743
232610	Manufacture of glass and glass products	6	30781
232620	Manufacture of ceramic goods	4	10625
232640	Manufacture of other mineral products	49	239137
232650	Manufacture of cement, lime and plaster	9	446588
232710	Manufacture of basic iron and steel	51	120641
232730	Aluminium production	13	182330
232740	Other non-ferrous metal production	175	7628
232750	Casting of metals	93	5933
232810	Manufacture of fabricated metal products, except machinery and equipment	165	25966
232860	Manufacture of cutlery, tools and general hardware	198	2089
232870	Manufacture of other metal products	126	5478
232910	Manufacture of general purpose machinery	122	17149
232930	Manufacture of special purpose machinery	139	13057
232960	Manufacture of weapons and ammunition	199	136
232970	Manufacture of domestic appliances	152	3884
233000	Manufacture of office machinery and computers		0
233110	Manufacture of electric motors, generators and transformers, manufacture of electricity distribution and control apparatus	60	5414
233130	Manufacture of insulated wire and cable	196	1425
233140	Manufacture of other electrical apparatus and equipment	131	473
233210	Manufacture of electronic components and television and radio transmitters	0	387
233230	Manufacture of television and radio receivers, sound or video recording apparatus	199	16
233310	Manufacture of medical and precision instruments	199	228
233340	Manufacture of optical instruments, photographic equipment, watches and clocks	199	25
233400	Manufacture of motor vehicles and parts and accessories for motor vehicles	180	12950
233510	Building and repair of ships and boats	136	8160
233520	Building and repair of oil platforms	54	17039
233530	Manufacture and repair of railway and tramway locomotives and rolling stock	0	19
233540	Manufacture and repair of aircraft and spacecraft	0	1176
233550	Manufacture of other transport equipment	199	25
233610	Manufacture of furniture	199	7427
233620	Manufacture of jewellery and related articles	149	932
233630	Other manufacturing	182	941
233710	Recycling of metal waste and scrap	0	10019
233720	Recycling of non-metal waste and scrap	0	21

234010	Production of electricity	199	25081
234040	Steam and hot water supply	121	386481
234100	Collection, purification and distribution of water	199	2482
234500	Construction	120	121988
235000	Wholesale and retail trade, repair of motor vehicles and personal and household goods	193	190425
235500	Hotels and restaurants	123	51552
236010	Transport via railways	199	2263
236020	Tramway and suburban transport, other scheduled passenger land transport		0
236030	Taxi operation		0
236040	Other land passenger transport, freight transport by road		0
236080	Transport via pipelines	338	13548
236130	Inland and coastal water transport		0
236202	Domestic air transport		0
236300	Supporting and auxiliary transport activities	189	28056
236400	Post, telecommunications	199	4875
236500	Financial intermediation, insurance	199	24174
237000	Real estate activities	171	9661
237100	Renting of machinery and equipment	191	1830
237200	Computer and related activities		0
237400	Other business activities	195	10913
238000	Education	199	19200
238500	Health and social work	199	67572
239000	Sewage and refuse disposal, sanitation and similar activities	3	10495
239100	Activities of membership organisations	196	22990
239200	Recreational, cultural and sporting activities	198	20065
239300	Other service activities	196	80420
246300	Supporting and auxiliary transport activities		0
247300	Research and development		0
247510	Public administration	169	1442
247520	Defence	191	38746
248000	Education	160	3073
248500	Health and social work	15	19538
249200	Other service activities	91	571
257510	Public administration	187	14323
258000	Education	192	76673
258500	Health and social work	197	83605
259000	Sewage and refuse disposal, sanitation and similar activities	0	19348
259200	Other service activities	190	1688
330000	Private household	181	719873
	Total emissions		19140288

[a] As mentioned in 3.1, the detailing level implies that the figures within each sector should be interpreted with care. Particularly this is true for the service sectors, i.e. the service sectors within the sectors 235000-259200. The interpretation issues are particularly problematic if the data in the table are connected to other data sources than the Norwegian environmental accounts.

[b] One sector is removed from the table due to confidentiality concerns

[c] Some sectors with the same name appear more than once in the table, e.g. health and social work, for these sectors the leading two digits indicate as follows; 23=private sector, 24=central government and 25=local government.