Quarterly estimates of greenhouse gas emissions in accordance with the IPCC guidelines

Krista Keller
Sjoerd Schenau

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Abstract

Statistics Netherlands published a first estimate of greenhouse gas emissions in 2020 in mid-March 2021. This is the result of a new methodology that was developed to estimate quarterly emissions in accordance with the IPCC guidelines. These quarterly estimates are used to gain more rapid insight into actual emission trends in support of Dutch climate policies. Hence, Statistics Netherlands will publish the GHG-emissions of a certain quarter 2.5 months after the end of that quarter (mid-June for the first quarter of 2021).

1. Introduction

Increased atmospheric greenhouse gas concentrations over the past centuries have disrupted the balance of the climate system. As a series of regulations and agreements have been formulated to reduce global warming, it is essential to measure the amount and origin of greenhouse gases (GHG) emitted accurately and rapidly to help governments achieve their objectives.

In the Netherlands, annual data on GHG emissions (national emission inventory[1] and environmental accounts[2]) usually become available nine months after the end of the year under review.

In 2010, Statistics Netherlands developed a quarterly based CO2-emission account that served as a short-term indicator for policymakers and researchers to assess how GHG emissions change in response to economic growth or decline, as carbon dioxide is the most important anthropogenic greenhouse gas. This quarterly estimation uses the same concepts and definitions as the national and environmental accounts, which makes it possible to derive the impact of the economy on the environment.

In 2020, the Dutch Ministry of Economic Affairs and Climate Policy requested Statistics Netherlands to develop quarterly estimates in accordance with the IPCC guidelines. In addition, as the Dutch Climate Agreement distinguishes five climate sectors (industry, power, mobility, agriculture, and built environment), Statistics Netherlands also investigated the possibility of disaggregating the figures into these five sectors. On 15 March 2021 Statistics Netherlands published a first news release based on these new data: Greenhouse gas emissions 8 percent down in 2020 (cbs.nl). This shows an improved timeliness of annual emission data as a result of earlier availability of data for the underlying four quarters.

The main differences between the IPCC method and the environmental accounts method (SEEA) is that that the former excludes international sea and air transport and biomass combustion. Moreover, the IPCC method is based on a territory approach, while the SEEA figures are based on a residency approach. On an annual basis GHG emissions based on SEEA are about 20 percent higher[3].

This paper summarizes the applied methodology and outcomes of the study, which was conducted by Statistics Netherlands in cooperation with the National Institute for Public Health and the Environment (RIVM)/Dutch Pollutant Release and Transfer Register (PRTR), and financed by the Ministry of Economic Affairs and Climate Policy in the Netherlands.

[1] Since 1974 a number of organizations have been working closely together in the Dutch Pollutant Release and Transfer Register (PRTR) to collect and formally establish the annual releases of pollutants to air, water and soil in the Netherlands. Results serve to underpin the national environmental policy and provide data for the many environmental reports to international organizations such as the European Union and the United Nations, e.g. the National Inventory Report for the Kyoto Protocol.

[2] The air emission accounts of the environmental accounts (SEEA) register all emissions to air by resident units. This includes all emissions by transport activities that occur outside the national borders. The air emission accounts are consistent with the data form the SNA (System of National Accounts. The scope of these SEEA emissions differs from the IPCC guidelines, on which most national and international agreements are based.

[3] Hoe groot is onze broeikasgasuitstoot? (cbs.nl) (Dutch)

2. Methodology

2.1 IPCC methodology for annual greenhouse gas emissions

The general methodology for the official yearly estimates of emissions according to IPCC definitions is based on statistics on activities and corresponding emission factors:

$$\text{Emission } E(t) = \text{activity data } A(t) \times \text{emission factor } EF(t) \quad (1)$$

The activity data are derived mainly from national statistics, supplemented with source-specific information. Examples of activity data are energy consumption by energy carrier (from the energy balance sheet), volume of processed iron and steel, number of livestock, etc. The emission factor is a coefficient that converts activity data into GHG emissions. It is the average emission rate of a given source, relative to units of activity or process. These emission factors are based on (model-based) calculations or international literature.[4] The emission factors can change over time and are set after the year under review is completed.[5]

2.2 Adjusted methodology for the quarterly estimations

Not all activity data used for the yearly estimations are available on a monthly or quarterly basis. Neither are the emission factors. Therefore, an alternative method has to be applied for a quarterly estimation.

In general, the same activity data are used whenever possible (mainly use of energy carriers) and the most recent emission factors are incorporated (*t-1*), with the exception of the emission factor of natural gas which is known for *t*. If official activity data are not available on a monthly or quarterly basis, alternative activity data reflecting the official data are applied as a proxy, and can thus be seen as the emission driver.

Instead of applying formula 1, an alternative approach is applied in order to stay as close as possible to the official yearly figures. The quarterly emissions of a certain activity in year (*t)* equals the emissions of this activity in the same quarter of the previous year (*t-1*) multiplied by the change of the activity data in this period.

$$EQ(i,t) = EF(i,t-1) \times AQ(i,t) \quad (2)$$

$$= EF(i,t-1) \times AQ(i,t-1) \times [AQ(i,t)/AQ(i,t-1)] \quad (3)$$

$$= EQ(i,t-1) \times AQ(i,t) / AQ(i,t-1) \quad (4)$$

With *EQ (i,t)* as the emissions of activity *i* in quarter *Q* of year *t*, *EF (i,t-1)* as the emission factor of activity *i* a year earlier (*t-1*), *AQ (i,t)* as the activity data of activity *i* in quarter *Q* of year *t*, *AQ (i,t-1)* as the activity data of activity *i* in quarter *Q* a year earlier *(t-1),* and *EQ(i,t-1)* as the emissions of activity *i* in quarter Q a year earlier *(t-1).*

[4] http://www.emissieregistratie.nl/erpubliek/misc/documenten.aspx (Dutch)

[5] With the exception of natural gas, which is set annually at the beginning of the year concerned.

As not all activity data are available on a quarterly basis, alternative (proxy) indicators are included, based on econometric research, which reflect the development of the official activity.

$$EQ(i,t) = EQ(i,t-1) \times IQ(i,t)/IQ(i,t-1) \quad (5)$$

With *IQ (i,t)* as proxy indicator of activity *i* in quarter *Q* of year *t*, and *IQ (i,t-1)* as proxy indicator of activity *i* in quarter Q a year earlier *(t-1).*

The indicators used and the quality of these indicators can be found in appendix A.

An estimation of the quarterly GHG emissions can be made by using formulas (4) and (5), including a break down to climate sector.

2.3 Calculation steps

The method described in section 2.2. is translated into the following calculation steps:

1) Clusters of emissions
   The official annual emissions according to the IPCC guidelines of t-1 are used as a benchmark. These are broken down into a) greenhouse gas (CO_2, CH_4, N_2O, F-gasses), b) activity, and c) energy carrier. Additionally the emissions are linked by their activity to a climate sector: industry, power, mobility, agriculture, and built environment.

2) Activity data / indicators
   Each cluster of emissions defined in step 1 is either linked to the quarterly available activity data or to a proxy.

3) Emission factors
   The methodology assumes the same emission factors of one year earlier (t-1), except for natural gas.

4) Quarterly distribution
   The annual emission of a specific emission cluster one year earlier (t-1) is divided into quarters based on the quarterly pattern of the activity data/proxy the same year.

5) Estimation of the quarterly emission in year t
   The quarterly greenhouse gas emissions in year t can be compiled by using formulas (4) and (5). Subsequently, the estimated emissions are aggregated by climate sector.

6) Rebase (to final figures)
   Finally, after carrying out the estimation for the four quarters, the
   sum of the four quarters has to be rebased with the aid of 'official' annual emissions. For consistency reasons rebasing is required every time an annual emission figure is revised.

2.4 Main data sources

Energy balance sheet
The energy balance sheet is an overview of energy flows in the Netherlands: production, imports, exports, stock changes and consumption. It describes the supply and the type of consumption of energy commodities, but also the energy consumption by sector. Statistics Netherlands publishes a monthly balance sheet of natural gas, coal and coal products, electricity, crude oil and petroleum products. These statistics contain data used for the official annual figures of IPCC emissions which are also used for the quarterly estimation. For more information see Manufacturing and energy (cbs.nl).

Supply and use tables (SUT; national accounts, quarterly basis)
The supply table describes the supply of different kinds of products by industry. The use table describes the use of different kinds of product by industry. A row in the use table describes the destination of each product. The volume development of the production of certain industries can be used as proxy for some activities for which no quarterly activity data are available. For more information see Macroeconomics (cbs.nl).

Data from the NEMA model / data on cattle
The National Emission Model for Agriculture (NEMA) was developed to calculate emissions from livestock (including CH_4 and N_2O). The most important inputs for the model are the development of the livestock (activity data) and the associated emission factors. On a quarterly basis, the calculations of the NEMA model are not yet available and the development of the livestock (cattle) is used from the agricultural statistics as an indicator.

3. Quality assessment and results

The methodology has been tested on some older years of which the annual figures are already known. The quarterly estimations were summed up to annual figures and these were compared to the official annual figures. Table 1 shows the average deviation over 2016-2019.

Table 1. Average deviation (2016-2019) of the quarterly estimation on an annual basis compared to the official annual IPCC figures.

	CO_2	CH_4	N_2O	Total GHG
Total	0.3%	0.7%	4.3%	0.3%
Agriculture	2.0%	1.3%	2.8%	1.3%
Industry	0.7%	1.0%	8.0%	0.7%
Power	0.6%	3.9%	1.2%	0.7%
Built environment	1.4%	1.1%	2.1%	1.4%
Mobility	0.9%	3.2%	2.6%	0.9%

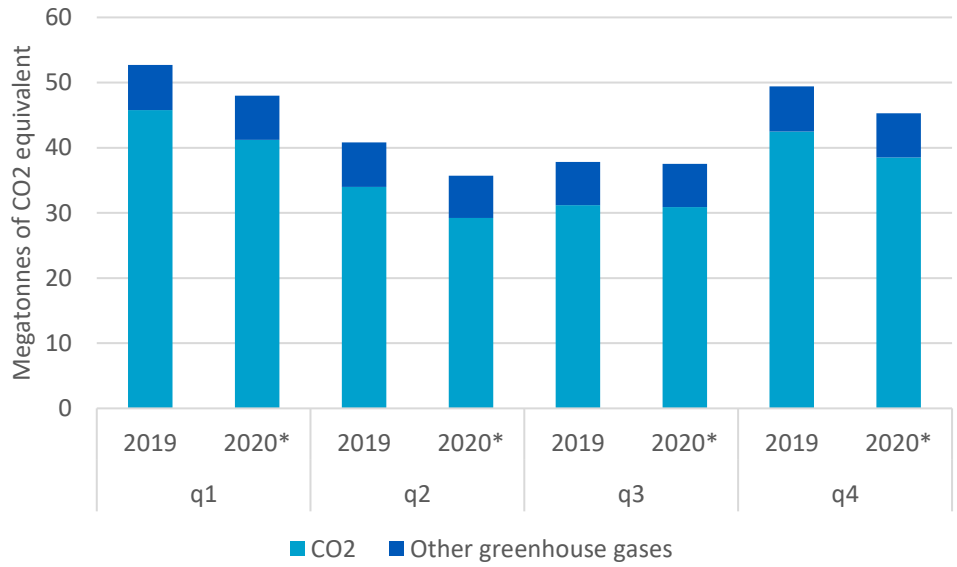
Source: Statistics Netherlands.

For the total figures, the deviation is on average 0.3 percent. The quarterly estimation of CO_2 is slightly more robust than the other greenhouse gasses. There is also a difference in robustness among the five sectors. The main reason for these differences is the quarterly availability and quality of the of underlying data by sector and GHG.

Based on the quarterly estimation of IPCC-emissions, in March 2021 Statistics Netherlands published a first annual estimate of GHG emissions in 2020. The figures are subject to minor revisions based on new data sources that become available at a later stage.

Figure 1 shows the greenhouse gasses per quarter for 2019 and 2020. In Q4 2020, CO_2 emissions according to IPCC guidelines were 9 percent lower than in the same quarter of the previous year. This marked a continuation of the declines in Q1 and Q2, after virtually no change was recorded in Q3. A large part of the decrease in Q4 can be attributed to lower coal consumption in the electricity sector and less transport movement on account of COVID-19 measures. In the industry sector, CO_2 emissions were at approximately the same level as in Q4 2019.

Figure 1. Dutch GHG emissions according to IPCC guidelines.

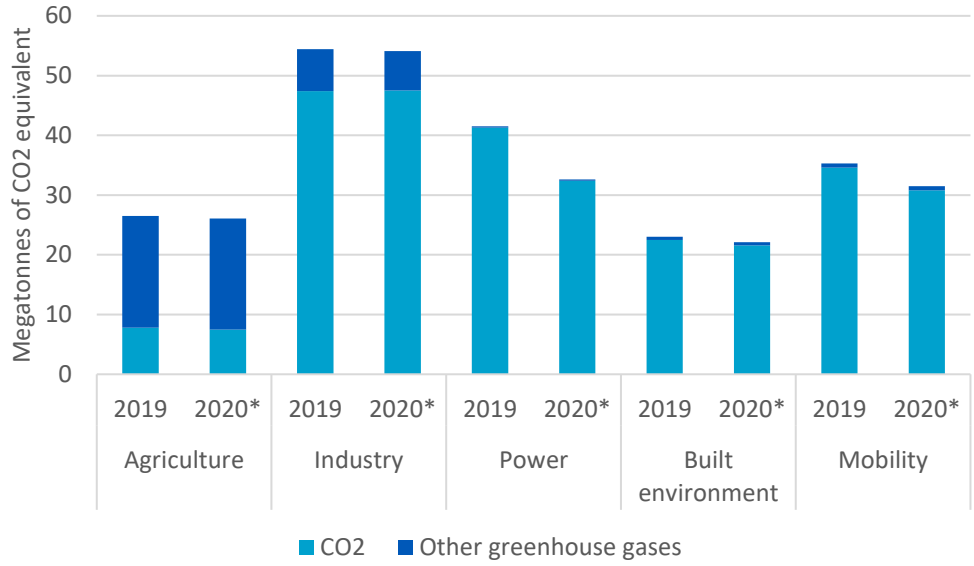


Source: Statistics Netherlands

The sum of the four quarterly estimations for 2020 results in a first estimation of the annual emission for 2020. In 2020, GHG emissions showed a year-on-year decrease of 8 percent, from 181 to 166 megatonnes CO_2 equivalent. This is 24.5 percent lower than in 1990 and comes close to the Urgenda target[6], i.e. a reduction in GHG emissions of at least 25 percent between 1990 and 2020. The most substantial decrease in GHG emissions last year was recorded in the power sector, namely 21 percent from 2019. This is related to the reduced consumption of coal. The year-on-year reduction for mobility, a drop of 11 percent, is mainly the result of the COVID-19 outbreak. The Dutch government urged people to stay at home and work from home as much as possible. As a result, there was less reason to drive a car and motor fuel sales fell substantially.

[6] In the Urgenda climate case of 24 June 2015, a Dutch court ruled that by 2020 national emissions must be reduced by at least 25 percent from the 1990 levels. In its Coalition Agreement of 10 October 2017, the government set the target of 49 percent lower emissions by 2030 relative to 1990. In 2020, GHG emissions may not exceed 166 megatonnes CO_2 equivalents. This limit is set at 113 megatonnes CO_2 equivalents for the year 2030.

Figure 2. Dutch GHG emissions by sector



Source: Statistics Netherlands

The official annual emission figures for 2020 will be published at the beginning of September 2021. These are compiled under the responsibility of the Dutch Emission Registration and are used in international reporting. These figures will be more accurate, especially at sector level. The definite figures for 2020 will be available in February 2022.

Appendix A. Indicators per greenhouse gas and sector

Indicator group (quality indicator):

1) **The indicator is identical to the emission variable (activity data)**
   e.g. consumption of coal by power plants
2) **The indicator represents a large part of the emission variable**
   e.g. consumption of natural gas by power production as reported in the monthly energy statistics does not equal the exact consumption of natural gas by the climate sector power.
3) **The indicator correlates with the emission variable**
   e.g. trends in Gasunie Transport Services (GTS) data. This indicator correlates reasonable well with emissions from consumption of natural gas by the industry.
4) **The emission is kept constant at the level of the previous year**
   e.g. other CO_2 emissions in the built environment. No reliable proxies or sources are (yet) available.

Greenhouse gas: CO_2

Sector	Energy carrier	Indicator	Indicator group
Agriculture	Natural gas	Input of natural gas for CHP in agriculture and remaining use of natural gas in homes using the degree-days method (energy database, Statistics Netherlands)	2
	Crude oil products	Net consumption of petroleum products in agriculture (energy database, Statistics Netherlands)	1
Industry	Natural gas	Trends in GTS data	3
	Coal	StatLine: coal use in coke ovens and the iron/steel industry	1
	Crude oil products raffinaderijen	Net consumption of all petroleum-based raw materials and products by refineries (energy database, Statistics Netherlands)	2
	Crude oil products, chemical industry	Net consumption of petroleum products by the chemical industry (energy database, Statistics Netherlands)	2
	Crude oil products, other	Net consumption of petroleum products by other industry (energy database, Statistics Netherlands)	2
	Other	Constant (not related to use of coal, natural gas or petroleum)	4
Power	Natural gas	Consumption of natural gas to produce power (energy database, Statistics Netherlands)	2
	Coal	Consumption of coal by power plants (energy database, Statistics Netherlands)	1
	Residual gases	Net consumption of residual gas by power plants (energy database, Statistics Netherlands)	1
	Blast furnace gas/cokes oven gas	Net consumption of blast furnace and coke oven gas by power plants (energy database, Statistics Netherlands)	1
	Other	Constant (not related to use of coal, natural gas or petroleum)	4

Built environment	Natural gas	Consumption by dwellings and services based on degree-days method (energy database, Statistics Netherlands)	2
	Petroleum products	Net consumption of petroleum products by dwellings and services (energy database, Statistics Netherlands)	2
	Coal	Net consumption of coal by dwellings and services (energy database, Statistics Netherlands)	2
Mobility	Road tansport: diesel	StatLine: motor fuels, deliveries; diesel by road transport	1
	Road traffic: gasoline	StatLine: motor fuels, deliveries; gasoline by road transport	1
	Road traffic: automotive LPG	StatLine: motor fuels, deliveries; automotive LPG by road transport	1
	Water transport	StatLine: motor fuels, deliveries; motor fuels by water transport	2
	Other transport	constant	4
	Fishing	Consumption of diesel by fisheries (energy database, Statistics Netherlands)	2
	Other mobile sources	Constant	4

Source: Statistics Netherlands.

Greenhouse gas: CH_4

Sector	Energy carrier	Indicator	Indicator group
Agriculture	Natural gas	Input of natural gas for CHP in agriculture and remaining consumption of natural gas by dwellings using the degree-days method (energy database, Statistics Netherlands)	3
	Process	Cattle	2
	Other	Constant	4
Industry	Process	Linear reduction in landfill	2
	Extraction	StatLine: natural gas balance sheet; extraction	3
	Other	Constant	4
Power	Total	Constant	4
Built environment	Total	Consumption by dwellings and services based on degree-days method (energy database, Statistics Netherlands)	3
Mobility	Total	Constant	4

Source: Statistics Netherlands.

Greenhouse gas: N_2O

Sector	Energy carrier	Indicator	Indicator group
Agriculture	Process	Cattle	3
	Other	constant	4
Industry	Process	SUT: production by fertlizer industry	3
	Other	Constant	4

Power	Coal	Consumption of coal by power plants (energy database, Statistics Netherlands)	3
	Overig	Constant	4
Built environment	Total	Constant	4
Mobility	Total	Constant	4

Source: Statistics Netherlands.

Greenhouse gas: F-gassen

Sector	Energy carrier	Indicator	Indicator group
Total	Total	Constant	4

Source: Statistics Netherlands.