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UK GHG Inventory Improvements: Industrial Process Sector Compliance with IPCC 2006 Guidelines

Final Report to the Department of Energy and Climate Change

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Contents

Glossary

1996 GLs	1996 IPCC Guidelines for National GHG Inventories
2000 GPG	2000 IPCC Good Practice Guidance
2006 GLs	2006 IPCC Guidelines for National GHG Inventories
CEMS	Continuous Emission Monitoring Systems
CRF	Common Reporting Format
CS	Country Specific
DUKES	Digest of UK Energy Statistics (the UK energy balance)
EA	Environment Agency
EF	Emission Factor
EU	European Union
EUETS	European Union Emissions Trading System
EUMM	European Union Monitoring Mechanism
IE	Included Elsewhere (within CRF reporting)
IEF	Implied Emission Factor
IPCC	Intergovernmental Panel on Climate Change
IPPC	Integrated Pollution Prevention and Control
IPPU	Industrial Processes and Product Use
ISSB	International Steel Statistics Bureau
LRTAP	Convention on Long-Range Transboundary Air Pollution
MMR	(European Union) Monitoring Mechanism Regulation
MS	(European Union) Member States
NE	Not Estimated (within CRF reporting)
NEU	Non-Energy Use (of fuels)
NFM	Non-Ferrous Metals
NGLs	Natural Gas Liquids
NIR	National Inventory Report
NO	Not Occurring (within CRF reporting)
ODU	Oxidised During Use
PI	Pollution Inventory
SNCR	Selective non-catalytic reduction
SEPA	Scottish Environment Protection Agency
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

The UK GHG inventory is submitted annually to the EU and UNFCCC. The UK inventory is subject to annual reviews by the UNFCCC Expert Review Teams to assess compliance against reporting guidelines and review the completeness, accuracy, transparency, consistency and comparability (against other reporting parties) of the UK inventory. For the first time in 2015, all national GHG inventory submissions to the UNFCCC must be reported under the revised UNFCCC Reporting Guidelines and using the 2006 IPCC Guidelines (2006 GLs). The 2006 GLs set revised methods for existing sources, and methodologies for new sources of emissions from Industrial Processes and Product Use (IPPU) compared to previous inventory submissions using the 1996 IPCC Guidelines (1996 GLs). The revised UNFCCC reporting guidelines specify that the 2006 GLs must be used, and defines the reporting structure (CRF).

DECC has commissioned this project to ensure that the UK GHG Inventory submitted in 2015 meets all of the new requirements set out in the 2006 IPCC GLs for the Industrial Processes and Product Use sector, and to ensure completeness of the UK inventory ahead of the Initial Report for the 2nd Commitment Period of the Kyoto Protocol. The report also considers emission projections for IPPU sources to 2035. This report provides an overview of the analysis conducted and the improvements recommended for the UK GHGI method, and forms the underlying reference material for the National Inventory Report to be submitted by DECC to the European Union Monitoring Mechanism and the UNFCCC in 2015.

The project team have reviewed available literature, operator-reported fuel use and emissions data, and have consulted with UK industry contacts (trade associations, individual companies), industry regulator sector leads, DECC energy projections experts and inventory compilers from other Member States in order to review the UK GHGI estimates and formulate solutions to take forward within the 2015 UK GHGI submission.

Table 1 below outlines the recommendations for DECC to consider to improve the UK inventory for the source categories assessed under the scope of this project.

Whilst there are many recommended method improvements listed to achieve compliance with the 2006 GLs, the overall impacts of these recommended revisions is very small in the context of the total UK GHG inventory. Many of the revisions are reallocations between Energy and IPPU, and as such the impact on total emissions is zero. The highest-emitting source categories (i.e. emissions from production of cement, lime, inorganic chemicals and petrochemicals) are already accurately estimated within the UK GHGI under the 1996 GLs, and no changes are needed for compliance with the 2006 GLs.

IPPU sector GHG projections to 2035 have been developed through consultation with industry and energy projections experts. In line with the EU MMR requirements, emission values calculated for 2013 are used as basis for the projections. The IPPU inventory is dominated by emissions from a small number of high-emitting source categories, and a small number of companies / installations. Therefore the IPPU projections data are highly sensitive to future decisions that affect this small number of high-emitting installations, for example whether new investment goes ahead or not in a handful of industry sectors (e.g. cement, lime, ethylene production). Hence the projections are regarded as highly uncertain, despite being based on the best available current information and projected economic / industry trends.

Table 1 Recommended Improvements for the UK GHGI IPPU Sector

Source Category	New Source?	Gas	Recommended improvements
2A1 Cement Production	No	CO_2	No recalculation necessary.
2A2 Lime Production	No	CO_2	No recalculation necessary.
2A3 Glass Production	No	CO_2	New data identified. Method improvement and recalculations proposed.
2A4 Other process uses of carbonates	No	CO_2	New data identified. Method improvement and recalculations proposed.
2B1 Ammonia production	No	CO_2	No overall recalculations necessary, but propose to re-allocate the combustion emissions previously reported in 1A2c to 2B1.
2B2 Nitric Acid Production	No	N_2O	Revision to default EF applied where installation-specific or CS data not available.
2B3 Adipic Acid Production	No	N_2O	No recalculation necessary.
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production	Yes	N_2O	These sources are *Not Occurring* in the UK.
2B5 Carbide Production	Yes	CO_2	This source is *Not Occurring* in the UK.
2B6 Titanium Dioxide Production	Yes	CO_2	New emission estimates developed, which re-allocate emissions from Energy to IPPU.
2B7 Soda Ash	Yes	CO_2	New emission estimates developed, which re-allocate emissions from Energy to IPPU.
2B8 Petrochemical and Carbon Black Production	Yes	CO_2, CH_4	New emission estimates developed, which in part re-allocate emissions from Energy to IPPU
2C2 Ferroalloy production	Yes	CO_2	In recent years this source is *Not Occurring* in the UK. In early years of the time series, emission estimates are *Included Elsewhere* within 1A2, as DUKES and ISSB statistics do not provide explicit activity data for ferroalloy production, and the production plant has closed, so no further information is available.
2C5 Lead Production	Yes	CO_2	New emission estimates developed, reported combined with 2C6 Zinc production.
2C6 Zinc production	Yes	CO_2	New emission estimates developed, which re-allocate emissions from Energy to IPPU, and include estimates from a combined lead and zinc production plant.
2D1 Lubricants	No	CO_2	Revised inventory method and assumptions and all lubricant emissions now consolidated in 2D1 (previously allocated across several source categories under Energy).
2D2 Paraffin waxes	No	CO_2	Revised inventory method assumptions and hence recalculations, also re-allocated to 2D
2D3 Asphalt Production and Use	No	n/a	Not Occurring (no direct GHGs from this source)
2D (other)	No	CO_2	Previous estimates of CO_2 emissions from use of pesticides and detergents removed from the UK inventory, as no 2006 GL methods and assessed as probable double-counts and over-estimates in previous submissions.

1. Introduction

The UK GHG inventory submission to the EU and UNFCCC in 2015 must, for the first time, use the methodologies set out in the 2006 IPCC Guidelines, and this infers changes in the scope and structure of the emissions from Industrial Processes and Product Use (IPPU) compared to previous inventories. The revised "Guidelines for the preparation of National Communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories" were formally adopted at COP19 in November 2013. These set out how Annex I countries, including the UK, need to report emission inventories from 2015 onwards, and how the 2006 IPCC methodology guidelines are to be implemented.

This project has been commissioned by DECC to ensure that the UK GHG Inventory submitted in 2015 meets the new requirements for reporting emissions from the IPPU sector. The UK GHGI submission is used to under-pin national target-setting and tracking of progress for mechanisms such as Carbon Budgets, domestic GHG mitigation targets (national and sub-national), and UK mitigation targets for the non-traded sector under the Effort Sharing Decision and international commitments under the UNFCCC and Kyoto Protocol. Therefore it is essential that the UK inventory data are as complete and accurate as possible, and in order to comply with the new reporting obligations under the new MMR (for EU-level reporting of GHG emissions), the UK data should as far as possible be directly comparable and consistent with national inventory data from other EU Member States.

In addition, this project aims to develop new GHG emission projections to 2035 for the IPPU sector, in order to support MMR reporting and delivery of UK data for UNFCCC national communications and Biennial reports.

During 2013-14, the UK inventory was reviewed by DECC, the National Inventory Steering Committee (NISC) and the inventory agency to identify emission sources where additional research was warranted in order to ensure compliance with the 2006 GLs. DECC has commissioned separate research to address the needs of the UK GHGI reporting to 2006 GL requirements for all F-gas sources in the IPPU sector and all sources from integrated iron and steel works; this project has been commissioned to address all of the remaining IPPU sources, either new or existing, to achieve compliance with the 2006 GLs.

The scope of the project is to deliver inventory and projection estimates for the following existing and new source categories:

Existing Source Categories[1] (i.e. already included in the GHGI under the 1996 GLs)

- 2.A.1 Cement
- 2.A.2 Lime Production
- 2.A.3 Use of limestone and dolomite - glass
- 2.A.4 Use of limestone and dolomite - other process uses of carbonates
- 2.D.1 Lubricants
- 2.D.2 Paraffin waxes

[1] Note category codes (e.g. 2.A.1) listed are consistent with the Revised UNFCCC Reporting Guidelines, i.e. the new categories for use from 2015

The project team also considered any impacts on data, methods and reporting requirements for other existing IPPU source categories, and the report includes recommendations for revisions to estimates from 2B2 Nitric Acid production.

New Source Categories (i.e. new sources introduced by the 2006 GLs)

- 2B4 Caprolactam, Glyoxal, Glyoxylic Acid
- 2B5 Carbide production
- 2B6 Titanium Dioxide production
- 2B7 Soda ash production
- 2B8 Petrochemicals and Carbon Black
- 2C2 Ferroalloy production
- 2C5 Primary lead production
- 2C6 Primary zinc production

It should be noted that 2.B.8 includes some emission sources that are already included in the UK inventory (although included previously under the Energy sector) and therefore this source category comprises both existing and new emission sources.

There are a range of outcomes possible for the new and existing sources in the IPPU sector:

- Existing sources in the UK GHGI where the inventory data, method and reporting are entirely consistent with the 2006 GLs and therefore no further action is needed;
- Existing sources in the UK GHGI where the 2006 GLs introduce a new or revised method or allocation in the CRF, where the previous (1996 GLs) method in the UK does not satisfy the new requirements, and hence new estimates must be developed;
- New source where a new method is described in the 2006 GLs, the activity occurs in the UK and therefore new emission estimates need to be developed, either in isolation or in combination with other sources ("Included Elsewhere") depending on the available raw data for UK activities;
- New source in the 2006 GLs that does not occur in the UK. In these instances, the project team has aimed to collate sufficient documentation to satisfy an ERT that the source can be reported as "Not Occurring" in the UK GHGI submission;

All new or revised methods must be transparently documented for inclusion within the 2015 submission National Inventory Report (NIR); the study team has developed draft method statements for all new methods derived through this study, and these are included in Annex 1.

Report Structure

Section 2 outlines the study method.

Section 3 presents the main results of the research, outlining the recommended recalculations for new and existing source categories and gases and presenting the projections data to 2035.

Annex I presents further details of the proposed new or revised inventory data, methods and assumptions for new and existing source categories, as will be required for the NIR.

Annex II summarises the results of emission inventory calculations and the proposed new set of emission projections for new and existing sources.

Annex III presents the research references: literature sources, reference materials, reported emissions and energy data, consultees.

Annex IV provides the summary of information from consultations with other Member States as part of the efforts to ensure that the UK GHG inventory meets the requirements of the MMR and presents data allocated across Energy and IPPU sources in a manner that is comparable with other Member States and easily assimilated into EU-wide GHG inventory estimates.

2. Study Method

The following tasks were carried out under this project:

a) Assessment of compliance of current UK GHGI methods for existing source categories with the 2006 IPCC GL requirements, and improvements to data, methods and reporting practices where necessary;

b) Development of new methodological approaches, identifying suitable source data and generating a full time series of new emission calculations for the new source categories in IPPU set out in the 2006 IPCC GLs;

c) Development of projections for all (new and existing) IPPU source categories in line with the requirements of the EU Monitoring Mechanism Regulation (MMR).

Throughout all tasks, the study approach has taken into consideration the over-arching data quality requirements for national inventory reporting, aiming to ensure that recommended improvements to the UK GHGI and projections data meet 2006 GL requirements and are:

- ✓ **Transparent** – through clear documentation of data sources, methods, assumptions and outputs, for both the historic inventory and projections data;
- ✓ **Consistent** – taking consideration of impacts of the recommendations across Energy and IPPU sources, and developing a method that delivers a consistent approach across the time series;
- ✓ **Complete** – i.e. ensuring that all emission sources identified are included within the GHGI;
- ✓ **Comparable** - by following the methods set out in the 2006 GLs and through consultation with inventory experts across the EU to ensure that the UK GHGI data will be comparable with data from other Parties and easily assimilated within the EU GHG inventory dataset;
- ✓ **Accurate** – through the identification and use of the best available data and methods, especially for high-emitting sources that are Key Source Categories where country-specific data and methods are required.

The study team has prioritised resources to focus on more significant emission sources and to ensure completeness of the historical inventory estimates. Wherever possible the study team has aimed to develop source-specific estimates that provide full transparency of the data and methods, minimising the need for use of the IE notation key. However, where very limited data are available this has not always been possible, for example where sites have closed and there is very little information to support detailed assessment of the Energy / IPPU split of emissions or to determine the emissions associated with a specific IPPU source. Wherever possible the study team has aimed to develop inventory methods that will be easily updateable in future, using readily-available UK data to underpin the calculations.

Throughout the research and consultation process, information has been sought to help inform estimates of data uncertainty, in order that the project outputs can be used to inform future UK GHGI uncertainty analysis; this is particularly important due to the need to re-design the UK uncertainties model for the 2015 submission to reflect the change in reporting structure under the revised UNFCCC reporting guidelines. Information on uncertainties is included in Annex 1.

The study has included a brief review of materials available from the Overseas Territories (OTs) and Crown Dependencies (CDs), to assess whether any new source estimates are required for the IPPU sources within the scope of this project. The Aether team that lead UK inventory compilation for the Overseas Territories and Crown Dependencies have confirmed the feedback from GHGI contacts across all CDs and OTs that no major sources are evident in any of these territories (i.e. no cement kilns, lime kilns, glass-works, brick-works, chemical and petrochemical production facilities, NFM plant). The study team has developed new estimates for emissions from lubricant and petroleum waxes use in the OTs to add to those based on activity data available from DUKES (which covers UK and CD lubricant and waxes activity data already), and these are included in the data presented in Section 3.

The study method for the three individual tasks is outlined in more detail below.

2.1 Assessment of compliance for existing IPPU Source Categories

This task was relatively straightforward and constituted two aspects:

- A desk-based review of available data, method options and the current UK GHGI compilation method and reporting details, to compare against the requirements set out in the 2006 GLs. In each case we considered the key method parameters, assumptions and reporting approach, including a review of whether the UK inventory data met the IPCC data quality criteria of transparency, completeness, consistency, comparability accuracy:
    - Activity data - Complete? Transparent? Any verification?
    - Emission factors – CS or defaults? Updated defaults available? How do CS EFs compare with IPCC defaults?
    - Assumptions – e.g. are gap-filling or extrapolations in line with the 2006 GLs? What oxidation factors assumed? Are current assumptions the most defensible / accurate for the UK situation or should other defaults / assumptions be applied?
    - Method – Consistent with which Tier of IPCC 2006 GLs? Is the source currently (or expected to be) a Key Category in the 2015 submission?
    - Time series consistency – any methodological step-changes evident? Do approaches to overcome these follow the 2006 GLs?
    - Scope – Is the scope of emission reported complete? Is there any evidence of other (missing) plant data (in which years?). Are there other sources / sectors that have not been included to date?
    - Reporting allocations – Any use of IE, NO, NE that need to be reviewed? Any changes in allocation of source emissions between IPCC source categories needed to improve transparency or meet the new GLs?
- Consultation with inventory agency contacts in other Member States, to review the approaches to reporting under the 2006 GLs that are expected to be adopted by other MS. The project team focussed on follow-up with leading EU experts from Denmark, Germany, Italy, Czech Republic, Ireland, Luxembourg, The Netherlands and France to seek their feedback on any uncertain or ambiguous reporting allocations, building on work at EU-wide stakeholder workshops that aimed to develop consensus on reporting decisions under the new MMR. Key issues covered through this consultation included:
    - Methodology definitions for lime production
    - Completeness discussions for ceramics production
    - Allocation discussions regarding ammonia and ethylene production
    - Methodology approaches for metal production sources
    - Requirement for indirect emissions of CO2 and N2O
    - The progress of Member States with emission estimates of additional sources and gases
    - Completeness of reporting of emissions from urea uses, and links to use of process CO2 from other IPPU source categories

These discussions and conclusions provided information applicable to this project to better inform the project team of the current status and remaining issues concerning other Member States, in particular relating to the reporting options for sources where allocations across Energy or IPPU source categories may vary due to different data availability in different countries.

In the analysis of source data and emissions that should be allocated to 2.A.4 (Other use of carbonates), the existing emission estimates in the UK GHGI only relate to part of the scope of the source category as described in the 2006 GLs. Therefore for the UK GHGI this is (to some extent) a new source category and the project team researched available UK activity and emission factor data in order to address this new source in 2A4.

In the case of 2.D.1 Lubricants and 2.D.2 Paraffin Waxes, the country-specific approaches already in use in the UK inventory were assessed against the new methods in the 2006 GLs. The study team took into consideration the source data and emission allocation options for lubricant use within different sources, i.e. to ensure that there would be no double-counts with GHG emissions from vehicle engines where the component of carbon dioxide from lubricant use should now be allocated to 2D1 rather than (as previously) within the Energy sector.

The research method enabled the project team to review available data sources in order to identify potential for methodological improvements, even where existing methods may already be in compliance with the 2006 GLs. The study team reviewed materials such as EUETS data returns and installation IPPC permits, Annual Emission Reports and consulted with trade associations and other sector experts in order to identify improvements for the time series estimates. This approach identified several options to improve extrapolation methods for historic estimates as well as new data for emission sources to improve accuracy and completeness of the UK inventory existing IPPU sources.

2.2 Development of inventory methods and estimates for new IPPU Source Categories

The first step for this task considered whether the new sources are applicable to the UK – either now or earlier in the time series. This phase included a review of available production statistics, literature from regulatory sources, such as EUETS benchmarking studies, and consultation with trade associations.

Based on this initial screening, it was possible to decide which sources were:

- Not Occurring now, or at any point since 1990 – therefore no further work required;
- Not Occurring now, but has been a source of emissions earlier in the time series;
- Current emission sources.

The time period over which there is evidence for the sources being relevant for the UK, as well as the significance of the source, helped to define which data sources could be used to estimate emissions. For example, for large emitters post-2005, EUETS data may be available. For sources occurring after 1998, information could be obtained from the regulators' inventories and environmental permits. For small emitters, especially earlier in the time series, the availability of data is scarcer.

Efforts were prioritised on larger emission sources. Attempts were made to gather data to implement higher tier methods where the identified emissions sources were large; for smaller sources, tier 1 methods were considered sufficient for the completeness of the inventory.

Information sources considered included:

- Literature review
- The Pollution Inventory & other regulators' inventories
- Information from Environmental Permits
- BREF notes
- Data reported under the EU Emissions Trading System
- Stakeholder consultation of industry associations and companies
- Digest of UK Energy Statistics

A summary of the key information from these sources is highlighted below. Further information and a full list of references are included in Annex 3.

The Pollution Inventory and other regulators' inventories.

Almost all of the industrial production sites of interest for this research are included in the Pollution Inventory (PI), Scottish Pollutant Release Inventory (SPRI), or Northern Ireland Pollution Inventory (NIPI) and, since many sites are located in England and therefore in the PI, emissions data for CO_2 extends from 2013 back to 1998, and in some cases even 1994. Emissions data for other pollutants such as SO_2 will also often be available in the PI for the period 1994-1998 and the trends in emissions of these pollutants can be used to give some indication of the likely trend in CO_2 emissions over the same period.

The Capper Pass plant at Melton in Humberside is likely to have been a major source of industrial process emissions of CO_2 through the use of coke oven coke in the smelting of tin, lead and other metals, but closed in 1991. This is the only significant IPPU site omitted completely from the regulator's inventories.

Information from Environmental Permits

Although most of the installations were found to have over 100 documents listed under each EPR, this information source yielded little in the way of useful data. The documents available included environmental permits and permits variations, notices of environmental incidents, such as periods of high pollutant emission, and emission reporting data, including waste water and air pollutant emissions. Relevant information on raw material usage and carbon sources could be obtained only for one installation.

Data reported under the EU Emissions Trading System

The EU Emissions Trading System provides installation-level emission data – including CO_2 emissions as well as data on input materials like carbonates - for a vast range of industrial activities since 2005. Data collected in the first phase (2005-2007) was somewhat limited, especially so in the context of this work, since many of the installations of interest were opted out in that period (due to their involvement in UK emission trading or other schemes at the time). With the start of phase II in 2008, the vast majority of industrial processes relevant to this study started to report data, with just a small number of additional sites starting to report with the commencement of phase III in 2013. So, for many of the sectors studied, EUETS provides a time-series of emissions and activity data from 2008 onwards. The table below summarises the coverage available.

Table 2 Availability of IPPU Installation-level data from EUETS

Sector	Coverage	Comments
2.A.1 Cement Production	2008-2013	A few sites reported from 2005 onwards, complete coverage from 2008 onwards.
2.A.2 Lime Production	2008-2013	A few sites reported from 2005 onwards, complete coverage from 2008 onwards
2.A.3 Glass Production	2008-2013	Large glassworks only but that includes all flat and container glass and all glass/stone wool production.

Sector	Coverage	Comments
2.A. 4 Other process uses of carbonates: heavy clay products	2008-2013	Few sites from 2005 onwards. Nearly all producers of bricks and roofing tiles from 2008 onwards. Single additional site added in 2013.
2B1 Ammonia	Not included	Combustion at the site is included, not ammonia production itself.
2B6 Titanium Dioxide Production	Not included	Combustion at the sites is included, not the production of titanium dioxide. However, the EUETS emission (combustion only) can be subtracted from PI emissions (combustion + process) to yield estimates of the emissions from processes only.
2B8 Petrochemical and Carbon Black Production	2008-2013	Carbon black, acrylonitrile and ethylene producers included. Ethylene oxide plant not included
2B7 Soda Ash	2013 only	Both UK sites included from 2013.

A number of high-emitting IPPU sites closed before the start of the EUETS and so the data set contains no information on them:

- All UK manufacturers of special glasses and domestic (non-lead) glass closed before or during 2005;
- Britannia Zinc (primary lead and primary zinc), closed in 2003;
- IMI Refiners (secondary copper), closed in 1999.

This impacts on the method choices available for individual source categories, since the EUETS data set is the only dataset that is both site-specific, source-specific and activity-specific; where the IPPU installations report to the EUETS, therefore, a full analysis of the combustion and process emissions can be conducted, and the dataset can then be used with a degree of confidence to back-cast that Energy-IPPU division to earlier years, whilst maintaining PI estimates as the upper bound of the total site emissions. In the case of the two non-ferrous metal works listed above, the PI does contain CO_2 emissions data for the years before their closure, which provides an upper limit for IPPU emission estimates, but does not provide an insight into the energy and process emissions split.

Stakeholder consultation

The study team used email and phone contact to consult with a wide range of trade associations, regulatory experts, statistical agencies and individual experts in industry in order to gather information to inform the development and improvement of inventory methods.

The team also contacted inventory experts from other EU MS to find out what data sources and methods they were using, and also made use of the wiki set up for inventory experts to share experiences in the implementation of the 2006 IPCC GLs.

Annex III provides an overview on the stakeholders contacted. In many cases no answers were received. Where contact could be made, data confidentiality concerns proved a serious barrier to the provision of data. However, some process operators did provide useful background information which helped in the interpretation of data from the PI and EUETS.

We also asked stakeholders to review the time series once calculated, and Environment Agency industry sector leads (minerals, chemicals, metals) were contacted to review the emissions data for inventories and projections.

2.3 Projections for new and existing IPPU Source Categories

Projections have been developed using, as a baseline, the 2013 emission estimates calculated as part of this work. The projection of emissions requires the consideration of:

- Future changes in the level of those activities leading to emissions e.g. ethylene produced, or lubricant consumed;
- Future changes in the emissions of greenhouse gases per unit of each activity. i.e. will emission factors change in the future?

Since most of the industrial processes that are the subject of this report involve the emission of carbon as an intrinsic part of an industrial process, (e.g. production of cement or lime, or production of metal in a blast furnace using a reductant), there is often a fixed relationship between the input materials and the CO_2 emissions due to the nature of the chemical reactions taking place in each process. Our approach has therefore assumed that the emissions per unit production / activity will not alter in the future.

Carbon dioxide could be captured and stored in the future, but there is limited or no scope for reducing emissions at source in the production process. Therefore, for this work, we have considered only how activity levels are anticipated to change in the future.

Many of the industrial processes looked at have either not been used in the UK during the period covered by the inventory, or else have ceased to be used. Where this has happened, we have assumed that no new processes are built, and so emissions from those sources do not reappear in the future. Clearly, this is a judgement, and should be reviewed periodically.

For the remaining sources that are still operating in the UK, we have looked at future trends in activity on two levels:

- changes in the near future, such as the closure of plant or commissioning of new plant
- longer-term trends

Industry stakeholders have been consulted to find out about short term changes and, where they have supplied feedback, have not identified any closures that are currently planned or other imminent issues that would impact on GHG emissions. One soda ash plant had closed in early 2014, so our projections take account of that change in the industry just after the 2013 baseline. For all other sectors, however, we assume no change in the number of plant in the near future.

Industry consultees were not able to provide any views on longer-term trends and so for these, we have, as a default, used the assumptions available from DECC which underpin the latest UK Updated Energy and Emission Projections published in September 2014 (DECC, Updated Energy and Emissions Projections 2014[2]). DECC have provided a series of indices for different industrial sectors, which can be used to project activity within that sector. Separately, we have also consulted with Environment Agency sector leads and obtained a figure for annual growth in the chemicals sector, from the Chemicals Growth Strategy paper published by DBIS[3]. The chemical sub-sectors which give rise to GHG emissions can generally be classified as lower-value, bulk chemicals, where growth is less likely than higher value speciality chemicals. Following consultation with sector experts, the more conservative DBIS growth assumption has been applied to forecast the chemical and petrochemical IPPU emissions, rather than the DECC indicator for the chemical industry. This DBIS 'driver' and the DECC assumptions for the mineral sector are then used to project emissions for most of the IPPU sectors as shown in the table below, with other DECC drivers used for a few other small sectors.

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[2] see https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/368021/Updated_energy_and_emissions_projections2014.pdf

[3] DBIS, Strategy for delivering chemistry-fuelled growth of the UK economy, DRAFT

Table 3 Projections Drivers used for IPPU GHG projections to 2035

Activity trend driver	Used for:
DECC UEP driver for minerals sector	Cement, lime, bricks, glass
DBIS chemical industry growth strategy (“BAU”)	Ammonia, Nitric Acid, Titanium dioxide, ethylene, ethylene dichloride, acrylonitrile, other petrochemicals
DECC UEP driver for soda ash production & use	Soda ash
DECC UEP driver for construction	Lubricants for industrial machinery (including off-road & mobile machinery)
DECC UEP driver for food, drink & tobacco sector	Lubricants for agricultural machinery
DECC UEP driver for use of marine gas oil	Lubricants for shipping
DECC UEP driver for road transport fuels	Lubricants for road vehicles

The activity drivers used are designed to represent broad sectors of industry and therefore may not be accurate for individual sub-sectors of that industry. In addition, many of the industrial processes covered in this report are represented by a handful of sites in the UK, and sometimes just a single site, so the gradual changes which are indicated by the various drivers contrast with the dramatic changes that might be expected in reality as sites might face sudden closure, or be upgraded to provide greater capacity. The projections are therefore subject to very high uncertainty and need to be reviewed on a regular basis.

The projections are presented in this report as a “with existing measures” central estimate only, and are based on the latest available economic forecasts by sector or from industry operator or regulator information. Due to the sensitivity of the projections to decisions at a small number of high-emitting plant, future work should focus on keeping track of the individual decisions at high-emitting installations where expansions or closures may occur; in particular the European ethylene production market may develop in response to more cost-effective feedstocks coming into the market as outputs from the growing US shale oil and gas industry. This may impact significantly on decisions at the remaining UK plant to close or expand production, for example to move from using naphtha-based feedstocks to more Natural Gas Liquids (NGLs). The likely decline in NGL output from UK oil and gas production in the North Sea is likely to be another key influencing factor on the economic prospects for future ethylene production in the UK.

In order to determine whether the proposed UK IPPU projections approaches are consistent with the approach to projections adopted by other EU MS, a number of EU MS were consulted to compare the proposed UK methods against their own. This information served as indication of what might be considered viable when developing emission projections and what typical barriers might be. Countries consulted include Bulgaria, France, Germany, Ireland, The Netherlands, Poland and Romania. Countries were selected based on an internal EEA report evaluating the quality of the previously submitted emission projections.

Generally, the most relevant factors used are economic-based drivers such as gross value added (GVA) data by sector, corrected by expert judgement, e.g. on efficiency improvements.

Further factors that were raised for the UK's consideration include:

- The number of plants – where only a limited number of plants exist which are producing at full capacity emissions are typically kept constant, unless there are clear indications from industry that capacity increases/new installations are planned. In general MS had difficulties obtaining such information from industry, as has been the case in the UK.
- For cement production the growth rate of the building sector might be used, while the utilization of existing capacities in the worldwide cements markets might be considered, e.g. where there is an over-capacity.

Aside from these specific items of feedback, the review of current MS projections methods indicates that in general the methods adopted by other MS are quite simplistic, typically using economic projections of GVA and comparing the projected GVA with historical emission trends.

3. Results

The research has identified a range of recommended actions for DECC to consider as part of the improvement of the UK GHGI for the 2015 submission. For many source categories to be compliant with the 2006 GLs the study team has developed new estimation methods, new reporting allocations and the use of new reference materials to improve the transparency of the NIR. In some cases the study findings indicate that no changes are necessary (for several of the existing sources) whilst there are a number of the new sources introduced in the 2006 GLs that can be reported as "Not Occurring" in the UK.

The research has also concluded that most of the IPPU sources in the scope of the project are Not Occurring in the Overseas Territories, Gibraltar and the Crown Dependencies. Emissions from lubricant use and petroleum waxes in Gibraltar and the Overseas Territories have been identified as a gap in previous estimates, and new emission estimates are proposed for these source categories (2D1 and 2D2).

The table below outlines the recommendations for each source category, and further details are given below. Annex I presents full descriptions of the proposed new or revised inventory methods, and Annex II presents the proposed time series of emissions data and emission projections to 2035 for each source category.

Table 4 Recommended Improvements for the UK GHGI IPPU Sector

Source Category	New Source?	Gas	Recommended improvements
2.A.1 Cement Production	No	CO_2	No recalculation necessary.
2.A.2 Lime Production	No	CO_2	No recalculation necessary.
2.A.3 Glass Production	No	CO_2	New data identified. Method improvement and recalculations proposed, including some extension of the scope of emission estimates.
2.A. 4 Other process uses of carbonates	No	CO_2	New data identified. Method improvement and recalculations proposed for fletton bricks, addition of estimates for non-fletton bricks and roofing tiles.
2B1 Ammonia Production	No	CO_2	No overall recalculations necessary, but propose to re-allocate the combustion emissions previously reported in 1A2c to 2B1.
2B2 Nitric Acid Production	No	N_2O	Revision to default EF applied where installation-specific or CS data not available.
2B3 Adipic Acid Production	No	N_2O	No recalculation necessary.
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production	Yes	N_2O	These sources are *Not Occurring* in the UK.
2B5 Carbide Production	Yes	CO_2	This source is *Not Occurring* in the UK.
2B6 Titanium Dioxide Production	Yes	CO_2	New emission estimates developed, which re-allocate emissions from Energy to IPPU.
2B7 Soda Ash	Yes	CO_2	New emission estimates developed, which re-allocate emissions from Energy to IPPU.

Source Category	New Source?	Gas	Recommended improvements
2B8 Petrochemical and Carbon Black Production	Yes	CO_2, CH_4	New emission estimates developed, which in part re-allocate emissions from Energy to IPPU but also extend the scope of the emissions reported.
2C2 Ferroalloy production	Yes	CO_2	In recent years this source is *Not Occurring* in the UK. In early years of the time series, emission estimates are *Included Elsewhere* within 1A2, as DUKES and ISSB statistics do not provide explicit activity data for ferroalloy production, and the production plant has closed, so no further information is available.
2C5 Lead Production	Yes	CO_2	New emission estimates developed, reported combined with 2C6 Zinc production.
2C6 Zinc production	Yes	CO_2	New emission estimates developed, which re-allocate emissions from Energy to IPPU, and include estimates from a combined lead and zinc production plant.
2D1 Lubricants	No	CO_2	Revised inventory method and assumptions and all lubricant emissions now consolidated in 2D1 (previously allocated across several source categories under Energy).
2D2 Paraffin waxes	No	CO_2	Revised inventory method assumptions and hence recalculations, also re-allocated to 2D
2D3 Asphalt Production and Use	No	n/a	Not Occurring (no direct GHGs from this source)
2D (other)	No	CO_2	Previous estimates of CO_2 emissions from use of pesticides and detergents removed from the UK inventory, as no 2006 GL methods and assessed as probable double-counts and over-estimates in previous submissions.

3.1 Summary of Key Findings for each Source Category

2A1 Cement Production

The existing methodology is compliant with the 2006 GLs, and consists of a mixed Tier 2/3 approach. Installation-specific emissions data, covering all UK sites and collected for the purposes of EUETS reporting are the basis for sector emission estimates from 2005 onwards. The installation-specific data are then used to derive a UK-specific emission factor that is applied to UK clinker production data for earlier years in the time-series when installation-level data are not available. Data for 2005 is used to derive the UK-specific factor applied to 1990-2004. An average factor could be used instead, but the data for the period 2005-2013 yields an average factor that is nearly identical to the 2005 factor, and so we recommend no change. The time series of activity data is based on information provided by the industry trade association, the Mineral Products Association (formerly the British Cement Association), and therefore the time series consistency and completeness of the AD is good. There is, therefore, no requirement for any recalculations or other changes to the UK emissions data for this source category.

Whilst there are no required changes to the method or the estimates, it is recommended that the NIR text should be improved to clarify that the UK method is compliant with the requirement that a correction is made for cement kiln dust (CKD) losses, and therefore that the emission estimates are complete.

2A2 Lime Production

As with cement production, the existing methodology is essentially a mixture of approaches (Tier 2 & 3) across the time series, with the method choice defined by the different level of data availability across the time series. Detailed installation-specific, source-specific (i.e. combustion and process) emissions data are available from EUETS reporting from 2005 onwards, giving a split between calcination (IPPU) and fuel related (Energy) emissions. Total CO_2 emissions data are available from the PI for 1994 onwards for all UK lime manufacturing facilities. These installation-specific data are used to generate UK emission estimates for the period 1994-2013.

Comparison of the UK emission estimates derived from installation-level reporting against activity data for limestone & dolomite used for calcination in this sector, which are published annually by the British Geological Survey (BGS), indicates that the BGS activity data are significantly too low. The reason for this is unknown, and the data supplier believes their data to be accurate, but because of the consistent nature of the difference, we have assumed that the BGS activity data systematically underestimates limestone / dolomite consumption; we have disregarded these lower activity statistics and derived UK GHGI estimates based on the sum of operator-reported data instead.

No installation-level data are available for 1990-1993, and therefore emission estimates are calculated based on the BGS activity data for those years but corrected for the observed under-report in later years. The method includes an assumption that UK lime plants consume a mix of 85% limestone, 15% dolomite, and that the BGS activity data represent only 92.5% of actual consumption of these minerals. This correction is based on the apparent underestimate for the years 1994-2000, calculated from the installation-level emissions data for those years. We note that there is a step change in the difference between the BGS activity data and the installation-level data from 2000 to 2001 onwards, and hence the 1994 to 2000 average difference is sued to inform 1990-1993 activity data estimates, to maintain time series consistency.

Table 5 Activity data from BGS for the UK lime sector expressed as a percentage of the operator-reported activity data estimates, 1994-2012

1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
84%	90%	86%	94%	97%	111%	90%	71%	62%	64%
2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
86%	81%	72%	82%	72%	38%	57%	89%	64%	

The EUETS data for 2005 onwards include an allowance for CO_2 emissions from lime kiln dust (LKD) losses and are therefore regarded as complete; there is close consistency between emissions data reported via the EUETS and PI for later years and therefore it is assumed that the PI data for years pre-EUETS also are calculated on the same basis, i.e. that emissions associated with lime kiln dust losses are included. The UK approach is in line with findings from consultation with other MS as outlined in Annex IV, indicating that where input data at plant level is available, application of the LKD-factor is not required

Lime manufactured as part of the process of sugar refining is included in the UK estimates for this source category assuming the carbonatation stage to be 76% efficient, with 24% of the lime left unreacted in waste products from the process. Again this approach is in line with findings from consultation across other MS presented in Annex IV, indicating that lime production in other industries should be included to ensure completeness.

The existing methodology is compliant with the 2006 GLs. The use of lower tier methods for the early years of the time-series is not ideal, but is necessary due to a lack of better data. The estimates for 1990-1993 are more uncertain due to lack of data and the lower tier method used.

2A3 Glass Production

The existing methodology is compliant with the 2006 GLs, and is a mixed Tier 2/3 approach across the time series. Glass production data broken down by sub-sector (glass type) are provided by the trade association, British Glass, and are available on a consistent basis back across the time series to 1990. Installation-specific emissions data for the year 2006, covering all UK sites in the flat (float & rolled) glass, container glass, and glass fibre sectors are used to calculate country-specific factors that are applied for all other years in the time-series. However, this existing approach does not make use of further installation-specific data from EUETS reporting for the years 2008-2013. Therefore an improvement to the methodology is recommended, to use more of the available EUETS data, extending the use of installation-specific data (Tier 3 method), and reducing the use of country-specific factors (Tier 2 method).

Glass production in the UK in the period since 1990 has covered all of the main sub-types, although both special glass and domestic glass have not been produced on a large scale in the UK since 2005. This does have a bearing on methodology since it means that these types of glass manufacture were not covered either in the 2006 industry-wide study that is used as the current basis for UK-specific emission factors, or in the EUETS data that we propose is used to improve the current methodology. Instead, improvements should focus on the three sectors where the EUETS data provide new information – container glass, flat glass, and glass fibres (including continuous filament glass fibre, glass wool, and stone wool).

The EUETS data for 2008 onwards, which cover all known installations within these sectors of the glass industry, provides sector-specific emission estimates and emission factors for use of limestone, dolomite and soda ash, and it is recommended that these data are used in the UK GHGI for those years. No installation-specific data are available for 2007, so we recommend that emission factors derived from the 2006 study and the 2008 EUETS data are averaged and applied to glass production activity data for 2007. For 1990-2005, there are no new data available and it is recommended that the existing approach involving use of factors based on the 2006 study is maintained.

The 2006 study did not cover stone wool and therefore the existing methodology does not include any estimates for carbonates used in that sector. In order to improve completeness and accuracy of estimates for the glass sector, it is recommended that emission factors derived from EUETS reporting are applied to stone wool production activity data across the time series.

2A4 Other Process Uses of Carbonates

The 2006 GLs gathers together a number of processes within this category, including both existing and new sources, some of which are not relevant for the UK. The GLs identify four broad source categories: 1) ceramics; 2) other uses of soda ash; 3) non-metallurgical magnesia production; 4) other uses of carbonates.

Ceramics is already partially covered in the UK inventory as emissions of CO_2 and methane are estimated for the production of fletton bricks. Fletton bricks are a type of brick manufactured from the Lower Oxford Clay, a type of clay occurring in South East England. This clay has an abnormally high content of carbonaceous material which acts as an additional fuel when the bricks are fired, but also produces a characteristic appearance in the finished bricks. Fletton bricks are made on a substantial scale, however the majority of UK bricks are of the non-fletton type, made with other types of clays and shales. Clay roof tiles are also made on a large scale. It is recommended that new emission estimates for the production of non-fletton bricks and clay roofing tiles be included in the GHG Inventory to ensure completeness.

The EUETS provides a nearly complete set of emissions data for the UK brick and roofing tile industry; the British Ceramic Confederation estimates 93% coverage for 2010, and the coverage in other years is regarded to be comparable. In 2013, a further process is included in the reported data, bringing coverage to 95%. EUETS-based emission estimates for the years 2008-2013 are used to derive UK-specific emission factors which are then combined with brick production data to yield a full time-series of CO_2 emission estimates for non-fletton bricks and roofing tiles. The new inventory method is a mixture of a Tier 2 (country-specific EF for earlier years) and Tier 3 (installation-specific EFs for later years) method.

Current estimates for fletton bricks are based on the use of PI emissions data, with the application of a split to divide those emissions into process-related and fuel-related emissions. Currently, those splits are based on assumptions about the fuel usage, but EUETS data provides the actual split. We recommend, therefore, that the methodology for CO_2 emissions be revised to make use of the higher quality data available in EUETS for the fletton works.

The GLs list uses of soda ash as glass production (covered in 2.A.3 above), soaps and detergents, flue gas desulphurisation (FGD), chemicals, pulp & paper & consumer products. The only known FGD systems in the UK use limestone rather than soda ash and emissions are already reported, based on CO_2 emissions reported in the EUETS and in the PI. Consultations with other EU Member States indicate a preference to report emissions from FGD under source category 1.B.3., following the IPCC 2006 provision that emissions from carbonates should be reported in the source categories where they are consumed (see Annex IV). However, the IPCC 2006 GLs do not mention emissions from flue gas desulphurisation related to the energy sector. For reasons of transparency, e.g. in order to avoid influencing fuel IEFs in the Energy sector, it is recommended that emissions from FGD be reported in source category 2A4d.

Based on our consultations with the soda ash manufacturers, there is no other information to indicate the use of soda ash in the UK for any of the other applications listed in the GLs and therefore these sources are Not Occurring in the UK.

Magnesia production in the UK was conducted at a single site, which closed in 2004, which extracted magnesia from sea water and which did not lead to any process emissions of CO_2.

The GLs do not give any further information on the 4th category listed (other uses of carbonates), and we have not identified any emission sources that would fit within this category.

In summary for this source category, we recommend that CO_2 emission estimates are added to the UK inventory for non-fletton bricks and roofing tiles, and that CO_2 emission estimates for fletton bricks are revised to make use of EUETS data. Emission estimates for methane from fletton works should be retained. There is insufficient information to determine whether process-related emissions of methane would occur at non-fletton works and we do not recommend the inclusion of any emission estimates at this stage.

2B1 Ammonia Production

The UK inventory uses a Tier 3 method for most of the time-series, with a Tier 2 approach in earlier years when detailed site-specific inputs are not available. Previously, however, emissions of CO_2 have been split between those emissions related to natural gas used as a fuel (reported in 1.A.2.c) and those emissions related to natural gas used as a feedstock (reported in 2.B.1). We recommend that, in line with 2006 GLs, both sources of emissions (fuel and feedstock gas) be reported under 2.B.1, and this appears to be the consensus across other Member States also, based on recent MMR workshops (see Annex IV).

In previous versions of the inventory, CO_2 sequestered into methanol has been assumed as short-term storage only and therefore included in emission estimates. The 2006 GLs do not recommend such an approach and treats methanol production as a separate industrial process source category. Due to the integrated ammonia-methanol production plant in the UK (until closure in 2001), emissions from the use of natural gas as fuel for both processes are reported under 2.B.1, rather than being split between 2.B.1 and 2.B.8 Methanol. In the absence of a complete time series of methanol production (1990 to 2001) in the UK, it is not feasible in any case to generate separate emission estimates specific to methanol using production-based emission factors, and therefore to report these as IE within 2B1 is the pragmatic solution.

2B2 Nitric Acid Production

The UK methodology is a combination of Tier 3 for later years when detailed installation-specific data are available, and Tier 1/2 methods for earlier years. The default emission factor used in the Tier 1 calculations (applied to production estimates at production plant where no plant-specific EFs are available) has been updated in the 2006 GLs. Therefore it is recommended that UK GHGI estimates be revised to apply this updated default emission factor, and the updated default emission factor for N_2O emissions from the 2006 GLs.

2B3 Adipic Acid Production

The UK inventory uses a mixture of Tier 2 and Tier 3 methods, with the lower tier required for earlier years where plant-specific measurement data are not available. The current method is compliant with the requirements of the 2006 GLs and therefore no changes are required to the UK method across the time series, other than to apply the updated GWP for N_2O emissions.

2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production

Caprolactam was made at one site in the UK in the early 1970s. The site was destroyed in a serious explosion in 1974, and no other production sites have been built since. Glyoxal and glyoxylic acid have not been produced on an industrial scale in the UK at any time. A literature search of documents from the last 25 years on chemical production in Europe as well as consultation with the Chemical Industries Association has confirmed that these sources should be reported as Not Occurring in the UK GHGI in future submissions.

2B5 Carbide Production

This source category includes silicon carbide and calcium carbide. Neither chemical is known to have been manufactured on an industrial scale in the UK since the 1960s, when calcium carbide plants at Kenfig and Runcorn closed. As above for 2B4, our literature search and consultation exercise have confirmed that this source should be reported as Not Occurring in the UK GHGI in future submissions.

2B6 Titanium Dioxide Production

Titanium dioxide can be produced by two methods: i) from ilmenite, using the sulphate process; and ii) from rutile, using the chloride process. Both methods are used in the UK, but only the chloride process leads to process emissions of greenhouse gases. In 1990, there were two sites each using the chloride and the sulphate process, but the two sulphate processes closed in 1997 and 2009, so all titanium dioxide in the UK is now produced using the chloride process at the two sites at Stallingborough and Greatham. The chloride process involves the chlorination of rutile ore in a reducing atmosphere to titanium tetrachloride, followed by oxidation of the $TiCl_4$ to titanium dioxide. The reducing atmosphere is produced by combustion of petroleum coke or coke oven coke.

The 2006 GLs recommend the use of either a Tier 1 method involving a default emission factor and national activity data, or a Tier 2 method using installation-specific data on reducing agent usage. For the UK, neither of these methods are feasible options due to limited data; there are no UK activity data (i.e. annual production statistics) for any individual chemical product, and the only site-specific data for the UK plant is in the form of CO_2 emissions data. These emissions data are available from two regulatory reporting sources:

- from the PI, covering CO2 from reducing agents and fuel use in plant utilities;
- from the EUETS, covering fuel use only.

Operator reporting has been variable over the years, in line with the evolving scope and detail required for EUETS and PI data returns.

- During Phase II of the EUETS (2008-2012), the titanium dioxide plants only reported CO2 from fuels burnt in the site boilers;

- During Phase III (2013 onwards), coverage of EUETS reporting was extended to cover fuels burnt in furnaces, driers etc.;
- For three years (2006-2008), the process operators were required to report thermal CO_2 and chemical CO_2 separately to the PI.

From these data it is possible to obtain the emissions from the chemical process for 4 years: 2006-2008 (using the PI data for chemical CO_2 emissions), and 2013 (by difference between the PI data covering all CO_2 emissions and the EUETS data covering all fuel-related emissions. The fuel/process split in emissions for these 4 years can be calculated, and the PI provides total CO_2 emissions at each site back to 1998. Prior to 1998, there is no data on either emissions or production, and therefore it is assumed that emissions in 1990-1997 are at the same level as in later years (the production capacity at all UK sites producing TiO_2 by the chloride route is the same for all years).

In order to avoid a potential double-count in emissions in the UK GHGI, it is necessary to ensure that the reductant used in the processes is not included as a fuel and emissions reported in 1.A. The method developed by the study team addresses this issue by back-calculating the coke/petcoke activity data (used as a reductant) from the emissions data using UK carbon emission factors for the feedstock, and discounting this amount from the Energy sector estimates.

In the absence of a time series of annual titanium dioxide production activity data, this country-specific method is regarded as the best available method for the UK GHGI estimates. The use of site-specific EUETS and PI data, even if not relating to input materials as required by the Tier 2 method in the GLs, ensures that emissions data are quite certain for the period from 1998 onwards. Estimates for 1990-1997 are more uncertain due to the need to extrapolate 1998 data backwards in the absence of any specific information on production, materials usage or emissions in those years.

2B7 Soda Ash Production

Soda ash is produced in the UK using the Solvay process. This involves the conversion of limestone (calcium carbonate) and brine (sodium chloride) to soda ash (sodium carbonate) and calcium chloride. The initial stage in the process is the calcination of limestone in a kiln to produce lime and CO_2 gas, both of which are used in the process. Coke oven coke is used to fire the lime kilns and CO_2 from the coke is included in the gases used in the soda ash plant. In theory, if limestone and brine are converted completely to soda ash and calcium chloride, then that part of the soda ash process is carbon-neutral and the CO_2 emitted should be equal just to those emissions occurring from the coke. In practice, the process is not 100% efficient, so emissions of CO_2 are actually somewhat higher than would just be due to the coke use.

The 2006 GLs suggest that emissions should be based "on an overall balance of CO_2 around the whole chemical process." In the UK, soda ash is produced at two sites and both began to report under the EUETS in 2013. The EUETS emissions data for the two sites is calculated using a carbon balance approach with inputs in coke and limestone balanced against soda ash and waste products. The 2013 EUETS data therefore meets the requirements for the method outlined in the GLs.

Prior to 2013, no data for the UK plant were reported in EUETS, but CO_2 emissions were reported in the PI between 1998 and 2013. Comparison of the PI and EUETS data for 2013 shows that EUETS data were 38% higher than emissions in the PI. The reason for this is not known, but since the PI data for 1998-2013 are fairly consistent, it is assumed that there is a systematic underestimate in the PI data (possibly they represent CO_2 releases from just part of the process, rather than the whole-process balance used in the EUETS).

In the absence of other data we therefore propose that the PI data for 1998-2012 should be multiplied by a factor of 1.38 to give conservative estimates of emissions in those years. For 1990-1997, no data of any type are available, but since the same two sites have been in operation in the UK across the entire time-series, emissions in 1990-1997 are assumed to be at the same level as in later years.

It is recommended that emissions calculated using this approach be included in the UK inventory. As there is only a single year's worth of data to generate the EUETS:PI relationship applied across all years, this is a priority for further work to develop a bigger dataset to reduce uncertainty in the GHGI process emission estimates.

2B8 Petrochemical & Carbon Black Production

The 2006 GLs provide specific guidance on the estimation of emissions for methanol, ethylene / propylene, ethylene oxide, ethylene dichloride, and acrylonitrile, as well as carbon black, but also states that these chemicals do not represent the entire petrochemical industry, and that small amounts of greenhouse gases may be emitted during the manufacture of other chemicals.

The UK GHG Inventory has previously reported emissions of CO_2 from ethylene crackers and a handful of other chemical industry sources (under 1A2c in the 2014 submission), as well as methane emissions from the manufacture of methanol, ethylene and 'other chemicals'.

Discussion and recommendations are given below, separated into the categories of chemicals listed in the GLs.

Methanol

Methanol was manufactured in the UK until 2001, at a site where the process was integrated with ammonia production. Emissions from this integrated site are currently reported in 2.B.1 and we recommend that this approach be retained. Methanol production emissions are therefore to be reported “IE” within 2B1.

Ethylene

Emissions from ethylene crackers are already reported in the UK inventory, with estimates being based on a combination of Tier 3 estimates (using site-specific information from EUETS, PI, SPRI, and operators), and lower tier methods for the earlier parts of the time series where site-specific data are not available. The existing estimates also cover the only acrylonitrile plant still in operation in the UK, as well as a handful of other 'petrochemical' sites, although the ethylene crackers are typically responsible for ~ 95% of sector emissions. The start of phase III of the EUETS has meant that some new data are available this year (i.e. reporting emissions in 2013), covering a few petrochemical plant that did not report during phase II, and we recommend that these data are added to the UK GHGI estimates for 2B8g to ensure completeness.

Consultations with other EU Member States indicate that CO_2 emissions from ethylene production are mostly allocated under fuel combustion, i.e. in the energy sector (see Annex IV). In previous submissions the UK GHGI has reported these emissions in 1A2c, but our interpretation of the 2006 GLs is that the emissions associated with ethylene production, such as those from combustion of process off-gases that are derived from chemical feedstock materials, should be reported in 2B8.

Methane emissions from ethylene crackers are already included in the UK inventory and no changes are needed.

Ethylene Oxide

One plant manufactured ethylene oxide in the UK between 1990 and January 2010, when the process was closed. Emissions of CO_2 were reported in the PI for the years 1995-2009. The emissions reported for the permit covering ethylene oxide production are assumed to cover process emissions only: during 2006-2008, when the Environment Agency required separate reporting of thermal CO_2 and chemical CO_2, all emissions were reported as chemical CO_2.

It is recommended that the PI data for the ethylene oxide plant are used in the UK inventory, and that emissions for 1990-1994 are generated by assuming the same emissions as in 1995.

Ethylene Dichloride (EDC)

In 1987, the UK had 3 plants (at Hillhouse, Runcorn, and Wilton) manufacturing EDC on a large scale, and one much smaller plant at Ellesmere Port where EDC is produced, possibly as a side-product of ethyl chloride. Production of EDC from ethylene is normally by one of two routes – direct chlorination or oxychlorination. The 2006 GLs identifies only the oxychlorination process as a source of process-related CO_2 emissions. The oxychlorination route is used at Hillhouse, and also used for part of the production at Runcorn (direct chlorination is used there also). In 1987, capacity for EDC via the oxychlorination route was 500,000 tonnes/year, out of a UK total capacity of 965,000 tonnes/year (figures from Chemical Intelligence Services, 1987).

Emissions of CO_2 are reported in the PI for both the Runcorn & Hillhouse sites, but in both cases the emissions data are likely to be dominated by CO_2 from fuel combustion on site: the permits covering the ethylene dichloride processes on each site also cover the cracking furnaces used to produce vinyl chloride monomer (VCM) from the EDC. The 2006 GLs provide an emission factor for process-related emissions from the oxychlorination process and if this is applied, assuming that production is equal to the 500,000 tonne capacity of the known plant, then this confirms that process-related emissions from Hillhouse and Runcorn would be a very small proportion of the reported CO_2 emissions.

In 1999, the EDC and VCM processes at Hillhouse were closed, but the loss in VCM capacity was at least partially offset by the expansion of capacity at Runcorn. We do not have a time-series of either production or capacity, so will assume that the 500,000 tonne capacity given for 1987 is also accurate for subsequent years as well. We recommend that a time series of emission estimates is included in the UK inventory using this figure of 500,000 tonnes/year for production across the time-series and the process-related emission factor from the GLs.

The GLs recommend that process and fuel related emissions are reported together in the IPPU sector. However, we have no data on the fuel-related emissions at either the oxychlorination route or direct chlorination-route sites and so we recommend that energy related emissions from EDC manufacture continue to be reported under 1A2c.

Acrylonitrile

Acrylonitrile was produced at two sites in the UK in 1987 (Chemical Intelligence Services, 1987): Seal Sands and Grangemouth. The Grangemouth site closed soon afterwards, whereas the Seal Sands plant is still in operation. CO_2 emissions from Seal Sands are currently included with other petrochemical sites and ethylene crackers. Although the 2006 GLs lists acrylonitrile production as a source separate from ethylene, since the existing emission estimates are already included with 2B8 Ethylene, and because emissions are small, it is recommended for the sake of simplicity that the current inventory method is maintained.

Methane emissions from Seal Sands are recorded in the Pollution Inventory as less than the annual reporting threshold of 10 tonnes for each year in the period 1998-2009, although no information at all is given for 2010 onwards. We recommend that an annual emission of 5 tonnes is assumed for the UK GHG Inventory.

Carbon Black

The UK had two carbon black manufacturing processes, at Avonmouth, and Ellesmere Port, until their closure in early and mid-2009 respectively. Both sites reported CO_2 emissions in the Pollution Inventory (Ellesmere Port for 1998-2009, Avonmouth for 2003-2008). Data are also available in the EUETS for 2008-2009 and give some insight into the split between process and fuel-based emissions but the precise allocation of emissions from ETS data are uncertain for one site. The EUETS data indicate that process emissions are around 80% of the total emissions from the two sites, but it is a limited, uncertain dataset based on only 2 years of data and during the period leading up to the closure of both sites. Therefore it is uncertain whether these data are representative of the emissions from the two plant in earlier years where the PI CO_2 emissions data (and by implication the annual production of carbon black) were significantly higher. PI data are also slightly higher than the EUETS data for reasons that are unknown. Therefore, it is recommended that a conservative approach is taken and that the PI data are assumed to be 100% process-related and that an emission time-series be included in the UK Inventory on this basis.

Methane emissions from Ellesmere Port are recorded in the Pollution Inventory as less than the annual reporting threshold of 10 tonnes for each of the years 2004-2006. An emission of just over 5 tonnes is reported for Avonmouth in 2004. No other emissions data are available for other years for either site. Therefore, for the UK GHG Inventory, we recommend that an annual emission of 5 tonnes is assumed for Ellesmere Port, and that the reported emission at Avonmouth in 2004 is assumed accurate for other years as well.

Other Chemicals

The UK Inventory already includes methane emission estimates for various chemical processes not reported in the categories given above, and based on Pollution Inventory data, and we recommend that these emission estimation methods be retained.

2C2 Ferroalloy Production

The term ferroalloy covers a wide range of products, manufactured by various means, only some of which lead to industrial process emissions of greenhouse gases. Potential sources of CO_2 emissions include:

- use of reductants such as coke oven coke:
- consumption of carbon electrodes in furnaces used for melting raw materials;
- decarbonisation of limestone or dolomite used as a fluxing agents
- decarbonisation of any carbonate ores used.

The UK has been a minor producer of ferroalloys. The current version of the BREF note (Best Available Techniques Reference document) for the non-ferrous metals industry, produced by the European IPPC Bureau estimates UK production in 1993 as 55 ktonnes out of a European total production of 2,620 ktonnes (downloadable from http://eippcb.jrc.ec.europa.eu/reference/) while the updated draft of that document, currently in final draft form (October 2014), does not identify any production of ferroalloys at all in the UK in the period 2005-2012.

Other than the estimate for 1993 given in the BREF note, we have not found any data on UK production of ferroalloys. The absence of the UK as a European producer in the recent update of the BREF note suggests that UK production is either zero or insignificant and we have been able only to identify a few small-scale manufacturers of specialist ferroalloys such as ferro-molybdenum and ferro-vanadium. The production data for 1993 lists 45,000 tonnes of ferromanganese production in a blast furnace (so emissions would have occurred from reductants), and 10,000 tonnes of other ferroalloys in electric furnaces. The ferroalloy producers we have identified as in operation in recent years either carry out exothermic processes only (for ferro-molybdenum alloys) or use electric induction furnaces for melting. None of the processes report any CO_2 emissions in the Pollution Inventory, or are included in the EUETS, and we have not identified any process currently in operation that would cause any industrial process emissions. The estimated production of 45,000 tonnes of ferromanganese in 1993 would, we presume, involve the use of coke oven coke or coal as a reductant, but emissions would be included in the inventory anyway since all consumption of these fuels is assumed to lead to emissions of CO_2. Any emissions associated with ferroalloy production would therefore already be included in 1.A.2.a or 1.A.2.b for coal, or 1.A.2.f for coke. Given the lack of a time-series of production data, or information on the type or quantities of any reductant used in ferromanganese production, there seems little justification for making a re-allocation of emissions from 1.A to 2.C.2.

We have found no evidence for any use of electric arc furnaces, or the use of limestone or dolomite fluxes or carbonate ores. We therefore recommend that emissions from ferroalloys are considered as i) included elsewhere in the case of any emissions from use of reductants; ii) not occurring in the case of emissions from other sources.

2C5 Lead Production
Primary lead production is limited in the UK to a single site, which produced zinc and lead from imported ore concentrates. This process is described in the following section.

2C6 Zinc Production
Zinc was produced in the UK until early 2003, using the Imperial Smelting Process (ISP) at a smelter operated by Britannia Zinc at Avonmouth. The site processed imported ore concentrates, and had a capacity to produce approximately 150,000 tonnes of zinc, as well as 65,000 tonnes of lead and small quantities of other metals such as cadmium. The ISP involves the use of a blast furnace to reduce zinc and lead oxides to the metal using coke as a reductant. Limestone can also be added to act as a slag-forming agent.

Britannia Zinc reported CO_2 emissions in the Pollution Inventory from 1998 until 2002, at which point the site ceased operation. Emissions of CO_2 would have occurred from the use of coke in the ISP, but also from decarbonisation of any limestone used, and from the other fuels used on site e.g. gas/oil burners used on the sinter plant and oil-fired furnaces used in the zinc refinery. We have not been able to discover any data on the quantities of coke and other fuels used, or the quantities of limestone that might have been used. The operator-reported CO_2 emissions in the Pollution Inventory are totals only, and no conclusions can be drawn regarding the split between coke, other fuels and limestone. The reported emissions are, however, much higher than would be implied by the Tier 1 factors given in the 2006 GLs for the ISP at Avonmouth. There is insufficient data to determine whether this is due to a high level of fuel combustion emissions on site, or that the process-related emissions at this site were higher than is typical for this type of process.

The Digest of UK Energy Statistics (DUKES) does give a full time-series of data on the consumption of coke oven coke by the non-ferrous metal industry. The consumption shown in this source is zero after 2003, confirming that after the closure of Britannia Zinc, no other non-ferrous metal processes in the UK use coke oven coke. We also believe that very few, other than Britannia Zinc, have used coke oven coke at any point in the period covered by the UK inventory. However, the following almost certainly did:

- the Capper Pass Tin Smelter at Melton, Humberside (closed in 1991)
- IMI Refiners' secondary copper smelter at Walsall (closed in 1997)

Of the three sites, it is likely that IMI Refiners used relatively small amounts of coke, whereas the Capper Pass smelter was the largest of its kind in the world, and its closure in 1991 coincides with a big reduction in the non-ferrous metal industry's consumption of coke as shown in DUKES. There is insufficient data to split the coke consumption data between the three sites, and instead we recommend that all of the coke use in DUKES is reported in 2.C.6. This will ensure completeness (there is no separate category for copper) and reduce the uncertainty in the reported emissions, since only the total coke use figure is known to a high level of certainty.

As previously described, limestone may have been used at Britannia Zinc (and perhaps at Capper Pass as well) but we do not have any evidence on which to base emission estimates. Since all of these plants closed more than 10 years ago, there is no scope to access new information to improve this situation, and therefore we recommend that no emission estimates for these source categories be reported. Further, we note that the UK GHGI already includes emissions from all reported limestone and dolomite activity based on data from the British Geological Survey on UK supply and demand of these materials, and hence there is no gap in the UK GHGI, but possibly a small mis-allocation with higher estimates in another sector to counter the possible under-report here.

2D1 Lubricant Use

The UK GHG Inventory already includes CO_2 emission estimates for the oxidation of lubricants. The method is country-specific and was developed for the 2006 submission. The calculations begin with a detailed set of activity data for 1999 which is used to provide a percentage split of lubricants into different types of engine oils, greases, transmission oils etc. This percentage split is assumed to be applicable across all of the period covered by the UK GHGI. A set of expert judgements are then made for each class of lubricant regarding the fraction of the product that would be burnt/oxidised during use. Separate assessments are made for the years 1990 and 2004 (at the time of the development of the method, this was the latest year in the time-series). For most types of lubricant, the fraction burnt is assumed to be the same in both 1990 and 2004, with differences only in the assumptions for some types of engine oil. The fraction of lubricants burnt is assumed to vary from zero in the case of greases and transmission oils, to 50% for some types of engine oils.

The 2006 GLs provide methodologies that are based on the same approach, but with different assumptions. The Tier 1 approach requires the use of an 'oxidation during use' (ODU) factor of 0.2, to be applied to total lubricant consumption. The Tier 2 method requires more detailed activity data and separate ODU factors for lubricating oils and greases: either the default values of 0.2 and 0.05 respectively, or country-specific values if available.

The existing approach is therefore broadly in line with the Tier 2 approach in the 2006 GLs, however, it does have some serious weaknesses:

- the split into various categories of lubricants is done using data for a single year, and it is unlikely that this will be accurate;
- the UK-specific ODU factors are based on expert judgement only. For example, most classes of lubricants are assumed not to oxidise at all, which is inconsistent with the use of the lower default ODU factor of 0.05, given in the 2006 GLs, and therefore indicates that the UK data are based on very limited data and not comparable to other reporting Parties that apply the defaults, even if this is regarded as generating a slightly conservative estimate.

Detailed activity data on lubricants are not available in the UK; DUKES does include data on sector-specific lubricant use (e.g. use by industry, agricultural sector, shipping etc.) in addition to the total lubricant demand time-series, but this falls short of what is required for the Tier 2 method. Therefore we recommend that the 2006 GLs Tier 1 method is adopted for the UK GHGI in future submissions and have calculated revised emission estimates based on the UK lubricant activity data, the IPCC default assumption for the Oxidation During Use (0.2) and the UK carbon emission factor for lubricants which is based on analysis of UK oil samples.

2D2 Paraffin Wax Use

As with lubricants, the existing UK approach uses the same concept as the methods given in the 2006 GLs: the use of an 'oxidation during use' (ODU) factor, applied to consumption data. As with 2.D.1, the GLs provide two tiers of method: Tier 1, with a default ODU of 0.2, or Tier 2, using country-specific ODU factors for each sub-category of paraffin wax use.

The existing UK approach applies an ODU factor of 0.42 which is taken from the US GHG inventory, and is more than double the IPCC default. The current UK approach does not use UK-specific data; to apply a US-derived assumption rather than an IPCC default does not provide a more accurate assumption to derive the UK source estimates. Therefore, we recommend that the most appropriate methodology would be to use the Tier 1 method given in the 2006 GLs. This will reduce emission estimates for the sector due to the use of the lower ODU factor of 0.2, and improve comparability of the UK data with other reporting Parties using the IPCC default.

2D4 Other Non-Energy Products
The UK GHGI 2014 submission includes CO_2 emission estimates for two additional sources that fit within the description of 'non-energy products':

- emissions during/after use of pesticides
- emissions during/after use of detergents

These sources were introduced to the UK GHGI for the 2006 submission and emission estimates were made using an approach given in the US NIR for the 2005 submission. This involved the use of a simple assumption that all carbon in detergents and related products, and 40% of carbon in pesticides was released to atmosphere following their use.

The 2006 GLs dos not refer to either pesticides or detergents as sources of CO_2 emissions. In the case of detergents, some of the carbon will already be accounted for in the GHGI in the methane emissions reported for sewage treatment. Furthermore, there is a strong likelihood that the carbon from these sources remains bound in organic matter and/or the aqueous environment following their use, rather than being emitted as CO_2, and as such the previous estimates introduce systematic over-estimates to the UK GHGI.

We have discussed the current UK approach with a UNFCCC Lead Reviewer (and IPPU sector reviewer), and have been advised to remove these items from the UK GHGI on the grounds that they are not mentioned in the GLs and that their presence in the UK GHGI reduces the comparability of the UK data with that for other Parties. We therefore recommend that these items are removed from the UK inventory.

3.2 Summary of Recommended Inventory Improvements

The impacts of this research on the UK GHGI are illustrated in the table presented below. The research identified specific changes for sources to be reported under the IPPU sector, and also a range of knock-on impacts to the reporting within the Energy sector, to harmonise the UK GHGI reporting and avoid double-counts or gaps. Furthermore, the project team is aware of related concurrent research into the improvement of emission estimates through greater use of EUETS Phase III data, and to improve the UK time series of Energy / Non-energy use of several petroleum commodities, which will also impact on the final data for the UK GHGI 2015 submission. The table below presents analysis using the latest known data for the UK inventory, but these are understood to be subject to change through the UK GHGI compilation and quality checking processes ahead of the 2015 submission.

The table highlights where emissions will be re-allocated from one source category to another, in moving from reporting under the 1996 GLs to the 2006 GLs. In some cases, re-allocations simply involve moving an existing emission estimate from one sector to another (e.g. emissions from carbonates used in steel-making, are to be re-allocated from 2A3 to 2C1a and 2C1d). In many other cases, the re-allocations are more complex and involve splitting existing emission estimates (e.g. in the case of lime kilns used at soda ash plants, removing the estimates from other lime plant reporting in 1A2f, and adding them to 2A7) and often involve the need to revise methodologies as well (e.g. for soda ash, new estimates for additional sources need to be added to the inventory).

New estimation methodologies have been derived to generate estimates for sources that are new to the inventory under the 2006 GLs (e.g. the estimates for 2B6, 2B8c, 2B8d, 2B8f), whilst existing source methods have also been revised and/or extended and in some cases re-allocated (e.g. estimates for 2A3, which are re-allocated from 2A7 as well as being revised). In some cases, sources included in the previous inventory have been deleted (e.g. emissions from use of pesticides and detergents that were previously reported in 2B5 under the 1996 GLs).

IPPU GHGI estimates on a CO_2-equivalent basis are also affected by the change in Global Warming Potentials for methane and nitrous oxide under the 2006 GLs compared to the 1996 GLs, which is especially significant for emissions of nitrous oxide from 2B2 and 2B3. The revised GWP for nitrous oxide is 298, compared to 310 under the 1996 GLs, and hence the 2B2 and 2B3 emissions on a CO_2 equivalent basis are lower than in the 2014 submission.

The various changes – revisions, re-allocations – have a large impact on the emissions reported for many of the detailed IPCC categories, and the changes are not just limited to the IPPU sector, due to the re-allocation of various emission estimates to/from the Energy sector.

Overall, however, the recommended changes have a minor impact on the UK GHGI total. Re-allocations have no impact on overall UK emissions. Revisions have included new sources and deletions, and increased estimates for some sources and decreases for others.

The table below shows that overall, there has been a small decrease in estimated total GHG emissions in 1990 of 0.54 Mtonnes CO_2 equivalent, and a small increase in estimated total GHG emissions in 2012 of 0.48 Mtonnes CO_2 equivalent, which equate to an overall change of approximately -0.07% in 1990 and +0.08% in 2012 compared to the 2014 submission.

Table 6 Summary of Proposed revisions to the Energy and IPPU sector estimates in the UK GHGI

Category (1996 GLs)	Source sector/sub-sector	Emission, Mt CO_2		Category (2006 GLs)	Source sector/sub-sector	Emission, Mt CO_2		Comments	Change to UK GHGI
		1990	2012			1990	2012		
1A2c	Ammonia - combustion	0.573	0.625					Moved to 2B1	R, UC
1A2c	Chemical industry - process gases	2.903	3.153					Moved to 2B8g	R, UP
1A2c	Chemical industry, OPG - CH4	0.006	0.006					Moved to 2B8g	R, DOWN
1A2f	Lime kilns - coke	0.213	0.136	1A2f	Lime kilns - coke	0.047	0	Some emissions moved to 2B7	R, UC
1A2f	Lime kilns - coal	0.061	0.102	1A2f	Lime kilns - coal	0.356	0.102	NEU task-related	R, UC
1A2f	Other industry - coke	2.579	0	1A2f	Other industry - coke	0.159	0	Most moved to 2C6	R, UC
1A2f	Other industry - pet coke	0.277	0.097	1A2f	Other industry - pet coke	0	0.344	NEU task-related	R, UP
1A2f	Lubricants - industrial engines	0.022	0.008					Moved to 2D1	R, UP
1A3b	Lubricants - road vehicle engines	0.263	0.099					Moved to 2D1	R, UP
1A3d	Lubricants - marine engines	0.108	0.056					Moved to 2D1	R, UP
1A4c	Lubricants - agricultural machinery	0.017	0.006					Moved to 2D1	R, UP

Category (1996 GLs)	Source sector/sub-sector	Emission, Mt CO_2		Category (2006 GLs)	Source sector/sub-sector	Emission, Mt CO_2		Comments	Change to UK GHGI
		1990	2012			1990	2012		
2A1	Cement - decarbonisation	7.295	3.716	2A1	Cement - decarbonisation	7.295	3.716	No change	UC
2A2	Lime - decarbonisation	1.462	1.178	2A2	Lime - decarbonisation	1.462	1.178	No change	UC
2A3	Sinter - limestone	0.862	0.399					Moved to 2C1d	R, UC
2A3	Sinter - dolomite	0.193	0.180					Moved to 2C1d	R, UC
2A3	Oxygen furnaces - dolomite	0.135	0.082					Moved to 2C1a	R, UC
2A3	Power stations - FGD	0	0.517					Moved to 2A4d	R, UC
2A7	Glass - limestone	0.098	0.103	2A3	Glass - limestone	0.112	0.115	Moved from 2A7 to 2A3, methodology improved	R, UP
2A7	Glass - dolomite	0.111	0.097	2A3	Glass - dolomite	0.101	0.072		R, DOWN
2A7	Glass - soda ash	0.167	0.178	2A3	Glass - soda ash	0.195	0.196		R, UP
2A7	Fletton bricks	0.180	0.051	2A4d	Bricks	0.647	0.777	Moved from 2A7 to 2A4, CO2 methodology now covers all bricks, & roofing tiles	R, UP
2A7	Fletton bricks - CH4	0.024	0.003	2A4d	Fletton bricks - CH4	0.031	0.004		UP
				2A4d	Power stations - FGD	0	0.517	Moved from 2A3	R, UC
2B1	Ammonia production	1.431	0.948	2B1	Ammonia production	2.004	1.574	Now incorporates ammonia combustion (1A2c)	R, UC
2B2	Nitric acid - N_2O	3.904	0.061	2B2	Nitric acid - N_2O	3.860	0.039		DOWN
2B3	Adipic acid - N_2O	20.737	0	2B3	Adipic acid - N_2O	19.935	0		DOWN
				2B4	Caprolactam etc.	NO	NO	Not occurring in the UK	
				2B5	Carbide production	NO	NO	Not occurring in the UK	
				2B6	Titanium dioxide	0.105	0.110	New source	UP
				2B7	Soda ash production	0.232	0.295	Emissions moved from 1A2f + methodology update	R, UP

Category (1996 GLs)	Source sector/sub-sector	Emission, Mt CO_2		Category (2006 GLs)	Source sector/sub-sector	Emission, Mt CO_2		Comments	Change to UK GHGI
		1990	2012			1990	2012		
2B5	Energy recovery in chemical sector	0.087	0.087					Deleted to remove double-count with 2B8.	DOWN
2B5	Carbon in pesticides	0.039	0.039					Deleted as no IPCC method. See text.	DOWN
2B5	Carbon in detergents	1.151	1.541					Deleted as no IPCC method. See text.	DOWN
2B5	Methanol production - CH4	0.001	0	2B8a	Methanol production - CH4	0.001	0	Minor revisions only	UP
2B5	Ethylene production - CH4	0.013	0.033	2B8b	Ethylene production - CH4	0.015	0.039	Minor revisions only	UP
				2B8c	Ethylene dichloride	0.006	0.006	New source	UP
				2B8d	Ethylene oxide	0.131	0	New source	UP
				2B8d	Ethylene oxide - CH4	0.009	0	New source	UP
				2B8e	Acrylonitrile	IE	IE	Included in 2B8g	
				2B8e	Acrylonitrile - CH4	0.001	0.000	New source	UP
				2B8f	Carbon black	0.437	0	New source	UP
				2B8f	Carbon black - CH4	0.000	0	New source	UP
				2B8g	Petrochemicals (incl ethylene)	3.462	3.233	Moved from 1A2c. Recalculations include other petrochemical sites	R, UP
				2B8g	Chemical industry - CH4	0.002	0.001	Moved from 1A2c	R, DOWN
2B5	Other chemicals - CH4	0.156	0.049	2B10	Other chemicals - CH4	0.186	0.059	Revisions to include further sites	R, UP
2B5	Petroleum waxes	0.073	0.043					Moved to 2D2	R, DOWN
				2C1a	Electric arc furnaces - pet coke	0.035	0.020	New source based on review of EUETS	UP
				2C1a	Oxygen furnaces - dolomite	0.135	0.082	Moved from 2A3	R, UC
				2C1d	Sinter - limestone	0.862	0.399	Moved from 2A3	R, UC
				2C1d	Sinter - dolomite	0.193	0.180	Moved from 2A3	R, UC
				2C5	Lead production	IE	NO	Included in 2C6	R, UC
				2C6	NFM processes	1.359	0	Moved from 1A2f	R, UC

Category (1996 GLs)	Source sector/sub-sector	Emission, Mt CO_2		Category (2006 GLs)	Source sector/sub-sector	Emission, Mt CO_2		Comments	Change to UK GHGI
		1990	2012			1990	2012		
				2D1	Lubricant use	1.197	0.630	Moved from 1A2. 1A3. Methodology improved	R, UP
				2D2	Petroleum waxes	0.033	0.019	Moved from 2B5	R, DOWN
				2D4	Non-energy use - pet coke	0	0.368	New source identified. NEU task-related	UP
Bunkers	Lubricants - aircraft	0.004	0.001	Bunkers	Lubricants - aircraft	0.002	0.002	Revised methodology	R, UP
TOTAL		45.145	13.596	**TOTAL**		44.606	14.077		

Key: R = re-allocated, UC = emission estimate unchanged, UP = emission estimate increased, DOWN = emission estimate decreased

3.3 Emission Projections for New and Existing IPPU Source Categories

Results of the projections are summarised in the tables below. For the IPPU sectors covered by this research, emissions in both the latest inventory year (2013) and into the future are dominated by cement manufacture and petrochemicals, which together are responsible for about three quarters of the emissions. Of the remaining sectors, lime production and ammonia production are the most important.

These projections suggest very little change in emissions from the mineral sectors (2A to 2D), whereas petrochemical industry emissions are predicted to increase significantly (45% increase from 2013 to 2035). Note, however, that these projections are subject to a high level of uncertainty (higher uncertainty than would be expected with projections for energy-related emissions, for example).

Whilst it is unlikely that emission factors will change much in the future, the forecasting of activity levels for the IPPU sectors is very difficult. Activity in the petrochemicals sector, in particular, will be very sensitive to the decisions made regarding the handful of high-emitting UK production plant; any changes to plant capacity and annual production will have a and if just one of the plant were to close, for example, then this would mean that the current projection would need to be re-assessed. The projections for at least the three largest sectors (2A1, 2A2 and 2B8) should, in any case, be reviewed on a regular basis.

Table 7 Summary of projections base year (2013) and projected emissions of CO2 to 2035 for the new and existing IPPU sources studied, ktonnes Carbon

Sector	2013	2015	2020	2025	2030	2035
2A1 Cement production	1,043	1,043	1,044	1,023	1,012	1,000
2A2 Lime production	338	338	338	332	328	324
2A3 Glass production	106	106	106	104	103	102
2A4 Brick production	75	75	75	74	73	72
2B2 Ammonia production	377	390	425	462	502	547
2B6 Titanium dioxide	34	35	38	41	45	49

Sector	2013	2015	2020	2025	2030	2035
2B7 Soda ash	78	36	35	35	35	35
2B8g Petrochemicals	803	830	903	982	1,069	1,163
2D2 Lubricants	72	74	77	78	81	84
Other sectors	5	5	5	5	6	6
Total	**2,930**	**2,932**	**3,047**	**3,137**	**3,253**	**3,381**

Annex I Recommended Improvements to Inventory Methods

The research findings are presented here in more detail to outline the recommended new or revised inventory estimation methods and reporting requirements. The information comprises:

- Information on uncertainties, Key Source Categories and UK EFs compared to IPCC default factors
- Inventory method details for existing source categories where changes are recommended
- Inventory method details for the new source categories

A1.1 Information on Uncertainties, Key Source Categories and UK EFs compared to IPCC default factors

The table below summarises the uncertainty parameters for activity data and emission factors that are recommended for each source category in terms of % uncertainty to be taken forward in the UK GHGI inventory-wide Monte Carlo uncertainty analysis for the 2015 submission. The table also indicates which of the source categories are expected to be assessed to be Key Categories in the UK inventory, either by virtue of the Level of emissions, Trend in emissions or due to qualitative reasons.

(The UK GHGI Key Category Analysis is being revised ahead of the 2015 submission, and therefore the assumptions below may not reflect the actual outcome of the revised UK KCA, but are based on historic KCAs and expert judgement.)

Table A.I.1 Recommended IPPU Source Category Uncertainty Parameters

Source Category	Gas	Key Source	U AD (%)	U EF (%)	Comments
2.A.1 Cement Production	CO_2	Yes	1	5	High quality AD and emissions data. Data can be validated between multiple information sources: PI, trade association, EUETS for recent years.
2.A.2 Lime Production	CO_2	Yes	1	5	(As above for cement.)
2.A.3 Glass Production	CO_2		5-20	5-20	AD are somewhat uncertain as trade association data differ from other national statistics from British Geological Survey. Good quality time series of manufacture of different types of glass. Low uncertainty from 2008 onwards.
2.A. 4 Other process uses of carbonates	CO_2		5-20	5-30	AD uncertainty reflects variability of data across the time series, lack of comprehensive information on site openings and closures, and risk that some small-scale ceramics producers may be excluded. Higher uncertainty for earlier years where data is scarce.

Source Category	Gas	Key Source	U AD (%)	U EF (%)	Comments
2B1 Ammonia Production	CO_2		2.5	1.5	High level of accuracy on both AD and EF reflects the complete, consistent level of reporting by a small number of operators leading to a good time series of activity and well-characterised gas CEFs through regular monitoring.
2B2 Nitric Acid Production	N_2O	Yes	2.5	10	High level of accuracy of AD reflects the complete, consistent level of reporting by a small number of operators leading to a good time series of activity data. EFs are based on plant-specific estimates and (recently) continuous monitoring. Operator feedback stated “5 to 10% uncertain”.
2B3 Adipic Acid Production	N_2O		2.5	10	(As above for nitric acid.)
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production	N_2O				Not occurring.
2B5 Carbide Production	CO_2				Not occurring.
2B6 Titanium Dioxide Production	CO_2		15-50	5	Limited time series for activity data, but only two UK plant of known capacity. EF based on operator-reported data.
2B7 Soda Ash	CO_2		5-70	5	Limited time series for activity data, but only two UK plant of known capacity. EF based on operator-reported data.
2B8 Petrochemical and Carbon Black Production	CO_2, CH_4	Yes	15-50	5	Limited time series for activity data, but for recent years the sector is dominated by a small number of very well-documented emissions from EUETS. Estimates for 1990s are much more uncertain due to lack of source data. EF based on operator-reported data.
2C2 Ferroalloy production	CO_2				In recent years this source is *Not Occurring* in the UK. In early years of the time series, emission estimates are *Included Elsewhere* within 1A2, as DUKES and ISSB statistics do not provide explicit activity data for ferroalloy production, and the production plant has closed, so no further information is available.
2C6 Zinc production (includes 2C5 Lead production)	CO_2	Yes	10	10	Very limited time series of data for this source and closed sites, but good quality DUKES data on NFM coke use, therefore moderate AD uncertainty.
2D1 Lubricants	CO_2		5	50	AD is based on DUKES, but the EF is derived using IPCC GLs but actual lubricant lost in engines is uncertain. ODU also using IPCC default which is uncertain to apply to UK circumstances.
2D2 Paraffin waxes	CO_2		10	50	As above for lubricants, but the AD is also more uncertain for waxes as the DUKES data shows greater variability and higher statistical differences
2D3 Asphalt Production and Use	n/a				No direct GHGs emitted.

Where a range of uncertainty parameters are presented above, the lower number applies to the most recent inventory year (2013) and the higher number applies to the Base Year (1990).

The recommended development of new and revised methods for IPPU sources has taken consideration of the UK-specific data on activity, emissions as well as emission factors and in several cases there is a need to validate the UK country-specific data against the recommended IPCC default emission factors[4]. Where the UK data deviate from the IPCC defaults this is due to the use of facility-specific data, and text recommended for inclusion in the NIR to explain / validate the CS factors is outlined here:

- **2A1 Cement production**. The 2006 GLs default factor is 0.52 tonnes CO_2 per tonne of clinker produced. The UK activity data are commercially confidential data (but made available to UNFCCC Expert Review Teams on request) and are based on detailed bottom-up operator analysis and reporting. The UK data have been subject to reviews annually and they are regarded as the most accurate representation of UK emissions available and compare well with the IPCC default factor.
- **2A2 Lime production.** The 2006 GLs default factor is 0.75 tCO2 / t lime produced, and assumes 85% high calcium lime and 15% dolomitic lime. The UK data are based on installation-level reporting across all UK lime plants and in recent years the data have been reported and validated through the EUETS. The UK emission factor varies year-to-year, depending on the precise mix of different raw material use across the UK inventory, but is typically 0.72-0.73 tCO2/t lime produced, which is fractionally lower than the IPCC default, but accurate for UK production.
- **2A3 Glass production**. The 2006 GLs default factor is 0.20 tCO2 / t glass produced. The UK factor is again based on operator-reported data and takes consideration of all of the use of recycled glass and different speciality glass sub-sectors. The UK factor varies across the time series but is typically in the range of 0.10-0.12 tCO2 / t glass produced, and is notably lower than the IPCC default due to the very high proportion of recycled cullet glass use in UK production, which is typically around 30-40% of production of by far the biggest UK glass sector, production of container glass. The UK data also apply specific factors for each sub-source of glass production, including EFs that are notably lower than the IPCC default, for UK production of glass fibres which is around 10% of total UK glass production.
- **2A4 Other use of carbonates.** The UK methods use the IPCC default EFs for use of limestone, dolomitic limestone and dolomite, and therefore are fully consistent with the 2006 GLs. These are emission source estimates are based on stoichiometric equations for the decarbonisation of raw materials.
- **2B1 ammonia production**. The 2006 GLs default factor is 1.7 tCO2 / t ammonia produced for conventional reforming plants in Europe. The UK IEF fluctuates according to the relative contribution to UK production by the individual plant, but in recent years is in the range of 1.4-1.6 tCO2/ t ammonia produced. This factor is lower than the IPCC default, but this is due to one UK plant producing ammonia using a hydrogen feedstock rather than natural gas. Excluding the production from this plant, the UK IEF is in the region of 1.8-1.95 tCO2/ t ammonia produced, which is slightly higher than the IPCC default for modern reforming plants.
- **2B2 Nitric Acid production**. The 2006 GLs default factor is 2 kg N2O / t NA produced at plant fitted with selective non-catalytic reduction (SCNR). The UK factor is notably lower than this for recent years following the retro-fitting of nitrous oxide abatement equipment at all UK plant by 2011. The UK data are based on plant-specific data taken from continuous emission monitoring systems and are therefore regarded as accurate for the UK production sites.
- **2B3 Adipic Acid production.** The 2006 GLs presents a range of default factors for technology options for different AA plant designs for the calculation of an overall default emission factor. Considering the design of the only UK installation, which closed in 2009, it had been fitted with nitrous oxide abatement equipment (thermal process) and choosing the respective factors for technology options leads to an IPCC default value of 0.135 kg

[4] Where several IPCC defaults are available for one source category, the option which best reflects the production processes applied in the UK has been chosen.

N2O per tonne AA production. The UK plant was achieving lower IEFs than the IPCC default calculated for this prior to closure. The UK data are based on operator-reported data from continuous emission monitoring systems (CEMS) and are regarded as accurate for the UK production plant.

- **2B6, 2B7, 2B8, 2C5/6.** In all cases the UK data cannot be presented in a format that allows comparison against the default IEFs in the 2006 GLs, as there are no UK production data for the chemicals being produced, and all of the default IEFs are cited on a production basis. This is a short-coming of the available UK data. However, we can state that the UK emission estimates are based on operator-reported emissions data from each of the handful of production sites in each sector., In those cases where reductants are used, the country-specific carbon emission factors applied for those reductants are all closely consistent with available IPCC defaults for those substances.
- **2D1, 2D2.** In both cases, the UK methods use the IPCC default assumptions regarding the so called oxidised during use (ODU) factor. The UK method for emissions from lubricants uses a CS factor for carbon content of lubricants based on analysis of UK oil samples.

A.1.2 Recommended method revisions for existing source categories

The below table shows the results of the assessment of methodological approaches for existing source categories with the requirements of the IPCC 2006 Guidelines and proposes changes in order to ensure compliance, where necessary.

Table A.I.2 Review Findings for Existing IPPU Sources in the UK GHG

Source Category	Findings of review against 2006 GLs requirements
2.A.1 Cement Production	Calculation approach in line with IPPC 2006 GL requirement. In order to increase transparency in the NIR, we suggest that description of the methodology states that the calculation approach used ensures that cement kiln dust losses are covered.
2.A.2 Lime Production	Calculation approach in line with IPPC 2006 GL requirement. In order to increase transparency in the NIR, we suggest that description of the methodology states that the calculation approach used ensures that lime kiln dust is covered.
2.A.3 Glass Production	Recommended update to the inventory method and a recalculation of time series, see below.
2.A. 4 Other process uses of carbonates	Emission estimates for production of heavy clay goods required recalculation in order to add emissions from non-Fletton bricks and roofing tiles, to the Fletton brick production emissions previously included. A detailed description of the calculation approach for this sector is presented below. For other uses of carbonates, emission estimates are either already included in the UK inventory (e.g. for flue-gas desulphurisation), or deemed not required, e.g. for magnesia production.
2B1 Ammonia	Approach in line with IPPC 2006 GL requirements. We recommend that the UK re-allocates the fuel gas component of natural gas use in ammonia production to 2B1 (allocated to 1A2c under the 1996 GLs) in line with the 2006 GLs and feedback from other MS.
2B2 Nitric Acid Production	The IPCC 2006 GLs provide an updated default emission factor for medium pressure plants of 7kg N_2O /t nitric acid. We recommend that the UK GHGI time series be recalculated using this default emission factor where plant-specific data are not available.
2B3 Adipic Acid Production	Approach in line with IPPC 2006 GLs requirement.
2D3 Asphalt Production and Use	There are no methodologies for the calculation of direct GHG emissions in the IPCC 2006 GLs, see Chapter 3, section 5.1.
2D1 Lubricant Use	Recommend that the UK approach be revised to report all lubricant uses under 2D1 instead of within Energy (as under the 1996 GLs) and that the UK revises its ODU to use the IPCC default.
2D2 Petroleum Waxes Use	Recommend that the UK approach be revised to use the IPCC default ODU for waxes.
2D Other	Recommend that the UK removes the estimates of emissions of CO_2 from use of detergents and pesticides, as these sources do not have methods defined within the 2006 GLs. The estimates are also regarded as highly uncertain as the likelihood is that most of the organic content will remain bound up in soils and in the aqueous environment and not be released. Therefore to retain these estimates would be poor for comparability against other Parties, and would also retain estimates that are very conservative (across the time series).

The need for significant methodological changes was only identified for two source categories: 2A3 Glass production and 2A4 Other process uses of carbonates. The revised methodological approaches for these categories are presented in the following sections. For category 2A4 Other process uses of carbonates only the methodological approach for ceramics production is presented, while the approaches for the remaining activities under the categories remain unchanged.

Aside from changes recommended for 2A3 and 2A4, revisions to Oxidation During Use (ODU) factors to use 2006 GL defaults for lubricants (2D1) and waxes (2D2) are recommended, as is an update to use a revised IPCC default EF for N_2O emissions from nitric acid plant (2B2).

Proposed NIR text for existing IPPU sources where method revisions are recommended

2A3 Glass production (NIR TEXT)

The UK had 22 large sites making glass at the end of 2013, for the production of container glass (12 sites), flat glass (5 sites), continuous filament glass fibre (1 site), or glass wool (4 sites). There are also 2 sites producing stone wool. Ballotini are produced at three sites, but these processes are based almost exclusively on the use of recycled glass (cullet) and therefore carbonates are assumed not to be used in significant quantities at those sites. Discussions with the British Glass Manufacturers Confederation indicated that special and domestic glasses are no longer manufactured on a large scale in the UK. It is assumed that limestone, dolomite, and soda ash are used in the production of container, flat, special, and domestic glasses, and in glass and stone wool. Sector-specific assumptions are made, however, regarding the rate of use of each type of carbonate.

Emission Sources	Sources included	Method	Emission factor
	2A3. Glass production	Tier 2	C
Gases Reported	CO_2		
Key Categories (Trends)	No		
Key Categories (Level)	No		
Key Categories (Qualitative)	No		
Overseas Territories and Crown Dependencies Reporting	Not occurring		
Completeness	No known omissions.		
Major improvements since last submission	Recalculation for activity data		

Methodological Issues

Emissions from the use of carbonates in glass production are calculated using data from two sources:

- a detailed, site by site survey of raw material usage in the glass industry, carried out in 2006 (GTS, 2008). This report covered the flat, container, and fibre sectors;
- data reporting under the EU Emissions Trading System (EUETS) from 2008 onwards.

In the case of the survey of raw material usage, data are available on the quantities of each type of carbonate used by each sub-sector of the industry during 2006. Emissions must be estimated, and this is done based on the stoichiometric relationship between carbon and the related carbonate:

- 120 t carbon / kt limestone;
- 130 t carbon / kt dolomite;
- 113 t carbon / kt soda ash.

These factors assume that all of the carbon in the carbonates is released to atmosphere.

The data from the EUETS are for emissions of CO_2, but disaggregated by the source of the emission (e.g. use of natural gas, or use of limestone etc.) The data have first to be analysed so that the emissions can be separated into those that occur due to use of various fuels, and those that are due to use of the three carbonates. Data are available for all significant glassmaking sites for the period 2008-2013. Consumption of carbonates can be back-calculated, using the same stoichiometric relationships as given above. Since ETS data are available on a site by site basis, the emissions data, and the derived activity data can be agglomerated to give estimates for each sub-sector of the glass industry. The EUETS data set also includes details of extremely small emissions (less than 1 tonne) occurring due to the use of barium carbonate or potassium carbonate, but these have been ignored from the UK inventory due to their trivial nature.

The two data sources allow the derivation of estimates for different sectors of the glass industry. The 2006 survey of raw material usage enables the derivation of estimates for the subsectors flat glass, container glass, glass wool, whilst EUETS data informs estimates for flat glass, container glass, glass wool, stone wool.

The two data sets indicate some changes over time in rates of carbonate use for flat, container and glass wool, and partial EUETS data for 2005-2007 also support this. Therefore the 2006 survey, rather than the later EUETS data, is assumed to be more reliable as a guide to the rates of carbonate usage in the three sectors in the years 1990-2005. Carbonate usage for that period is therefore extrapolated from the 2006 figures on the basis of production in each sub-sector in each year.

For stone wool, we only have data from the EUETS for 2008-2012, and so the average consumption rate calculated for those years is then applied to the period 1990-2007 using stone wool production estimates for each year.

Neither data source contains information on special or domestic glasses because the only significant UK sites producing either type of glass closed before 2006. Therefore, carbonate consumption rates for both types of glass have been assumed to be equal to the average rate for container, flat and glass wool in 2006, as given in the raw material usage study.

Glass production data are available on an annual basis for container glass only (British Glass, 2014), and a full time-series of production for other types of glass has therefore to be estimated based on the partial time series of production data covering a limited number of years (e.g. data for late 1990s from EIPPCB, 2000, flat glass data for 2003 onwards from British Glass), which are then extrapolated to other years on the basis of estimated plant capacity. In the case of flat and container glass, the glass production data used to estimate carbonate usage are corrected for the amount of cullet used in each year, so the estimates do take into account changes over time in recycling rates and use of cullet. This is not possible for other types of glass, and so the calculation of carbonate usage for these glass types is based on total production. Therefore, the estimates for glass wool, special glasses and domestic glass implicitly assume that the rate of recycling in these sectors remains constant over the time series.

(NIR) Table AI3 gives summary details for the UK glass industry and the scope of estimates for CO_2 emissions from carbonate use.

Table A.I.3 Background Information on the Estimation of Emissions from Carbonate Use in Glassmaking and Related Industries, UK 1990-2013

Glass Sector	1990 production (kt)	2013 production (kt)	Emissions included from use of:		
			Limestone	Dolomite	Soda Ash
Container	C	C	Yes	Yes	Yes
Flat	C	C	Yes	Yes	Yes
Special	226	0	Yes	Yes	Yes
Domestic, including lead	76	0.3	Yes	Yes	Yes
Continuous filament glass fibre	82	37	Yes	Yes	Yes
Glass wool	104	293	Yes	Yes	Yes
Stone wool	83	93	Yes	Yes	Yes
Ceramic fibres	14	14	No	No	No
Frits	13	7	No	No	No

C – confidential data

Uncertainties and Time Series Consistency

The uncertainty analysis in (NIR) **Annex 7** provides estimates of uncertainty according to IPCC source category and fuel type.

For the years 2008-2013, the methodology is based on the use of highly accurate emissions data reported under the EU Emissions Trading System. For activity data this compares to a tier 3 approach, for the emission factors to a tier 2 approach.

The emission estimates for 2006 are based on activity data given in a detailed industry study. These emission estimates should be assumed to be slightly more uncertain than the EUETS data of 2008-2013, since the source gives carbonate usage figures only, and emissions have to be calculated assuming that the carbonate usage figures refer to pure carbonates and that all carbon in the minerals is released to atmosphere. While the emissions data are therefore conservative, we think that the uncertainty is still likely to be relatively low since fairly pure carbonate minerals are readily available.

For the remaining years in the time-series, the methodology relies upon the extrapolation of highly accurate activity/emissions data for one year to all other years based on glass production. The glass production data are, however, a mixture of actual production data from the glass industry, and estimates, which are far more uncertain. The emission estimates for 2A3 are therefore subject to far greater uncertainty for the earlier part of the time-series than for recent years, because of the greater reliance on extrapolation, and the lower quality of the glass production estimates for the earlier part of the time-series.

Source-specific QA/QC and Verification
This source category is covered by the general QA/QC processes of the UK greenhouse gas inventory.

Source-specific Recalculations
This source category has undergone a reallocation as well as a recalculation. In previous submissions, emissions from glass production were reported under source category 2A7 Other Mineral Products, together with emissions from the production of fletton bricks. The IPCC 2006 GL require reporting of glass production under source category 2A3.

2A4 Other process uses of carbonates (NIR TEXT)

Emission Sources	Sources included	Method	Emission factor
	2A4 Production of Ceramics Production of fletton bricks	Tier 2 Tier 2	C C
Gases Reported	CO_2		
Key Categories (Trends)	No		
Key Categories (Level)	No		
Key Categories (Qualitative)	No		
Overseas Territories and Crown Dependencies Reporting	Not occurring		
Completeness	No known omissions.		
Major improvements since last submission	Source category newly included.		

The UK has a large number of sites involved in the production of heavy clay goods – bricks and roofing tiles, and similar items. These sites range from the smallest operations where bricks are hand-made, to bigger sites where bricks are manufactured on a large scale, using automatic production methods. The brick industry can also be divided into fletton and non-fletton types. Fletton bricks are manufactured using the Lower Oxford Clay, found in South-East England only. This clay has an exceptionally high content of carbonaceous material which acts as an additional fuel when the bricks are fired, but also produces a characteristic appearance in the finished bricks. Non-fletton bricks are made from other clays and shales and these have much lower carbon contents. Limestone, dolomite and barium carbonate are also added to bricks and release CO_2 when fired. Finally, brick manufacturers add crushed coke ("colourant") to some bricks, to change the final appearance of the bricks. Coke oven coke is known to be used in this manner, and we have assumed that petroleum coke is as well.

Numerous closures have occurred in the UK brickmaking sector over the years and brick production has steadily fallen. There were 5 fletton brickworks in the early 1990s, with 2 closing at the end of the 1990s, and further closures in 2009 and 2011

Other types of ceramics are manufactured in the UK, including wall and floor tiles, refractories, sanitaryware, household ceramics etc. However, we do not have a robust set of time-series data on either the levels of production or suitable emission factors for these types of ceramic goods, so no emission estimates can be made. However, the likely significance of the 'non-brick' part of the ceramics sector has been estimated as described below.

The UK Minerals Yearbook (BGS, 2014) gives production, imports and exports for 4 types of clay (ball clay, china clay, fireclay, other clays & shales). This reference also gives a breakdown of the uses to which the 'other clays & shales' are put – mostly bricks, cement production, and construction, with very little used for other ceramics. Fireclay can be assumed to be used solely for ceramics, and the EUETS data shows that fireclay is used by many brickmakers. It will also likely be used for refractories and sanitaryware and, in the absence of any data, we have assumed a 50/50 split of fireclay usage between bricks and other ceramics. The Kaolin and Ball Clay Association (KABCA) give estimates of the markets for both ball clay and china clay on their website[5] . Neither type of clay will be used in any significant quantity in bricks but KABCA indicate figures of 22% of china clay and 'over 80%' of ball clay used in ceramics. Based on BGS figures for 2008, 2009, 2011, and 2012 (data are not available for 2010), we can then derive some approximate figures for clays used in bricks and in other ceramics:

Table A.I.6 Consumption of Clays in Brickmaking and Other Ceramics Manufacture (Mtonnes):

		2008	2009	2011	2012
Bricks	Ball clay	0	0	0	0
	China clay	0	0	0	0
	Fire clay	0.092	0.066	0.082	0.049
	Other clay & shales	4.993	2.839	4.022	3.591
	Total	5.085	2.904	4.104	3.640
Other ceramics	Ball clay	0.224	0.196	0.199	0.161
	China clay	0.052	0.053	0.051	0.044
	Fire clay	0.092	0.066	0.082	0.049
	Other clay & shales	0.160	0.120	0.137	0.023
	Total	0.527	0.434	0.470	0.277

Over the four years for which we have data, the average consumption of clay for bricks and other ceramics is estimated as 3.933 Mtonnes and 0.427 Mtonnes respectively. In other words, clay used in the manufacture of other ceramics in the UK is just 11% of the quantity used in brick manufacture. The carbon content of fire clay and other clays and shales could be obtained from EUETS data for bricks, and the carbon content of ball clay is known to be very low since the British Ceramics Confederation produce carbon emission factors for ball clay in their guidance for EUETS reporting. No emission factor data are available for china clay. For the purposes of determining the likely significance of the source, if we assume that clay consumption for other

[5] See http://www.kabca.org/what-is-kaolin.php and http://www.kabca.org/what-is-ball-clay-.php

ceramics is 11% of the clay usage in bricks, and then assume the same average carbon content in clay for ceramics as in the common clays used in brickmaking (which would be a worst case because of the very low carbon content of ball clay and, probably, china clay as well), this would yield emission estimates that were well below 0.05% of the national total (0.0064% in 1990 and 0.0037% in 2013) and therefore insignificant.

The 2006 GLs draws attention to other sources of CO_2 emissions from use of soda ash and other carbonates. These other uses include flue gas desulphurisation (FGD), magnesia production, and use of soda ash in soaps & detergents, and other applications.

Limestone is used in FGD systems at most remaining UK coal-fired power stations and emissions are reported under 2A4. The power stations at Drax and Ratcliffe were the first to get FGD (in 1997), followed by West Burton A in 2004, Eggborough and Cottam in 2005, then Ferrybridge C, Fiddlers Ferry and Rugeley B in 2008.

Magnesia production in the UK is limited to a single plant that closed in 2005. This site produced magnesia from seawater, with magnesium salts in the seawater precipitated as magnesium hydroxide, followed by conversion to magnesia in kilns. No process emissions of CO_2 occurred at this site. We have no information on any use of soda ash in the UK outside of the glass industry, and so no emission estimates are made.

Methodological Issues

CO_2 emissions from production of bricks and tiles are based on data reported in the EUETS. The EUETS data set provides site by site emissions, broken down by the source of emission (e.g. from clays, fuels, colourants etc.) and begins in 2005, although the data are only representative of the sector from 2008 onwards, when practically all significant sites began to be included. The data can easily be divided into emissions from fuels, and emissions from non-fuels (i.e. process emissions). It is slightly more difficult to divide the non-fuel data into sub-types such as emissions from clays, colourants, or 'pure' carbonates like limestone, dolomite and barium carbonate, since some of the information within the ETS data set on the source of the CO_2 is ambiguous. So, although it is possible to make a split, we have instead reported the process emissions as a group. Note that this does mean that emissions from the colourant (coke oven or petroleum coke) are included here, but we think this is justified both because of the slight ambiguity in some of the ETS data, but also because there is no other category which would be more appropriate.

The ETS data are calculated by each brick and tile producer using site-specific activity data, and industry-wide emission factors, compiled by the industry trade association each year (e.g. British Ceramics Confederation, Ceramics - Methodology for the Determination of EUETS Annual Emissions - BCC / CERAM Calculation Methodology Version 14, 31st January 2013). These include factors for simple carbonates based on the stoichiometric relationship of carbon to the carbonate, as well as measured emission factors for different types of clay e.g. Keuper Marl, Weald Clay, Lower Oxford Clay. The industry factors also include an estimate for colourants which is based on the assumption that 50% of carbon in the colourant is oxidised during firing.

Based on discussions with the industry, we have assumed that the ETS data for 2008-2010 represents 93% of sector production. In 2013, a single further site reported in EUETS, bringing coverage to 95%. The emissions data for 2008-2013 are therefore increased slightly to reflect non-reporting sites, assuming that emission rates at non-reporting sites will be the same as on average at reporting sites. With the exception of the large site that joined EUETS in 2013, the non-reporting sites over the period 2008-2013 are all the smaller producers and it is not known how representative the industry factors will be for these atypical sites. In the absence of better data, however, we have assumed that emission rates are the same.

(NIR) Table A.I.5 gives a timeline for the brick sector, summarising what is known about the sites operating and the data available for emission estimates over the time series.

Table A.I.6 Timeline for the brick sector in the UK: production sites and data availability

Years	Number of sites and fuels	Availability of data
1990-1997	Possibly 6 fletton works in operation in 1990; only 5 still in operation by 1993. Those in 1993 burnt coal, or a mixture of coal and natural gas. Unknown number of non-fletton works.	No emissions data available, annual production (numbers) of all bricks available and fletton and non-fletton brick production estimated from this. Emission estimates require use of emission factors generated from later PI and ETS data.
1998-2007	Two of the 5 fletton works in operation since 1993 close in 1998/1999. Both used coal only as a fuel so by the end of 1999, 3 works remain: Stewartby burns coal, the other two (Saxon/Kings Dyke), both in the same area in England, now burn natural gas only. Approximately 100 non-fletton brickworks in early 2000s	Annual emissions of CO_2 and methane available in the Pollution Inventory for each fletton site until 2004, when emissions for the two gas-burning sites, which are located about 1.5 km apart, start to be reported as combined totals. Reported emissions have to be split between energy-related and process-related emission. Annual production (numbers) of all bricks available[6], so fletton brick production is assumed a 25% share in 1990, falling to 20% in 1995, then falling to 10% by 2010 and remaining at 10% thereafter – based on industry estimates. [7] Emission estimates for non-fletton bricks have to be generated using emission factors from later EUETS data (an average of 173 grammes CO2 per brick can be calculated from the ETS-based emission estimates for 2008-2013). .
2008	Closure of coal-burning fletton works at end of 2008, leaving only the 2 gas-burning works remaining. 63 non-fletton brickworks report in EUETS in 2008.	Annual emissions of CO_2 and methane available in the Pollution Inventory for Stewartby, and for Saxon/Kings Dyke. EUETS data for the same two fletton brickmaking units, and also for non-fletton brickworks. These data are detailed, allowing fuel-related and

[6] Monthly Statistics of Building Materials and Components, September 2014, available from www.gov.uk

Years	Number of sites and fuels	Availability of data
		process-related emissions to be separated. Emission estimates can be based directly on EUETS data.
2009-2012	Saxon works closed in 2011, leaving only the Kings Dyke fletton brickworks remaining. Many closures of non-fletton brickworks, with 49 reporting in EUETS by 2011. In 2013, final large site joins EUETS, with total of 46 non-fletton sites then reporting.	Annual emission of CO_2 and methane available in the Pollution Inventory for the Saxon/Kings Dyke works. EUETS data for all significant fletton and non-fletton works for all years except for one site that joins ETS in 2013. Emission estimates can be based directly on EUETS data.

Uncertainties and Time Series Consistency
The uncertainty analysis in (NIR) **Annex 7** provides estimates of uncertainty according to IPCC source category and fuel type.

In the case of ceramic production, the methodology for the years 1990-2007 is based on the extrapolation of highly accurate activity data from 2008-2013 reported under the EU Emissions Trading System and estimation of (non-fletton) brick production based on a national statistic. Because the estimates of brick production are themselves quite uncertain, these activity data for ceramic production are more uncertain.

For the years 2008-2013, the methodology is based on highly accurate activity data reported under the EU Emissions Trading System.

The emission factors are based on the stoichiometry of the chemical reaction undergone by the soda ash, limestone and dolomite and are associated with low uncertainty.

Source-specific QA/QC and Verification
This source category is covered by the general QA/QC process of the UK greenhouse gas inventory.

2D1 Lubricants (NIR TEXT)

Emission Sources	Sources included	Method	Emission factor
	2D1 Lubricants	Tier 1	C
Gases Reported	CO_2		
Key Categories (Trends)	No		
Key Categories (Level)	No		
Key Categories (Qualitative)	No		
Overseas Territories and Crown Dependencies Reporting	Occurring – included in the UK GHGI		
Completeness	No known omissions.		
Major improvements since last submission	Source category newly included.		

Methodological Issues

Annual lubricant demand is reported in the Digest of UK Energy Statistics (DUKES). Carbon dioxide emission estimates for the oxidation of lubricants within vehicle engines and machinery are based on annual lubricant consumption multiplied by an oxidation during use (ODU) factor of 0.2 as provided by section 5.2.2.2. of the IPCC 2006 Guidelines. The carbon emission factor is derived from UK analysis of petroleum fuels.

Uncertainties and Time Series Consistency

The uncertainty analysis in (NIR) **Annex 7** provides estimates of uncertainty according to IPCC source category and fuel type.

The activity data from DUKES are associated with low uncertainty; statistical differences for lubricants are generally very low in the UK commodity balance tables and the uncertainty is therefore estimated to be +-5%.

The assumed ODU from the IPCC default method combined with the UK-derived carbon emission factor are associated with high uncertainty as the oxidation of lubricants within engines of different types, the changes in oil formulations through the time series and the proportions of different types of lubricants ranging from greases (with low ODU factors) compared to lubricating oils for road vehicle engines (with higher ODU factors) will all impact on the emissions. Therefore the uncertainty of the derived emission factor applied to lubricant activity data is estimated to be +-50.

Source-specific QA/QC and Verification

This source category is covered by the general QA/QC processes of the UK greenhouse gas inventory.

2D2 Paraffin waxes (NIR TEXT)

Emission Sources	Sources included	Method	Emission factor
	2D2 Paraffin waxes	T1	D
Gases Reported	CO_2		
Key Categories (Trends)	No		
Key Categories (Level)	No		
Key Categories (Qualitative)	No		
Overseas Territories and Crown Dependencies Reporting	Occurring – included in the UK GHGI		
Completeness	No known omissions.		
Major improvements since last submission	Source category newly included.		

Methodological Issues
Petroleum wax consumption is given in the UK energy statistics (DUKES). The methodology for estimating carbon released from the use of paraffin waxes are based on the annual consumption of paraffin waxes multiplied with a default ODU factor of 0.2 as provided by section 5.3.2.2. of the IPCC 2006 Guidelines and the default IPCC carbon emission factor for waxes, converted to a mass basis using the DUKES Net Calorific Value for waxes.

Uncertainties and Time Series Consistency
The uncertainty analysis in (NIR) **Annex 7** provides estimates of uncertainty according to IPCC source category and fuel type.

The activity data from DUKES are associated with moderate uncertainty; statistical differences for waxes are generally low in the UK commodity balance tables and the uncertainty is therefore estimated to be +-10%.

The assumed ODU from the IPCC default method combined with the default IPCC carbon emission factor and UK net calorific value are associated with higher uncertainty, estimated to be +- 50%.

Source-specific QA/QC and Verification
This source category is covered by the general QA/QC processes of the UK greenhouse gas inventory.

(End of recommended NIR text for existing sources.)

A1.3 Recommended inventory methods for the new IPPU source categories

The study team has developed new inventory estimation methodologies for the following IPPU source categories, all of which are new to the UK GHGI under the 2006 GLs:

- 2B6 Titanium Dioxide Production
- 2B8 Petrochemical and Carbon Black Production
- 2B7 Soda Ash
- 2C5 Lead Production (To be reported “IE”, and new estimates are included within 2C6.)
- 2C6 Zinc production

Note that through research of literature sources and consultation with trade association and regulatory contacts, the study team has established that the following source categories are **Not Occurring** in the UK throughout the inventory time series from 1990 to the present day:

- 2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production
- 2B5 Carbide Production
- 2C3 Ferroalloy Production

It is proposed therefore that these three source categories be reported as “NO” in future UK GHGI submissions.

The evidence was collated via consultation with the Chemical Industries Association, the Iron and Steel Statistics Bureau and the Environment Agency, and through review of documents from the last 25 years of research and reporting on chemical industry and emissions within Europe.

Proposed NIR Text for New IPPU Sources

2B6 Titanium Dioxide Production (NIR TEXT)

Emission Sources	Sources included	Method	Emission factor
	2B6	Tier 2	C
Gases Reported	CO_2		
Key Categories (Trends)	No		
Key Categories (Level)	No		
Key Categories (Qualitative)	No		
Overseas Territories and Crown Dependencies Reporting	Not occurring		
Completeness	No known omissions.		
Major improvements since last submission	Source category newly included.		

In titanium dioxide production CO_2 emissions arise from the consumption of carbon-containing reductants such as anthracite, coke or petroleum coke within the production process. In the UK throughout the inventory time series there have been only two titanium dioxide production plants, both using the chloride production process. Until 1997 one of the plants additionally used the sulphate production process, which does not give rise to CO_2 emissions.

Methodological Issues

Titanium dioxide manufacturers were contacted as part of this work and were able to confirm the type of reductant used and also provided some useful background on the scope of EUETS and PI data which was useful in developing the methodology for this sector. As with all chemical industry sectors, in the UK there are no annual production statistics for individual chemicals with which to compare / validate the emissions trends.

Table A.I.7 Plant-specific estimates of process and combustion emissions: UK Titanium dioxide production 1990-2013

<table>
<tr><th>Year</th><th>Source data</th><th colspan="2">Share of process emissions to total emissions</th></tr>
<tr><th></th><th></th><th>Greatham</th><th>Stallinborough</th></tr>
<tr><td>2013</td><td>Process emissions derived from the difference between PI (total CO_2) and EUETS (combustion CO_2 only).</td><td>Split calculated from reported data</td><td>Split calculated from reported data</td></tr>
<tr><td>2009-2012</td><td>Total CO_2 available from the PI.</td><td>Interpolation between split value in 2008 and split value in 2013</td><td>Average split value 2006-2008</td></tr>
<tr><td>2006-2008</td><td>2006-2008: Reporting of thermal and chemical CO_2 emissions in the PI.</td><td>No split calculated, reported chemical CO_2</td><td>Reported chemical CO_2</td></tr>
<tr><td>2002-2005</td><td>Total CO_2 available from the PI.</td><td>Interpolation between split value in 2001 and split value in 2006</td><td rowspan="2">Average split value 2006-2008</td></tr>
<tr><td>1998-2001</td><td>1998-2001, separate permits for combustion and titanium dioxide installation at one site, thus separate reporting in the PI.</td><td>Carbon dioxide + carbon monoxide emissions from the same plant (CO data for 1998-2000 was in addition to CO_2 emissions)</td></tr>
<tr><td>1990 - 1997</td><td>No emissions or production data available, therefore emissions are assumed to be the same as in 1998.</td><td></td><td></td></tr>
</table>

Uncertainties and Time Series Consistency

The uncertainty analysis in (NIR) **Annex 7** provides estimates of uncertainty according to IPCC source category and fuel type.

Uncertainty varies across the time-series. Uncertainty is lowest in 2006-2008 and 2013 were we have reported emissions. These data are based on reductant use & assumed/measured carbon content and the uncertainty is estimated at +- 5%. Data for rest of the period from 1998 is dependent on assumptions applied to total CO_2 and is therefore associated with higher uncertainty, estimated at +- 15%. For 1990-1997 we have no activity, emissions or production data from any of the UK plant; the UK GHGI estimates are therefore highly uncertain (if the plant were, for example, mothballed or out of action for any reason during the period). Therefore the uncertainty is estimated to be +- 50% back to 1990.

Source-specific QA/QC and Verification
This source category is covered by the general QA/QC of the greenhouse gas inventory

2B7 Soda Ash Production (NIR TEXT)

Emission Sources	Sources included	Method	Emission factor
	2B7 Soda Ash	Tier 2	C
Gases Reported	CO_2		
Key Categories (Trends)	No		
Key Categories (Level)	No		
Key Categories (Qualitative)	No		
Overseas Territories and Crown Dependencies Reporting	Not occurring		
Completeness	No known omissions.		
Major improvements since last submission	Emissions re-allocated from Energy source categories and presented for this new source.		

Soda ash has been produced at two sites in the UK, both operating over the entire time period covered by the inventory and both using the Solvay process. Emissions from the energy use of fuels at these sites are included in data reported under 1A2c. Process CO_2 emissions occur due to non-energy use of carbon-containing reductants such as anthracite, coke or petcoke for the calcination of limestone. Part of the CO_2 from calcination is sequestered in the soda ash product.

Methodological Issues

Previous inventory submissions based on the methodological approaches of the 1997 Revised IPCC Guidelines have fully allocated emissions from fuel use to the energy sector (1A2c), assuming that all CO_2 from the calcination of limestone is stored in the produced soda ash. The 2006 IPCC Guidelines indicate that this is not the case as more CO_2 is produced than is stoichiometrically required for the production of the soda ash. Process emissions from soda ash production have thus been included for the first time with this submission. Emissions from the fuels used in the soda ash process have also to be included within 2B7 (i.e. re-allocated from 1A2f under the 1996 GLs)

Soda ash is made in the UK at two sites, both employing the Solvay process, and using coke oven coke in the lime kilns. Emissions for 1998-2012 have been reported in the Pollution Inventory, and the sites were both included in the EUETS for 2013 as well, so a detailed breakdown of emissions, including a split between energy and non-energy emissions is available for 2013.

The EUETS emissions for 2013 were significantly higher than the PI data for the same year, so we have assumed that there is a systematic difference between the two. The EUETS data are based on a carbon balance across the entire process, whereas it is probable that the PI data cover just some of the emissions. Therefore the PI data for 1998-2013 are used to determine the trend in CO_2 emissions, and then derived emissions for 1998-2012 from the 2013 EUETS data using that trend.

Emissions in 1990-1997 are assumed to be the same as in 1998 since we have no emissions or production data for the plant. As with all chemical industry sectors, in the UK there are no annual production statistics for individual chemicals with which to compare / validate the emissions trends.

Uncertainties and Time Series Consistency

The uncertainty analysis in (NIR) **Annex 7** provides estimates of uncertainty according to IPCC source category and fuel type.

Uncertainty varies across time-series but is significantly lower in 2013 than in other years. For 2013, reported emissions based on a full carbon balance are available and therefore the uncertainties are estimated to be low at +- 5%. For the years 1998-2012, total CO_2 emissions are reported in the PI, but based on the relationship between EUETS and PI data in 2013 it has been assumed that these PI data returns systematically under-estimate the total plant emissions and the study team has opted to take a conservative approach and scaled-up the PI emissions accordingly.

This 'correction' may not be appropriate, or may over- or underestimate any systematic error that does exist in the PI data. Therefore, based on the size of this correction, the uncertainty is estimated to be +-50%. For 1990-1997 there are no data available on activity, emissions or production and therefore 1998 data are used as the best estimate. Either of the two plant could have been mothballed or out of action for a period, or production may have been considerable higher in that period and therefore the uncertainty is estimated to be very high, at +- 70%.

Source-specific QA/QC and Verification

This source category is covered by the general QA/QC of the greenhouse gas inventory.

2B8 Petrochemical and Carbon Black production (NIR TEXT)

Emission Sources	Sources included	Method	Emission factor
	2B8: Methanol Ethylene Ethylene Dichloride Ethylene Oxide Acrylonitrile Carbon black	Tier 2, Tier 1	C, D
Gases Reported	CO_2, CH_4		
Key Categories (Trends)	No		
Key Categories (Level)	No		
Key Categories (Qualitative)	No		
Overseas Territories and Crown Dependencies Reporting	Not occurring		
Completeness	No known omissions.		
Major improvements since last submission	Source category newly included.		

Methodological Issues

Methanol production occurred at a single site in the UK until 2001, and this process was integrated with ammonia production on the same site. Emissions from the steam-reforming used to produce raw materials for both the ammonia and methanol plant is included in 2B1. Methane emissions from the methanol plant are already included in the GHGI and do not require any revision.

Ethylene production is carried out at 3 sites currently in the UK. Emission estimates for both methane and CO_2 are already included in the GHGI and do not require any revision.

Ethylene dichloride (EDC) has been produced at 4 sites over the period covered by the GHGI, although only 1 is still in operation, and only some of the processes used the direct chlorination route that causes process emissions of CO_2. In 1987, UK capacity for EDC by the direct chlorination route was 500,000 tonnes, at 2 sites (Chemical Intelligence Services, 1987). One of those two sites closed in 1999, but capacity at the other site is understood to have been increased to at least partially offset the closure. In the absence of definitive data or information from chemical industry experts, the study team has assumed that 500,000 tonnes per year is the best available UK production estimate for UK EDC capacity across the full time-series of 1990-2013. CO_2 emissions data are reported in the PI for the sites, however these emissions are likely to be dominated by emissions from co-located combustion plant. These emissions are already included in the UK GHGI in 1A2c, therefore, we have estimated process emissions only, using the Tier 1 emission factor given in the 2006 GLs of 11.3 kg CO_2 / tonne EDC and assuming that annual production is 500,000 tonnes i.e. the maximum possible, consistent with our estimates of UK plant capacity. This estimate is used across the time series.

Ethylene oxide (EO) was produced at a single UK plant between 1990 and its closure in January 2010. The operator reported emissions of CO_2 in the PI between 1995 and 2009, and these data have been assumed to be wholly due to the EO process i.e. not to include any CO_2 from fuel combustion. This assumption is consistent with the IPPC permit documentation for the process (see Annex 3) which makes no mention of any fuel combustion plant in the description of the permitted process. For the period 1990-1994, where we have no reported data, CO_2 from EO production is assumed to be the same as in 1995. A very low level of methane emissions from the EO plant are also reported in the PI for a few years; a time-series of emission estimates has been derived by extrapolating and interpolating from the reported methane emissions data in the PI.

Acrylonitrile has been_manufactured at a single UK site since 1990, and CO_2 emissions for this site are already included in the UK GHGI together with the CO_2 emissions from ethylene crackers and other petrochemical sites. Methane emissions from the plant are reported in the PI for a few years, but are trivial. A time-series of emission estimates has been derived assuming that methane emissions are similarly trivial in other years.

Carbon black was manufactured at two UK sites, until their closure at the very start, and in the middle of 2009 respectively. Most of the production was of furnace black. Emissions of CO_2 at one site were reported in the PI between 1998 and 2009, while at the other, emissions were reported between 2003 and 2008 (this site closed at the start of 2009, so emissions in 2009 are assumed zero). The emissions reported in the PI are assumed to be 100% from process sources, and emissions in earlier years for which we have no PI data are assumed to be at the same level as in the earliest year for which data exist. A very low level of methane emissions from the carbon black plant are also reported in the PI for a few years; a time-series of emission estimates has been derived by extrapolating and interpolating from the reported methane emissions data in the PI.

Uncertainties and Time Series Consistency

The uncertainty analysis in (NIR) **Annex 7** provides estimates of uncertainty according to IPCC source category and fuel type.

Emission estimates are based on a mixture of PI and/or EUETS data with estimates for earlier years always based on the assumption that emissions are as in later years. No UK-wide activity data (production data) are available with which to generate a better time series, but this does mean that the earlier part of the time-series for all of the chemical industry sectors is particularly uncertain. EUETS-based emissions are considered the most reliable basis for estimates in the GHGI and the uncertainty is estimated to be +- 5%. PI data are more uncertain, because it is not clear what methods are used and the emission sources (combustion, process, other) are not transparent. Uncertainty for GHGI estimates based on the PI data is estimated to be +- 15. Emissions data for methane are likely to be more uncertain than those for CO_2 since the former are often fugitive in nature, or minor components in stack emissions (thus requiring stack monitoring to quantify). The uncertainty estimates for the petrochemical sector emission sources are presented in Table AI7.

Table A.I.8 Uncertainty estimates for petrochemical sources

Source	Uncertainty estimate for CO_2	Uncertainty estimate for CH_4
Ethylene dichloride:	GLs Tier 1 EF +- 20%;	NO
Ethylene oxide	1990-1994 +-50%; 1995-2010 +/- 15%	+- 50%
Acrylonitrile:	IE	+-50%
Carbon black	1990-1997 +-50%, 1998-2002 +- 30%, 2003-2009 +-15%;	+- 50%

Source-specific QA/QC and Verification

This source category is covered by the general QA/QC of the greenhouse gas inventory.

2C5 Lead production and 2C6 Zinc production (NIR TEXT)

Emission Sources	Sources included	Method	Emission factor
	2 C5 Lead production 2C6 Zinc production	Tier 2	C
Gases Reported	CO_2		
Key Categories (Trends)	No		
Key Categories (Level)	No		
Key Categories (Qualitative)	No		
Overseas Territories and Crown Dependencies Reporting	Not occurring		
Completeness	No known omissions.		
Major improvements since last submission	Source category newly included.		

Methodological Issues

Lead and zinc were smelted at a single plant in the UK until 2003, using the Imperial Smelting Process (ISP). This involved the use of coke oven coke as a reductant in a blast furnace, but fuels were also used onsite in the sinter plant, and in the zinc refinery. Some limestone may also have been added to the blast furnace. Coke oven coke is also thought to have been used in two other processes – a very large tin smelting operation, which closed in 1991, and a small copper refinery, which closed in 1997.

Emission estimates cannot be derived separately for these three sites: the lead/zinc smelter and the copper refinery reported in the PI but the CO_2 emissions would have included (and likely to be dominated by) emissions from fuels used in combustion plant. No emissions data at all are available for the tin smelter.

Emission estimates for these processes are therefore derived from the Digest of UK Energy Statistics (DUKES), since these annual statistics report the annual quantities of coke oven coke used in the ferrous metals industry. It has been assumed that all coke reported in these statistics is used for these three processes and that the carbon contained is fully emitted. The statistics have reported no coke used in the non-ferrous metal sector since the closure of the last of the three processes in 2003, and also show a very large decrease in coke use following the closure of the tin smelter. This evidence indicates that the assumption to use DUKES data is a good basis for the IPPU emission estimates.

Uncertainties and Time Series Consistency

The uncertainty analysis in (NIR) **Annex 7** provides estimates of uncertainty according to IPCC source category and fuel type.

The coke consumption data in DUKES are assumed to be very reliable because coke would have been available from only a handful of UK producers, plus imports, and would have been supplied to only 3 UK production sites in the non-ferrous metal sector. The UK GHGI estimates assume all carbon in the coke was emitted, which is also highly likely. However, there are no reliable data available for these closed plant from which to generate estimates of CO_2 emissions from the possible use of other raw materials such as from limestone used in the lead/zinc process. Whilst the overall UK statistics for limestone use (from the British Geological Survey) are all accounted for in the UK GHGI (and therefore we are confident that there is no gap in the UK estimates overall), the sector-specific estimates for 2C6 may be under-reported and for this reason, the 2C6 emissions are estimated to be accurate to +- 10%.

Source-specific QA/QC and Verification

This source category is covered by the general QA/QC of the UK greenhouse gas inventory.

Annex II GHG Emission and Projection Estimates: 1990-2013, 2014-2035

The tables and charts below present the summary of the recommended emission and projection estimates for all IPPU sources covered in this study.

Figure A.II.1 IPPU source category CO_2 emissions and projections, 1990-2013, 2014-2035 (kt Carbon)

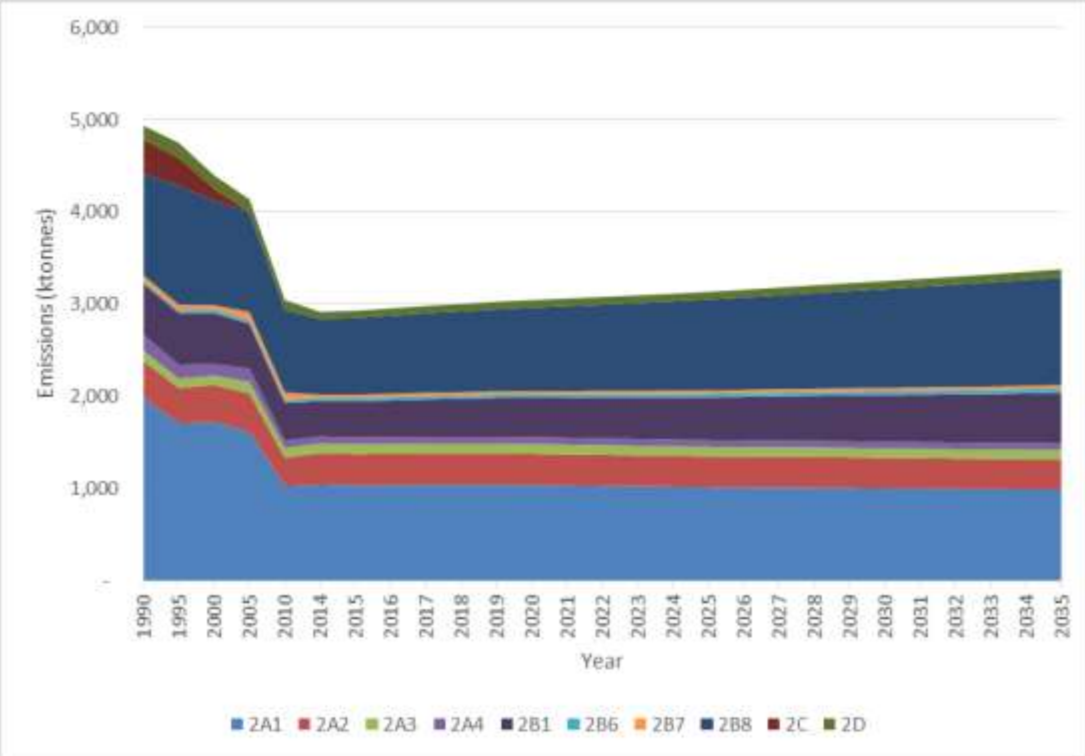

Figure A.II.2 IPPU source category CO_2 emissions in 2013 (kt Carbon)

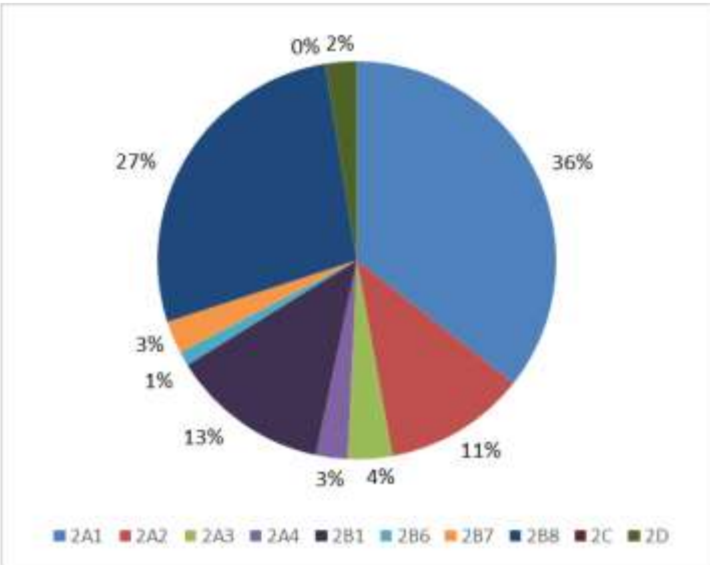

Table A.II.1 IPPU Sector Emissions and Projections of Carbon, 1990-2013, 2014-2035 (kt Carbon)

kt Carbon	Emission Year -> Projections											
CRF Category	1990	1995	2000	2005	2010	2012	2013	2015	2020	2025	2030	2035
2A1: Cement Production	1,990	1,714	1,727	1,620	1,034	1,013	1,043	1,043	1,044	1,023	1,012	1,000
2A2: Lime Production	399	380	402	416	305	321	338	338	338	332	328	324
2A3: Glass Production	111	104	101	127	109	104	106	106	106	104	103	102
2A4d: Other Carbonates	176	148	128	141	80.2	70.9	75.3	75.3	75.4	73.9	73.1	72.2
2B1: Ammonia Production	547	560	547	485	406	429	377	390	425	462	502	547
2B6: Titanium Dioxide	28.5	28.5	39.1	38.0	30.9	29.9	33.7	34.8	37.9	41.2	44.8	48.8
2B7: Soda Ash	63.1	63.1	48.1	92.9	82.8	80.4	77.8	36.5	35.4	34.8	35.0	35.3
2B8c: Ethylene Dichloride	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.7	1.9	2.1	2.2
2B8d: Ethylene Oxide	35.7	35.7	41.9	20.2	0	0	0	0	0	0	0	0
2B8f: Carbon Black	119	119	110	84	0	0	0	0	0	0	0	0
2B8g: Petrochemicals	944	1134	974	971	893	882	803	830	903	982	1069	1163
2C5 Lead and 2C6: Zinc Production	371	300	136	0	0	0	0	0	0	0	0	0
2D1: Lubricants -Road veh. engines	51.4	52.5	41.2	36.3	37.4	32.2	32.2	31.6	30.4	28.8	27.8	27.8
2D1: Lubricants –Agric. engines	2.9	3.6	1.9	0.9	0.7	0.5	0.5	0.5	0.6	0.6	0.6	0.6
2D1: Lubricants - Industrial engines	78.6	89.0	89.5	87.0	58.3	35.5	36.5	38.8	43.3	46.3	49.7	53.2
2D1: Lubricants - Marine engines	8.7	9.2	5.7	4.7	3.3	2.5	2.5	2.5	2.5	2.5	2.5	2.5
2D2: Petroleum Waxes	9.0	7.2	5.3	11.7	6.5	5.3	3.5	3.5	3.5	3.5	3.5	3.5
Aircraft engines - International – (Memo Item)	0.5	0.5	0.3	0.9	0.7	0.6	0.6	0.6	0.6	0.7	0.7	0.7
Total (excludes memo item)	4,936	4,749	4,399	4,138	3,048	3,009	2,930	2,932	3,047	3,137	3,253	3,381

Table A.II.2 IPPU Sector Emissions and Projections of Methane and Nitrous Oxide, 1990-2013, 2014-2035 (kt gas)

	Emission Year -> Projections											
CRF Category	1990	1995	2000	2005	2010	2012	2013	2015	2020	2025	2030	2035
kt Methane												
2B8a: Methanol	0.03	0.03	0.03	0	0	0	0	0	0	0	0	0
2B8b: Ethylene	0.6	0.7	0.9	1.3	0.7	1.6	1.4	1.5	1.6	1.8	1.9	2.1
2B8d: Ethylene Oxide	0.35	0.35	0.42	0.02	0	0	0	0	0	0	0	0
2B8e: Acrylonitrile	0.047	0.047	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.007
2B8f: Carbon Black	0.009	0.009	0.009	0.010	0	0	0	0	0	0	0	0
2B10: Other chemicals	7.4	6.1	2.9	2.2	3.3	2.4	2.7	2.7	3.0	3.3	3.5	3.8
Total (all CH_4)	8.5	7.3	4.2	3.5	4.0	3.9	4.1	4.2	4.6	5.0	5.5	5.9
kt Nitrous oxide												
2B2: Nitric Acid Production	13	9	14	7	4.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2
2B2: Adipic Acid Production	67	39	4	3	0	0	0	0	0	0	0	0
Total (all N_2O)	79.8	48.0	17.9	9.5	4.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2

Annex III References

British Ceramic Confederation (2014). Personal communication (Andrew McDermott) confirmed that the proposed approach to generate new estimates from EUETS data was the best available data to use together with a time series of production data. Also provided examples of the industry guidance documents used by BCC members to estimate emissions. The guidance includes emission factors for different clay types, based on measurements. Not aware of any factors that would significantly change emissions in the foreseeable future.

British Glass (2014). Personal communication (Lucinda Heneghan) confirmed the veracity of historic emission estimates which deviate from British Geological Survey statistics and draw upon British Glass activity data trends to present more accurate sector data. Not aware of any factors that would significantly change emissions in the foreseeable future.

Chemical Intelligence Services, Chem-Facts United Kingdom,1987 edition

Cristal Tioxide (2014). Personal communication (Stephen Blair) provided commercially sensitive information on the emission sources from the tioxide manufacturing facility which the project team has taken into consideration in the analysis of Energy and IPPU emission estimates. Not aware of any factors that would significantly change emissions in the foreseeable future.

DBIS (2014). “Strategy for delivering chemistry-fuelled growth of the UK economy”, including estimated growth indices for the sector under a range of policy scenarios, including a baseline scenario, utilised in the derivation of the IPPU projections.

DECC (2014). Personal communication (David Wilson) to provide underlying analysis with industry-specific economic indices and fuel use trends, consistent with the DECC UEP of September 2014, for use in deriving the IPPU projections estimates.

Ecofys (2009), “Methodology for the free allocation of emission allowances in the EUETS post 2012: Sector report for the chemical industry”. http://www.ecofys.com/files/files/091102_chemicals.pdf This report on the allowances for EUETS for the European Commission indicates UK production capacity of carbon black, and also indicates zero UK production of glyoxal and the acid – the only producers are noted as Germany, France and one site in Austria that closed in 2003.

Enger (1995). Pyrometallurgy article “Reflections on the future of the ferro-alloy industry in Western Europe” (1995), available at: http://www.pyrometallurgy.co.za/InfaconVII/079-Enger.pdf. This paper indicates no UK ferro-alloy production in 1995. (Map of EU sites provided.)

Environment Agency (2014). Personal communication (Les Thomas / Paul Nash) from the Agency’s chemicals sector leads. Reviewed the historic time series and made recommendations to consider the 2012 BIS study “Chemicals Growth Strategy” as the best available reference to inform UK chemical sector growth linked to emissions trends for 2B sources, in preference to sector indices from the DECC Updated Energy Projections.

Environment Agency (2014). Personal communication (Paul Stevens) from the Agency’s minerals sector lead reviewed the draft projections. Although energy-related emissions might be reduced, for example through the use of wastes or biofuels, did not expect clinker production to decrease significantly, or know of any planned site closures, so didn't expect cement industry process emissions to change significantly.

Environment Agency (2014). Personal communication (Dave Canham) from the Agency's metals sector lead to review the historic data and advise on likely future trends for the sector in comparison to draft projections proposed to follow sector indices used to underpin DECC Updated Energy Projections.

GTS (2008). "UK Glass Manufacture 2008 : A Mass Balance Study", Edgar et al, Envirowise.

Huntsman Tioxide (2014). Personal communication (Robert Bird) provided commercially sensitive insights into the emission sources from the tioxide manufacturing facility which the project team has taken into consideration in the analysis of Energy and IPPU emission estimates. Projections insights also provided.

ISIS European Chemical Profile: caprolactam (2010). Information from ICIS website http://www.icis.com/resources/news/2010/11/22/9411972/european-chemical-profile-caprolactam/ which supports other evidence that there is no UK production of caprolactam. The site indicates EU production capacity in 2010 – zero in UK. There are plant in Belgium, Russia, Ukraine, Netherlands, Spain, Poland, Belarus, Germany, Czech Republic. Consistent with other references such as ChemFacts 1991 (covers UK chemical production sites).

ISSB (2014). Personal communication (Sophie Fatoba) of the Iron and Steel Statistics Bureau to clarify that no ferro-alloy manufacturing plant are currently operating in the UK and hence there are no such production data within ISSB national statistics.

Mineral Products Association (2014). Personal communication (Diana Casey) confirmed the veracity of historic emission estimates, the scope of MPA data and provided insight into future trends for the sector.

Mineral Products Association (2014). Personal communication (Sian Hill) of the British Lime Association to confirm that the UK GHGI historic emission estimates are complete and accurate. No specific insight into future industry trends available.

Steel Founders Society of America (2011). Presentation on global production of ferro-alloys for the steel foundry industry, at: http://www.sfsa.org/meetings/spring11/alloys.pdf The presentation provides an overview of world producers of a range of ferro-alloys, with no indication that UK produces any such materials, supporting other evidence that emissions from ferro-alloy manufacture do not occur in the UK. United States Geological Survey data from 2010 is cited as the source for EU production which is dominated by plant in Norway, Finland and France.

Tata Chemicals (2014). Personal communication (Stephen Weston) to clarify use of different fuels and reductants in soda ash manufacturing facilities.

<u>Consultees within EU Members States</u>

EU Member State contacts consulted on the implementation of the IPCC 2006 GLs:

- Netherlands, Tinus Pulles, TNO, September 2014
- Denmark, Ole-Kenneth Nielsen, DCE, October 2014
- France, Julien VINCENT citepa, September 2014
- Germany, Michael Strogies, UBA-B, September 2014
- Ireland, Paul Duffy, EPA Ireland September 2014

· Italy, Daniela Romano, ISPRA, October 2014
· Czech Republic, Dusan VACHA, Czech Accreditation Institute October 2014
· Luxembourg, Marc SCHUMAN, Administration de l'Environnement, September 2014

EU Member State contacts consulted with regards to approaches to emission projections:

· Netherlands, Coenen, P.W.H.G. (Peter), TNO, November 2014
· Germany, Sabine Gores, Oeko-Institut, December 2014
· Ireland, Bernard Hyde, EPA Ireland, November 2014
· Bulgaria, Rayna Angelova, Ministry of Environment and Water, December 2014
· Romania, Mihaela Smarandache, Ministry of Environment, December 2014

List of IPC/IPPC Permit Documents Reviewed

Britannia Zinc Limited (zinc)
Kingsweston Lane, Avonmouth, Bristol, BS11 8HT
Area: Wessex
IPC permit was **AS7396.** There was also at least one variation – **BG4607**

Sevalco Limited (carbon black)
Severn Road, Avonmouth, Bristol, BS11 0YL
Area:Wessex
EPR Ref **YP3538LY**. This was surrendered in 2011. IPC permit was **AF7916** (and a variation – **BJ0064**)

Cabot Carbon Limited (carbon black)
Lees Lane, Stanlow, Ellesmere Port, South Wirral, L65 4HT
Area Greater Manchester Merseyside and Cheshire
EPR Ref **BS5142IK**. Surrendered 2011. IPC permit was **AF8343**, with a variation **BQ4157**

Brunner Mond & Company Limited (lime kilns and soda ash) - now Tata Chemicals Europe
Winnington Site, Winnington, Northwich, Cheshire, CW8 4DT
Area Greater Manchester Merseyside and Cheshire
EPR Ref **SP3630BE**. The IPC permits were **AO0377** (lime kilns) and **AO0393** (soda ash manufacture).
.
Brunner Mond & Company Limited (soda ash) - now Tata Chemicals Europe
Lostock Site, Lostock, Northwich, Cheshire
Area Greater Manchester Merseyside and Cheshire
EPR Ref **SP3430BF**. The IPC permits were **AO0407** (lime kilns) and **AO0385** (soda ash manufacture).

Tioxide (Europe) Limited (titanium dioxide)
Grimsby Works, Moody Lane, Grimsby
Area: Lincolnshire and Northamptonshire
EPR Ref **NP3438SE**. IPC permit was **AL8282**

Tioxide Europe Limited (titanium dioxide)
Greatham Works, Tees Road, Hartlepool, Cleveland, TS25 2DD
Area: Northumberland Durham and Tees
EPR Ref **TP3532PK**. The IPC permits were **AA2305**, covering the site boiler/CHP plant, **AL8363** covering the TiO_2 manufacture.

SCM Chemicals-Europe (titanium dioxide)
Stallingborough, Grimsby, South Humberside, DN40 2PR
Area: Lincolnshire and Northamptonshire
EPR Ref **UP3537SJ** Millennium Inorganic Chemicals and Cristal Pigment Ltd.

London & Scandinavian Metallurgical Co Limited (ferroalloys)
Fullerton Road, Rotherham, South Yorkshire, S60 1DL
Area: Yorkshire. EPR Ref **BK6866IW** seems to cover the ferroalloy production. The IPC permit was **AQ8824.** IPC permit AV2676 and EPR Ref BQ3916IQ, transferred to GP3639ZY in 2013

Climax Molybdenum UK Ltd (ferroalloys)
Needham Road, Stowmarket, Suffolk, IP14 2AE
Area: Essex Norfolk and Suffolk
EPR Ref **BL1240IC**. IPC permit was **AS7337**

Ferro Alloys and Metals Ltd (ferroalloys)
Surrey Street, Glossop, Derbyshire, SK13 9AL
Area; Greater Manchester Merseyside and Cheshire
IPC permit was **AS8929**

Further information on selected data sources

The Pollution Inventory and other regulators' inventories.
The Pollution Inventory (PI) has, since 1998, provided emission data for the six Kyoto gases and other air pollutant for installations regulated by the Environment Agency (EA) in England and Natural Resources Wales (NRW) in Wales. The PI does contain some earlier data as well, with carbon dioxide emissions at some sites reported from 1994 onwards. The Scottish Pollutant Release Inventory (SPRI) covers processes regulated by the Scottish Environment Protection Agency (SEPA), and contains data from 2002 and 2004 onwards. The Northern Ireland Pollution Inventory (NIPI) covers processes regulated by the Department of the Environment (Northern Ireland) and includes data for 1999 onwards. Most of the processes of interest to this study are, or were, located in England, therefore the PI is the most important source of data. These three sets of data are subject to some very significant limitations:

- emissions of each pollutant are reported for each permitted installation as a whole, so emissions data for carbon dioxide, for example, can cover emissions from fuel use as well as from an industrial process. No information is given on what the source of emissions is, so a judgement has to be made about the scope of reporting.
- permitting arrangements have changed over time, so the reporting of data is not on a consistent basis across the time-series. In general, the tendency has been to reduce the number of permits, so that whereas in the early 1990s there might have been separate permits at an industrial installation covering the boiler plant and the chemical processes, from the late 1990s onwards the tendency would be to issue a single permit to cover both. Therefore, the problems with the scope of emissions data mentioned in the first bullet point are most severe for the second half of the GHGI time series.
- Since 1998, process operators need only report emissions of each pollutant if those emissions exceed a reporting threshold. So, if the emissions from an installation are less than 10,000 tonnes in the case of CO2, or 10 tonnes in the case of methane, data are not available. Reporting thresholds are irrelevant for many of the sectors of interest to this study, since emissions would be many times higher than the thresholds, but the reporting thresholds do mean that it is necessary to consider whether the data available in the PI (and in the SPRI & NIPI for later years) will be complete,

Despite these limitations, the PI data in particular are one of the most valuable sources of information for this project.

Information from Environmental Permits

A team member visited the Environment Agency office for North London and Hertfordshire on September 24 in order to review the information stored on the National databases, accessible via the Public Register. The aims of this visit were to identify documents that would help to confirm GHG emissions arising from the processing of materials within the selected IPPU sectors and to determine the quantities of raw material used by these processes. In addition it was also hoped this approach may shed further light on the production practices in place, providing useful background data to be used in the calculation of emissions. Our team member viewed all available documents for selected installations performing among other production of soda ash or titanium dioxide.

Annex IV Key findings from EU Monitoring Mechanism Regulation Workshops and EU Inventory Expert Contacts

This annex provides the results of a consultation with inventory agency contacts in other Member States, to review the approaches to reporting under the 2006 GLs that are expected to be adopted by other MS. Information has been gathered from a number of EU experts from Denmark, Germany, Italy, Czech Republic, Ireland, Luxembourg, The Netherlands and France to identify and discuss any uncertain or ambiguous reporting allocations, building on work at EU-wide stakeholder workshops that aimed to develop consensus on reporting decisions under the new MMR.

Key issues covered through this consultation included:

- Methodology definitions for lime production
- Completeness discussions for ceramics production
- Allocation discussions regarding ammonia and ethylene production
- Requirement for indirect emissions of CO2 and N2O
- Completeness of reporting of emissions from urea uses

These discussions and conclusions provided information applicable to this project to better inform the project team of the current status and remaining issues concerning other Member States.

2A2 Lime production

Difference between Tier 2 and Tier 3
The differences between tier 2 and tier 3 methods related to the treatment of lime kiln dust (LKD) were discussed at the Dessau workshop organised by UBA Germany in March.

Tier 3 for lime production is the same as the Tier 3 for cement production, with one minor difference. Instead of collecting information on cement kiln dust, data on the quantity and fraction of calcination achieved of LKD should be collected.

It was confirmed that where a tier 3 method based on plant-specific carbonate input is used which is already adjusted for the amounts of filter dust, it is correct to assume that the subtraction due to the LKD factor in the tier 3 equation should not be applied.

> Where a Tier 3 method based on plant-specific carbonate input in lime production is used, the subtraction due to the LKD factor in the tier 3 equation should not be applied.

Allocation of emissions from lime produced by the iron and steel industry
2A2 Lime production should include emissions from lime production at sugar mills and captive lime production in the iron and steel sector according to the Section 2.3.1.1 of the new GLs, which indicates that all marketed and non-marketed production of lime should be reported under Lime Production.

2A4a Ceramics Production

The 2006 IPCC Guidelines include a new source category of emissions from 2A4a ceramics production which requires collecting either data on clay consumption or ceramics production and the carbon content in the raw material (clay) may not always be readily available.

This category does not include emissions from Bricks (emissions should be reported under 2A4d Other) and it is unclear whether emissions from Tiles are included.

Many MS do not have data on the raw material use in all these subcategories. It is not possible to do a bottom up approach as the EUETS threshold does not always include the whole industry under its reporting.

Some MS assume that all ceramic and tiles production that are not included in the ETS are insignificant (very small) and will qualify under the NE threshold. This could be a solution but is likely to be scrutinised by the expert review teams from the UNFCCC and therefore tier 1 estimates may be needed to prove the below threshold "NE".

Some MS report emissions from ceramics, bricks and tiles using bottom up installation approaches so the main issue under this sub-category is how to ensure completeness.

> Most MS report emissions from ceramics, bricks and tiles using bottom up approaches so the main issue under the sub-category other process uses of carbonates is how to ensure completeness.

2B1 Ammonia production

Treatment of exports and imports of the CO_2 recovered in ammonia production
Following discussions at the Workshop on 2006 IPCC methods in Brussels in June 2014 it was concluded that when reporting urea use, exports should be deducted and imports included. If CO_2 captured for downstream uses is no longer reported with ammonia production but in categories where the products are used, exports should be deducted as the CRF footnote refers to 'use within the borders of the country'. The imported products should be taken into account in the inventory similar to the application of urea fertilizers.

> If CO_2 captured for downstream uses is no longer reported with ammonia production but in categories where the products are used, exports should be deducted and imports included.

Treatment of CO_2 recovery in ammonia production
The 2006 IPCC Guidelines changed the reporting practice concerning the allocation of CO_2 emissions from ammonia production/urea. In the current IPCC methodology urea production based on CO_2 emissions from ammonia production was considered short term storage and hence not subtracted from ammonia production. In the 2006 IPCC Guidelines this has been changed so that the CO_2 emissions recovered from ammonia production are subtracted from the ammonia production category and reported where the recovered CO_2 is used (e.g. use of urea in agriculture and from catalysts). However, quantities of CO_2 for later use and short-term storage should only be deducted from CO_2 emissions in the ammonia production category except when the CO_2 emissions are accounted for in the other downstream categories.

The CO_2 recovered for industrial gas applications is a relatively low volume short term use and it is assumed that all industrial gas carbon will be emitted to the atmosphere in the producing country. Therefore, this is often included under the ammonia production category.

In Germany, CO_2 recovered is used for urea fertilizers and as technical CO_2. The CO_2 recovered used for urea will be subtracted.

In Italy, the single ammonia production plant reports the CO_2 recovered. It is used for urea fertilizers and as technical gas as well. Under ETS the plant reports the amount of CO_2 recovered by providing a country-specific emission factor and this amount will be estimated and reported by inventory compilers under urea use.

In Belgium, CO_2 recovered is used to produce limestone. Currently Belgium subtracts the amount of CO_2 recovered because the amounts of lime use reported under LULUCF are much higher so Belgium is assuming that they are accounted for under LULUCF.

For transparency it is suggested that the NIR includes a simple table in with the total CO_2 process gas emitted and then a breakdown of where it is reported in the inventory across different source categories (such as urea use in fertiliser).

In most MS with ammonia production, CO_2 recovered is used for urea fertilizers and as technical CO_2. The CO_2 recovered used for urea will be subtracted.

Fuel used for energy in ammonia production

According to the 2006 IPCC GLs and a footnote in the corresponding CRF tables, there is no distinction made between energy fuel and feedstock emissions with all emissions accounted for in the IPPU Sector. Such an approach might cause problems in the energy sector (e.g. when integrated with other chemicals production).

A number of MS use energy balance “Feedstocks” data to estimate emissions for IPPU from ammonia production. Other MS have found that other data (e.g. from industry and EUETS) contradict energy balance data and therefore use plant specific data for country specific data. A number of MS have problems with the new 2006 IPCC approach as their energy balance provides explicit and accurate estimates of energy use in ammonia production. These MS will continue reporting emissions from feedstock in IPPU and emissions from the fuel used for energy in the energy sector.

Other MS will follow the new 2006 IPCC guidance and combine energy and process emissions into 2.B.1 ammonia production.

MS, at the Brussels workshop June 2014 (2006 IPCC), noted that it is worth looking at EUETS data to see if it has a useful breakdown of emissions from Ammonia plant

Most MS with ammonia production plan to allocate all of the gas use for ammonia production (fuel and feedstock) into IPPU as suggested by the 2006 IPCC GLs.

2B8b Ethylene Production

Allocation of CO_2 emissions

The reporting of CO_2 emissions from ethylene production is a new requirement under the 2006 IPCC GLs. The default value can lead to a double-counting with the energy sector (consumption of residual gases). Conversion processes in chemical industry are normally outside of the energy balances. System boundaries are not clearly defined and the product structure is complex. The development of a carbon balance for ethylene production (as required by the new Guidelines) might be not possible.

During the Brussels June 2014 workshop on 2006 IPCC there was a question that could not be answered on the origin of the CO_2 from this sub-category. The following provides a summary from 2006 IPCC:

1. 2006 IPCC volume 3 page 3.58: The steam cracking of petrochemical feedstocks to produce Ethylene also produces by-product hydrogen and methane and C4+ hydrocarbons that are generally burned for energy recovery within the process.
2. 2006 IPCC volume 3, Box 3.10 page 3.59: For ETHYLENE DICHLORIDE AND VINYL CHLORIDE MONOMER, the oxychlorination process produces a process off gas containing by-product CO2 produced from the direct oxidation of the ethylene feedstock.
3. 2006 IPCC volume 3 page 3.60: Ethylene oxide (C2H4O) is manufactured by reacting ethylene with oxygen over a catalyst. The by-product CO2 from the direct oxidation of the ethylene feedstock is removed from the process vent stream using a recycled carbonate solution, and the recovered CO2 may be vented to the atmosphere or recovered for further utilization

Most MS allocate CO_2 emissions from ethylene production under combustion.

Comparison between Tier 1 and Tier 2

Austria have published a feedstock-based EF (year 2000) much lower than the product-based default EF. Germany have also calculated an EF based on the amount of naphtha and ethylene from national statistics and using a carbon content factor of 0.800 for the other products and the CO_2 emissions are considerable lower than with the tier 1 method calculation.

2D1. & 2D2. Non-energy products from fuels and solvent use

The 2006 IPCC GLs include two new source categories: 2D1 Lubricant use and CRF 2D2 Paraffin wax use.

Denmark and France have activity (imports/exports and production) data available so can apply tier 1 estimates for 2D1 and 2D2.

Italy has data for lubricants from the petrochemical bunkers and it is assumed they are consumed in marine international bunkers.

Denmark uses statistics on volume and weight of asphalt used and a fixed EF. For Solvent use Denmark follows a chemical based approach using the carbon content of the different chemicals and a database on the different use of chemicals as solvents which allows them to apply a tier 3 methodology.

Indirect GHG Emissions

Parties may (but are not required to) report indirect CO_2 and N_2O emissions. When indirect CO_2 or N_2O are not reported, total emissions including indirect gases are not required.

CO_2 emissions

The 2006 IPCC Guidelines estimate carbon emissions in terms of the species which are emitted. Most of the carbon emitted as these non-CO_2 species eventually oxidises to CO_2 in the atmosphere; and this amount can be estimated from the emissions estimates of the non-CO_2 gases. In some cases the emissions of these non-CO_2 gases contain very small amounts of carbon compared to the CO_2 estimate and it may be more accurate to base the CO_2 estimate on the total carbon. Volume 1 Section 7.2.1.5 provides an approach to estimating these inputs of CO_2 to the atmosphere. Examples are fossil fuel combustion (where the emission factor is derived from the carbon content of the fuel) and a few IPPU sectors where the carbon mass balance can be estimated much better than individual gases.

According to some MS, the conversion of NMVOC emissions to CO_2 equiv. using the 2006 IPCC GLs default values does not make scientific sense (it is not possible to identify all usages and amounts of all chemicals and carbon contents in the detail needed to get the correct quality to convert these NMVOC emissions in CO_2 equiv.). For this work to be done annually, as the amounts used vary from year to year, it would take considerable effort.

Other MS follow a chemical based approach using the carbon content of the different chemicals recorded in an annually updated database on the different use of chemicals as solvents.

N_2O emissions

The GPG2000 lists sources of anthropogenic nitrogen deposition that subsequently give rise to anthropogenic emissions of nitrous oxide (N_2O), but provides estimation methods only for a subset of these, associated with agricultural sources of ammonia (NH_3) and nitrogen oxides (NO_x). The 2006 IPCC Guidelines extend this approach to all significant sources of N deposition, including agriculture, industrial and combustion sources, with the ultimate N_2O emission attributed to the country responsible for the nitrogen originally emitted.

The reporting categories for the Convention on Long-Range Transboundary Air Pollution (LRTAP) are being updated to align with the greenhouse gas emissions reporting updates and requirements.

Allocation Issues

Catalyst refineries of emissions from catalyst regeneration in refineries

Member States have been discussing the allocation of emissions from catalyst regeneration in refineries. It is clear that due to differences in energy balance detail, EUETS reporting and interpretation of IPCC guidebooks, that MS allocate emissions to a range of different categories.

Considered as process emissions some MS had allocated emissions to 2.B.5 (Other Chemical Industry process) although this will not be possible from 2015 onwards due to changes in the CRF reporting structure. Some MS argue that allocation to the energy sector is the most appropriate (CRF 1.A.1.b), since fossil fuel residue is burned off and energy and heat are used in the process and there is usually heat recovery.

Although for the EU GHG inventory it is preferred that all MS report in the same way, the most important consideration is that emissions are transparently included (somewhere (1.A.1.b, 1.B.2 or 2.B.5) and not incomplete.

- Germany is still considering where to allocate these emissions for 2015 reporting. In German EUETS reporting some operators consider pet coke from catalyst regeneration as energetic use and that the regeneration process is combustion with energy recovery, while others consider it to be an industrial process focussed on cleaning the catalyst. Germany use a mix of EUETS and national energy statistics to complete its estimates for emissions from catalytic regeneration. Until now these emissions were reported in source category 2.B.5. Germany also considered reporting of emissions from catalyst regeneration in 1.B (Fugitive Emissions from Fuels). However, this would lead to poor transparency since the fugitive sector is very small (around 1.5 Mio t of CO2 in 1.B in 2012), so an additional reporting of 2 – 3 Mio t of CO2 would change this sector considerably.

- France currently reports these emissions under CRF 1B2a fugitive emissions using EUETS data from refineries (under catalyst regeneration).
- Greece, Hungary, the Netherlands, UK and Belgium are reporting these emissions in 1.A.1.b. (as reported in the energy balances).
- In the United Kingdom the GHG inventory includes three distinct types of "petcoke" with a range of country EFs (1. several industries such as cement and energy plants import and burn petcoke as a cheap alternative fuel, 2. the production and use of anode-grade coke, and 3. the refinery use of "petcoke" which is from fluid catalytic cracking catalyst regeneration). In the Digest of UK Energy Statistics (DUKES), the catalytic regeneration is reported as if it is an energy use of petroleum coke, and the UK reports all such emissions under 1A1b (it is reported in the energy balances as refineries own use and is cross-checked with EUETS data). Reporting under the EUETS varies; operators in the UK use several different methods (measurements, mass balances etc) and some choose to report the source as a process source "Refineries: Catalytic cracker regeneration" whilst others report it as "Combustion" of FCC coke.
- The Netherlands has petcoke in the energy balances and the same uses as the UK.
- In Romania only one operator reports the consumption of petroleum coke in the energy balances as a fuel, according to the statistical manual definition. It is not used for energy purposes (heat recovery) but just as a catalyst. Romania removes petcoke from the energy balances assuming that the EF for fugitive emissions already contains this kind of process emissions.

Emissions from catalyst regeneration in refineries are allocated by MS to CRF 2.B, CRF 1A1b or CRF 1B2a.

Carbonate use in flue gas desulphurisation
Currently MS report this in either 1.A (other) or 2 (Industrial Process) sector under decarbonisation of carbonate minerals.

The allocation of emissions related to carbonate use in flue gas desulphurisation has changed for 2015 reporting. The category “other” in the energy sector does not exist in the 2015 CRF reporting and the reporting sub-categories for energy production 1.A are all fuel-specific.

Under 2006 IPCC emissions should be allocated to the ‘source category where the carbonates are consumed’, which would mean the energy sector. This new allocation is consistent with ETS data or other plant-specific data used in energy sector. However, the 2006 IPCC GLs in the energy sector do not mention emissions from carbonates from desulphurisation and it is generally considered good practice to include only fossil fuels used for energy/heat generation in the sector. In addition, the 2006 IPCC methodological equations are fuel-specific and do not include limestone use in the sector. Including limestone consumption in the energy sector would influence the IEF of solid fuels and would increase differences and a lack of transparency between sectoral and reference approaches.

One MS plans to report emissions related to carbonate use in flue gas desulphurisation in the IPPU sector under “Other”, while discussions amongst MS concluded that reporting under 1.B.3 would be most appropriate. The 2006 IPCC Brussels workshop participants proposed to adopt a common approach by all MS.

Workshop participants proposed to adopt a common approach by all MS to allocate emissions related to carbonate use in flue gas desulphurisation.

Completeness of reporting of emissions from urea uses

Whereas the 2006 IPCC guidelines recommend that “all quantity of CO_2 recovered for downstream use in urea production must be subtracted from the total quantity of CO_2 generated”, the guidelines only recommend that “emissions of CO_2 from urea use should be accounted for in the corresponding sectors”. Apart from the lack of completeness, the switch of the allocation principle of emissions towards urea use, also potentially implies a shift of emissions to Parties which are net importers of urea fertilizers.

A significant weakness of the proposed new approach is that the 2006 IPCC Guidelines only consider two uses of urea, which are fertilizer in agriculture and for catalysts in road transportation. Urea may be used either by direct application on land or in manufactured products[8]. It could be impossible for most MS to get the detailed activity data for all of the relevant uses of urea. In addition, some MS confirmed that activity data is not available for all sources (e.g. urea use in navigation).

The 2006 IPCC Guidelines do not contain guidance on the completeness of emissions from all relevant urea uses and on estimating emissions for other uses than as fertilizers and as urea based catalysts. Therefore, the reporting of all urea uses is not mandatory.

Workshop participants agreed that the approach followed by Germany of only subtracting urea use as fertilizer and urea based catalysts in ammonia production and reporting the estimates under ammonia production, AFOLU and 2D3 ensures a complete and “conservative” reporting of the emissions. In that case one may be sure of not subtracting something that cannot be reported elsewhere in the inventory.

The 2006 IPCC Guidelines do not contain guidance on the completeness of emissions from all relevant urea uses and on estimating emissions for other uses than as fertilizers and as urea based catalysts. The approach followed by Germany of only subtracting urea use as fertilizer and urea based catalysts in ammonia production and reporting the estimates under ammonia production, AFOLU and 2D3 ensures a complete and “conservative” reporting of the emissions. In that case one may be sure of not subtracting something that cannot be reported elsewhere in the inventory.

[8] Some examples of other urea uses are feed additive for ruminants, urea-based herbicides or pesticides, in aquaculture, de-icing agents at airports and for other de-icing purposes, spread on coastal oil spills, materials such as urea formaldehyde and plastics, in melamine production, as an ingredient in the manufacture of resins, plastics, adhesives, coatings, textile anti-shrink agents, and ion-exchange resins, additive in fire retardant paints, tobacco products, and in some wines, ingredient in moisturising creams, in holistic medicine therapies, reductant in catalytic and non-catalytic reduction of combustion products in vehicles.

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