

# Inventory of large CO<sub>2</sub> point sources in Denmark (1994 - 1999)

A GESTCO contribution

Michael Larsen



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## Introduction

Over the past three years the potential for underground storage of CO<sub>2</sub> in Denmark has been evaluated as part of the European Community supported research project GESTCO (Geological storage of CO<sub>2</sub> from fossil fuel combustion) (Christensen 2000). This report describes the criteria for CO<sub>2</sub> source selection in the Gestco study and list the major CO<sub>2</sub> sources in Denmark. The list has been established using public available databases and is cross checked with existing European CO<sub>2</sub>-inventories in order to validate data. The data forms the Danish contribution to the European CO<sub>2</sub> source inventory made available through the Gestco GIS and DSS system.

<http://www.nitg.tno.nl/projects/eurogeosurveys/projects/GestcoWeb>

## Data requirements

Considering geological storage of CO<sub>2</sub> requires large point sources (at least 1 Mtonnes) and preferably with a high concentration of CO<sub>2</sub> in the emission gas. The minimum value of a source is set on 200 ktonne/year but smaller sources of highly concentrated CO<sub>2</sub> as well as groups of smaller point sources are included.

Source	Cause of CO <sub>2</sub> emission
Power plant	combustion
Iron & steel	combustion
Refineries	combustion, production process
Ammonia	combustion, production process
Cement	combustion, production process
LNG	production process
Others	Production process

**Table 1.** *List of sources and the cause of CO<sub>2</sub> emission considered in the Gestco project (Eco-Fys 2000).*

The data on CO<sub>2</sub> emissions is compiled in an inventory for the seven countries participating in the Gestco project. The compilation of data is handled by Eco-Fys, Netherlands.

The data requirements are listed in Table 2.

Required data	Description
Emission	tonne CO <sub>2</sub> /year
Concentration	g/kg
Location	longitude, latitude
Fuel type	gas/coal/oil, carbon content
Type of process	type of power generation cycle, type of production process etc
Activity	tonne steel/year etc

**Table 2.** Required data for the Gestco CO<sub>2</sub> inventory (Eco-Fys 2000).

## Data sources

The Danish CO<sub>2</sub> inventory is based on statutory reports on energy producers (power stations and industry) to the authorities (The Danish Energy Agency). Additional data on CO<sub>2</sub> emission from industry processes were acquired from the National Environmental Research Institute of Denmark and direct contact to the industry. The CO<sub>2</sub> emissions are calculated values based on the fuel type and fuel consumption.

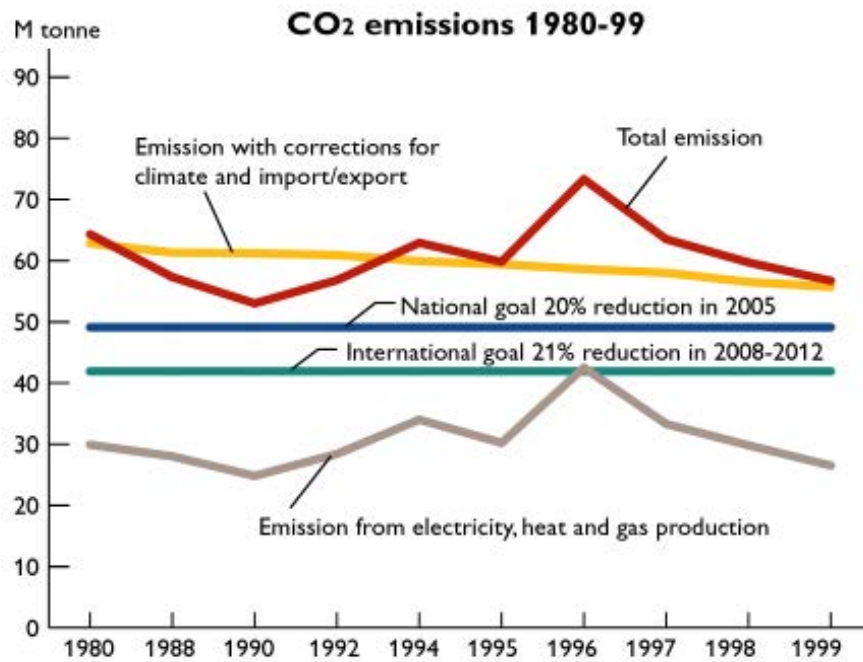
## Data confidentiality

Data on fuel consumption and CO<sub>2</sub> emission related to combustion is reported to the Danish Energy Agency according to the Danish statutory. Industry data on CO<sub>2</sub> emission related to production processes are often presented as bulk values in their annual "green accounts". However, data on CO<sub>2</sub> concentrations and relative emissions from various processes are not public available.

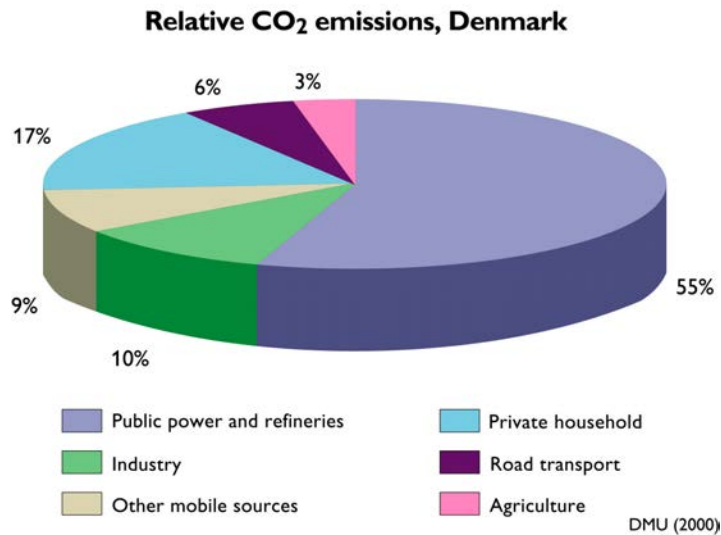
## CO<sub>2</sub> emission in Denmark

The total emission of greenhouse gases in Denmark is approximately 60 Mtonnes/year (Fenger 2000). CO<sub>2</sub> forms the main part of these gases. Denmark has decided to ratify the Kyoto agreement and the national goal is to reduce the total amount of greenhouse gases by 20% in year 2005. The total emission after reductions is calculated to 49.1 Mtonnes with 1990 as reference year.

The major part of CO<sub>2</sub> emission in Denmark is related to the public power stations and refineries. The two categories produced 55% of the total CO<sub>2</sub> emission in Denmark in 1997 whereas the emissions from industry sources in Denmark amounts to only 9% (Fenger 2000) (Fig. 2).



**Figure 1.** CO<sub>2</sub> emission in Denmark in the period 1980–1999 according to the Danish Energy Agency and own calculations. The 20% reduction in CO<sub>2</sub> and other greenhouse gasses according to the Kyoto agreements amounts to approximately 12 Mtonnes/year. Modified from Christensen & Larsen (2001).



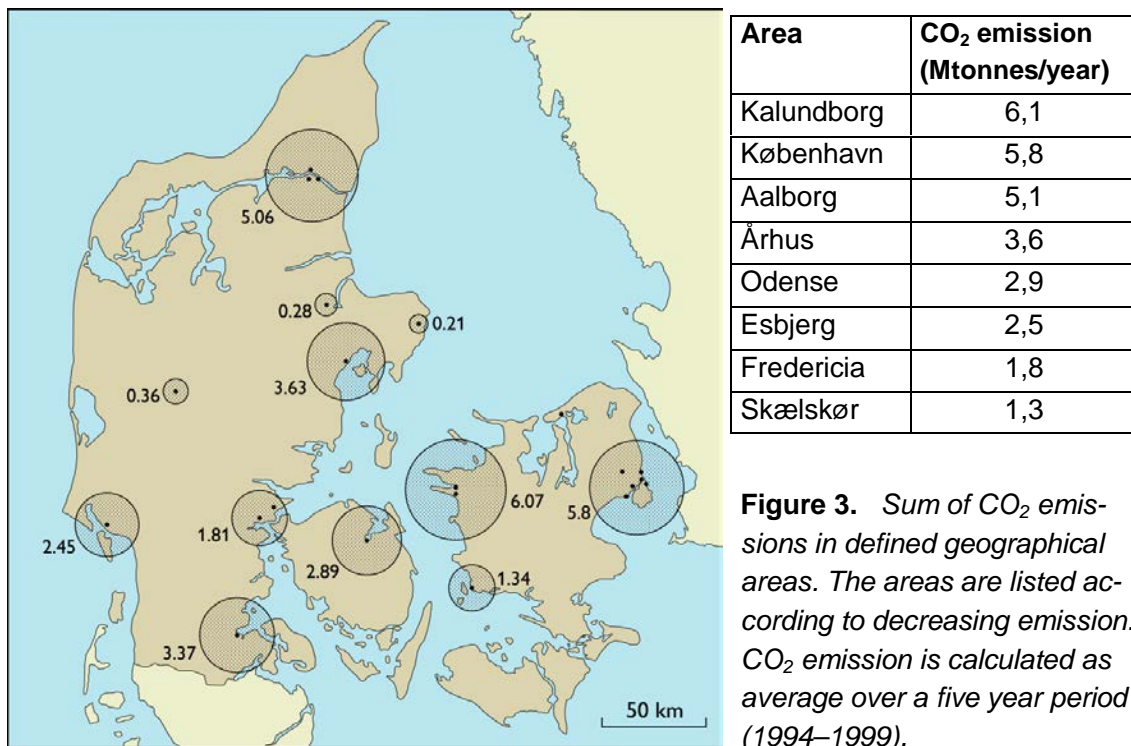
**Figure 2.** Emission of CO<sub>2</sub> related to six major groups. Note that the large stationary point sources; public power, refineries, and industry amounts to 64% of the total emission in Denmark. Modified from Fenger (2000).

## Large CO<sub>2</sub> point sources onshore Denmark

The main source of CO<sub>2</sub> emission in Denmark is from coal, oil and gas fired power plants (Table 3). These are often situated close to the major urban areas. The power plants are operated by two companies: Elsam and Energi E2, dividing the country into a western (Jutland and Fyn) and an eastern (Sjælland, Lolland, Falster) supply region.

In Denmark large power consuming industries are very restricted. In the categories studied in the Gestco project only two refineries, one iron and steel and one cement producer are represented (Table 3).

Based on the geographical distribution of the mapped point sources it is possible to define clusters with high CO<sub>2</sub> emissions (Fig. 3). These areas are especially interesting for CO<sub>2</sub> storage.



**Figure 3.** Sum of CO<sub>2</sub> emissions in defined geographical areas. The areas are listed according to decreasing emission. CO<sub>2</sub> emission is calculated as average over a five year period (1994–1999).

## Offshore sector

The production facilities in the Danish offshore sector in 1999 had a total CO<sub>2</sub> emission of 2.2 Mtons and thus accounts for about 3.5% of the total CO<sub>2</sub> emissions in Denmark (Energi styrelsen 2000). The CO<sub>2</sub> emission comes from energy production (2/3) and gas flaring (1/3). In general the natural content of CO<sub>2</sub> in the natural gas is low in the Danish sector and facilities to separate CO<sub>2</sub> from the gas does not exist on any of the platforms.

## CO<sub>2</sub> sources - projection 2000–2005

An estimate of the development of individual point sources during the next five year period (2000–2005) is considered important. The highest CO<sub>2</sub> emissions in Denmark thus originate from power plants and industrial production using older technologies. It is thus likely that these plants will be modernized or closed in the coming years in order to meet governmental demands. New industrial or public facilities with major CO<sub>2</sub> emissions are to our knowledge not planned in Denmark at the moment.

## Conclusions

The annual emission greenhouse gases in Denmark is close to 70 Mtonnes. Approximately half of this originate from fossil fuel combustion related to power and heat generation. Based on yearly reports to the Danish Energy Agency a list of 23 major CO<sub>2</sub> point sources have been identified. These source contributes with 33.6 Mtonnes CO<sub>2</sub> or approximately half of the total CO<sub>2</sub> emission in Denmark. The largest single source in the reported period is the Asnæs Power Plant situated in Kalundborg. The coal fired plant thus contributed with 5.8 Mtonnes CO<sub>2</sub>/year in the period 1994–1999. This corresponds to half of the reductions required for Denmark in the Kyoto agreement. The Danish inventory forms part of the European GIS and DSS system prepared for the Gestco project.

## References

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Name	Region	Type	Fuel	Average (1994-99) CO <sub>2</sub> tonnes/year
Asnæsværket	Kalundborg	Electricity production	Coal/orimulsion	5661848
Studstrupværket	Aarhus	Electricity production	Coal	3629584
Enstedværket	Aabenraa	Electricity production	Coal	3374830
Fynsværket	Odense	Electricity production	Coal	2892658
Aalborg Portland	Aalborg	Cement production	Coal/Petcoke/heavy oil	2605308
Amagerværket	København	Electricity production	Coal	2528496
Vestkraft	Esbjerg	Electricity production	Coal	2451401
Avedøreværket	København	Electricity production	Coal	1603361
Vendsysselværket	Aalborg	Electricity production	Coal	1445075
Stignæsværket	Skælskør	Electricity production	Coal	1343299
Skærbækværket	Fredericia	Electricity production	Coal/gas	1313334
Aalborgværket	Aalborg	Electricity production	Coal	1006362
Vestforbrændingen	København	Combustion of waste	Heavy oil	529490
Shell Raffinaderi	Fredericia	Refineri	Gas from refinery	499290
H.C. Ørstedsværket	København	Electricity production	Gas/heavy oil	481369
Statoil Raffinaderi	Kalundborg	Refineri	Gas from refineri	411130
Herningværket	Herning	Electricity production	Coal	364013
Svanemølleværket	København	Electricity production	Gas	339113
Amagerforbrændingen	København	Combustion of waste	Heavy oil	321790
Måbjergværket	Ringkøbing	Electricity production	Coal	260440
Grenå Kraftvarmeværk	Grenå	Electricity production	Coal	211830
Stålvalseværket*	Frederiksværk	Iron and steel	Industry processes	117190
			<b>Total CO<sub>2</sub> emission</b>	<b>33672758</b>

\*Production processes changed in 2000

**Table 3.** CO<sub>2</sub> inventory, showing selected CO<sub>2</sub> point sources in Denmark listed after falling average yearly emissions. The list contains information on; name, industry category, city, fuel type and average CO<sub>2</sub> emission during the study period 1994–1999.