UK Greenhouse Gas Inventory,1990 to 1998

Annual Report for submission under the Framework Convention on Climate Change

A G Salway

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Executive Summary

The United Nations Framework Convention on Climate Change (FCCC) was ratified by the UK in December 1993 and came into force in March 1994. As a Party to the Convention, the UK aims to reduce emissions of greenhouse gases to 1990 levels by 2000 and is committed to monitoring progress towards achieving this target by:

- developing, periodically updating, publishing and making available national inventories of anthropogenic emissions by source and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol;
- using comparable methodologies for inventories of greenhouse gas emissions and removals.

In addition, the Kyoto protocol will, when ratified, commit the UK to reducing emissions by 12.5 % below 1990 levels in the period 2008 - 2010, taking into account the subsequent redistribution of commitments agreed in June 1998 under the UK Presidency of the European Union. The Government has also adopted a domestic goal of reducing CO_2 emissions by 20% below 1990 levels by 2010.

The UK submits emission inventories of the six direct greenhouse gas under the Kyoto Protocol. These are :

- Carbon dioxide
- Methane
- Nitrous oxide
- Hydrofluorocarbons
- Perfluorocarbons
- Sulphur hexafluoride.

These gases contribute directly to climate change owing to their positive radiative forcing effect. Also reported are four indirect greenhouse gases:

- Nitrogen oxides (reported as NO_2)
- Carbon monoxide
- Non-methane volatile organic compounds (NMVOC)
- Sulphur dioxide.

Of these, nitrogen oxides, carbon monoxide and NMVOC can produce increases in tropospheric ozone concentrations which increase radiative forcing. Sulphur dioxide, however, contributes to aerosol formation in the atmosphere. This is believed to have a negative net radiative forcing effect, tending to cool the surface.

To provide a single, comprehensive source of information on the methodologies and data used in the UK inventory, a technical report has been published annually since 1995, (Salway, 1995, 1996, 1997, 1998, 1999). The current report extends the data for all gases to 1998 and provides additional information related to the 1998 National Inventory recently submitted to the FCCC

In the UK, emissions of all the major greenhouse gases have declined between 1990 and 1998 with carbon dioxide falling by 7%, methane by 28% and nitrous oxide by 15%. Emissions of nitrogen oxides, carbon monoxide, non-methane volatile organic compounds and perfluorocarbons have also declined significantly over the same time period although releases of hydrofluorocarbons and sulphur hexafluoride are increasing. Reasons for the changing emission levels are discussed in the report. Table I summarises the emissions of each greenhouse gas as its equivalent emission of carbon dioxide.

Table I: GWP Weighted Greenhouse Gas Emissions (Tg CO_2 Equivalent)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	% change 1990-98
Carbon Dioxide[1]	616.0	619.9	604.9	589.0	583.8	574.7	593.9	567.6	570.2	-7.4%
Methane	77.2	76.2	74.2	66.8	61.8	61.3	59.9	58.0	55.4	-28.3%
Nitrous Oxide	65.7	63.7	56.7	53.0	57.7	55.1	57.0	58.7	56.0	-14.8%
HFCs	11.4	11.9	12.3	12.9	13.8	15.2	16.3	18.4	20.2	77.4%
PFCs	2.3	1.8	1.0	0.8	1.0	1.1	0.9	0.7	0.7	-71.4%
SF_6	0.7	0.8	0.8	0.9	1.1	1.1	1.3	1.3	1.3	78.0%
Total[1]	773.2	774.2	750.0	723.4	719.2	708.4	729.4	704.7	703.7	-9.0%

1 Carbon emissions in 1994-1998 are slightly lower than in previous publications due to a correction to Iron & Steel processes

Weighted by the relevant global warming potentials, total emissions of direct greenhouse gases from the UK have fallen by 9% from 1990 to 1998.

The UK Greenhouse Gas Inventory was submitted to the FCCC in the form of the Common Reporting Format. This is attached to this report in the form of a CD ROM containing EXCEL spreadsheets. The Common Reporting Format (CRF) reports net carbon emissions, that is, emissions minus removals. The data in the body of the report quote emissions and removals separately. Hence the National Total Emission quoted is a gross figure, not allowing for removals, and so is higher than the figure quoted on the CRF basis.

Contacts

This work forms part of the Global Atmosphere Research Programme of rhe Department of the Environment. Transport and the Regions. (Contract EPG/1/1/62). The land use change and forestry estimates were provided by the Centre for Ecology and Hydrology (Edinburgh) (Contract EPG/1/1/39)

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A copy of this report and related data may be found on the website maintained by NETCEN for DETR: www.aeat.co.uk/netcen/airqual/naei

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Tables

1 Introduction

The United Nations Framework Convention on Climate Change (FCCC) was ratified by the United Kingdom in December 1993 and came into force in March 1994. Parties to the Convention are committed to develop, publish and regularly update national emission inventories of greenhouse gases (GHG). The first UK programme, published in *Climate Change: the UK Programme (DOE, 1994)*, included national inventories for greenhouse gases from anthropogenic sources for 1990 disaggregated by sector. The second UK programme, published in *Climate Change: the UK Programme (DOE, 1997*), included national inventories for greenhouse gases from anthropogenic sources for 1990 to 1994 disaggregated by sector

National greenhouse gas emission inventories have been submitted to the FCCC for 1990 to 1998. This report includes these annual emission inventories and describes the methodology on which the estimates are based. The major source for the GHG inventory is the UK National Atmospheric Emissions Inventory (NAEI) compiled by the National Environmental Technology Centre of AEA Technology. The NAEI does not cover all the sources required by the Intergovernmental Panel on Climate Change (IPCC), and it has been necessary to add these sources. Emissions and removals from land use change and forestry are provided by the Centre of Ecology and Hydrology (CEH) and agricultural emissions by the Ministry of Agriculture, Fisheries and Food (MAFF).

This report is divided into two parts. The main part of the report presents greenhouse gas emissions for the years 1990-1998, and discusses the reasons for the trends and any changes in the estimates due to revisions made since the last inventory. Tables 1-9 give the UK summary data for these years and the IPCC Sectoral Tables are given for 1990 and 1998. Appendix 1 describes in detail the methodology of the estimates and how the Greenhouse Gas Inventory relates to the IPCC Guidelines and the NAEI. This contains mappings between IPCC, NAEI source categories and fuel types as well as emission factors and references to the technical literature.

The Inventories for 1990-1998 were submitted to FCCC in the new Common Reporting Format (CRF), IPCC (2000). This is in accordance with a decision of the Conference of the Parties to the FCCC (FCCC/CP/1999/7). The CRF reports much more detail than the IPCC Sectoral Tables, in that it contains additional tables of activity data as well as updated versions of the IPCC Sectoral Tables. It should be noted that carbon dioxide is reported as net emissions (=emissions –removals) in the CRF whilst in the main part of this report, emissions and removals are reported separately. This means that the totals reported for CO_2 and total greenhouse gas emissions weighted by global warming potential are reported on a different basis between the CRF and the main report. A copy of the CRF is accompanies this report on a CD ROM.

Since the submission of the 1998 Inventory to the UNFCCC, it has been necessary to make a revision to emissions from 2C1 Iron and Steel Blast Furnaces. Hence reported emissions for 1994-1998 in this report are slightly lower than previously submitted to the UNFCCC.

2 Summary Reports of UK Greenhouse Gas Emissions 1990-98

Tables 1-9 give summary data for UK greenhouse gas emissions for the years 1990-1998. These data are updated annually to reflect revisions in the methodology and the availability of new information. These adjustments are applied retrospectively to earlier years which accounts for any differences in data published in previous reports.

Table 1

Table 2

Table 3

Table 4

Table 5

Table 6

Table 7

Table 8

Table 9

Footnotes for Tables 1 to 9

a) Net flux may be estimated as the sum of emissions and removals
b) Naval vessels and military aircraft
c) Emissions arise from refrigeration, electronics applications, electrical insulation, foams, aerosols and training shoes
d) The CO_2 equivalent of solvent NMVOC (excluding 3C) is 1571 Gg in 1990 and 1262 Gg in 1998
e) Field burning ceased in 1993
f) 5A Removals include removals to forest litter and to forest products
g) 5D Emissions include removals to soils due to set aside of arable land and emissions due to liming
h) 5E Emissions include emissions from soils due to upland drainage, lowland drainage and peat extraction
i) 5E Removals are increases in crop biomass
j) Emissions from own wastewater treatment by industry are not estimated
k) Emissions are for information only and are not totalled
l) Emissions arise from wood, straw, biogases and poultry litter combustion for energy production
m) Carbon emissions are slightly lower than in previous publications due to a correction to Iron & Steel processes

3 UK Emissions of Carbon Dioxide

3.1 INTRODUCTION

The major source of carbon dioxide in the UK is fossil fuel combustion. The UK CO_2 emission estimates use an emission factor for each fuel which were determined by fuel analysis. This is consistent with the IPCC(1997) methodology, though some uncertainty is introduced because the carbon content of some fuels may vary (by a few per cent) over time. Fuel consumption data are from the Digest of UK Energy Statistics (DTI, 1999) which is compatible with the IEA system of international energy statistics (though there are some small differences in reporting conventions), and has a similar level of uncertainty. Some additional imprecision is introduced because of uncertainties in CO_2 emissions from sources other than fuel combustion, though these make up around 6 per cent of the CO_2 inventory. An estimate of the uncertainty in the 1995 total was made by analysing the uncertainties in each main source using a statistical simulation (Eggleston *et al*, 1998). The overall uncertainty for carbon dioxide emissions was ±3-3.5%. A more detailed discussion of uncertainties is given in Appendix 1.

Some carbon dioxide emissions, however, arise from biological sources that can also act as sinks because of the role of carbon dioxide in photosynthesis. Hence it is necessary to decide whether a source is a net emitter, part of the carbon cycle or indeed a net sink. IPCC (1997) specify guidelines for the treatment of such sources and sinks. For example the category Land Use Change and Forestry contains both emissions and removals. For transparency, both emissions and removals are reported in the tables in this report. This differs from the format used in the Common Reporting Format where net emissions are reported. Other examples include, carbon dioxide emissions from sewage which are excluded from the inventory since almost all of carbon dioxide from this source comes originally from uptake by plants and is therefore part of the natural carbon cycle. In the case of waste disposal, the issue is complex as the carbon content of waste can be from both fossil and recent sources: plastics are an example of a source of old carbon since they are normally made from fossil fuels, and crop residues are an example of recent carbon. Hence estimates have been made of the amounts of recent carbon in waste and the associated emissions excluded from the inventory.

3.2 DEVELOPMENT OF THE METHODOLOGY

The methodology of these estimates is described in Appendix 1. There have been a number of changes in the methodology since the 1997 Inventory was published (Salway, 1999). These are:

1) Fuel Combustion
   - There has been a revision of emissions from MSW combustion for electricity generation. From 1997 all incinerators generated electricity, so all emissions are reported under 1A1a Public Electricity rather than 6C Waste Incineration.
   - There has been a significant revision in offshore gas consumption (+370 Gg CO_2 in 1997)
   - There has been a reclassification of coke consumed by the coke production industry from energy use to feedstock use. Hence, around 192 Gg CO_2 have been transferred from 1A1c to 1B1a

- There have been some significant revisions in coal and coke consumption in Iron and Steel and Other Industry resulting in a reduction of 893 Gg CO_2. A further smaller reduction in emissions has resulted from the reclassification of a small amount of fuel oil from the petrochemical industry to Refineries.
- There has been a small transfer of around 89 Gg CO_2 from 1A4a Commercial/Institutional to 1A4b Residential owing to a reclassification of coke consumption.
- There has been a significant revision in military aviation emissions (+646 Gg CO_2) to take account of known fuel consumption by UK forces abroad.
- Other changes arise from various revisions in the fuel statistics, in particular coke, coal, LPG and refinery gas

2) Fugitive Emissions from Fuels
   - There has been an increase (192 Gg CO_2) in emissions reported under 1B1b Solid Fuel Transformation. This is due to a reclassification of coke comsumption by the coke industry as a feedstock.
3) Industrial Processes
   - Emissions from glass production now include flat glass as well as container glass.. This revision has resulted in an extra emission of 36 Gg CO_2.
   - The emission of CO_2 from ammonia production has increased. This arises from a revision in the estimates of plant capacity. The revision should have no effect on total emissions as total gas consumption by industry is unchanged.
   - Emissions from Iron and Steel Production have increased. This is a result of the inclusion of the use of coke for non-ferrous metal feedstocks and an increase in flaring of blast furnace gas. The increase is 506 kt CO_2 in 1997
4) Memo Items
   - Emissions from aviation bunkers have decreased by 646 Gg CO_2 which matches the increase in military aviation.
5) Land Use Change and Forestry
   - There have been revisions to the activity data mainly in 5D CO_2 Emissions and Removals from soils resulting in a decrease of 951 Gg CO_2 in emissions

3.3 DISCUSSION OF THE ESTIMATES

Figure 1 shows emissions of carbon dioxide for the years 1990-1998 broken down by major IPCC source category. Emissions have shown a steady decline since 1990 and are currently lower by around 7% than 1990 levels.

Since the first submission of the 1998 Inventory it has been necessary to make a revision to emissions from 2C1 Iron and Steel Blast Furnaces. Hence reported emissions in 1994-1998 are slightly lower than previously published estimates.

Analysing emissions by source shows significant changes have occurred over the past nine years in 1A1 Energy Industries, 1A2 Manufacturing Industry and 1A3 Transport. Emissions from 1A4 Other Sectors and the remaining smaller categories show less pronounced trends.

The major components of 1A1 are electricity generation, refineries, offshore gas consumption and manufacture of solid fuel and coke. Since the privatisation of the power industry in 1990, there has been a move away from coal and oil generation towards nuclear and combined cycle

gas turbines (CCGT). Over this period there has been only a modest increase of around 11% in the amount of electricity generated† but a large decrease in CO_2 emissions of around 25% due to:

(i) The greater efficiency of the CCGT stations compared with conventional stations - around 47% as opposed to 36%.

(ii) The calorific value of natural gas per unit mass carbon being higher than that of coal and oil.

(iii) The proportion of nuclear generated electricity supplied increasing from 21% to 29%.✦

The contribution from other components is much smaller. Emissions from refineries have increased over the period whilst those from the solid fuel transformation industries have declined. There has also been a marked increase in offshore gas use since 1993.

Emissions from industrial combustion declined by 6% over the period. Since 1994 they have declined by 5.5%. This compares with a 4.5% decrease in energy (excluding electricity) consumption by industry (DTI, 1999) suggesting an overall improvement in emission per unit energy consumption.

Emissions from transport have increased by 5% since 1990. Transport emissions are dominated by the contribution from road transport. This rose by 6% over the period. Petrol usage has declined by 10% since 1990, but this was offset by increased use of diesel fuel in cars as well as trucks.

The main components of 1A4 Other Sectors are residential and commercial/institutional. Residential emissions have increased by 8 % since 1990. However they fluctuate from year to year and probably reflect average temperatures. The fuel consumption shows a trend away from coal towards oil and natural gas. Overall emissions from the commercial/institutional sector have increased throughout the period by 1%. Again gas use has increased with coal and oil usage declining. Overall, emissions from other sectors have increased by 6%.

Emissions from military aircraft and naval vessels declined over the period.

Land Use Change and Forestry differ from other categories in that they contain both sources and sinks of carbon dioxide. The removals are plotted as a negative quantity in Figure 1 and are reported separately from emissions in the inventory tables. Emissions from land use change and forestry were around 5% of the UK Total in 1998 and are declining gradually. Removals from land use change have decreased by 9% since 1990 and in magnitude are 2% of the UK Total Emission.

International bunker emissions (international aviation and shipping) are not included in the National Total but are reported separately. For the UK they are around 6% of the National Total. The shipping emission has shown little variation over the period and accounts for 27% of bunker emissions in 1998. The remainder is air traffic and this has risen by 63% since 1990.

† Electricity generated by Major Power Producers, DTI(1999)
✦ Electricity supplied (gross) by Major Power Producers, DTI (1999)

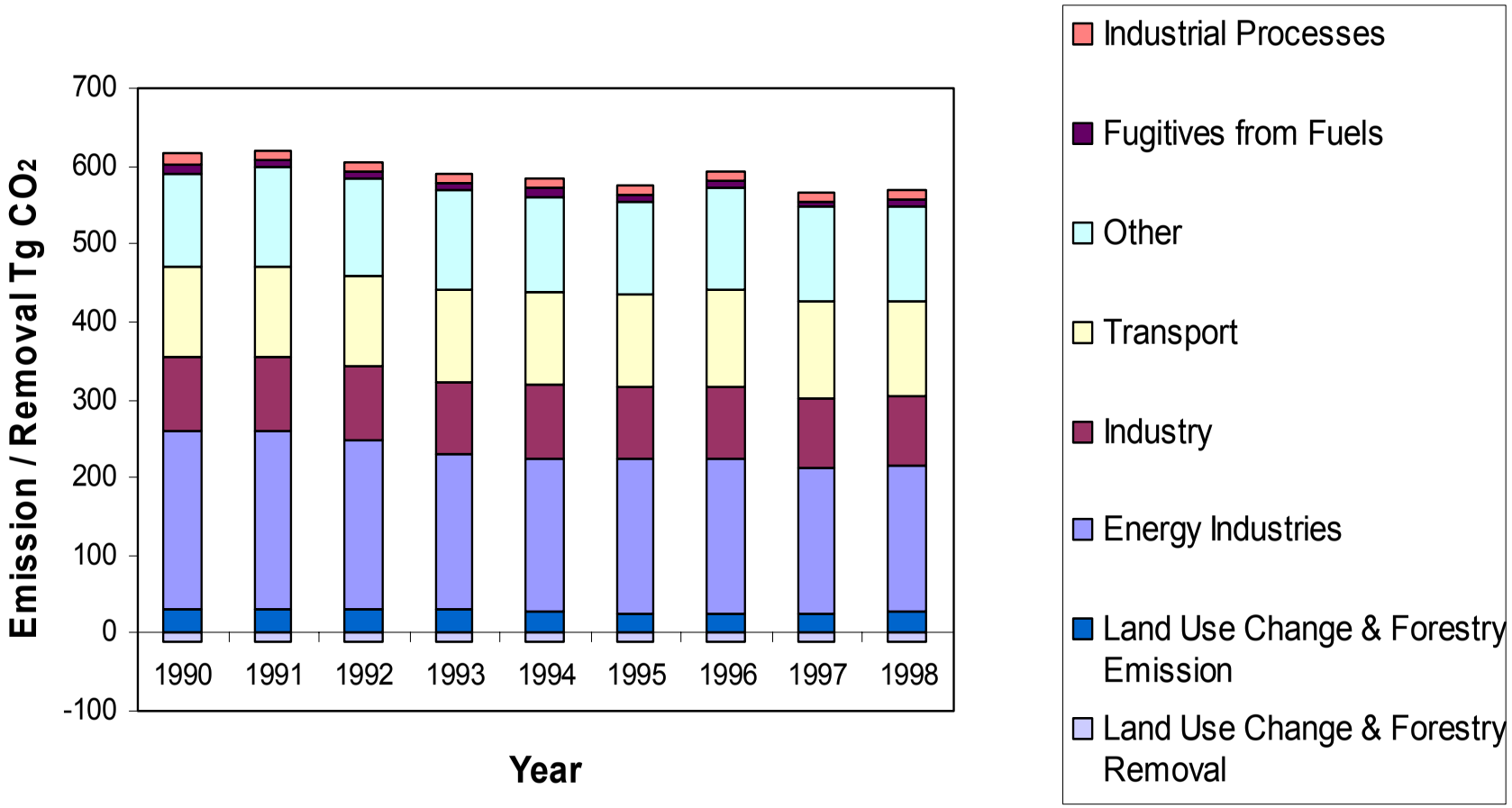
3.4 THE IPCC REFERENCE CARBON DIOXIDE INVENTORY

Summary Table 7B includes the IPCC Reference Inventory total for carbon dioxide. This is a 'top-down' inventory calculated from national statistics on production, imports, exports and stock changes of fossil fuels. All other Sectoral Tables report emissions of pollutants estimated using a 'bottom-up' approach with emissions estimated from activity statistics (mostly fuel consumption) in the various economic sectors and processes. The reference inventory has been revised since the 1997 Inventory. The main changes are a more detailed set of coal gross calorific value data taking into account coal imports . The new GCV data are higher resulting in slightly higher emissions in the Reference Inventory.

In principle the IPCC Reference Total is comparable to the Table 1A total plus the fuel consumption emissions in 1B1 Solid Fuel Transformation and 2 Industrial Processes. However, the IPCC Reference approach produces totals that are 1-4% higher than the comparable sources estimated by the 'bottom-up' approach, largely because it is based on a different set of statistics. Reasons for the discrepancies between the two estimates are discussed in Appendix 1. Over the period, emissions estimated by the Reference Approach have fallen by 4.4% compared with 6.6% for the comparable 'bottom-up' totals.

A detailed comparison between the IPCC Reference Inventory, the UK Greenhouse Gas Inventory and a UK Inventory based on the IPCC Default Methodology is given by Salway (1998a).

Figure 1: UK Emissions and Removals of Carbon Dioxide



4 UK Emissions of Methane

4.1 INTRODUCTION

Unlike most of the other major pollutants in the Greenhouse Gas Inventory, fuel combustion is not the predominant source of methane. The major sources are waste disposal, coal mining, leakage from the gas distribution system and agriculture. Estimation of methane emissions is very uncertain and the methodologies are subject to change as further research is undertaken. An estimate was made of the overall uncertainty in methane emissions based on the uncertainties in the major sources. This showed that the overall uncertainty was around 17 %. A more detailed discussion of the approach used is given in Appendix 1. Methane has a much greater warming effect on the climate than carbon dioxide. (See Chapter 10).

4.2 DEVELOPMENT OF THE METHODOLOGY

A number of changes have been made to the methane estimates since the 1997 Inventory (Salway, 1998). These are:

1) Fuel Combustion
   - There has been a small increase in the emissions reported under power stations due to a revision of landfill gas utilisation.
2) Fugitive Emissions from Fuels
   - There have been small revisions in emissions from the offshore industry, mainly reductions in fugitives and venting but also a small increase in flaring. Overall, these account for a reduction of 4Gg methane.
   - Emissions from the gas distribution network have been revised to take account of high pressure mains. These have increased by 40 Gg methane.

The methodology of the estimates is discussed in the Appendix 1.

4.3 DISCUSSION OF THE ESTIMATES

The emissions of methane from the UK are shown in Figure 2. Total emissions are declining and have fallen by 28% since 1990.

The largest source of methane emissions in the UK is 4 Agriculture, which includes enteric fermentation emissions from livestock and emissions from their wastes. Since 1990, livestock emissions have fallen by 4%. Emissions depend on the numbers of farm animals with dairy cattle being the most significant source. The recent decline reflects the reduction in dairy cattle numbers.

The second largest component of the total methane emission is 6 Waste. This comprises landfills, waste water treatment and waste incineration. Waste water treatment emissions are small compared with landfill, and incineration is negligible. Waste water emissions depend on the mode of disposal: sea dumping, land spreading or incineration. The sewage sludge disposed of in landfills is allocated to the landfill estimate. Emissions are likely to rise as a result of the EC

Urban Waste Water Treatment Directive but the rate of increase will depend on disposal routes adopted. The UK ceased dumping sewage at sea in 1998.

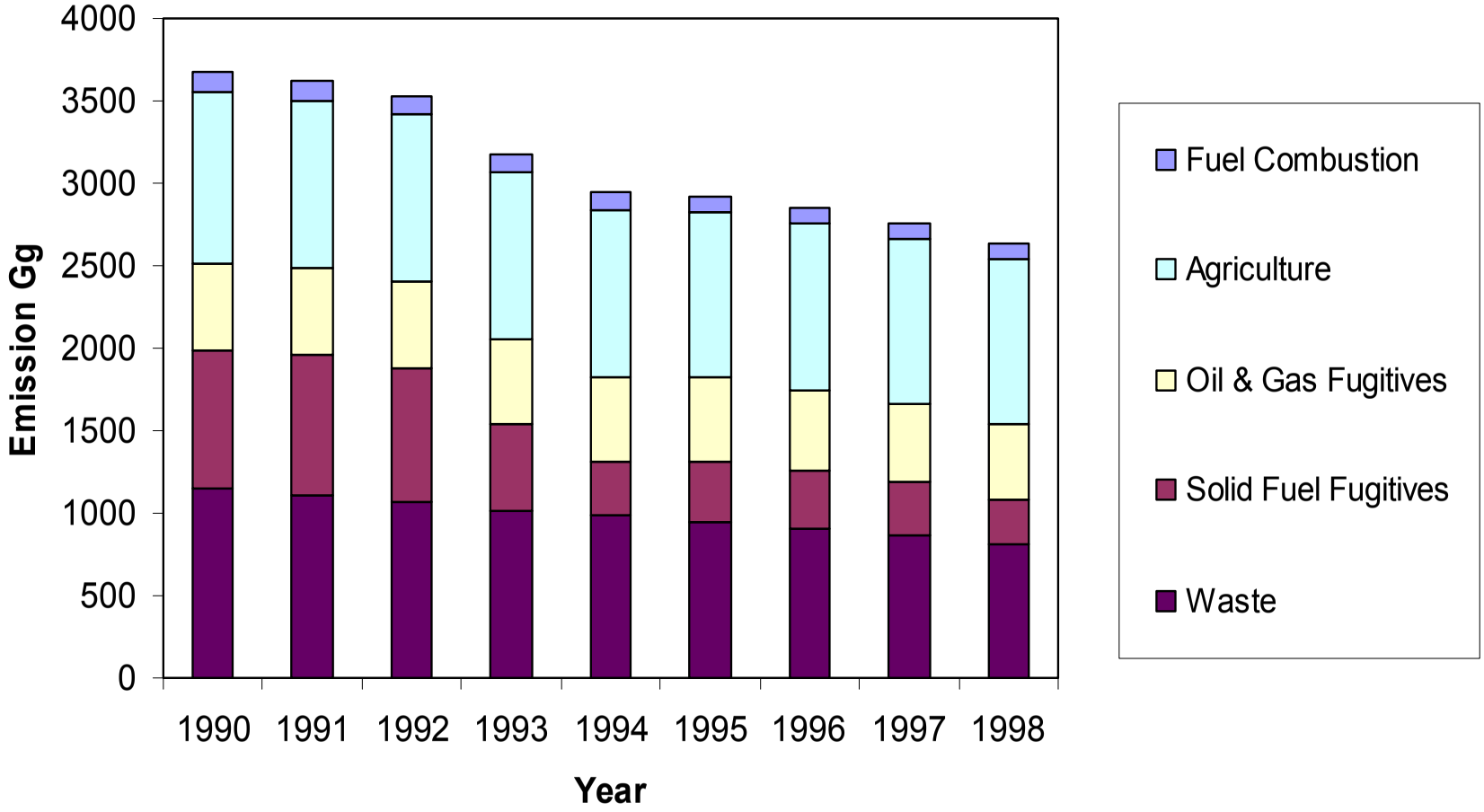
The largest single source of emissions in the waste category is landfills and it is also the most uncertain. Estimates are derived from the amount of putrescible waste disposed of to landfill, and are based on a model of the kinetics of anaerobic digestion involving four classifications of landfill site. The model accounts for the effects of methane recovery, utilization and flaring. Methane emissions from landfill have declined by 31% since 1990, because of the implementation of methane recovery systems. This trend is likely to continue as all new landfill sites are required to have these systems and many existing sites may have systems retrofitted. However, uncertainties are great and the overall methane estimate from landfill maybe subject to revision as more information becomes available.

Emissions from 1B2 Oil and Natural Gas have fallen by 14% over the period 1990 to 1998. Sources include leakage from the gas transmission and distribution system and offshore emissions. Estimates of leakage from the gas distribution system are based on leakage measurements made by British Gas together with data on their gas main replacement programme, and have declined since 1990 as old mains are replaced. The major sources of emissions from the offshore oil and gas industry are venting, fugitive emissions, loading and flaring from offshore platforms. Emissions are estimated on the basis of a survey of operators by SCOPEC(1999). Other emissions in the oil and gas industries arise from fuel oil and gas combustion, but these are reported as energy emissions in category 1A1c.

The emission of methane from coal mining is the fourth largest component of the total UK emission. Emissions have fallen by 61% due to a general decline in coal production.

Since publication of the 1998 methane inventory, new data from TRANSCO suggest that gas leakage emissions from natural gas distribution are slightly higher than previously estimated, namely 391.5 kt CH_4 rather than the 381.8 kt CH_4 reported in the current figures.

Figure 2: UK Emissions of Methane



5 UK Emissions of Nitrous Oxide

5.1 INTRODUCTION

Emissions of nitrous oxide are uncertain because there are many small sources, both natural and anthropogenic, and detailed emission factors for some man-made sources, (e.g. combustion) are not yet available. The main anthropogenic sources are agriculture, biomass burning, coal combustion and some industrial processes.

5.2 DEVELOPMENT OF THE METHODOLOGY

A number of changes have been made in the methodology used for the emission estimates since the 1997 Inventory (Salway, 1998). These are.

- The emission factors for nitric acid production have been revised downwards. Emission data from plant operators and the Pollution Inventory (Environment Agency, 1999) have allowed the estimation of plant specific emission factors. Emissions have been recalculated back to 1990 using the new factors. In consequence, emissions in 1997 have reduced by 2.6 Gg N_2O.
- Various small changes have been made arising from revisions in the fuel statistics and reclassification of categories.

The methodology of the estimates is discussed in Appendix 1.

5.3 DISCUSSION OF THE ESTIMATES

UK Emissions of nitrous oxide have declined by around 15% over the period 1990 to 1998. Emissions are very uncertain with an estimated mean emission of 181 Gg in 1998, within a range of 81 Gg to 421 Gg (See Appendix 1). Emissions are dominated by agriculture, which accounted for 53% of the total in 1998. Agricultural emissions arise from a number of sources:

- Cultivation of legumes
- Synthetic fertilizer application
- Crop residues
- Histosols
- Improved grass
- Wastes from grazing animals
- Manure used as fertilizer
- Animal waste management systems
- Leaching
- Atmospheric deposition of NH_3 and NO_x
- Field Burning (Discontinued in 1993)

Emissions from agriculture have declined by 5% over the period 1990 to 1998 driven by a slight fall in dairy cattle numbers and synthetic fertiliser application over the period. Agricultural

stubble burning was discontinued in England and Wales in 1993 resulting in a slight decrease in the agricultural emission.

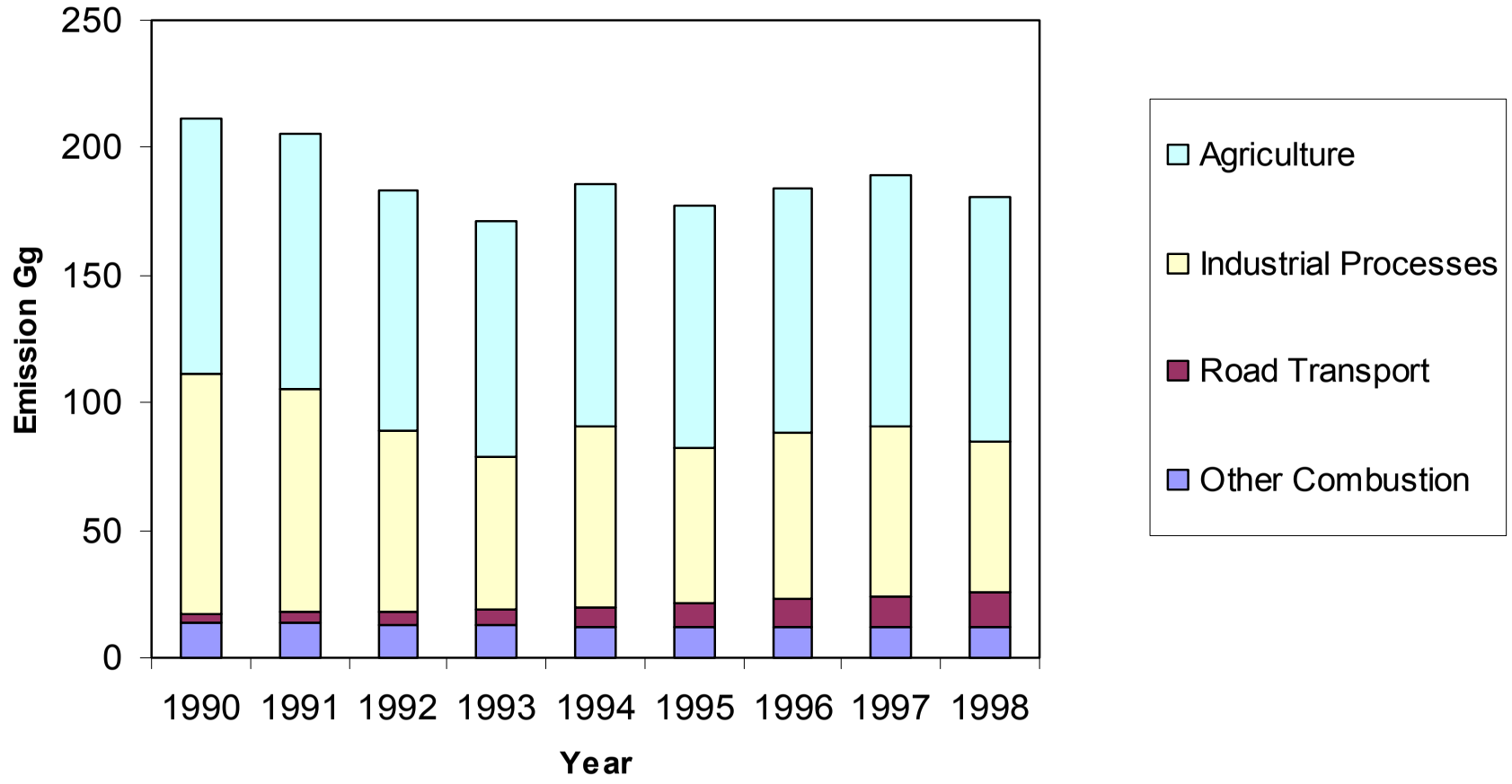
The next largest sources are adipic acid manufacture (a feedstock for nylon) and the production of nitric acid. In 1998, these contributed 27% and 6% respectively to the total. The magnitude of the emission depends on the production of these acids and since most other sources show little variation with time, variations in the UK Total tend to reflect fluctuations in production. The emissions from nitric acid manufacture show a fall in 1995 due to improved controls at one of the plants. Emissions from adipic acid manufacture fell notably in 1998 as a result of the retrofitting of an emissions abatement system.

Combustion emissions account for around 14% of the total and arise mainly from solid fuel combustion, electricity generation and road traffic.

Unlike other pollutants, the nitrous oxide emission from public power shows little variation over the period 1990 to 1998 in spite of the trend away from coal towards natural gas combustion. The emission factor for gas combustion is similar to that for coal combustion so no particular trend is apparent. However, these estimates are uncertain because there is very limited data on N_2O emissions from large gas turbines. Public power emissions are around 4 % of the total.

Emissions from road transport are increasing as a result of the increasing numbers of petrol driven cars fitted with three way catalytic converters. The contribution from petrol vehicles has risen by a factor of 4 since 1990, because cars with catalytic converters produce significantly larger emissions of nitrous oxide than uncontrolled cars. Catalytic converters are used to reduce emissions of nitrogen oxides, carbon monoxide and non-methane volatile organic compounds but a by-product is increased nitrous oxide emissions. The contribution of road transport to the total in 1998 was 7%.

Figure 3: UK Emissions of Nitrous Oxide



6 UK Emissions of Hydrofluorocarbons, Perfluorocarbons and Sulphur Hexafluoride

6.1 INTRODUCTION

This chapter discusses the emissions of:

- hydrofluorocarbons (HFCs)
- perfluorocarbons (PFCs)
- sulphur hexafluoride (SF_6)

HFCs and PFCs are used mainly as substitutes for chlorofluorocarbons (CFC) and hydrochlorofluorocarbons (HCFC) which are being phased out under the Montreal Protocol because they deplete the ozone layer. A more detailed description of the usage, emission estimates and the methodology used to derive the emissions of these gases is given in MCG (1999).

The UK reports both actual and potential emissions of these gases.

- Actual emissions are estimates of the emission of a gas to atmosphere in a given year.
- Potential emissions are estimated as the apparent consumption of fluid in a given year. (IPCC, 1997). Apparent consumption is based on data on annual production, imports, exports and destruction of fluid. Hence, it is assumed that the entire emission occurs in the year of use and neglects leakage over the lifetime of a piece of equipment.

In this chapter, only actual emissions are discussed. Potential emissions provide a convenient benchmark to compare emissions between countries and are simpler to estimate but do not include emissions arising from metal or halocarbon production. The estimation of potential emissions in the UK is discussed in Appendix 1.

Emissions of individual halocarbon species are not reported individually because some of these are considered commercially sensitive data within the industries involved. Consequently, emissions data have been aggregated to protect this information. The total global warming potential of the individual emissions is reported.

6.2 HYDROFLUOROCARBONS

Figure 8 shows the UK emissions of in terms of their global warming potential (GWP). The HFC emissions comprise many species each with its own GWP, hence it is more helpful to express emissions in terms of GWP as CO_2 eqivalents. This allows the relative influence of sectors on Global Warming to be compared. This approach differs from previous reports where mass emissions were quoted. Eggleston *et al* (1998) estimated the uncertainty in the emissions as ± 25% in 1990. HFCs had limited usage prior to the phase out of CFCs, in the production of

semiconductors and as refrigerants blended with CFCs. They are now being used increasingly as:

- substitutes for CFCs and HCFCs in domestic, commercial and industrial refrigeration and air conditioning
- substitutes for CFCs and HCFCs in plastic foam blowing
- substitutes for CFCs for industrial and specialist aerosols
- substitutes for CFCs for medical dose inhalers (MDI)
- firefighting fluids

Fugitive emissions from the manufacture of HCFCs and HFCs accounted for 82% of the total GWP emission in 1998. Refrigeration is the next largest source and contributes 11% of the total. Here emissions arise due to leakage from refrigeration and air conditioning equipment during its manufacture and life time. Aerosols contribute 6% to the total emission, and here it is assumed that all the fluid is emitted in the year of manufacture. The category aerosols includes mainly industrial aerosols and also medical use in metered dose inhalers. The remaining emission sources, namely, foams and fire fighting are very small and only comprise 0.2% of total emissions. The total emission has increased by a factor of 1.8 since 1990 due to the increasing use of HFCs in aerosols and refrigeration and the increased manufacture of HCFCs and HFCs.

6.3 PERFLUOROCARBONS

Figure 9 shows the UK emissions of PFCs in terms of their GWP. Eggleston *et al* (1998) estimated the uncertainty in the emissions as ± 19% in 1990. PFCs had limited usage prior to the phase out of CFCs in the electronics and electrical industry in:

- etching processes in the semiconductor industry
- chemical vapour deposition in the electronics industry
- soldering processes
- leak testing of electrical components
- cooling electrical components, for example in super computers and radar systems.

Other significant uses include:
- refrigerant blended with HFC
- fire fighting in specialist applications
- cushioning in the soles of training shoes

Other minor uses were in cosmetics and as a tracer gas. PFCs also form as a by-product during aluminium smelting and this is the major emission source contributing around 34% of the UK GWP total of PFC emissions in 1998. The emissions are caused by the anode effect which occurs when alumina concentrations become too low in the smelter. This can cause very high electrical current and decomposition of the salt - fluorine bath. The fluorine released then reacts with the carbon anode, creating CF_4 and C_2F_6. Emissions from aluminium production have fallen by 89% since 1990 due to significant improvements in process control and an increase in the rate of aluminium recycling. Other significant sources are uses in the electronics industry and also leakage from the soles of training shoes. Together these account for 61% of emissions in 1998. Emissions from refrigeration, fire fighting and fugitives from PFC production are very small and together account for around 4% of emissions.

6.4 SULPHUR HEXAFLUORIDE

Figure 10 shows the UK emissions of SF_6 in terms of its GWP. One tonne of Sulphur hexafluoride is equivalent to 23900 tonnes of carbon dioxide in its effect on global warming. Eggleston *et al* (1998) estimated the uncertainty in the emissions as ± 13% in 1990. It has the following applications:

- insulation medium in high voltage applications such as switch gear and circuit breakers
- cover gas in magnesium foundries to protect the molten magnesium from re-oxidising when it is cast
- degasser in aluminium casting applications, though its use in the UK is rather limited
- insulating gas in double glazing applications, replacing vacuum as an insulation technique
- plasma etching of polysilicon and nitrite surfaces
- atmospheric tracer for scientific studies
- cushioning in the soles of training shoes

The largest source is from magnesium manufacture which accounted for 56% of the UK total in 1998. It is not possible to recover the SF_6 so the total annual consumption is emitted to atmosphere. The other main source is electrical insulation accounting for 16% of emissions in 1998. Emissions arise during the manufacture and filling of the circuit breakers and from leakage and maintenance during the equipment lifetime. This application has only been in use for the last 20 to 30 years and little of the equipment has been decommissioned. It is expected that users will take great care over future fluid recovery so that emissions will be minimised. The remaining sources are emissions from applications in the electronics industry and training shoes.

Figure 4: UK Emissions of HFCs

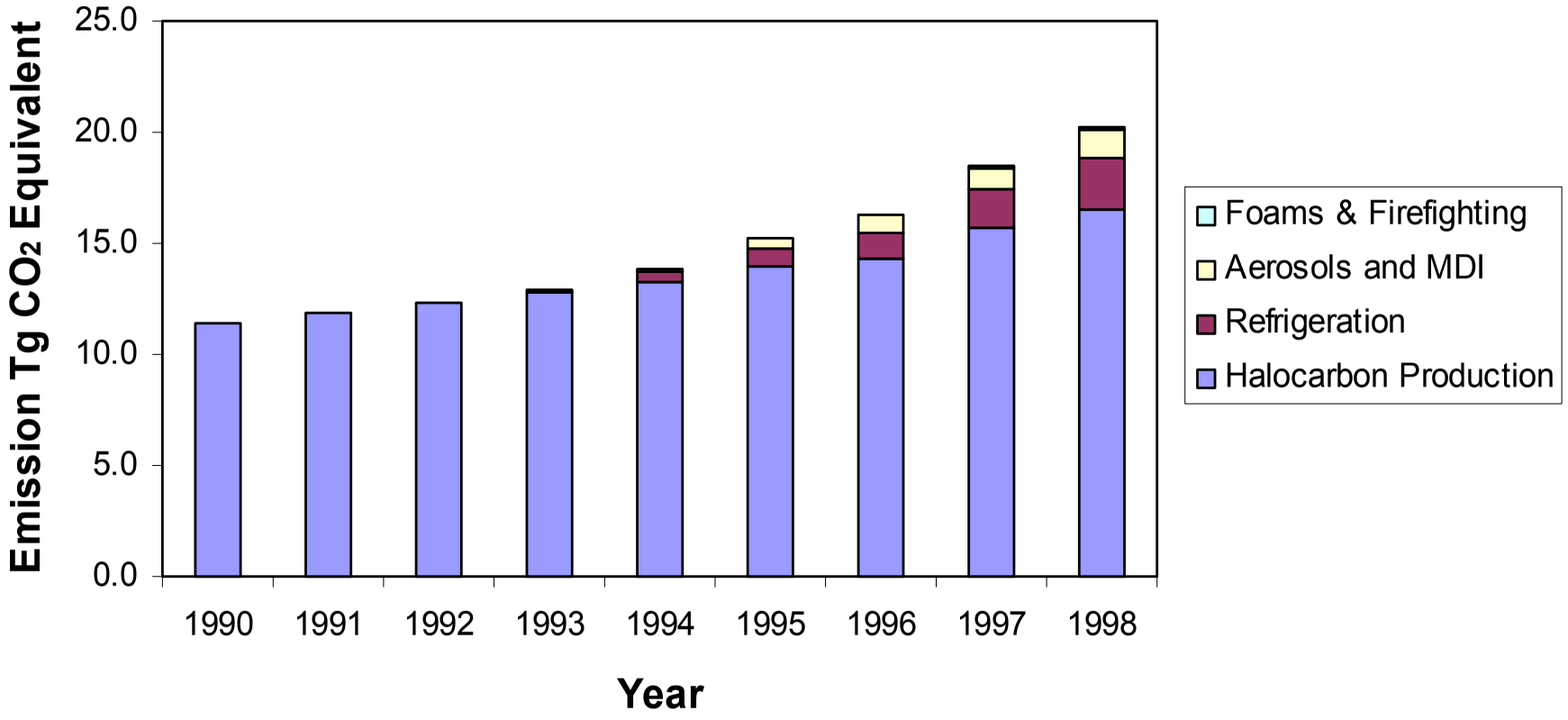


Figure 5: UK Emissions of PFCs

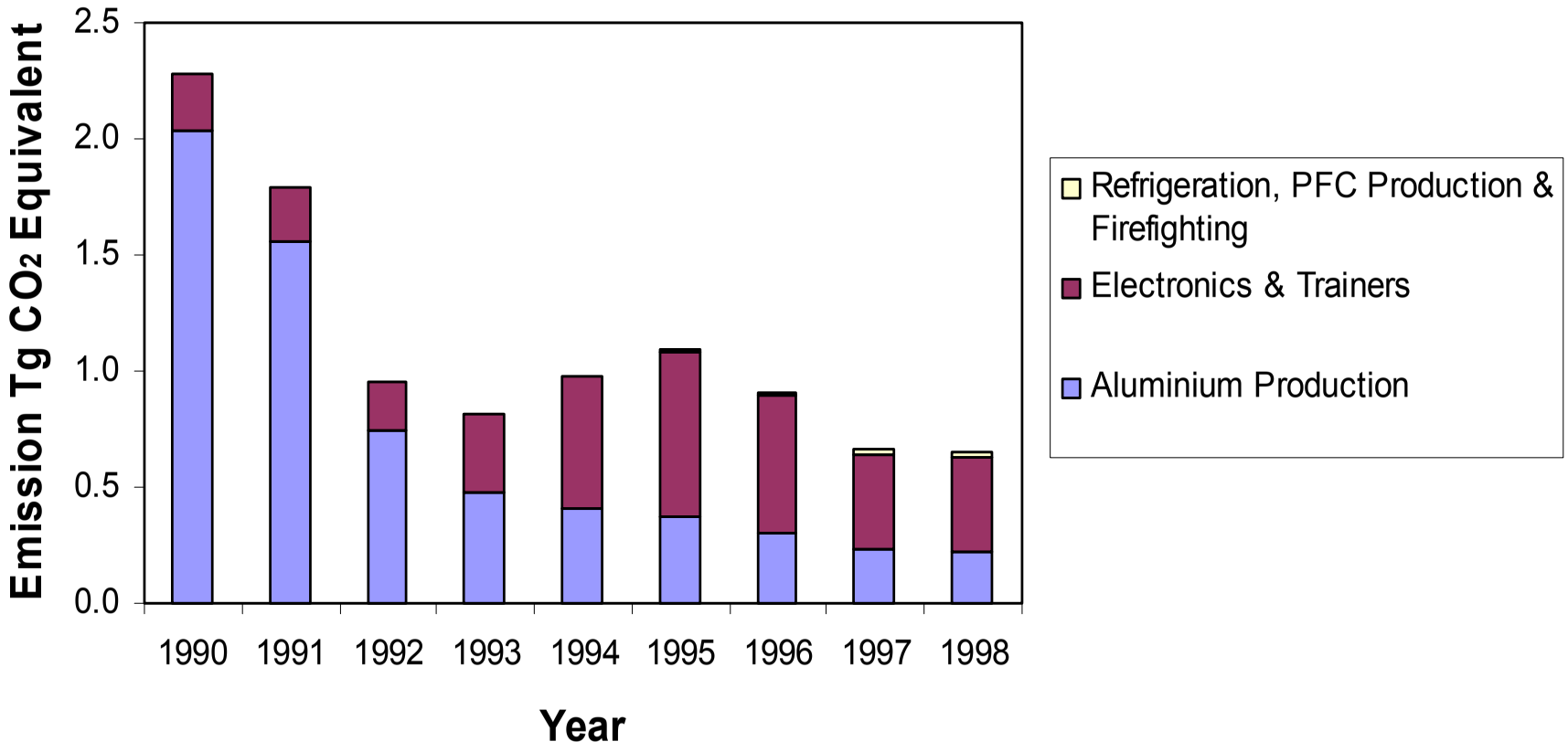
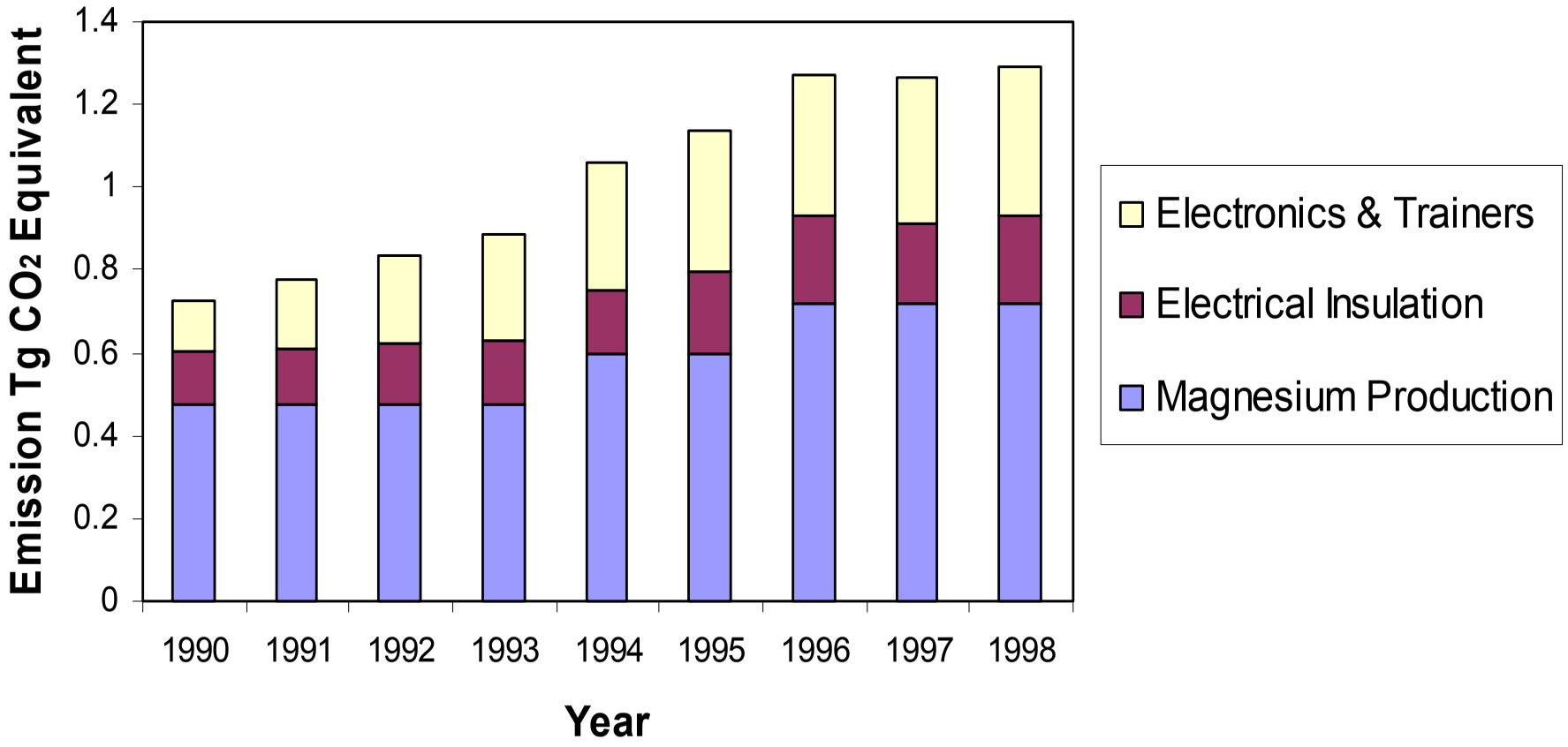


Figure 6: UK Emissions of Sulphur Hexafluoride



7 UK Emissions of Nitrogen Oxides

7.1 INTRODUCTION

The main source of NO_x ($NO + NO_2$) in the UK is fuel combustion. However, such emissions are complex since the nitrogen can be derived from both the fuel and the combustion air. In addition, emissions are dependent on the conditions of combustion, in particular on the temperature and excess air ratio, which can vary considerably. Thus combustion conditions, load and even state of maintenance are important. The estimation of NO_x emissions is often based on relatively few measurements and, in view of the possible variation in emissions from apparently similar combustion plant, there is greater uncertainty in the estimates than for CO_2. It is estimated that the uncertainty in total NO_x emissions is about ±30%.

7.2 DEVELOPMENT OF THE METHODOLOGY

A number of changes to the methodology have been made since the 1997 Inventory (Salway, 1999). These are:

1) Fuel Combustion
   - There has been a small reduction in coke production emissions due to a revision in coke-oven gas consumption.
   - Emissions from military aircraft have been revised upwards to take account of fuel used by UK Forces abroad. This has also resulted in a reduction in aviation bunker emissions.
   - There has been a small increase in iron and steel combustion sources due to revisions in the fuel statistics.
   - The methodology for emissions from cement kilns has been revised. Emissions are based on a more complete dataset from the Pollution Inventory (Environment Agency, 1999). The revision has increased emissions by 16 Gg NO_x in 1997.
2) Transport
   - The road transport methodology has been revised resulting in a 16 Gg increase in 1997. The main change is the use a more detailed distribution of journey speeds applied to the journey types used in the model.

7.3 DISCUSSION OF THE ESTIMATES

Figure 4 shows the UK emissions of nitrogen oxides (as nitrogen dioxide) broken down into source categories.

Since 1990, total emissions have fallen by 37% mainly as a result of abatement measures on power stations, three-way catalytic converters fitted to cars and stricter emission regulations on trucks.

The main source of nitrogen oxide emissions is road transport. Other forms of transport are included with road transport in Figure 4 but are small in comparison. From 1970, emissions

from road transport increased (especially during the 1980s) and reached a peak in 1989, before falling by 40% since 1990. The total road vehicle kilometres in 1998 were 12% higher than in 1990. Hence the reduction in emissions is due to the requirement for new cars to be fitted with catalytic converters and stricter regulations on truck emissions.

Emissions from off-road sources are reported in the sectors in which they occur, namely, 1A2 Manufacturing Industry, 1A3 Other Transport, 1A4b Residential and 1A4c Agriculture. Emissions from machinery used in agriculture, construction, industry, gardening and aircraft support have declined over the period but contribute around 4% of the current total.

Over the period 1990 to 1998, emissions from 1A1 Energy Industries fell by 47%. The main reason for this was a fall in emissions from power stations of around 53%. Since 1988, the electricity generators adopted a programme of progressively fitting low NO_x burners to their 500 MWe coal fired units. Since 1990, further changes in the electricity supply industry such as the increased use of nuclear generation and the introduction of CCGT plant (see Section 2.3) have resulted in additional reductions in NO_x emissions.

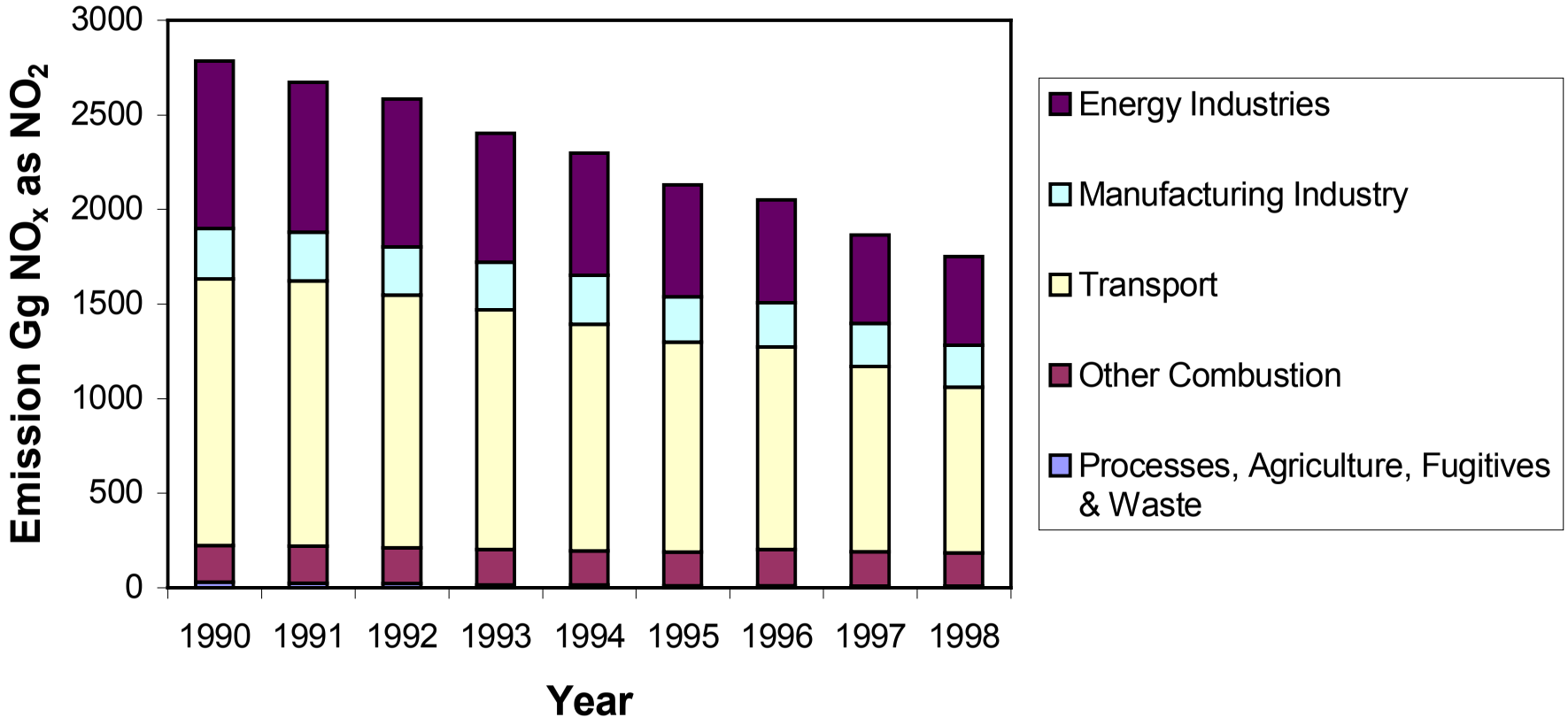
Combustion emissions from industry fell by 16% from 1990 to 1998. This is a result of a fall in energy consumption and the switch from coal and oil to natural gas.

Fugitive emissions from 1B2 Oil and Natural Gas have fallen by 26% over the period 1990 to 1998. Most of this is flaring.

Other Sectors combustion shows a 3% increase since 1990. There is probably little significance in this, since emissions from the main component sectors; residential and commercial/institutional fluctuate from year to year depending on energy consumption. This varies with annual temperature variations. The only discernible trends are a decline in coal use and an increase in natural gas use.

International bunker emissions are not included in the National Total but are reported separately. For the UK they are around 16% of the national total. The shipping emission is the major component and accounts for 57% of bunker emissions in 1998. This has shown little variation over the period. The remainder is air traffic and this has risen by 65% since 1990.

Figure 7: UK Emissions of Nitrogen Oxides



8 UK Emissions of Carbon Monoxide

8.1 INTRODUCTION

Carbon monoxide (CO) arises from incomplete fuel-combustion. In 1998, 73% of emissions came from petrol-engined motor vehicles. Many of the comments about the uncertainty of the emission estimates of nitrogen oxides also apply to carbon monoxide and the overall uncertainty in emissions of carbon monoxide is currently estimated to be ±40%.

8.2 DEVELOPMENT OF THE METHODOLOGY

A number of changes have been made to the methodology since the 1997 Inventory (Salway, 1999) and some retrospective data revisions have been incorporated. These are:

2) Fuel Combustion
   - An increase in 1A1c due to a revision in coke oven gas consumption in coke production.
   - Emissions from sinter plants have been revised upwards slightly based on new data from British Steel(1999) showing high CO emissions from Iron and Steel processes. Sinter plants are classified as combustion processes by IPCC
   - The emissions from cement and kilns have been revised based on a more complete data set from the Pollution Inventory (Environment Agency, 1999). The revision has reduced emissions by 17 Gg CO in 1997.
   - Coke consumption by the Public Service has been reclassified as residential in the UK Energy Statistics, hence the small increase in residential emissions.

3) Transport
   - The road transport methodology has been revised resulting in a large reduction of 132 Gg in 1997. The main change is the use a more detailed distribution of journey speeds applied to the journey types used in the model.

4) Fugitive Emissions
   - Emissions from coke production have been revised upwards based on data reported in the Pollution Inventory (Environment Agency, 1999). The increase is 25 Gg CO in 1997.

5) Industrial Processes
   - A large emission of 367 Gg is now reported under iron and steel processes. This covers blast furnaces, blast furnace gas flaring, electric arc furnaces and basic oxygen furnaces. The increase in emissions of 5 Gg CO in 1997 is from basic oxygen furnaces and electric arc furnaces. It is based on recent estimates from British Steel (1999).

8.3 DISCUSSION OF THE ESTIMATES

National emissions of carbon monoxide are shown disaggregated into the main IPCC source categories in Figure 5. Since 1990, total emissions of carbon monoxide have fallen by 31%. The most important source is road transport where emissions have fallen by 32% due primarily to the increased use of catalytic converters, although a proportion is a consequence of fuel

switching from petrol cars to diesel cars. The other significant reduction is the cessation of agricultural stubble burning in 1993.

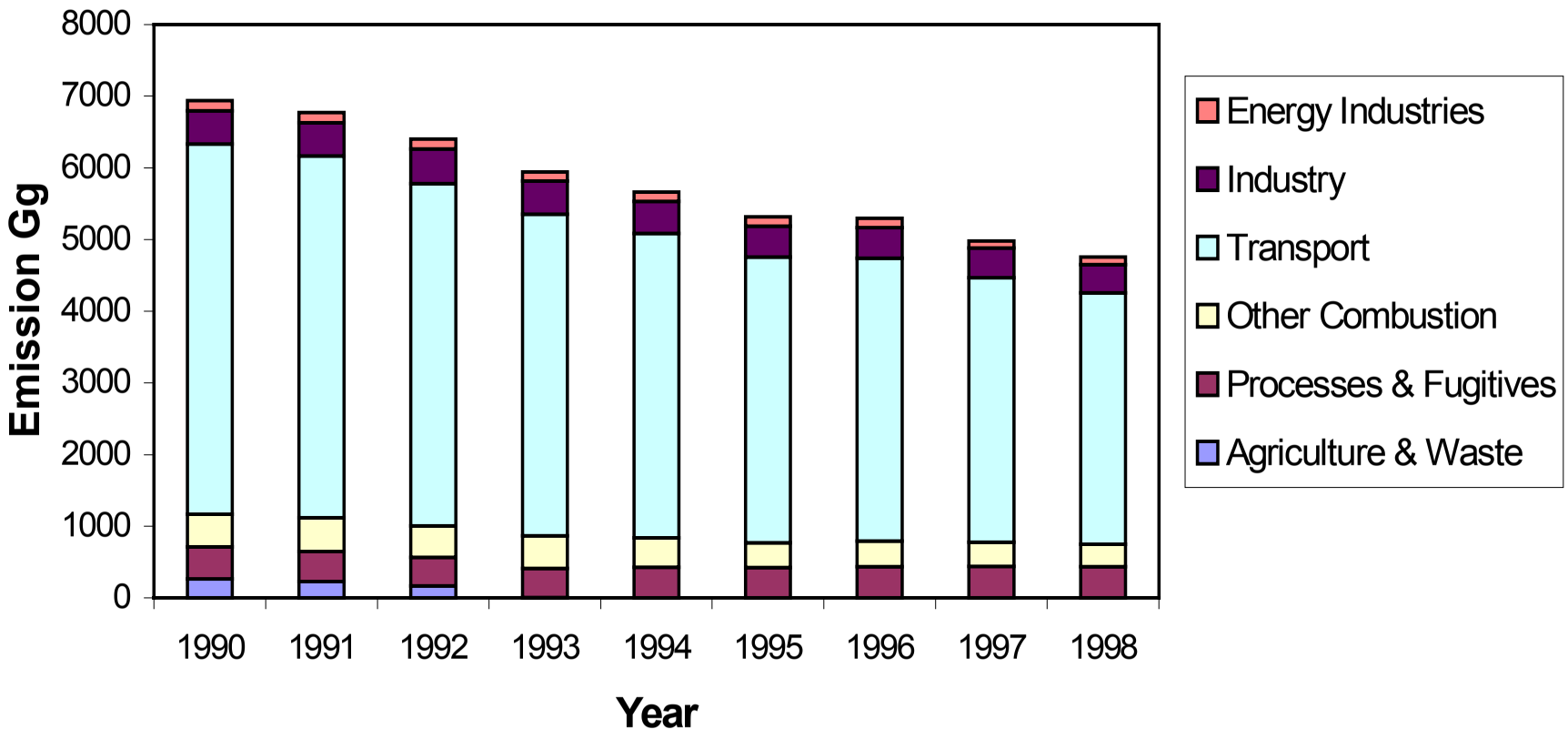
Other emission sources are small compared with transport. Emissions from Other Sectors have decreased by 29% since 1990 almost entirely as a result of decreased residential solid fuel combustion in favour of gas and electricity. This consumption has fluctuated considerably over the period but has fallen markedly since 1993. Emissions from the residential sector were 284 Gg in 1998 accounting for 6% of the total. Around 51 Gg of this arises from motor driven gardening equipment.

Emissions from off-road sources are reported in a number of sectors, namely: 1A2 Industry, 1A3 Other Transport and 1A4 Other Sectors. These include emissions from agricultural and construction equipment such as tractors, combine harvesters, portable generators, fork lift trucks, lawnmowers, and cement mixers. The petrol-engined machinery is a particularly important source of CO emissions. These estimates are very uncertain because they are based on estimates of equipment population and annual usage time. New data have been recently collected for certain important categories, namely, portable generators and forklift trucks resulting in a large reduction in the off-road estimates. Emissions from these sources are now believed to contribute 6.5% of the total emission.

Emissions from iron and steel processes based on data supplied by British Steel and reported in the Pollution Inventory (Environment Agency, 1999). The emission data are fairly approximate and has been allocated to basic oxygen furnaces, electric arc furnaces and sinter plant. Sinter plant emissions are reported in the combustion category 1A2a. The process emissions account for 9% of the total in 1998.

Other emission sources are small compared with transport and off-road sources. Power station emissions have been revised downwards and in 1998, this sector accounted for 1.5% of the total.

Figure 8: UK Emissions of Carbon Monoxide



9 UK Emissions of Non-Methane Volatile Organic Compounds

9.1 INTRODUCTION

The development of an accurate emission inventory for Non-Methane Volatile Organic Compounds (NMVOC) is complex. The diversity of processes which emit NMVOC is large, covering not only many branches of industry, but also transport, agriculture and domestic sources. Within a single industry sector such as printing, the variation in the quantity and composition of organic solvents used in the inks, the different printing processes used and the varying extent and types of abatement used on the different presses make it difficult to apply a single, generally valid, emission factor across the industry. Unlike CO_2, CO and NO_x, only about 33% of the UK estimate of NMVOC emissions comes from combustion sources.

Often emissions from sources are small individually, but important collectively. A good example of this is leakage from valves, flanges and other connections in petrochemical plants. A typical plant may have many other emission sources, each emitting a very small quantity of NMVOC which are difficult to locate and quantify.

The term NMVOC covers a large range of compounds and this can create difficulties when measuring emission factors. Many commonly employed measurement techniques such as flame ionisation detection do not respond with uniform sensitivity to all compounds. Large errors can therefore occur if emitted compounds are poorly detected by the measurement technique used. Methane is also associated with NMVOC emissions from many sources, for instance, combustion processes, transport, and the oil and gas industries. Methane is removed from the emission factors used so that NMVOC is reported rather than total hydrocarbons (THC).

NMVOC emissions are uncertain since data relating to emission from individual industrial processes and solvent use are incomplete. Therefore, the emission factors are very approximate and the uncertainty in total NMVOC emissions is currently estimated to be around ±50%.

9.2 DEVELOPMENT OF THE METHODOLOGY

A number of changes have been made to the methodology since the 1997 Inventory (Salway, 1999). These are:

1) Fuel Combustion
   - Emissions from cement kilns are now based on data reported in the Pollution Inventory rather than fuel specific emission factors. This has resulted in reduction in emissions of around 2 Gg in 1997
2) Transport
   - The road transport methodology has been revised resulting in a large reduction of 59 Gg in 1997. The main change is the use of a more detailed distribution of journey speeds applied to the journey types used in the model.
3) Fugitive Emissions from Fuels

- Emissions from the gas distribution network have been revised to take account of high pressure mains. These have increased by 2 Gg NMVOC in 1997

4) Solvent Use
   - Emissions from solvent use have been revised and have fallen by 40 Gg in 1997. This is a result of revisions in solvent consumption data for many sources. Most significant are the changes in agrochemicals use and aerosols.

9.3 DISCUSSION OF THE ESTIMATES

Figure 6 shows the UK emissions of NMVOC broken down by source category. The estimates suggest a decline in total emissions of 27% since 1990. The main sources are Industrial Processes, Fugitive emissions from fuels and Solvent Use which together account for 64% of current emissions. The next largest source is transport which accounts for 30% of the total. Almost all these emissions are from road transport and since 1990, they have fallen by 43%. This reduction is due mostly to the increasing use of catalytic converters on cars, although a proportion is due to switching from petrol to diesel cars.

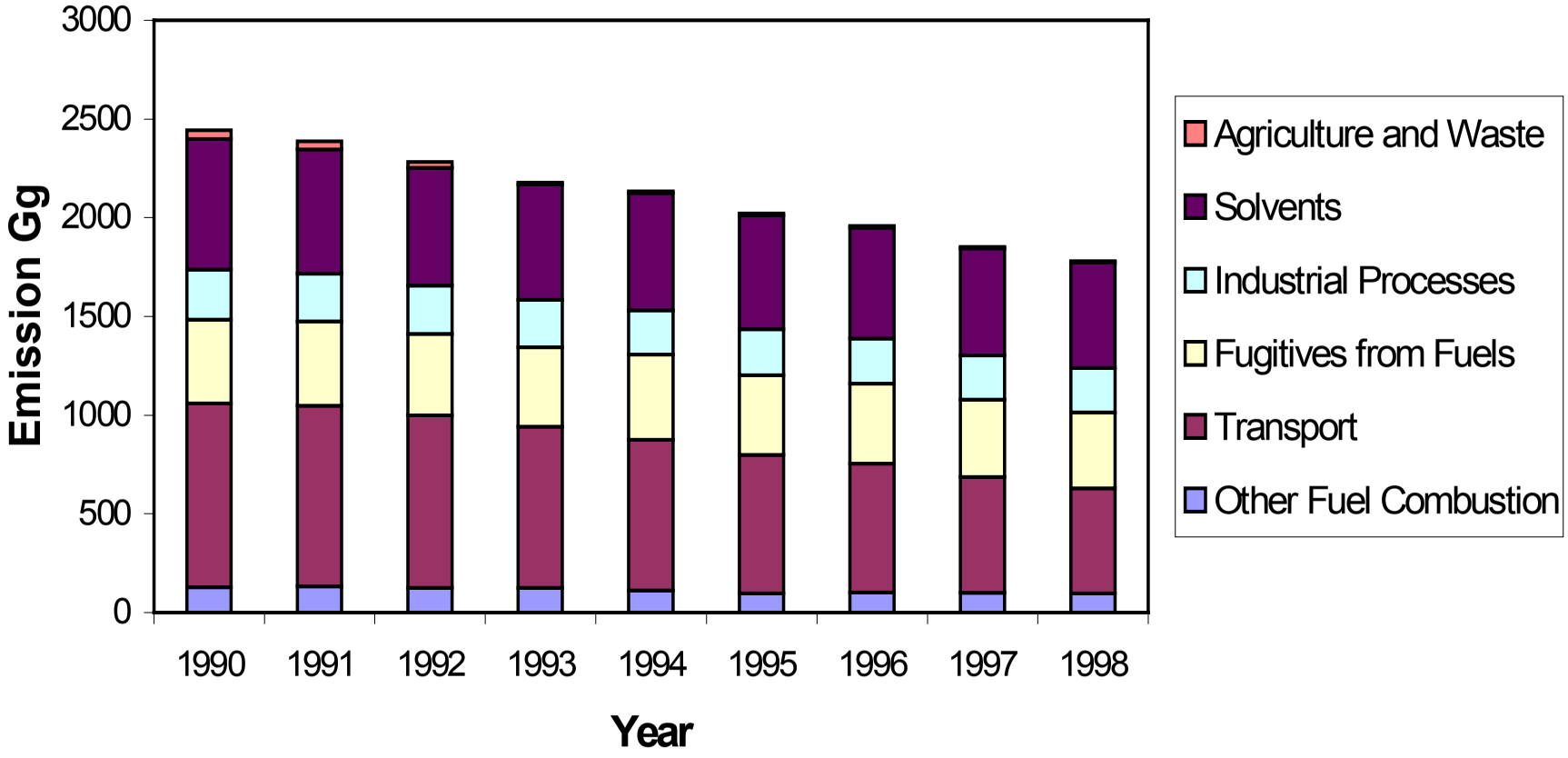
Emissions from 1B2 Oil and Natural Gas have increased by 9% since 1990 and constitute 21% of the UK Total. This includes emissions from gas leakage which comprise around 1% of the UK Total at present and are declining as a result of the gas main replacement programme underway since 1990. Emissions from petrol distribution are around 6% of the national total and depend on petrol consumption which has fallen recently owing to increased use of diesel oil. Emissions from the offshore industry, refining and storage account for the remainder. This includes a contribution from tanker loading and unloading.

Emissions from off-road sources have been included since the 1995 Inventory. Of particular importance are those from petrol-engined machinery. This includes portable generators, fork lift trucks, lawnmowers and cement mixers. The estimation of emissions from such machinery is very uncertain since it is based on estimates of equipment population and annual usage time. They are believed to contribute 2% of the total emission. In the IPCC reporting format these sources are reported under 1A2 Industry, 1A3 Other Transport and 1A4 Other Sectors.

Other combustion emissions are very small compared with the sources discussed above. Emissions from the residential sector contribute 3% to the total and derive from solid fuel combustion in domestic appliances. This source has declined by 33% since 1990 due fuel switching from solid fuels to gas and electricity.

The other significant reduction in emissions was the cessation of agricultural stubble burning in 1993.

Figure 9: UK Emissions of Non-Methane Volatile Organic Compounds



10 UK Emissions of Sulphur Dioxide

Emissions of sulphur dioxide have only been included in the Greenhouse Gas Inventory since the 1996 Inventory. Sulphur dioxide is now reported as an indirect greenhouse gas because of its role in aerosol formation. It has however, been reported as part of the NAEI for many years, originally because of its role in smog formation but more recently because of interest in acidification.

Fuel combustion accounts for more than 99% of UK SO_2 emissions with the sulphur deriving from the fuel itself. Hence, SO_2 emissions can be calculated from a knowledge of the sulphur content of the fuel and information of the amount of sulphur retained in the ash. The uncertainty in the emissions is estimated as ±10-15%.

10.1 DEVELOPMENT OF THE METHODOLOGY

A number of changes have been made to the methodology since the 1998 Inventory (Salway, 1999). These are:

1. Estimated emissions from refineries have increased due to a small amount of fuel oil being reclassified as refinery fuel rather than as consumption by the petrochemicals industry.
2. Estimated emissions from the Iron and Steel Industry have been reduced by 4 Gg SO_2 due to revisions in coke consumption data.
3. Estimated emissions from other industrial combustion have been revised downwards. This is as a result of a number of revisions in coal, coke, and oil consumption. Emissions from cement kilns are now based on a more complete set of data reported in the Pollution Inventory .
4. Estimated emissions from the residential sector have been revised upwards based on revised estimates of the sulphur content of anthracite, and the reclassification of some coke from the public service to residential.

10.2 DISCUSSION OF THE ESTIMATES

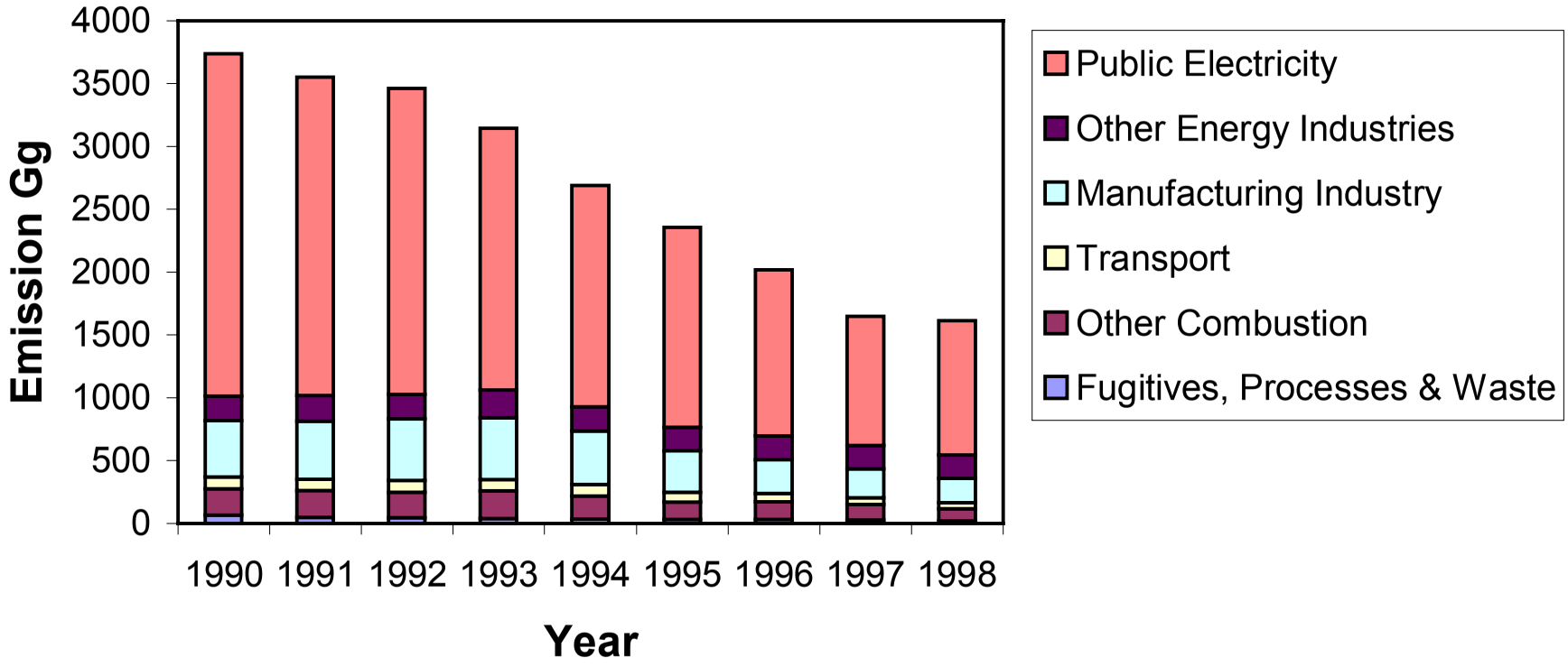
Figure 7 summarizes UK emissions of SO_2 disaggregated by source. Since 1990 there has been an overall decline in SO_2 emissions of around 57%.

The largest contribution to SO_2 emissions is from power stations which accounts for 66% of the total in 1998. Since 1990 these emissions have declined by 61% because of the increase in the proportion of electricity generated in nuclear plant and the use of Combined Cycle Gas Turbine (CCGT) stations and other gas fired plant. CCGTs run on natural gas and are more efficient than conventional coal and oil stations and have negligible SO_2 emissions. In addition the flue gas desulphurisation plants, constructed at Drax and Ratcliffe power stations have had a significant effect on emissions since 1994. It is estimated that around 0.285 Mt of SO_2 were removed in 1997 compared with a total emission from coal fired power stations of 0.958 Mt. Beween 1997 and 1998, there was a small increase in SO_2 emissions from power stations. This can be attributed to a small increase in coal consumption and a breakdown at the the FGD plant at Drax.

Industrial emissions of SO_2 accounted for 12% of the total in 1998. These have fallen by 57% since 1990. Since 1994 emissions have fallen by 54% which compares with a 4.5% decrease in fuel consumption (excluding electricity) by industry (DTI, 1999). Hence, the reduction is due to a decline in the use of coal and oil in favour of natural gas and some improvement in energy efficiency (See Section 2.2).

The remaining categories are rather small compared with two main ones and virtually all are decreasing. Emissions from the residential and commercial/institutional sectors have declined for the reasons given for industry. The only categories that show any increase over the period are aviation and international marine. Here domestic aviation emissions have doubled and aviation bunkers have increased by 50%. However, domestic aviation and bunkers only account for 0.9 Gg and 8 Gg respectively compared with a total emission of 1615 Gg. Marine bunkers are larger at 117 Gg and have increased by 26% over the period.

Figure 10: UK Emissions of Sulphur Dioxide



11 Global Warming Potential of UK Emissions

11.1 INTRODUCTION

The greenhouse gases discussed all have different degrees of effectiveness in global warming. The Global Warming Potential (GWP) is a means of providing a simple measure of the relative radiative effects of the emissions of the various gases. The index is defined as the cumulative radiative forcing between the present and some chosen time horizon caused by a unit mass of gas emitted now, expressed relative to that of CO_2. It is necessary to define a time horizon because the gases have different lifetimes in the atmosphere. Table 10 shows GWPs defined on a 100 year horizon, IPCC(1996).

Table 10: GWP of Greenhouse Gases on 100 Year Horizon

Gas	GWP
Carbon Dioxide	1
Methane	21
Nitrous Oxide	310
HFCs	140-11700
PFCs	6500-7000
SF_6	23900

A range of GWP values is shown for HFCs and PFCs because these refer to a number of species, each with its own GWP. By weighting the emission of a gas with its GWP it is possible to estimate the total contribution to global warming of UK greenhouse gas emissions.

11.2 GWP WEIGHTED EMISSIONS

GWP weighted emissions are shown in Table 11 and Figure 11.

Table 11 GWP Weighted Greenhouse Gas Emissions (Tg CO_2 Equivalent)

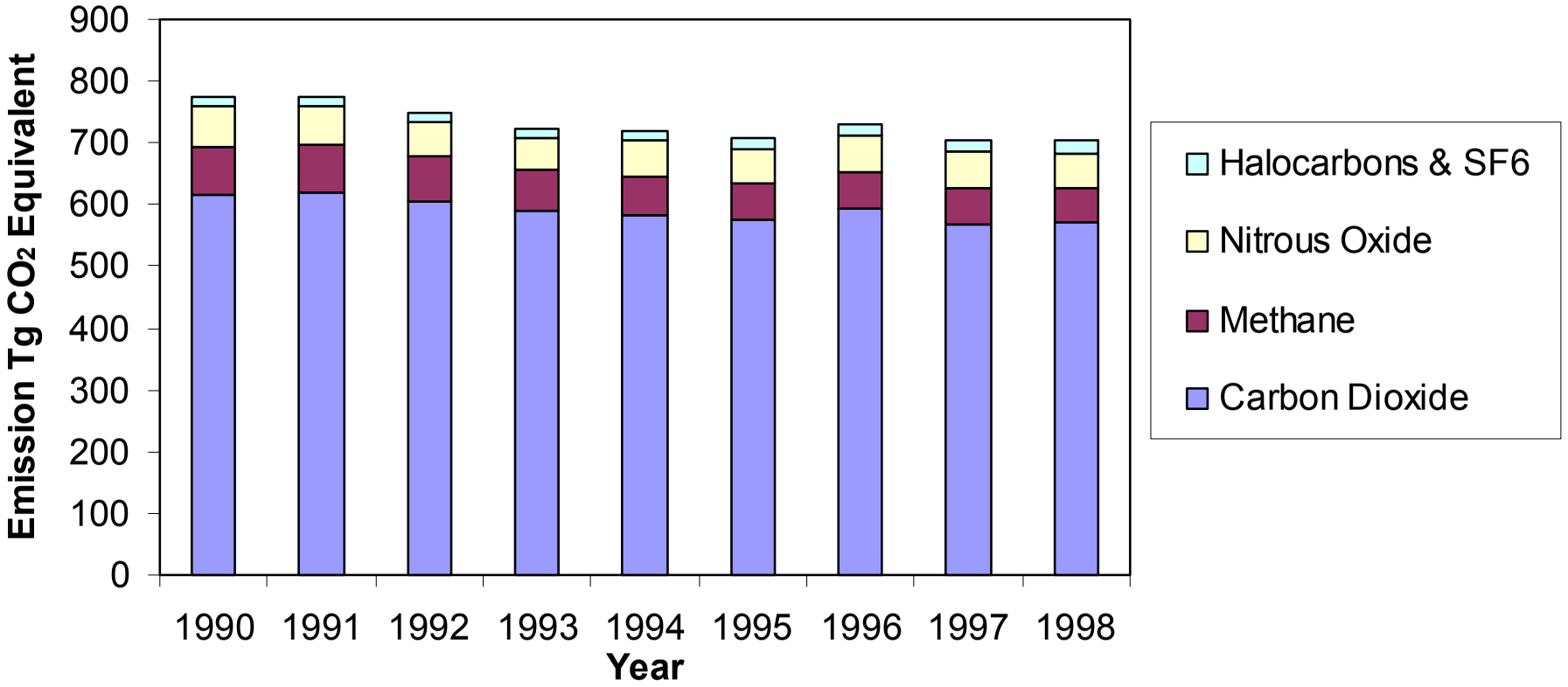
	1990	1991	1992	1993	1994	1995	1996	1997	1998	% change 1990-98
Carbon Dioxide[1]	616.0	619.9	604.9	589.0	583.8	574.7	593.9	567.6	570.2	-7.4%
Methane	77.2	76.2	74.2	66.8	61.8	61.3	59.9	58.0	55.4	-28.3%
Nitrous Oxide	65.7	63.7	56.7	53.0	57.7	55.1	57.0	58.7	56.0	-14.8%
HFCs	11.4	11.9	12.3	12.9	13.8	15.2	16.3	18.4	20.2	77.4%
PFCs	2.3	1.8	1.0	0.8	1.0	1.1	0.9	0.7	0.7	-71.4%
SF_6	0.7	0.8	0.8	0.9	1.1	1.1	1.3	1.3	1.3	78.0%
Total[1]	773.2	774.2	750.0	723.4	719.2	708.4	729.4	704.7	703.7	-9.0%

1 Carbon emissions in 1994-1998 are slightly lower than in previous publications due to a correction to Iron & Steel processes

The table shows that the largest contributor to global warming is carbon dioxide at 81% of the weighted emission. Methane and nitrous oxide have similar contributions at around 8% of the total. In spite of their high GWPs, the contribution of halocarbons is small at around 3% of the total. This is because their mass emissions are very small. Overall the total weighted emission has fallen by 9% since 1990 with all gases declining except HFCs and SF_6.

The uncertainty in the combined GWP weighted emission of all the greenhouse gases was estimated as 14%. The approach used is discussed in Appendix 1.

Figure 11: UK Emissions of Greenhouse Gases Weighted by GWP



12 References

British Steel, (1999), Personal Communication from E Hutton, Environmental Control.

DOE, (1994), Climate Change: The UK Programme; United Kingdom's First Report under the Framework Convention on Climate Change, HMSO, London.

DOE, (1997), Climate Change: The UK Programme; United Kingdom's Second Report under the Framework Convention on Climate Change, The Stationary Office, London.

DTI, (1999), Digest of United Kingdom Energy Statistics 1999, London, The Stationary Office

Eggleston, HS, Salway, AG, Charles, D, Jones, BMR, Milne, R, (1998), Treatment of Uncertainties for National Estimates of Greenhouse Gas Emissions, National Environmental Technology Centre, AEA Technology, Report AEAT - 2688.

Environment Agency, (1999), 1998 Pollution Inventory

IPCC, (1996), Climate Change 1995. The Science of Climate Change. Contribution of Working Group 1 to the Second Assessment Report of the Intergovernmental Panel on Climate Change. ed. Houghton, JT, Cambridge University Press.

IPCC, (1997), IPCC Revised 1996 Guidelines for National Greenhouse Gas Inventories, IPCC WGI Technical Support Unit, Hadley Centre, Meteorological Office, Bracknell, UK.

IPCC, (2000), Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

MCG, (1999), UK Emissions of HFCs, PFCs and SF_6 Potential Emission Reduction Options. A study for the Department of the Environment carried out by March Consulting Group. Telegraphic House, Waterfront Quay, Salford Quays, Manchester

Salway, AG, (1995), UK Greenhouse Gas Emission Inventory, 1990 to 1993. Annual Report for submission under the Framework Convention on Climate Change. National Environmental Technology Centre, AEA Technology, AEA/16419178/R/001, ISBN 0-7058-1709-1.

Salway, AG, (1996), UK Greenhouse Gas Emission Inventory, 1990 to 1994. Annual Report for submission under the Framework Convention on Climate Change. National Environmental Technology Centre, AEA Technology, AEA/20092001/R/003, ISBN 0-7058-1728-8.

Salway, AG, (1997), UK Greenhouse Gas Emission Inventory, 1990 to 1995. Annual Report for submission under the Framework Convention on Climate Change. National Environmental Technology Centre, AEA Technology, AEAT-2121, ISBN 0-7058-1755-5.

Salway, AG, (1998), UK Greenhouse Gas Inventory, 1990 to 1996. Supplementary Report for submission under the Framework Convention on Climate Change. National Environmental Technology Centre, AEA Technology, AEAT - 3436, ISBN 0-7058-1766-1.

Salway, AG, (1998a), Comparison between the IPCC default and UK Detailed Inventories 1990-1996, National Environmental Technology Centre, AEA Technology, AEAT-4457

Salway, AG, (1999), UK Greenhouse Gas Inventory, 1990 to 1997. Annual Report for submission under the Framework Convention on Climate Change. National Environmental Technology Centre, AEA Technology, AEAT-5689, ISBN 0-7058-1786-5.

SCOPEC, (1999), Environmental Database for Emissions and Discharges from Offshore Installations, Atmospheric Emissions Inventory, 1998. Personal communication from P Russell, Safety and Environment Directorate, BG plc.

Units

The following units are used in this report:

1 Gigagramme (Gg) = 1 thousand tonnes (kt)
1 Teragramme (Tg) = 1 million tonnes (Mt)

SECTORAL TABLES 1990

SECTORAL TABLES 1998

Footnotes for IPCC Sectoral Tables

(a) Net flux may be estimated as the sum of emissions and removals
(b) Naval vessels and military aircraft
(c) Emissions arise from refrigeration, electronics applications, electrical insulation, foams, aerosols and training shoes
(d) The CO_2 equivalent of solvent NMVOC (excluding 3C) is 1571 Gg in 1990 and 1262 Gg in 1998
(e) Field burning ceased in 1993
(f) 5A Removals include removals to forest litter and to forest products
(g) 5D Emissions include removals to soils due to set aside of arable land and emissions due to liming
(h) 5E Emissions include emissions from soils due to upland drainage, lowland drainage and peat extraction
(i) 5E Removals are increases in crop biomass
(j) Emissions from own wastewater treatment by industry are not estimated
(k) Emissions are for information only and are not totalled
(l) Emissions arise from wood, straw, biogases and poultry litter combustion for energy production
(m) Carbon emissions are slightly lower than in previous publications due to a correction to Iron & Steel processes