

Greenhouse Gas Inventories for SWEEG: Methodology Paper

CENTRE FOR ENERGY AND THE ENVIRONMENT

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1	Added notes on marine and aviation emissions.	A.D.S.Norton	27/11/2019
2	Added note on wastewater emissions change requested by DCC		
3	Updated descriptions of categories to reflect reallocation of industrial fuel emissions from Commercial and Institutional to Manufacturing and Construction		

Cover photo: East John Walk, Exeter.

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MANAGEMENT SUMMARY

The Centre for Energy and the Environment has produced baseline greenhouse gas inventories for district and unitary authorities within the south-west peninsula. The inventories inform the development of trajectories to net zero carbon. This report documents the methodology adopted to prepare the inventories.

1. INTRODUCTION

The Centre for Energy and the Environment has produced baseline greenhouse gas inventories for district and unitary authorities within the south-west peninsula. The inventories inform the development of trajectories to net zero carbon. This report documents the methodology adopted to prepare the inventories.

1.1 SCOPE – GREENHOUSE GASES

The inventories include the six greenhouse gases covered by the Kyoto Protocol, namely carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF₆). The global warming potential (GWP) of each gas has been used to combine the values for the six pollutants into a single carbon dioxide equivalent (CO₂e) value. The GWP values used were taken from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report 2013¹, as shown in Table 1.1. The values are based on a 100-year time horizon and exclude climate-carbon feedbacks.

Table 1.1. Global Warming Potential values from the IPCC Fifth Assessment Report.

Gas	Global warming potential
Carbon dioxide (CO ₂)	1
Methane (CH ₄)	28
Nitrous oxide (N ₂ O)	265
Hydrofluorocarbons (HFCs)	Varies with species (4 – 12,400)
Perfluorocarbons (PFCs)	Varies with species (6,630 – 17,400)
Sulphur hexafluoride (SF ₆)	23,500

1.2 SCOPE – GEOGRAPHIC BOUNDARIES

The geographic boundaries for the assessment were those of the unitary and district authorities within the former county of Devon, Cornwall and the Council of the Isles of Scilly. Separate inventories have been produced for each authority area.

1.3 SCOPE – EMISSION SOURCES

Emissions have generally been considered from sources within the geographic boundary. Sources have been categorised into the sectors and sub-sectors listed in Table 1.2. Emissions have been reported within these subsectors as far as possible given data availability; in some cases emissions are aggregated at a higher level. Attempts to estimate aviation and marine emissions are included in Section 2.7, but have been excluded from the main analysis due to uncertainty and incompleteness in the underlying data.

Table 1.2. Sectors and sub-sectors used to report greenhouse gas emissions.

Sector	Sub-sectors
Stationary energy	Residential buildings
	Commercial and institutional buildings and facilities
	Manufacturing industries and construction
	Energy industries
	Agriculture, forestry and fishing industries
Transportation	Road vehicles
	Railways
	Off-road vehicles
Waste	Solid waste disposal
	Biological treatment of waste
	Incineration and open burning
	Wastewater treatment and discharge
Industrial processes and product use (IPPU)	Industrial processes
	Product use
Agriculture, forestry and land use (AFOLU)	Livestock
	Land
	Aggregate source and non-CO ₂ emissions
Other indirect emissions	Other scope 3 emissions from all sources

Emissions are reported by *scope*, depending on where the emissions occur. Scope 1 emissions arise from sources located within the inventory’s physical boundary, for example direct combustion of fuel in a heating boiler. Scope 2 emissions occur as a direct consequence of the use of grid-supplied electricity, steam and cooling within the inventory’s physical boundary, i.e. from fuel combusted to produce the electricity or heat. Scope 3 emissions occur as a result of activity other than that covered by Scope 2 outside of the inventory’s physical boundary as a result of activity within the boundary. In this study, Scope 3 emissions were limited to losses associated with electricity transmission and distribution.

2. METHODOLOGY BY SUB-SECTOR

Sources of data including activity and consumption data and greenhouse gas emission factors are documented in this section for each sub-sector. In some cases alternative sources of information were available and may be used to verify the magnitude of uncertainty in calculated emissions.

It should be noted that there are some differences in the methodology adopted and that used to produce similar baseline inventories for Cornwall and the Isles of Scilly². These latest inventories were not subject to client-driven specifications of the inventories prepared previously, allowing simpler methodologies to be adopted that generally result in very similar output. The spreadsheet constructed allows output to be produced for Cornwall and the Isles of Scilly that can be directly compared to that for the Devon district and unitary authorities.

2.1 FUEL CONSUMPTION (STATIONARY SOURCES)

Emissions arising from fuel consumption in the domestic, non-domestic and transportation sectors were taken from greenhouse gas emissions data compiled by national government at local authority level³. Only CO₂ emissions are reported by that source; emissions of CH₄ and N₂O were estimated by comparing the fuel-specific emissions factor for each pollutant. The emission factors were sourced from those compiled by the UK government for company reporting. For electricity, the values used were taken from the methodology paper⁴ for the *data year*, as against the *reporting year*. Factors for the *reporting year* lag behind the *data year* values derived from underlying national greenhouse gas emissions inventory data by two years. Significant differences

arise between the two sets of values in the case of electricity where the emission factors have changed rapidly over the past few years as a consequence of the change in electricity generation technology mix. For other fuels and activity, this problem was addressed by taking values from the annual emission factor spreadsheets⁵, with a two-year offset applied (e.g. for 2016, the value in the 2018 version of the spreadsheet was applied).

Fuel consumption is generally reported by suppliers on a gross calorific value basis⁴. Emission factors calculated on this basis have therefore been used in the calculations described above. Petroleum product and manufactured solid fuel consumption data are not disaggregated further by fuel type. Consumption was mapped to the most ubiquitous type of fuel for each subsector, taken to be burning oil for the domestic consumption of petroleum products and coking coal for domestic MSF.

Emissions from electricity usage were disaggregated into scope 2 emissions from electricity production implicit in the consumption and scope 3 emissions from transmission and distribution losses on the basis of the emission factors.

In 2019 the government emissions data was refined to report non-domestic fuel emissions separately for the commercial, public administration and industry sectors, for each fuel (electricity, gas and other). The change has been applied retrospectively to figures reported for earlier years. Emissions categorised commercial and public administration have been reported under commercial/institutional, and emissions categorised industrial have been reported under manufacturing and construction. An additional emissions figure is provided for large industry; this continues to be reported under manufacturing and construction.

Emissions (including non-CO₂ greenhouse gases) have also been calculated for each sector (commercial, public administration and industry) by fuel separately from the categorised totals described above. These are available in a supplementary output table in the spreadsheet.

2.2 ENERGY INDUSTRIES

Emissions from electricity generation plant has been taken from the National Atmospheric Emissions Inventory (NAEI) list of point sources⁶. Energy from waste plants are at present excluded and their emissions reported under waste disposal. Given the lack of data on emissions from other auxiliary operations or small generators the magnitude of their emissions has not been estimated.

2.3 AGRICULTURE, FORESTRY AND FISHING

Data on agricultural emissions published at local authority level³ include the consumption of petroleum, solid fuels, urea application and liming. The majority of emissions are assumed to arise from petroleum combustion, and associated CH₄ and N₂O emissions have been estimated on this basis.

Agriculture emissions from livestock and cultivation have been reported separately, and include enteric fermentation in livestock, the management of manure produced by livestock, and nitrogen, phosphate, potash and magnesium application on cultivated land. Emissions have been estimated from agricultural activity data taken from government statistics⁷. Detailed data at local and district authority level are only published for selected years, coinciding with the EU Farm Structure Survey. The latest available data year is 2016. Data have been interpolated between years as necessary. Exeter and East Devon's emissions are reported as an aggregate figure, as are those for Plymouth,

Torbay and South Hams. In these cases, agricultural emissions for Exeter, Torbay and Plymouth were assumed to be negligible.

Greenhouse gas emission factors for each type of livestock, fertiliser application rates and emission factors for fertilisers were taken from Cornwall Council's 2008 inventory⁸. The latter only provide a CO₂e emission value. The figures have been checked against the latest versions of the source documents^{9, 10} and have been found to remain representative.

As an alternative, NAEI area¹⁵ source emission data for CO₂, CH₄ and N₂O are available for the agricultural sector. These have been summed for each district or unitary authority; they represent total emissions from agricultural fuel consumption, livestock and arable farming.

2.4 ON-ROAD TRANSPORTATION

Road transport emissions are reported at local authority level³, by road type. Emissions of CH₄ and N₂O have been estimated by comparison of fuel emission factors; the petrol / diesel split of fuel consumption was taken from local authority level transport fuel data¹¹. CO₂ emissions from "transport-other" have been included in the road transport figure; this includes emissions from LPG-powered road vehicles, the combustion of lubricants in road vehicles, aircraft support vehicles, coal-fired railways and inland waterways. Given the diverse mix of sources, no attempt has been made to estimate emissions of CH₄ and N₂O.

No data have been identified for electric and other alternative-fuelled vehicles. Electricity consumed to recharge vehicles will be reported under the domestic and commercial, institutional and industrial sectors.

2.5 RAILWAYS

Emissions from diesel-powered trains are reported at local authority level³. Emissions of CH₄ and N₂O have been estimated by comparison of fuel emission factors.

Electricity consumption by railway vehicles is reported under industrial and commercial electricity in the local authority emission dataset³. None of the national rail network in Devon or Cornwall is electrified; electric railways are limited to cliff lifts and heritage operations such as the Seaton Tramway and battery-electric on-rail maintenance vehicles and are therefore considered negligible.

2.6 OFF-ROAD TRANSPORTATION

Off road vehicles are defined as transportation within facilities such as airports. These were assumed to be negligible within the study area and were not estimated.

2.7 AVIATION AND MARINE

Limited data are available on aviation and marine transport activity in and around Devon. Furthermore there are questions as to where the boundary should be set for such emissions. Possible options might include setting the boundary at the border of Devon, at the boundary of UK territorial waters, or including only journeys originating in (or alternatively arriving into) Devon.

Aviation activity data are available from the UK Civil Aviation Authority (CAA)¹². Detailed data are available on domestic and international passenger flights from Exeter International Airport, the only sizeable public airport in the county. Flight distances have been taken as the straight line distance between the origin and destination, increased by 9% to allow for indirect flight paths¹³. Emission factors⁴ including the effects of radiative forcing have been applied, distinguishing

between domestic and short-haul flights. One-half of the total flight distance (for domestic flights) and the total distance of outbound international flights (incoming flight data not being available) have been used in the calculation. The resulting emissions are shown in Table 2.1.

Table 2.1. Flight emissions estimates for Devon for 2017 (passenger flights only).

Flight Type	Emissions (t per annum)			
	CO ₂	CH ₄	N ₂ O	Total CO ₂ e
Domestic Flights	46,861	11	234	47,105
International Flights	125,000	8	624	125,632
All Flights	171,860	18	858	172,737

The CAA data on air freight and air mail are in the form of tonnes lifted, with no distance information. Emissions from these flights could not therefore be estimated.

Data on marine activity are available from the UK Government on the fishing fleet¹⁴. Data were extracted for vessels with a home port within Devon. In 2017 there were 390 fishing vessels 10 m or under in length and 114 vessels with a length exceeding 10 m. The engine power is stated for each vessel, and this was multiplied by an assumed 1,600 operating hours per year to provide an approximate estimate of annual energy consumption. Applying emission factors for gas oil (red diesel) results in the emissions listed in Table 2.2.

Table 2.2. Emissions estimates for fishing vessels in Devon for 2017.

Vessel Size	Emissions (t per annum)			
	CO ₂	CH ₄	N ₂ O	Total CO ₂ e
≤ 10 m length	9,572	10	109	9,692
> 10 m length	13,426	14	154	13,594
All Fishing Vessels	22,998	24	263	23,286

Data for non-fishing vessels are extremely limited. The only data identified on commercial shipping data were in the form of tonnes lifted with no distance information, and hence could not easily be used to estimate emissions. Recreational boating data were not identified at a sub-national level, nor in a form that could easily be used to estimate emissions. Whilst there are indications that recreational boats far exceed the fishing fleet, perhaps by an order of magnitude, usage hours are likely to be low. Finally, the number of registered passenger boats is very small and therefore they will contribute a very small amount to total emissions.

Owing to the high levels of uncertainty and incomplete nature of the emissions estimated in this section, they have been excluded from the totals presented in the spreadsheet accompanying this analysis. Compared to total CO₂e emissions for the Devon local authority area, the calculated aviation figure amounts to 9.2% of transport emissions and 2.6% of total emissions. Estimated emissions from fishing vessels amount to 1.2% of transport emissions and 0.3% of total emissions.

2.8 SOLID WASTE DISPOSAL, INCLUDING INCINERATION

NAEI point⁶ and area¹⁵ source emission data for CO₂, CH₄ and N₂O were summed within each area. Point sources included emissions from landfill sites, biological waste treatment plants (composting and biogas plants) and waste incinerators (including energy-from-waste plants). All area source emissions were allocated to disposal by landfill, as any large incineration plants would be present in the point source data. Wastewater treatment plants were excluded as emissions from wastewater treatment were considered separately.

2.9 WASTEWATER TREATMENT AND DISCHARGE

Emissions from wastewater treatment were initially based on treated volumes and the wastewater emission factor issued by the government for company reporting⁵. This emission factor (708 kg CO₂e per million litres treated) is significantly higher than that implicit in South West Water's own reported emissions from wastewater treatment (equating to about 0.443 kg CO₂e per million litres treated). Furthermore, the source of the emissions factor has not been updated since 2012 and the report on which is based could not be located. It is likely that the carbon intensity of wastewater treatment has reduced as treatment methods have changed. It is also likely that the emission factor includes energy consumption for wastewater treatment, which would be double-counted as it would be reported under fuel consumption (stationary sources). South West Water has advised Devon County Council that about 5,890 t CO₂e is attributable to process and fugitive emissions for wastewater treatment in Devon (based on N₂O and CH₄ emissions, and about one-half of the company's emissions pertaining to wastewater arising in the county of Devon). This figure has been used in the updated inventory (version 0.10 for 2017 and version 1.1 updated with the latest available data throughout). Emissions have been apportioned to district and unitary authorities within the county on a household-weighted basis.

2.10 INDUSTRIAL PROCESSES AND PRODUCT USES

This category includes greenhouse gas emissions from industrial processes (the production and use of mineral products, chemicals and metals), and emissions from product use (non-energy use of lubricants and paraffin waxes, and emissions of fluorinated gases).

The National Atmospheric Emissions Inventory includes data on large point sources of greenhouse gas emissions⁶. Some of these are clearly already considered within other categories, e.g. power generation, waste treatment and disposal. Other entries include mineral operations and food processing plants. The vast majority of emissions from these facilities are expected to arise from fuel combustion and electricity consumption, and will therefore have been included under industrial and commercial stationary source emissions.

Data on the use of fluorinated gases were taken from the National Atmospheric Emissions Inventory¹⁶ and apportioned to each area on the basis of emissions from non-domestic electricity consumption¹⁷. Fluorinated gases are used in, and emitted from, refrigeration and fire-fighting systems, use as blowing agents and propellants, as an insulant in electrical switchgear and in metal production. Local usage will therefore vary and the apportioned value is subject to significant uncertainty.

2.11 LAND USE CHANGE

CO₂ emissions from land use change have been taken directly compiled by national government at local authority level³. CH₄ and N₂O emission are highly dependent upon the type of land use change occurring and therefore were not estimated. Examination of emissions from land use and land use change as reported to the IPCC¹⁸ indicate that CO₂ emissions dominate.

From 2019, the government dataset subcategorises emissions from land use by land type. Further analysis could be performed on these data if required.

3. CONCLUSIONS

Baseline greenhouse gas inventories have been produced for district and unitary authorities within the south-west peninsula. The inventories inform the development of trajectories to net zero carbon. This report documents the methodology adopted to prepare the inventories.

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