Department of Energy & Climate Change

GHG Inventory Research: Non-Energy Use of Fuels

Review of UK data on emissions of GHGs from chemical process feedstock and other non-energy uses of fossil fuels

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Final Report to the Department of Energy and Climate Change

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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
CCA	Climate Change Agreement
CRF	Common Reporting Format
DORS	Downstream Oil Reporting System
DUKES	Digest of UK Energy Statistics (the UK energy balance)
EA	Environment Agency of England and Wales
EU	European Union
EUETS	European Union Emissions Trading System
EUMM	European Union Monitoring Mechanism
IPCC	Intergovernmental Panel on Climate Change
IPPC	Integrated Pollution Prevention and Control
IPPU	Industrial Processes and Product Use
LPG	Liquefied Petroleum Gas
MS	(European Union) Member States
NEU	Non-Energy Use (of fuels)
NFM	Non-Ferrous Metals
NGLs	Natural Gas Liquids
PI	Pollution Inventory
PPRS	Petroleum Production Reporting System
SEPA	Scottish Environment Protection Agency
UKPIA	UK Petroleum Industry Association
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

The UK Greenhouse Gas Inventory (GHGI) is subject to annual reviews by UN Framework Convention on Climate Change (UNFCCC) experts; this is an important quality assurance mechanism to ensure that the UK GHGI meets international standards and is continually improving to achieve inventory data quality objectives of accuracy, consistency, completeness, comparability (with other reporting nations) and transparency. The UN expert reviewers conduct a range of quality checks, including a review of the emission estimates from carbon-containing materials that are reported within UK statistics as being used in Non Energy Use (NEU) applications in the UK, rather than being consumed as a fuel.

The UK Greenhouse Gas inventory (GHGI) includes estimates of emissions derived from feedstock materials that contain fossil carbon and are reported in the UK energy balance (Digest of UK Energy Statistics, DUKES) as consumed in non-energy use (NEU) applications. The approach in the UK inventory is to assume that emissions from NEU of these commodities are zero (and that the fossil carbon is therefore stored rather than emitted to atmosphere), unless evidence is available that indicates an emissive use of the feedstock. For many NEU applications of the feedstock materials, there is strong evidence and data from UK industry to enable the inventory agency to derive emission estimates with low uncertainty. For other commodities there is less documented evidence and therefore the emission estimates in the UK GHGI are based on limited data and expert judgement, and are subject to higher uncertainty.

UNFCCC reviewers analyse the UK GHGI estimates and compare them to the assumptions and estimates presented by other reporting countries, and against data from other reporting mechanisms such as the EU Emissions Trading System (EUETS). In recent UNFCCC reviews, potential gaps in the UK GHGI estimates relating to the potential use of NEU feedstock materials in emissive processes have been identified. It is therefore essential that the UK inventory data sources, assumptions and estimates are periodically reviewed and improved, where possible, to ensure that the UK GHGI estimates of emissions from NEU applications are complete, accurate and transparent using UK-specific data where available. This project addresses that need for periodic research and analysis, to minimise UK GHGI gaps and errors.

The study team has consulted extensively with statistical agencies, trade associations and other industry expert contacts in order to review the most uncertain and potentially emissive sources of GHGs from the reported NEU commodities. The research has gathered new data on emissive and non-emissive activities, as well as examining existing data sets, all as part of a thorough review of reported activity and emissions data via mechanisms such as the EUETS, in order to seek out data that can inform more accurate GHGI estimates in future inventory submissions.

The study findings have in many cases confirmed the validity of the method assumptions, data sources and reporting approach for UK emission estimates within the 2013 submission, including for: coal tars and benzole, ethane, propane, butane, naphtha, and bitumen.

For other commodities, the research has identified opportunities to improve current estimates, and a number of recalculations of GHGI emission estimates and revisions to reporting are recommended for future inventory submissions, including for: natural gas and petroleum coke.

Furthermore, through comparison against the reporting approaches used by other EU Member States, the UK's approach to reporting the Reference Approach inventory estimates (which is an energy sector verification mechanism required under the UNFCCC reporting commitments of all parties to the Convention) is recommended to be revised and simplified. The recommended changes to the Reference Approach method for the UK are primarily to ensure transparency and consistency with the methods adopted by other countries. As the Reference Approach is only a

verification mechanism, changes to the method will not affect the UK GHGI totals (which are calculated using a more detailed methodology referred to as the Sectoral Approach).

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 2014.

Supplementary information of a commercially confidential nature has been excluded from this report.

Introduction & Context

Many petroleum-based materials such as ethane, naphtha, petroleum coke, as well as other fossil-carbon-containing resources such as natural gas, are used within UK manufacturing processes as a feedstock material. These feedstock materials are not used directly as fuels, and in many cases the carbon from these feedstock materials is locked into products (such as plastics and rubber) and is regarded as “stored carbon” (i.e. not emitted to atmosphere). However, the use of these feedstock materials can also lead to emissions of carbon dioxide through product use, degradation or disposal, or from the use of carbon-containing process off-gases as a fuel in combustion.

The UK Greenhouse Gas inventory (GHGI) includes estimates of emissions derived from feedstock materials that contain fossil carbon and are reported in the UK energy balance (Digest of UK Energy Statistics, DUKES) as consumed in non-energy use (NEU) applications. These estimates of NEU in DUKES are based on the annual returns to DECC from energy suppliers, supplemented by surveys of industry and other economic sectors; the information provided to DECC typically indicates the annual sales of feedstock materials to UK companies for use in production processes. For example, sales of petroleum feedstock to chemical and petrochemical companies are explicitly presented within the annual reporting forms used by UK refiners to inform DECC as part of the DUKES compilation system.

The approach in the UK inventory is to assume that emissions from NEU of these commodities are zero (and that the fossil carbon is therefore stored rather than emitted to atmosphere), unless evidence is available that indicates an emissive use of the feedstock. For many feedstock materials that are used in UK industry, there are data reported via statistical agencies and environmental reporting mechanisms (such as the EUETS) that indicate that a proportion of the NEU allocation presented in DUKES is subsequently used in emissive applications, including:

- fossil carbon-containing off-gases, used for combustion in facility boilers; or
- products containing the “stored” carbon which are subsequently used / partly combusted / disposed and degraded with some proportion of the “stored carbon” in products ultimately emitted to atmosphere.

In other instances, the allocation of fuels to NEU in the UK energy balance is contrary to other statistical evidence from industry or surveys. For example, in the UK the allocation of petroleum coke to domestic and industrial combustion sources in the energy balance are missing for all years in the time series, whereas evidence from environmental reporting and research indicates that several industries use petroleum coke directly as a fuel or as an input to a fuel manufacturing process (e.g. cement kilns, domestic fuel manufacturers).

The inventory agency generates annual estimates to account for all emission sources that are derived from NEU allocations of commodities, effectively re-allocating a share of the DUKES NEU to either combustion or process emission sources in the inventory. The evidence that the inventory agency uses to make these estimates includes:

- annual reporting by plant operators (e.g. EUETS returns);
- periodic surveys or research by trade associations, research organisations, environmental regulators, such as to assess the fate of coal tars and benzole, petroleum coke or waste oils or the impact of regulations on solvents, waste, product design and use;

- information on the estimated split of stored: emitted carbon from feedstock chemicals in literature sources, including other country National Inventory Reports (NIRs), where UK-specific information is not available.

Therefore, for many NEU applications of the feedstock materials, there is strong evidence and data from UK sources to enable the inventory agency to derive emission estimates with low uncertainty. For other commodities there is less documented evidence and therefore the emission estimates in the UK GHGI are based on limited data and expert judgement, and are subject to higher uncertainty.

UNFCCC reviewers analyse the UK GHGI estimates and compare them to the assumptions and estimates presented by other reporting countries, and against data from other reporting mechanisms such as the EU Emissions Trading System (EUETS). Recent UNFCCC reviews have highlighted potential gaps in the UK GHGI relating to the use of NEU commodities in emissive applications, and this has led to recalculations within the 2013 UK GHGI submission to increase estimates of emissions from the use of feedstock-derived process off-gases as a fuel.

It is essential that the data available in the UK are periodically reviewed and improved, where possible, to ensure that the UK emission estimates are complete, accurate and transparent using UK-specific data where available. This research project aims to identify any other potential problems in the UK GHGI assumptions and methods, and to consult with industry and statistical agencies to seek current data and expert judgement to validate as far as possible any remaining areas of uncertainty, to minimise UK GHGI gaps and errors.

The scope of this research is potentially very broad; emissions from NEU of fuels occur through many routes and in numerous economic sectors, often embedded within complex manufacturing processes or as a sub-component of an emission source where feedstock contribution is uncertain. The project has therefore focussed on the areas of greatest uncertainty and significance for the UK GHG inventory, addressing in detail the analysis of the most likely high-emitting and uncertain NEU emission sources, taking more simplistic approaches for other sources and commodities.

The project has sought to:

- Access UK data to improve inventory emission estimates from NEU of fuels that are complete, accurate and defensible, to meet all of the UNFCCC reporting requirements and that are future-proofed to meet 2006 IPCC GL requirements as well as current 1996 GLs and 2000 GPG;
- Review the underlying data sources and data flows within energy and emissions reporting systems including DUKES, EUETS, IPPC and other mechanisms; to evaluate the data, understand reasons for data inconsistencies and seek solutions to streamline and harmonise data flows, for example to highlight where DUKES data may be augmented through greater, regular access to industry data sources;
- Improve UK estimates for stored carbon and emissions from fuels reported as NEU in DUKES, and ensure that UK inventory reporting is consistent and comparable with other EU Member State inventories, making best use of available methods, activity data and emission factors – preferably UK-specific, but otherwise defaults;
- Address specific source estimates that are known to be uncertain and currently conservative, and to derive the most defensible approach to a consistent time series of estimates back to 1990;

- Evaluate the level and uncertainty of emissions from NEU of fuel sources, to improve future GHGI Key Category and uncertainty analyses;
- Deliver recommendations for improvements to the 2014 inventory submission and for further research to further minimise inventory uncertainty.

Reference Approach Inventory estimates

As part of the annual UK inventory submission to the UNFCCC, in addition to the detailed UK inventory estimates that are based on fuel-specific activity estimates and emission factors (referred to as the Sectoral Approach), the UK is required to report a separate set of inventory estimates that take a more simplistic approach to deriving estimates for the Energy sector. This is referred to as the Reference Approach; all Annex 1 parties to the Convention are required to submit both a Sectoral Approach and a Reference Approach set of inventory estimates. The Reference Approach data constitute a verification mechanism for the Energy sector national estimates that are submitted using the Sectoral Approach.

One aspect of the Reference Approach methodology is to apply carbon storage factors to the reported national activity data for NEU of fuels. This research project has sought to review the current UK method and data used in the Reference Approach of the 2013 submission, to compare the carbon storage fractions used for each commodity by the UK and a number of other EU Member States, and to provide recommendations for the future UK inventory submissions to improve accuracy and comparability of the UK reporting.

Overview of Available Data in the UK to Estimate Emissions from NEU of Fuels

Emissions from NEU of fuels can arise from a range of processes: burning in use (e.g. lubricants and waxes); chemical transformations either during industrial processes or degradation of NEU products during or after use; incineration or use of waste products as fuels. These emitting processes can occur across many different economic sectors, as well as in non-industrial contexts, such as NEU of fuels by households. In many cases there is no direct measurement of precise activity that underpins the emissions, and there is no direct reported correlation between the use of a specific substance and the emissions of CO_2 from its use (for example where process off-gases are burned to raise heat and power, but the origin of the carbon could be derived from a wide range of process inputs).

This represents the major challenge then to quantifying emissions from NEU of fuels. National statistics will not adequately describe the processes causing emissions, and even where relevant emissions data are available, they can be difficult to put into context and in any case cover only a small proportion of NEU activity. For example, emissions from some large industrial sites, documented within datasets such as the EUETS, will include some reporting of process gases / residues from production processes where the feedstock material is primarily captured in products but also partially oxidised and released. However the EUETS data does not show the input of feedstocks, or the quantity of carbon stored, and nor does it cover smaller processes that might also be using fuels for similar NEU applications. Additional data, assumptions and extrapolations are needed in order to properly describe the NEU of fuels in the UK and to generate emission estimates.

Commodity balance tables in DUKES underpin the UK inventory, and are the starting point for the GHGI estimates for NEU emissions. They are compiled from user surveys and energy supplier returns. Complete “bottom-up” reporting of fuel use is not available, and therefore the allocation of commodities to either combustion within specific economic sectors or to Non Energy Use are based on surveys and assumptions by the energy statisticians. Where

information is available on sales to individual companies, the statisticians make assumptions to allocate these deliveries to energy or non-energy applications, often relying on information from periodic surveys (such as the ONS Fuel Purchases Inquiry) to allocate deliveries to different lines in the commodity balance tables. In the absence of perfect bottom-up fuel use data, there is inevitably a degree of uncertainty in the allocations made within DUKES. Nonetheless, the DUKES commodity balance tables provide the best available initial estimate of the proportion of each fuel type which is used for NEU applications in the UK.

The commodity balance tables follow a standard format with data on fuel supply (production, imports/exports, stock changes) and fuel demand (in energy industries, in fuel transformation and by final users – including NEU). The demand data are separated into their use by specific industrial and other economic sectors, and then the transport, domestic, commercial and public sectors. Finally the tables list 'non-energy use' as a single category, i.e. no disaggregation is given either by economic sector or by application. The tables are largely based on data collected regularly either from fuel/energy producers such as oil refiners, coal producers, gas distributors, electricity generators etc., or from import/export records from HMRC. The data for overall consumption of each fuel type are regarded as highly accurate; sector-specific allocations of fuels are subject to higher uncertainty.

Report overview and structure

This research project has enabled the study team to meet with the appropriate industry and statistical experts, learn the details of the data that are available from different sources, and develop an improved understanding of the NEU of commodities and the best available data to use in the UK GHG inventory, to reduce uncertainties.

This report presents the research approach, outlines the data obtained and expert opinions solicited, outlines the key data comparisons and analysis, summarises the improvement recommendations for consideration in compiling the UK GHGI for the 2014 inventory submission and presents options for further work to address outstanding issues.

Note, however, that due to the limited number of installations and companies operating in the economic sectors under discussion, that the detailed data are excluded from the published report in order to maintain commercial confidentiality.

The research approach is set out within the ***Method*** section, which also outlines the main data sources accessed and analysed by the study team.

The ***Results and Discussion*** section sets out the main findings, including an overview of the data supply systems available to DECC and the inventory agency, as well as specific findings from data analysis to enhance UK inventory methods, emission factors and activity data.

The ***Conclusions and Recommendations*** section outlines the research recommendations for DECC to consider in future inventory compilation and reporting of the Sectoral and Reference Approach.

Methodology

The project team's overall approach to the research can be summarised as follows:

- consultation with UK industry experts, trade associations, DECC energy statisticians, other statistical agencies such as the Office of National Statistics;
- review of the methods used and reporting of NEU and stored carbon in products within the National Inventory Reports of other EU Member States and consultation with EU Member State inventory agencies, focussing on experts in Energy and Industrial Process sources where NEU fuel use data and emissions are accounted for;
- literature review of materials related to NEU of fuels including the 2006 IPCC Guidelines, and documents from a range of industries including applications for: bitumen, coal tars and benzole, petcoke, ethane, LPG, naphtha; and
- analysis of data on energy use, NEU and emissions data from EUETS, operator-reporting under Integrated Pollution Prevention and Control, Climate Change Agreements, DUKES, the Downstream Oil Reporting System and the Petroleum Products Reporting System.

A list of consultees and documents reviewed is included in Appendix 3.

Review of available data on emissions from NEU of fuels

The project team met with the DECC team of energy statisticians that compiles DUKES and worked through the source data used to determine the NEU allocations for UK fuels. In many cases the deliveries (either from UK fuel suppliers or from Customs and Excise records) can be determined as energy use or NEU based on the company name or site details combined with the expert knowledge of the DUKES team and the project team. The findings from this meeting helped to focus and prioritise further research and consultation. The study team sought to address areas of uncertainty and to target energy and emissions data from specific sites and organisations where feedstock commodities may be used in emissive activities, through:

- Review of the fuel-specific data within EUETS reports for sites (predominantly chemical and petrochemical production sites, producing e.g. ammonia, acetic acid, acetic anhydride, nitriles, bulk petrochemicals such as ethylene, propylene), noting that data are only available since 2005, and in some cases from 2008;
- Review of CCA data for chemical production sites, where the use of by-products as an energy source is reported. Although there is a very limited CCA dataset (only data for 2008 and 2010), there are a number of sites where the use of process residues, waste solvents, process off-gases is reported as a fuel use;
- Review of IPPC permit information for several sites to assess the likelihood (based on plant description and emission sources) of use of feedstock materials in heat- or steam-raising end-uses;
- Review of the time series of disposals of Natural Gas Liquids to chemical and petrochemical sites, through the records of the Petroleum Products Reporting System (PPRS), noting that data are only available back to 2001;
- Literature research and web-searches to identify the products and markets in which specific companies trade, where their use of commodities was determined by DECC DUKES to be NEU;
- Direct consultation with trade associations and plant operators to request information on the fate of materials (process inputs or by-products) to clarify the proportion of different commodities that are stored in products or used in other applications.

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Through statistical analysis of these available data, comparing data between sources and assessing the variability of reporting across the time series, the study team has assessed the data completeness and accuracy on a commodity-by-commodity basis and applied expert judgement to derive uncertainty estimates. Where applicable, the study team has sought to identify where the gathering of new data or the development of an improved method (either through routine annual tasks or a one-off research task) may help to reduce the uncertainty of estimates.

The review of UK data aims to validate the country-specific assumptions used within DUKES and the GHGI for several commodities, and helped to focus research on sources / commodities of higher uncertainty. The study team has sought to identify all possible instances of use of commodities in combustion (or other emissive) activities where the materials are allocated in DUKES as NEU. For example, in the 2013 inventory submission, the UK GHGI incorporates deviations from DUKES where the use of feedstock materials in energy end-uses (as reported within EUETS, CCAs etc.) is inconsistent with data in DUKES, and therefore the study team has reviewed UK data to identify other similar potential gaps in the GHGI.

Where these UK data reporting mechanisms (e.g. EUETS, CCAs) indicate inconsistencies with DUKES, the study team has sought to clarify the data flows and underlying reasons that may lead to these data disparities, through consultation with statisticians and regulators, in order that DECC may consider options to address systematic or data quality management issues that undermine inventory data quality.

Review of completeness of NEU Reporting in the UK GHGI

The review of available data and consultation with industry, regulators and statistical agencies sought to ensure that the UK estimates for emissions from NEU of fuels are complete and accurate. The focus for the research was defined by the feedback from the DUKES team on the commodities where greatest uncertainty in NEU allocations was evident, and also by a review of the 2006 IPCC Guidelines for national inventory reporting which set out recommended data sources and methods for countries to calculate accurate emission estimates.

Our approach sought to ensure that research was targeted at commodities and sources of greatest uncertainty, prioritising the tasks that are most important to improving the UK GHGI estimates. Following an initial review of UK data and the 2006 GLs, the study team prioritised research on the following commodities and issues.

Natural gas

Natural gas is used as a feedstock in chemical production. The study team researched activity data from EUETS, CCAs and also information within IPPC permit documents for several UK chemical production installations. The team reviewed the flow of carbon-containing products and gases within integrated production facilities, seeking to ensure that the inventory estimates accurately reflect activity and emissions data reported by operators of the co-located plant.

Petroleum Coke

A proportion of the NEU allocation of **petroleum coke** in DUKES is known to actually be used as a fuel in heavy industry (mineral processing), or in the manufacture of fuels for the domestic sector. Some NEU applications are emissive, such as anode manufacture and use. The 2013 inventory submission already includes deviations from DUKES data on the basis of information from operators and industry experts regarding the consumption of petcoke as a fuel in heavy industry and in domestic sector fuels. The nature of all uses in NEU applications is uncertain. Research aimed to determine the fate of products (e.g. anodes used in ferrous and non-ferrous metal production); especially in recent years of the time series where UK production of anode-

grade coke exceeds UK demand due to the decline in Non-Ferrous Metals (NFM) manufacturing in UK. This led to a wider review of the data inputs to the DUKES commodity balance tables in conjunction with the DUKES petroleum statistics team.

Coal Tars and Benzole

The study team consulted extensively with the Iron and Steel Statistics Bureau (ISSB) and Tata Steel to review the industry data on the production and fate of coal tars and benzole. In DUKES, these commodities are entirely allocated to combustion processes, whereas industry information indicates that they are entirely used in NEU applications. The 2013 inventory submission already includes this deviation from the reported data in DUKES, i.e. no combustion emissions are currently reported in the GHGI as it is assumed that the DUKES data incorrectly allocates the activity data. The team sought clarifications from companies engaged in distillation of these industry by-products to seek information on the end uses of their products, including use within the UK and exports.

Ethane, Propane, Butane, Gas Oil and Naphtha

These are the primary petrochemical and chemical feedstock materials and are extensively used in production of chemicals and related products in UK industrial plant. Inventory agency research into operator-reported energy use and emissions data in EUETS has previously identified that several high-emitting chemical and petrochemical sites use carbon-containing process off-gases as fuel on-site, and that this component of “feedstock” materials is allocated entirely to NEU within DUKES. The UK GHGI already deviates from DUKES for these commodities, reporting emissions under 1A2f Other industrial combustion in the 2013 submission. The study team focussed on:

- Consulting directly with plant operators to improve the accuracy of the time series of emission estimates from carbon-containing off-gases;
- Identifying other industrial production sites where process off-gases or residues are used as a fuel, through review of data from EUETS, IPPC permits, CCAs, direct consultation with regulators and operators;
- Reviewing the handling of data within the inventory data management systems, e.g. to re-allocate these emissions to 1A2c (as recommended within the UK GHGI Annual Review Report 2013), and to review the spreadsheets used to compile emission from feedstock chemical use

Other Commodities

Other commodities that typically are associated with lower uncertainty and/or a lower potential impact on the UK GHGI estimates were not investigated to the same level of detail, due to the limited time-frame and resources for this study. These commodities include: lubricants, petroleum waxes, bitumen, white spirit and SBP liquids, miscellaneous oil products. The review of DECC DUKES assumptions did encompass these commodities, and the study-team also conducted consultation with key trade associations, such as the UK Petroleum Industries Association, the Refined Bitumen Association and the Health & Safety Executive, to solicit expert review of current UK GHGI assumptions.

Review of the 2006 IPCC Guidelines

The IPCC 2006 Guidelines for National Greenhouse Gas Inventories (2006 GLs) provide a clearer treatment of the energy supply balance (for the Reference Approach) and the energy transformation and energy final demand statistics (for the Sectoral Approach) compared to

previous guidance. The project team's UNFCCC Lead Reviewers have reviewed and interpreted the requirements of the 2006 GLs for the UK GHG inventory. The assessment of future needs for the UK inventory agency as regards additional data, quality checks and updates to methods clarifies the steps that need to be taken to ensure that the UK inventory will be compliant with the 2006 GLs in time for the 2015 submission.

Review of Other Member State Reporting Methods

Finally, the study team has also reviewed the available data from the CRF submissions by all parties on the UNFCCC website, and reviewed National Inventory Report text for several EU Member States that have economies that are similar to that of the UK. The analysis of the stored carbon fraction data and information on methods used by different Parties has enabled an assessment of how the UK data processing and reporting compares to other Parties, and where the observed differences or outliers indicate either country-specific circumstances or reporting inconsistencies, gaps or errors. The team has sought to identify the best practice for NEU reporting across reporting Parties that the UK GHGI can learn from and seek to apply as part of routine improvements and aiming for compliance with the 2006 GLs.

Results and Discussion

The project findings are summarised in this section, in a series of sub-sections:

- Overview of UK data and information sources for NEU of fuels
- Summary of NEU information from other countries *(see Annex 1 for more details)*
- Summary of 2006 IPCC Guidelines *(see Annex 2 for more details)*
- Commodity-specific findings
- Uncertainties

Overview of UK data and information sources for NEU of fuels

This section provides a summary of the data sources reviewed by the study team, and outlines the key issues for the UK inventory to review in future submissions, such as the assumptions that are applied and uncertainties in estimates for different commodities.

DUKES Energy and NEU Consumption Data

As outlined in the introduction section, the fuel allocations presented in DUKES commodity balance tables for 'final users' (i.e. the various industry sectors, transport, public, commercial, agricultural, domestic and the NEU allocation) are at least partly based on assumptions and extrapolations from periodic surveys as well as annual data returns from energy suppliers and HMRC. Whilst the annual demand total is regarded as very accurate, the sector-specific allocations (including the NEU allocation) are associated with higher uncertainty.

DUKES divide fuels into a relatively small number of categories and inevitably this leads to some simplification compared with the real-world. There can be a degree of uncertainty introduced when reconciling DUKES data with information from other sources such as individual fuel users (such as EUETS data, where fuels are described using a multitude of terms).

Solid fuels

All DUKES data are provided by HMRC, UK-based producers and fuel suppliers, i.e. collieries, power stations, ISSB. A limitation of HMRC data is that there is a risk of misreporting across fuels (e.g. coal, coke, anthracite, petroleum coke) because of ambiguities in the identification of imported solid fuels in these records. Within DUKES there is no allocation to NEU for any fuel derived from solid fuels: steam coal, coking coal, anthracite, coke oven coke, coke breeze, manufactured solid fuels, benzole and tars, coke oven gas, blast furnace gas. This is known to be incorrect for benzole and tars, where all of the fossil carbon has previously been regarded in the GHG inventory as being incorporated into chemical products or used in other applications that are not related to energy production and are ultimately non-emissive. Research into the fate of benzole and tars through consultation with the coke oven operators and the UK company that refines the benzole and tars has confirmed the assumptions applied within the 2013 submission.

Large quantities of coke are known to be used in industrial processes as a reductant (e.g. the use of coke in blast furnaces) and this could be regarded as a non-energy use. However, DUKES treats these applications as energy uses, they are emissive, and the estimates in the GHGI are accurate, so no further work has been done in this area. For reporting under the 2006 IPCC GLs, the emissions from use of coke as a reductant will be required to be reported within the Industrial Process sector rather than under the Energy sector; the data are available to the UK inventory agency to revise the reporting allocation and this will not affect the overall UK GHGI emission totals.

We have not identified any use of coal or manufactured solid fuel that could be considered as NEU and the DUKES approach and inventory methodology seem fully justified for these fuels.

Petroleum Fuels

Key providers of data to DUKES include HMRC, UK-based fuel producers and suppliers, and electricity producers. DECC collects data from industry via the Petroleum Production Reporting System (PPRS) for primary production of crude oils and natural gas liquids, and via the Downstream Oil Reporting System (DORS) for transformation of crude oil into products and delivery of these products to end users. DECC also collect data on disposal of liquid natural gases. As with other fuel types, the emphasis on collection of data from fuel suppliers ensures a high level of accuracy in UK consumption figures, but less certainty regarding the allocation to some individual end-user sectors.

The UK Petroleum Industries Association (UKPIA) provided an overview of the markets for petroleum products in the UK, including clarifications for some of the specialist refinery (non-fuel) outputs. For some commodities (bitumen, for example), all of the consumption is regarded to be non-energy and so the non-energy use statistics in DUKES are not considered uncertain. Other commodities are used in a wider range of energy and NEU applications; for example petroleum coke, gas oil, propane and butane find significant use both for energy and non-energy applications.

For commodities such as ethane and naphtha, the DUKES allocation of 100% consumption for non-energy use reflects that these commodities are almost exclusively supplied as feedstock for chemical and petrochemical manufacturing and therefore their initial use is for NEU applications. A proportion of the carbon from these feedstock materials is subsequently emitted; for example, the use of ethane/propane/butane/naphtha as chemical feedstocks with subsequent recovery of waste gases to be used as fuels, and the recovery of waste lubricants to be processed into fuel oil substitutes.

Natural Gas

The DUKES commodity balance is compiled using data from gas network operators, and gas suppliers, as well as surveys of major users such as electricity generators. All NEU allocation data is taken from data provided by Ricardo-AEA, and this includes the annual estimates of natural gas used for production of chemicals including ammonia, acetic acid and acetic anhydride, and (previously – plant now closed) methanol. These are the only major uses of natural gas in the manufacture of chemicals in the UK. No other operational production plant using natural gas as a feedstock have been identified in this research, through review of reported data and from industry consultation.

One other potential NEU of natural gas is in the manufacture of carbon black. The UK did have two carbon black manufacturing sites until several years ago when both were closed, but the feedstock used at each site is not known with certainty. The likelihood is that both mainly used either fuel oil or some other petroleum-based feedstock, but some natural gas may have been used as well. The current inventory method assumes that even if any gas were used, it would have been fully oxidised and not therefore stored, and no new information to revise that assumption has been found.

Summary of NEU information from Other Countries

The main findings of the review of the reporting of NEUs by other Parties to the Convention are outlined below. [For more information, see Annex 1.]

Reference Approach: Method and Carbon Storage Fractions

Compared to the reporting of carbon storage fractions by other Parties, in the 2013 inventory submission the UK has for most commodities taken a more detailed, country-specific approach to estimating the storage fractions and reporting the **Reference Approach** estimates.

There are no countries that stand out as clear "best practice" in the presentation of data for the Reference Approach; this is evidently an area where a lot of inventory agencies struggle to interpret the GLs in a consistent manner. The Lead Reviewers that have reviewed the data from other Parties have concluded that many inventory agencies are not consistent on their approach to presenting the Reference Approach – Sectoral Approach comparison, and that Expert Review Teams have not acted to develop a common, comparable approach across Parties.

For example, the Energy reviewer from the UK GHGI 2012 in-country review proposed that the UK inventory agency should seek to remove all areas of "known difference" between the RA and SA, correcting the RA activity data in a similar way to the SA corrections. The Lead Reviewers engaged by the study team had a contrary opinion, i.e. that the RA is a Quality Check only; it is a different approach to the SA and it is expected to be different to the SA, and therefore that the RA should simply be reported using the available data and the NIR text should discuss RA-SA differences, rather than attempting to amend the RA method to align with the SA data. This suggests that it will not be possible to adopt an approach that is guaranteed to be acceptable to all reviewers.

However, the review has identified that the UK has mis-calculated the country-specific carbon storage fractions presented in the 2013 submission, as the emissions reported from NEU of fuels across all IPCC source sectors has been used in the derivation of the storage fractions, rather than just the emissions from IPCC sources in the Energy sector.

[The comparison between the Reference Approach and the Sectoral Approach is limited to the Energy sector data, and therefore to consider emissions from non-Energy sources in driving the carbon storage fraction introduces errors to the comparison.]

The UK-specific carbon storage fractions used in the 2013 submission also exhibit notable trends across the time series; for example, the fraction of stored carbon for naphtha, ethane and LPG ranges from 60% in 1990 down to only 14% in 2011. This partly reflects the shift in import-export balance of commodities over time and the decline in UK manufacturing of petrochemicals (and hence a lower activity data in recent years for NEU allocations of these commodities), coinciding with increased consumption of imported materials (plastics, rubber) and the ultimate emission of GHGs from their disposal (e.g. within Energy from Waste plant, in 1A1).

- ➔ The UK approach is considered to be misleading and not comparable against the approach used by other reporting Parties to the Convention, and therefore it is recommended that the method for the Reference Approach analysis be revised in future submissions to use more of the default carbon fractions for each commodity. This will not impact upon the Sectoral Approach emission estimates, but will simplify the Reference Approach calculations and make the UK approach more consistent with other countries.

Reference Approach: Activity Data

Furthermore, the current UK method to reporting the Reference Approach uses the DUKES activity data, retaining a high % NEU allocation across commodities such as ethane, naphtha, LPG and petroleum coke. The method then seeks to take account for the known emissions (from the use of commodities and the process off-gases derived from feedstock materials) using the

carbon storage fraction. The Sectoral Approach method is less rigid; the inventory agency has amended the activity data for these known emission sources, and deviated from the published DUKES data. It would be preferable for the Reference Approach estimates to be based on a similar starting point of activity data.

➔ Therefore it is recommended that DECC considers revisions to future DUKES commodity balance tables to reflect the known energy uses that are reported by industry operators (such as the petroleum coke use in industry and domestic fuels. This would also remove the need to explain these GHGI deviations from DUKES in the NIR.

Sectoral Approach: Inventory Data and Methods

The comparison against other Member States has not identified any specific recommendations for revisions to the **Sectoral Approach** in the UK, i.e. the national GHGI estimates that are reported to the UNFCCC and used to track progress against GHG reduction targets. The study team did not find any specific literature references or commonly reported protocols or assumptions that were directly useful in the timescales of this project. The UK approach in general seems consistent with that of other countries.

Where the UK uses country-specific data, then this is the regarded as the most accurate option available; where the UK applies defaults from either IPCC guidance or based on research from other countries, then these approaches are more open to critique. For example, the UK estimates for emissions from petroleum waxes applies an assumption derived from research in the USA; conceivably this could be revised to apply an IPCC default. This was not researched in detail in this study, as the impact on the UK inventory of such a change would be very small, and hence no changes to the current approach are recommended.

Best practice from other Member States (e.g. Germany) includes use of a carbon balance approach to estimate the feedstock use in production of specific chemicals, to assess ("bottom-up") the carbon stored in chemical products, determine the overall carbon content of reported NEU commodities, and calculating emission estimates based on the difference. If the method could be replicated in the UK by gathering detailed annual production data for specific commodities, this would generate new, more accurate emission estimates or at least provide a valuable verification of current estimates.

Unfortunately, as things stand in the UK, data on chemical production that are available via PRODCOM are incomplete and not presented at a detailed level (i.e. product-specific) due to commercial confidentiality. Therefore this "bottom-up" approach to determining the carbon stored in products of the chemical and petrochemical industry is not currently possible in the UK.

➔ It is recommended therefore that DECC considers further work to seek any improvements in data completeness and transparency from other UK statistical agencies, to seek new data to help improve or validate the UK GHGI estimates.

Summary of reporting requirements from the 2006 IPCC GLs

The main findings from the review of the 2006 IPCC GLs, for the UK GHG inventory are outlined here. [For more information, see Annex 2.]

Requirements for reporting of NEU of fuels in the 2006 IPCC GLs are broadly consistent with the 1996 GLs but updated and clarified for all allocations in the IPPU sector. Specific provisions for some commodities are set out, which the UK inventory can address with existing data. Methods for lubricants, paraffin wax, asphalt use and solvent use are described in more detail than previously; the UK can achieve compliance with the required methods.

Compared to the 1996 Guidelines the treatment of emissions from NEU of fossil commodities is more clearly described in the 2006 Guidelines. Chapter 5 of Volume 3 (Industrial Processes and

Product Use) provides clear and complete guidance on how to treat emissions from NEU of fossil commodities in the Sectoral Approach. NEU of fossil commodities is by definition not reported in the energy sector. However, it is relevant as a correction in the Reference Approach and provides a cross-check for the total carbon in fossil commodities which are stored in products or used as feedstock.

The 2006 GLs also present much clearer guidance for the approach to reporting carbon in NEU commodities within the IPPU sector and in the Reference Approach (Volume 2, Chapter 6) for feedstock carbon (naphtha, LPG, refinery gas, gas oil, natural gas and ethane), reductant (coke oven coke, petroleum coke, coal and coal tar / pitch, natural gas), and NEU products (bitumen, lubricants, paraffin waxes and white spirit).

Commodity-specific Analysis and Recommendations

The detailed project findings are presented on a commodity-by-commodity basis, set out for:

- Solid fuels (coal tars and benzole)
- Gaseous fuels (natural gas)
- Petroleum fuels (ethane, LPG, OPG, naphtha, white spirit and special boiling point liquids, gas oil, lubricants, bitumen, petroleum waxes, petroleum coke, miscellaneous products)

Solid Fuels

Coal Tars and Benzole

UK-specific Information: data, references, assumptions

The DUKES NEU allocation for coal tars and benzole is zero across the time series, but the UK GHGI estimates deviate from this, assuming that the carbon is stored in products. Consultation with the iron and steel industry (Personal Communication, Bob Lewis, Tata Steel, 2013) and with the leading UK company that distils the tars and benzole to generate saleable products (Personal Communication: Glyn Currie, Koppers Ltd., 2013) has confirmed the UK GHGI approach to deviate from DUKES and to assume that all of the carbon is stored other than where electrodes produced using coal tar pitch are consumed in the UK metal industry. *(Any such emissions are already included elsewhere within the UK GHGI, and therefore for the purposes of handling the coal tar and benzole data, a 100% stored assumption is valid for the UK.)*

➔ Consultees have verified the assumptions applied in the 2013 submission and hence it is recommended that the UK retains the current assumptions over the fate of materials derived from coal tars and benzole. *The assumptions to be retained in the UK inventory are not published here, as the fate of the refined products is commercially sensitive.*

Information provided by the iron and steel industry indicates that the split of coal tars – benzole is typically 80-20% on an energy basis. In the current UK inventory calculations, it is assumed that a 50-50% split should be applied to the DUKES activity data total (which is presented as one figure – an aggregate of coal tars and benzole).

➔ Therefore it is recommended that the UK inventory calculations be revised to use the industry split data; this change has a very minor impact on overall emission estimates, but enables fuel-specific carbon factors to be applied.

In the allocation of emissions from the use of carbon anodes in metal processing industries, the current UK GHGI method does not allocate any of the emissions to the use of coal tar pitch derived from coal tars and benzole, but allocates all of the emissions to petroleum coke. This is

a simplistic assumption, but there is no quantitative data on the proportions of coal tar pitch and petroleum coke used to manufacture the electrodes used in the UK industry, or any information on the relative contribution of the two components to the carbon emitted. This approach does not affect the accuracy of the emission estimates, but does simplify the accounting of the emissions in the CRF.

➔ It is recommended that this approach be retained in future inventory submissions.

Comparison against other reporting Parties

UK and Italy are above average in assuming 100% of carbon from coal tars and benzole is stored compared to 58% - 75% carbon stored across Austria, France, Germany, Netherlands and Japan. In the UK GHGI, this is due to the simplified assumption that all anode-related carbon emissions are derived from the petroleum coke component.

Other notes / recommendations for the UK GHGI

➔ It is recommended that the DECC DUKES team considers revising the allocation of coal tars and benzole within the Commodity Balance table 2.5, to re-assign the data to NEU instead of combustion in unclassified industry.

Gaseous Fuels

Natural Gas

UK-specific Information: data, references, assumptions

The DUKES NEU allocation for natural gas is based on data provided by operators of chemical production plant in the UK to the inventory agency; these data are then provided to DECC to use in the DUKES compilation. Historically in the UK, natural gas has been used as a feedstock in the production of ammonia, methanol, acetic acid and acetic anhydride across four main production sites: Ince, Billingham, Severnside and Saltend. Methanol production at Billingham ceased in 2001, and all production at Severnside ceased in 2008;

Consultation with the plant operators and regulators at the Saltend plant, combined with a review of the plant permit details and data reported within the EUETS and the Pollution Inventory, has led to clarifications over recent production levels of different commodities on site (including ammonia) and regarding the flow of gases between production units. The site is an integrated production complex with several companies owning different plant, but the gas flow across the acetic acid, acetic anhydride and ammonia production units is managed by BP Chemicals. Natural gas is used as a feedstock for the acetic acid and acetic anhydride production units, and hydrogen off-gas from this process is used as feedstock in the adjacent ammonia plant. Carbon monoxide from the production process is also used as a fuel, and EUETS data is used in the current inventory method to inform the UK GHG inventory estimates from this source, which had previously been based on a limited dataset from operators in the mid-2000s.

➔ The Site Inspector for the Saltend plant has provided updated chemical production for the complex for recent years; it is recommended that these new data be used to inform the estimates of emissions in future submissions. No change in method is required.

UNFCCC ERTs have requested clarifications of the underlying reasons for the UK's time series of Implied Emission Factors for CO_2 emissions from ammonia production, which in 2011 was lower than the IPCC default (the UK IEF is around 75% of the IPCC default).

The study team have reviewed the available installation-specific data from individual plant in the UK and has identified a double-count in the estimates of carbon stored in products for the early part of the time series.

➔ It is recommended that this double-count be removed in future inventory submissions to improve the accuracy of the UK inventory for ammonia production and for the combustion of natural gas. Revision of the NEU allocation to remove this double-count will slightly increase the total amount of natural gas used as a fuel during 1990-2001, increasing the UK GHGI totals in those years for emissions from unclassified industry (1A2f).

ERTs have also commented on the reporting of natural gas activity data within IPCC 2B1 (Ammonia Production), which in the 2013 submission includes the activity data for UK production of other commodities including acetic acid and acetic anhydride production. The UK GHGI currently reports all use of natural gas as feedstock within 2B1, which is not consistent with the IPCC Guidelines and is not comparable to the data reported by other Parties to the Convention.

➔ It is recommended that this approach be revised in future submissions, such that only the natural gas used in ammonia production is reported under 2B1.

Comparison against other reporting Parties

The UK is one of a handful of Parties (together with Germany, USA, Netherlands and Russia) that reports a country-specific carbon storage factor; most Parties either report a 33% or a 100% carbon storage factor. The UK figure in 2011 of 41% compares with the Netherlands (39%), USA (59%) and is notably lower than that for Russia (72%) and Germany (90%). The UK data is not an outlier, the approach to reporting is consistent with other Parties, and as one of the lower carbon storage fractions reported this implies that UK emission estimates are (if anything) conservative. However, in the latest UK GHGI centralised review, the ERT noted that as the emissions from ammonia manufacture are within 2B1, and not in the Energy sector, then for the purposes of the RA-SA comparison (which only focussed on data reported in the Energy sector), it would be preferable to report a 100% carbon stored fraction.

➔ It is recommended that in the reporting of the Reference Approach the UK revises its carbon storage fraction to report 100% carbon stored, to enable a more accurate comparison against the Energy sector emissions reported in the Sectoral Approach.

Other notes / recommendations for the UK GHGI

➔ The plant-specific IEFs for CO_2 emissions per unit production of ammonia over the time series indicate an outlier for 2011 for the Ince production site. It is recommended that this feature of the IEF time series should be clarified with the operator for future submissions.

Liquid fuels

Petroleum coke (petcoke)

UK-specific Information: data, references, assumptions

The UK GHGI estimates in the 2013 submission deviate from DUKES based on information from plant operators and other sources. DUKES includes allocations of petcoke as a fuel used for electricity generation and by the refinery sector, but all of the remaining “final consumption” is allocated to NEU. Evidence from EUETS, trade associations and manufacturers of smokeless solid fuels all indicate that the DUKES allocation to NEU is an over-estimate, and the inventory includes estimates of petcoke use:

- as a fuel in the other industrial combustion sector; and
- as a feedstock for smokeless solid fuels that are then combusted within the domestic sector.

Consultation with DECC energy statisticians, UKPIA and Conoco, and comparison of DUKES data against EUETS data has clarified that:

- UK exports of petcoke are primarily (exclusively, perhaps) high quality calcined petcoke generated in one of the UK refineries and used globally as anode-grade coke for ferrous and non-ferrous metal production processes;
- Fuel grade petcoke is not produced as a refinery product in the UK. Petcoke burnt at UK refineries is 'catalyst coke' that builds up on catalysts used in the refinery processes and has to be periodically burnt off;
- UK imports of petcoke (and EUETS data) indicate that the companies buying the material are in some cases purchasing lower-grade (non-calcined) petcoke and using it directly as a fuel. The DECC review of import data has validated the existing deviations from DUKES for specific industries such as cement manufacture, and has also helped to clarify the companies importing petcoke for NEU applications, such as for cathodic protection of pipelines.

The research has confirmed the assumptions and approach in the 2013 submission, that petroleum coke as NEU in DUKES is over estimated, and that there are a number of industrial operators reporting use of petcoke as a fuel that are not reported in DUKES. Petroleum coke is also used in fuels destined for the residential sector, and again DUKES does not reflect this.

➔ It is recommended that the current approach in the UK GHGI Sectoral Approach is retained, i.e. to deviate from DUKES and report emissions from energy use of petcoke in sectors such as domestic combustion and cement production, re-allocating a proportion of the DUKES NEU data.

Comparison against other reporting Parties

The UK currently reports a 100% stored carbon fraction in the Reference Approach, which is consistent with many other Parties (e.g. Greece, Hungary, Israel, Norway and Sweden) whilst other countries report country-specific values (e.g. 85% in Germany, 75% in France). However, the UK report of 100% stored carbon is misleading as the method to report the petcoke data in the CRF tables is not consistent with the approach to UK reporting for other NEU commodities, as noted within the NIR of the 2013 submission. The UK Reference Approach reporting currently corrects the total NEU petcoke activity data to remove the amount of petcoke estimated to be used in emissive NEU activities such as electrode consumption in the ferrous and NFM sectors.

➔ This method is not consistent with the IPCC GLs, and it is recommended that in the reporting of the RA for the 2014 submission, the approach to accounting for the petcoke consumption in combustion activities, emissive NEU activities and non-emissive NEU activities be revised to coincide with the approach for other commodities in the UK GHGI. It is recommended that activity data for combustion (that is not reported in DUKES) be excluded from the NEU activity data input to the RA calculations, whilst the NEU consumption in 2C should be included. As all of the NEU emissive applications are reported in non-Energy sectors, then a 100% carbon storage fraction should be used.

Other notes / recommendations for the UK GHGI

(No other recommendations.)

Ethane, Propane and Butane (LPG), Naphtha

UK-specific Information: data, references, assumptions

The analysis of NEU and fuel use across these commodities is treated in an aggregated way in the UK inventory, and in general the findings for one commodity are applicable across all of them. The DUKES NEU allocations are typically very high across these commodities, but within

the UK GHGI the energy and emission estimates deviate from the DUKES allocations significantly. In 2012, the DUKES data indicate that 100% of ethane and naphtha final demand is to NEU applications, with 45% of propane and 80% of butane also allocated to NEU. This reflects the predominant use of these commodities as feedstock within the UK's large petrochemical and chemical production sectors.

Consultation with the DECC DUKES energy statisticians confirmed that for ethane and naphtha any reported disposals direct from refinery operators within DORS data or from import data are reported to petrochemical firms, and that all of the annual disposals are allocated directly to NEU as a result. For propane and butane, the DORS data and HMRC data are used, and are also supplemented by an annual LPG Association Survey to assess the division between use as a process feedstock and direct use as a fuel within industry (and other sectors), and this survey output influences the NEU allocation. The DECC team are aware of the issue regarding the use of process off-gases being used in combustion applications and support the approach currently used in the GHGI, i.e. to align emissions with the data reported in EUETS and back-calculate an estimate for activity data in combustion at chemical sites.

Through this project and a related (concurrent) inventory improvement research project into the reporting of energy use and emissions within EUETS by UK companies, the estimates of emissions from the reported NEU of these feedstock commodities have been revised and improved across the time series.

➔ The current approach to deriving and reporting emission estimates from the use of feedstock-derived process gases should be retained in the UK GHGI, and the time series updates to improve the completeness and accuracy of these source emission estimates should be used in future submissions

Comparison against other reporting Parties

The UK carbon stored fraction in 2011 is the lowest of all reported Parties for all of these commodities (14%). Other Parties report in the range of 55-100%. This is due to the method used to account for emissions from process gases within the manufacture of petrochemicals in the UK. As noted in the section above on findings from the review of other Member State data and methods, the current UK approach to deriving country-specific carbon storage fractions and reporting the Reference Approach estimates is not regarded as comparable to other MS data and therefore the UK method is recommended to be revised.

➔ It is recommended that the UK method to report Reference Approach estimates and carbon storage fractions from these commodities be revised and simplified to apply IPCC default fractions to aid comparability with data from other Parties.

Other notes / recommendations for the UK GHGI

➔ It is recommended that the DECC DUKES team reviews the NEU allocations for these commodities, as part of a review/analysis of the HMRC dataset (which we understand is scheduled to happen in 2014). This review may help to reduce the uncertainty of the NEU allocations for all commodities.

Gas Oil

UK-specific Information: data, references, assumptions

DUKES data indicates that a relatively modest amount of gas oil is used in NEU applications, and in recent years this equates to typically less than 3% of total gas oil demand in the UK.

Consultation with DECC and UKPIA has led to improvements in the understanding of end uses of gas oil within UK. The analysis of data returns from refinery operators indicates disposals of

"middle distillate oil" as a chemical feedstock to several petrochemical and chemical production sites, and these data are used to underpin the gas oil NEU allocations.

Previous ERT feedback has raised questions regarding whether any of the UK NEU allocations of gas oil may lead to emissions that are currently unaccounted for within the UK GHGI, e.g. through the use of gas oil in explosives manufacture. Therefore, the project team have contacted trade associations and the Health and Safety Executive who are responsible for regulating all companies in the UK that manufacture or handle explosives. The HSE have provided a list of all such companies and stated that in the UK there are very few sites that manufacture explosives, and that none of them use gas oil or fuel oil as a feedstock.

➔ There are no recommended changes to the UK GHGI method or source data for the NEU of gas oil. The research has confirmed that there are no known emission gaps in the UK GHGI, and the estimates in the 2013 submission are regarded as accurate and complete.

Comparison against other reporting Parties

The UK together with several other Parties (including France, Sweden and Hungary) reports 100% carbon stored, whilst most Parties apply the IPCC default of 50% carbon stored. Germany, Italy and the Netherlands all report country-specific figures of 55%, 24% and 78% respectively.

➔ It is recommended that in future submissions the IPCC default carbon storage fraction of 50% for gas oil be applied within the UK Reference Approach calculations.

Other notes / recommendations for the UK GHGI

(No other recommendations.)

Other commodities

The research and consultation has generally confirmed that simplistic assumptions regarding the storage fractions for commodities such as bitumen, white spirits and special boiling point liquids, petroleum waxes are defensible and can be applied across the time series. The final uses of these commodities are predominantly (and in some cases 100%) non-emissive, and the use of default assumptions does not introduce significant uncertainty to GHGI estimates.

- **Bitumen**. Consultation with the UK Refined Bitumen Association (Personal Communication: Chris Southwell, UKBRA, 2013), has confirmed that bitumen is used predominantly (almost exclusively) within road surfacing and weather-proofing applications and that the assumption of 100% carbon stored for all bitumen uses is therefore valid for the UK. This is consistent with all other reporting Parties.

- **Lubricants.** Analysis of EUETS data and data from trade associations (e.g. from the Mineral Products Association) provides data on the use of lubricants as fuels by specific industries. In addition, the UK inventory agency makes estimates of the consumption of lubricants with road vehicle engines, agricultural machinery engines, industrial (off-road) engines, marine and aircraft engines. These estimates are accounted for in the UK GHGI, deviating from the data presented in DUKES (100% of final consumption are reported as NEU in DUKES), and the reported stored carbon fraction in 2011 was 54%, which is broadly consistent with the reporting of other Parties. Other countries typically report either a 50% default assumption, or derive a country-specific estimate, as in the UK. Of the country-specific estimates, the UK figure is the lowest, indicating perhaps that the UK approach is a conservative one in emission terms. (Other Party lubricant carbon stored fractions: Austria 60%, Germany 90%, Italy 86%, Netherlands 78%, Norway 80%.)

- **Petroleum Waxes, white spirit, miscellaneous refinery products.** Based on the information gathered from DECC DUKES and UKPIA, and considering the very small significance of the carbon content of these commodities in the UK GHGI context, no detailed research was conducted, and no revision to historic assumptions is regarded as warranted.
    - The UK estimates of emissions from petroleum waxes is based on USA research and applies the same storage fraction (58%) as reported by the USA, which is the lowest storage fraction of any reporting Party and hence is likely to be a conservative estimate in emission terms.
    - The UK estimates of emissions from white spirit and miscellaneous refinery products apply the IPCC default carbon storage fraction of 75%.

Uncertainties

Some commodities have near 100% use for NEU and therefore minimal uncertainty regarding the energy/non-energy split e.g. ethane, naphtha, lubricants and bitumen. Other commodities have significant use in both energy and non-energy applications leading to much greater difficulty for the DECC DUKES team to assign deliveries accurately, and so increasing the uncertainty over the NEU/energy split. The detailed data used to determine the NEU/energy split are confidential and have not been accessed and analysed by the study team; however the NEU allocations within DUKES are derived through a data management system that is subject to rigorous QA in order to meet the requirements of UK Official Statistics and is not regarded as being any more or less uncertain than any other sector allocations within the UK energy balance. The allocations are derived using periodic surveys of consumers and annual returns from energy suppliers and HMRC, and in the absence of comprehensive bottom-up consumption data are the best available dataset for the inventory to be based on.

The GHGI uncertainty analysis currently assumes relatively high levels of uncertainty in the activity data used in the GHGI for these components, and continuation of this approach is justified at the moment. Any review of the DECC data compilation systems in 2014 may help to establish a better idea of the uncertainty within the DUKES allocations; for example, we understand that some research is planned by the Petroleum statistics team in DECC to review the import and export data from HMRC and assess whether any modifications to the data management systems should be implemented for future editions of DUKES.

The case of petroleum coke and coal tars & benzole are slightly different in that the DUKES allocations are contrary to other reported data from industry and the UK GHGI estimates utilise the industry data in preference to DUKES, re-allocating activity data whilst maintaining the overall commodity balance demand totals consistent with DUKES.

For coal tars and benzole it is assumed that all consumption is for NEU and that appears to be fully justified and not uncertain. For petroleum coke, the alternative (i.e. not from DUKES) activity data estimates are derived from a combination of very good quality data sources (e.g. 3rd party verified EUETS data) and some more uncertain expert judgements about consumption in specific sectors. Therefore we assume moderate uncertainty for these estimates.

An additional facet of the uncertainty relates to the proportion of deliveries for NEU that are either directly emissive or which involve transformation of some of the carbon into fuels with subsequent emission of carbon. Uncertainty estimates for these can be more easily judged by the inventory agency through analysis of the raw data used in the calculations:

- For the emissions from use of feedstock-derived process off-gases in the chemical production sector, the uncertainty is very low for recent years, as they are based on EUETS data (2005 onwards) and PI/SPRI data (1998 onwards for PI, 2002 onwards for SPRI). For the estimates in the early part of the time series, uncertainty is significantly

higher since no data are available before the late 1990s and estimates are extrapolated back based on plant capacity information. There is also more uncertainty in how the emissions data at these sites are related to the non-energy use figures in DUKES, resulting in greater uncertainty in allocating those site-specific emissions to particular commodities in DUKES.

- For lubricants, uncertainty is considerably higher. Data for the cement industry is available from the EUETS and the MPA, although there is uncertainty over the fuels used since both solvents and lubricants can be used to make secondary liquid fuels (SLF). Similarly, EUETS data are very ambiguous in identifying both different types of SLF but also in distinguishing SLF from refinery fuel oils. Currently, a figure of +/- 50% is used, and this is considered appropriate. In recent years, the market for waste oils was affected by the Waste Incineration Directive (WID), which imposed very stringent emission limits on sites burning any waste oils. Therefore the uncertainty in the activity data estimates for waste oil combustion is variable across the time series, and is greatest in the period most affected by WID.

Conclusions & Recommendations

The main research findings and recommendations are presented here and summarised in Table 1 below. For many commodities that are used in NEU applications in the UK the research findings support the current data, assumptions and methods used in the GHGI; consultation with industry experts and review of available data, guidance and evidence from other Member States has validated the approach for many commodities. Research recommendations for improvements to the UK GHGI Sectoral Approach are limited to a handful of commodities, whilst the overall UK method to the Energy sector verification mechanism, the Reference Approach, is recommended to be overhauled and simplified to be more consistent with other country methods.

Reference Approach Reporting
The Sectoral Approach (SA) for estimating emissions from the energy sector is based on the use of best available data for each source sector, whereas the Reference Approach (RA) is intended as a relatively simple verification methodology based on use of national energy statistics. There are instances where the national energy data in DUKES are different to data in other sources such as EUETS which are considered even more reliable, and these differences will impact on the UK inventory reporting of the RA (using DUKES data) compared with the SA (using a mixture of DUKES and alternative 'best available' data). Examples can be found in the data for petroleum coke, natural gas liquids (NGLs), and coal tars and benzole.

Therefore it is recommended that UK energy statistics in DUKES should be revised where necessary, taking into account the alternative data identified and used in the Sectoral Approach. This would allow a consistent set of energy demand statistics to be applied to both the SA and RA, and the carbon stored to be estimated, referring to the 2006 GLs Energy volume 2 Chapter 6 for clearer guidance than was provided in the 1996 GLs.

Regarding the UK's general approach to the Reference Approach method, the Lead Reviewers engaged in this review recommend that the UK revises its approach to the UK inventory reporting of the RA to utilise more of the IPCC default carbon storage fractions. The country-specific carbon storage fractions applied in the 2013 inventory submission appear to mis-represent the NEU emissions in the Energy sector of the UK GHGI, are highly variable across the time series and are also not comparable for several commodities with the approach adopted by most other reporting Parties to the Convention. It is therefore recommended that the UK reverts to a more simplistic application of the IPCC method for the RA and apply default carbon storage fractions across the time series. The RA is intended as a simple verification of the SA energy sector estimates and to conduct a more transparent, simple set of calculations and explain the RA-SA difference in the NIR is the recommended approach for future submissions

Sectoral Approach Reporting
This research has not found evidence that supports any major changes to the GHGI methodology for fuels used for NEU. Instead, the additional data and information collected during this research programme support the existing GHGI treatment of the DUKES data on NEU of fuels.

It is recommended that some minor revisions be made to the GHGI estimates of stored carbon associated with coal tars and benzole, based on EU ETS and industry data. However, this is an example of an inconsistency between DUKES data and alternative data used in the GHGI, rather than a case where the GHGI assumptions or methodology require any change.

Table 1 Overview of Non Energy Use Applications in the UK, Study Findings and Recommendations

Commodity[1]	NEU applications in the UK and reporting approach in the 2013 GHGI Submission	Study Findings and Recommendations for Sectoral Approach (SA) and Reference Approach (RA)
Ethane Naphtha LPG (propane and butane)	Chemical feedstock materials, with a large proportion used for ethylene production in the UK. In 2012, 100% of demand of ethane and naphtha are reported in DUKES as NEU, with just under 50% of LPG also reported as NEU. Emissions occur when carbon-containing process off-gases are used for energy recovery (reported in **1A2f**). Remaining carbon is stored in products such as chemicals, plastics and rubbers. Further emissions arise when products are disposed by incineration (**6C**) or as waste-derived fuels in power stations (**1A1a**) and industrial plants (**1A2f**).	**SA**: Study findings support the current approach to estimating emissions. A new time series of best estimates – more complete and accurate - are available and should be used in future submissions. UNFCCC ERT recommends moving the 1A2f emissions to 1A2c. EUETS Phase III will provide more data. Recommend review of these data in future to ensure GHGI uses all available source data. **RA:** 2013 submission method is not comparable to other MS and misleading. Recommend that the RA for chemical feedstocks is simplified by the use of IPCC defaults for carbon stored.
OPG / RFG (Other gases)	Chemical feedstock for chemical and petrochemical plant co-located on integrated sites with refineries. NEU in DUKES was 4% of demand in 2012. These NEU data exclude OPG/RFG used to fire boiler plant, which are recorded in DUKES as autogenerator use, but EUETS data indicates that a higher proportion of the OPG is used in combustion than is recorded in DUKES and therefore a re-allocation from NEU to 1A2f is made.	**SA**: Study findings support the current approach to estimating emissions. A new time series of best estimates – more complete and accurate - are available and should be used in future submissions. UNFCCC ERT recommends moving the 1A2f emissions to 1A2c. **RA:** 2013 submission method is not comparable to other MS and misleading. Recommend that the RA for chemical feedstocks is simplified by the use of IPCC defaults for carbon stored.
White Spirit and SBP	Used primarily as solvents and cleaning agents; they are not used as fuels.	**SA:** Research confirmed that current methodology is justified: all used for non-energy applications. No changes recommended. **RA:** Apply IPCC default carbon stored fraction.
Gas Oil	Used as a chemical feedstock at a small number of sites with off-gases burnt as fuel (**1A2f**). In 2012, DUKES reports 3% of gas oil demand as NEU.	**SA**: Research clarified that gas oil ("MDO") is used as a petrochemical feedstock at several sites, as previously assumed. Consultation also clarified that there is no use in the UK of gas oil (or fuel oil) in the manufacture of explosives, which was a possible gap identified by the UNFCCC ERT. No changes are recommended to the inventory methodology. **RA:** Apply IPCC default carbon stored fraction.
Lubricants	DUKES records 100% of demand as NEU. The GHGI includes emissions from combustion of waste lubricants in power stations (**1A1a**), industrial plant (**1A2f**), and from lubricant oxidation in transport equipment and machinery (**1A3a, 1A3b, 1A3d, 1A2f**).	**SA:** Research did not identify any new sources. No changes are recommended to the inventory methodology. **RA**: UK carbon storage factor (54% in 2012, 45% in 1990) is comparable to IPCC default (50%). Apply the IPCC default.

Commodity[1]	NEU applications in the UK and reporting approach in the 2013 GHGI Submission	Study Findings and Recommendations for Sectoral Approach (SA) and Reference Approach (RA)
Bitumen	No bitumen is used in combustion or otherwise emissive applications in the UK. All bitumen in the UK is assumed to be used in road surfacing, weather-proofing and other minor non-emissive applications. In DUKES, 100% of demand is NEU. No emission estimates are therefore included in the GHGI.	**SA:** Consultees validated the current approach, confirming current assumptions of 100% NEU and non-emissive applications in UK. No changes are recommended to the inventory methodology. **RA:** No changes recommended. Retain 100% stored fraction.
Petroleum coke	Petroleum coke is reported as used as a fuel within DUKES for the power sector and refinery sector only, with the remaining consumption (24% in 2012) for NEU. The GHGI deviates from DUKES, re-allocating petcoke from NEU to specific industry sectors where other data sources indicate use of petcoke as a fuel: by industry (**1A2f**) and in the domestic sector (**1A4b**). Emissions are also reported from NEU applications that are emissive, due to the degradation of specialty carbon products used as electrodes in the steel (**2C1**) and aluminium (**2C3**) industries. Estimates are based on operator information and annual metal production statistics.	**SA:** Research did not identify any additional sectors burning pet coke other than those already included in the inventory. Revised estimates for petcoke use in domestic fuels were received from industry representatives. It is recommended that these updated estimates be included in future inventory submissions. No changes to the inventory methodology are required. No additional emissive NEU applications for petcoke were identified, but it is recommended that the DECC energy statistics team consider revising the allocations of petcoke presented within DUKES to reflect the known uses of petcoke as a fuel (e.g. EUETS and MPA data for the cement sector) to reduce / remove the need for the GHGI to deviate from DUKES in future. EUETS Phase III may provide more data on petcoke use by UK industry. Recommend review of these data in future to ensure GHGI uses all available source data. **RA**: It is recommended that the reporting approach for petcoke be amended to be consistent with other commodities. The AD for the NEU allocation fo petcoke should be amended to reflect the known combustion uses in the SA (1A2f, 1A4b) that are not reported in DUKES. Emissive sources are then all reported in non-Energy sectors and therefore a 100% storage fraction should be applied.
Miscellanous oil products	This category includes petroleum waxes. There are no energy uses of these products in the UK. This is based on information provided historically by refinery operators, the refinery trade association (UKPIA). No emissions are reported in the GHGI.	**SA:** Consultees validated the current approach, confirming current assumptions of 100% NEU and non-emissive applications in UK. No changes are recommended to the inventory methodology. **RA:** No changes recommended. Retain 100% stored fraction.
Steam coal, coking coal, anthracite	There is no reported NEU for any solid fossil fuels in DUKES. Where coking coal is converted to coke and subsequently used in industrial processes, the UK energy balance reports all of the coke use as an energy source. Within the UK GHGI, all coke use emissions are reported within the Energy sector,	**SA:** Research confirmed that existing assumptions regarding use of coals, coke and coal tars and benzole were justified. Operator information indicates a different coal tar:benzole split (the data are reported aggregated in DUKES) than has previously been assumed. It is recommended that the calculation method be

Commodity[1]	NEU applications in the UK and reporting approach in the 2013 GHGI Submission	Study Findings and Recommendations for Sectoral Approach (SA) and Reference Approach (RA)
	with no activity allocated to NEU. DUKES reports coal tars and benzole as used for energy (i.e. 100% demand Energy, 0% demand NEU). The GHGI deviates from this, assuming all carbon is stored, based on previous industry consultation. Where emissions from electrodes may arise including a component from coal tars and benzole, in the UK GHGI emission estimates are allocated to the aluminium industry (**2C3**), but all carbon is assumed derived from petcoke.	amended to reflect an 80:20 split rather than a 50:50 split. This will have a very minor impact on overall emissions, but is a more accurate method. It is recommended that the DECC energy statistics team consider re-allocating the activity for coal tars and benzole to NEU, moving them from energy use in unclassified industry. This will reduce / remove the need for deviations from DUKES in future inventory submissions. **RA:** Apply IPCC default carbon stored fraction. Ensure that the activity data for NEU input to the RA calculations reflects the assumptions in the SA that 100% of coal tars and benzole are NEU.
Natural Gas	Natural gas is used as a feedstock in production of ammonia, acetic acid and acetic anhydride. Until 2001 it was also used to manufacture methanol. Less than 1% of gas consumption in 2012 was for NEU applications. Operator data is used from all UK production plant that use natural gas as a feedstock, and these data are used in DUKES to estimate the NEU allocation. Emissions from the use of natural gas as a feedstock in ammonia production are reported in **2B1**.	**SA:** Research did not identify any additional use of natural gas for NEU applications, but new information was provided by the regulator of one of the UK ammonia manufacturing sites, providing new production data for recent years. It is recommended that these updated production data be used in future submissions. Analysis of plant-specific IEFs highlighted an error in GHGI estimates for NEU of gas for 1990-2001. It is recommended that this error be corrected in future submissions. This will reduce the NEU allocation in those years and increase the Energy allocation (and hence UK GHGI emissions) in those years, to align with overall UK demand. In addition, an outlier IEF for one plant in 2011 has been identified and this warrants clarification / checking with the plant operator. The reporting of activity data in 2B1 currently includes the gas use as NEU for manufacturing other non-ammonia products such as acetic acid and acetic anhydride. It is recommended that the AD reported in 2B1 be revised in future submissions to only include gas used in ammonia production, to be consistent with IPCC GLs. **RA:** UNFCCC ERT has recommended that the carbon storage fraction be revised to 100% stored, reflecting the fact that this NEU does not lead to any emissions in Energy.

[1] *Note that this table excludes data for petroleum-based commodities that are reported in DUKES as 100% used as a fuel, including: aviation spirit, aviation turbine fuel, motor spirit, burning oil, DERV, and fuel oil.*

New data has also been collected on the nature of NEU for coal tars and benzole, and also for petroleum coke, although this will not require any revision to GHGI outputs.

The review of information from other Member States supports the conclusion that there are no major problems to be addressed in the UK GHGI Sectoral Approach. It found that no other countries stood out as clear 'best practice' and for many commodities the UK is not an outlier. Furthermore we note that there is extensive use of default assumptions by many Member States, and that there are few country-specific data with which to compare the UK-specific data.

In the case of naphtha, LPG and ethane, the level of carbon reported stored in the UK RA is very low compared with other countries, but this is a reflection of the method to derive the UK activity data and % stored figures in the 2013 submission of the RA. It is not a reflection of the accuracy of the underlying data or emission estimates that are reported in the UK GHGI; no changes are recommended to the UK GHGI method for estimating emissions from NEU applications of ethane, naphtha and LPG.

Reporting in the National Inventory Report

It is recommended that the DECC energy statistics team be requested to provide input to the NIR text on the compilation of DUKES Commodity Balance tables and the QA and level of uncertainty associated with them. This should ideally include consideration of:

(i) overall commodity balance consumption data, and
(ii) sector-specific (including NEU) allocations for each commodity.

Uncertainties

The research has not identified any issues that require immediate action in the GHGI uncertainty analysis carried out each year. Parameters used in that analysis are based on expert judgements and do not appear inconsistent with the new information gathered during this study. The research has confirmed the assumption made in the uncertainty analysis that the activity data for certain commodities such as propane, butane and naphtha are subject to high uncertainty, however the inventory agency do not have access to raw data used to generate the NEU statistics for these commodities and cannot easily estimate the level of uncertainty. Currently, the uncertainty analysis relies upon the statistical differences given in the DUKES commodity balance tables, and this approach should be maintained for the present.

Further work to be considered in future inventory improvements

Data on the fate of commodities allocated to NEU in DUKES

The preliminary annual review report of the 2013 UNFCCC Expert Review Team has requested that the UK provides data to validate all of the NEU allocations that are presented within the inventory, specifying what the NEU allocations are used for. This research has clarified that the NEU allocations are based on the best available data from UK fuel producers, importers and exporters, but that assumptions are made regarding the ultimate fate of the commodities reported, primarily based on the main operational activities of the company that has bought the commodity.

It is recommended therefore that the DECC energy statistics team consider a further review of their data compilation and reporting systems for NEU allocations, in order that more quantitative and transparent output for the UK GHGI compilation and reporting can be developed, whilst maintaining data confidentiality for individual operators and energy suppliers.

Use of 2013 EUETS Data: Extension of Scope to include Flaring

The scope of reporting of EUETS data in the UK will be extended in the 2013 dataset (reported to regulators in March 2014) to include new data on chemical industry flaring, as well as a wider interpretation of combustion activities to include some furnaces and reactors etc., that would currently be excluded. Access to these EUETS data will enable more accurate allocation of GHG emissions, as the inventory agency currently only has access to information on known combustion sources (from EUETS) and total site emissions (from the PI/SPRI/ISR). Therefore it is likely that the 2013 EUETS data will inform some revisions to GHGI data, but predominantly these should be revisions to allocation of emissions, rather than revisions to total UK emissions. This may impact upon the estimated use of feedstock in combustion activities in the UK.

It is recommended therefore that analysis of the 2013 EUETS dataset and use of any additional information to improve data transparency and accuracy be considered as a priority task within the improvement programme for the UK GHGI during 2014.

Development of bottom-up estimates of carbon stored in products

As noted in the section above on approaches by other Member States, the best practice approach used in Germany is to derive bottom-up estimates of the carbon stored in products through the use of detailed statistics on production of commodities manufactured from fossil carbon-containing feedstock. To enable the UK develop a similar approach, it is recommended that the UK seeks to develop a detailed, complete dataset on annual production of relevant chemicals and other products, to enable carbon content of UK output to be assessed and compared against the top-down data on fuel / NEU use from fuel suppliers, import and export data.

The current availability of chemical production data via the ONS PRODCOM reporting system is very limited and not sufficiently detailed (by product) due to the need to suppress commercially confidential data on production of individual chemicals. This issue would need to be addressed in order for the inventory agency to be able to use sufficiently detailed data to implement a method similar to that used in Germany, or to use production data to validate the current methods employed in the UK GHGI.

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- The Pollution Inventory team at the Environment Agency of England and Wales, and the Site Inspectors that have provided clarifications for specific UK process plant.
- Vicky Holloway of the Chemicals, Explosives and Microbiological Hazards Division of the Health and Safety Executive.

Annexes

Annex 1: Other Member State NEU Data and Methods

Annex 2: Requirements of the 2006 IPCC Guidelines

Annex 3: Commodity-specific reference sources for UK data and methods

Annex 1: Other Member State NEU Data and Methods

Observations of the UK Energy statistics for NEU

For simplicity of our analysis and in order to make comparisons with other Parties, we have assumed full consistency between the DUKES energy statistics and the data as available on the EUROSTAT website[1]. Table A2.1 provides the data for the latest year available: 2011 showing the products that have NEU.

Table A2.1 Final energy and non-energy consumption in the UK in 2011 for commodities where the energy statistics report final non-energy demand only (Data from EUROSTAT, downloaded in August 2013)

Product group	Product	Final Energy Consumption Commodity use (PJ)	Percentage of commodity	Final Non-energy Consumption Commodity use (PJ)	Percentage of commodity
All products					
	Crude oil and Petroleum Products	2 463.7	88.8%	310.6	11.2%
	Natural Gas	1 596.9	98.4%	26.1	1.6%
	Solid Fuels	156.3	100.0%		0.0%
All Petroleum Products					
	Gas / Diesel Oil	1 090.6	99.5%	5.3	0.5%
	LPG	59.3	43.2%	78.0	56.8%
	Naphtha		0.0%	47.4	100.0%
	Refinery Gas		0.0%	47.2	100.0%
Gas / Diesel Oil					
	Gas/Diesel oil	898.9	100.0%		0.0%
	Transport Diesel	188.6	97.3%	5.2	2.7%
Other Petroleum Products					
	Bitumen		0.0%	63.2	100.0%
	Other Oil Products		0.0%	23.0	100.0%
	Lubricants		0.0%	20.6	100.0%
	Petroleum Coke		0.0%	18.3	100.0%
	White & Industrial Spirit		0.0%	6.3	100.0%
	Paraffin Waxes		0.0%	1.1	100.0%

Observations:

- According to this table, non-energy demand only occurs for petroleum products and for natural gas. No non-energy use of solid fuels is reported in the UK energy demand statistics.
- An overall 11.2 % of all final demand for crude oil and petroleum products is used in NEU applications:
    - For naphtha, refinery gas, bitumen, lubricants, petroleum coke, white & industrial spirit, paraffin waxes and the “catch all other” commodity called “other oil products” the energy statistics report 100% non-energy use. This would mean that all carbon in these flows of commodities would be stored or emitted during product use or emitted in IPPU processes when used as a feedstock e.g. (For LPG, the energy

[1] http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/database on 28 August 2013, data update from 26 June 2013. There might be a version issue between the data as available from EUROSTAT and those in the latest version of DUKES. However the differences should be relatively small.

statistics report 56.8 per cent is used in non-energy applications, whereas a very small fraction of gas/diesel oil (2.7 per cent of a sub-fraction labelled “transport diesel”) is recorded as non-energy use).

- Finally 1.6 per cent of final natural gas use is recorded as non-energy use.

The data as reproduced in Table A2.1 are in good agreement with those of other EU Member States and are consistent with what is expected in an economy such as the UK: e.g. petroleum products that are generally not used for energy (for good economic and technical reasons) are showing high percentages of non-energy use and the fraction of non-energy use of natural gas and diesel oils is low and credible.

However, as indicated by the NIR from the 2013 submission, some of the data in the UK energy demand statistics are not consistent with other information that is available for Petroleum Coke, NGLs and coal tars and benzole and this alternative data has been used in the UK GHGI.

Comparison with other Parties

Error! Reference source not found. presents the data on carbon stored as reported by the UK in CRF table 1.A(d) and a selection of other Parties to the UNFCCC in 2013. The comparison shows that:

- The UK has a relatively comprehensive coverage of NEUs compared to other Parties, with some possible missing commodities (white spirit, waxes, refinery gas) reported by some other Parties and included in the Eurostat energy balance.

- The carbon stored in various commodities, as reported by the UK, is very low as compared to all other Parties in several cases (naphtha, LPG, ethane if we assume that ethane is part of the catch all other commodity “other oil products” in the energy demand statistics). This is inconsistent with UK’s energy demand statistics and, especially for naphtha, an outlier.

- For other commodities the UK seems to be in line with the values reported by other Parties, although these values show a relatively high variability amongst Parties.

<u>Recommendations:</u>

We note that In the UK, energy and non-energy use (commodities) data are primarily drawn from the national energy demand statistics in DUKES. However, for several commodities the NAEI team has evidence that the actual use differs from the use registered in DUKES. This occurs for petcoke, Natural Gas Liquids (NGLs), coal tars and benzole. The following approach should be taken to ensure consistency with IPCC guidance.

1. Where there are discrepancies between DUKES and data from other reliable sources (petcoke, Natural Gas Liquids (NGLs), coal tars and benzole) the UK should first correct the energy demand data it uses from DUKES to ensure that the final energy demand and the energy input into the energy transformation industry accurately describes the real world fossil commodity use and clearly and transparently explain this in the NIR (the

commodity by commodity recommendations below provide more details of approaches for each). Corrections of DUKES should of course be commodity neutral: any increase in energy use of a commodity should be compensated by an equal decrease of non-energy use or vice versa. This approach will ensure that the total final demand of fossil commodities together with the input into the transformation industry remains unchanged and therefore still can be compared with the gross national consumption, derived from the energy supply balance.

2. Apply these corrected energy demand statistics data to:

    a. Sectoral Approach

        i. Estimate combustion emissions in the *energy sector*, following the IPCC guidance in volume 2, Energy of the 2006 GLs

        ii. Estimate emissions from non-energy use of fossil commodities in the *IPPU sector*, following the guidance in volume 3 Industrial Processes and Product Use, chapter 5, of the 2006 GLs

    b. Reference Approach

        i. Estimate carbon stored to enable subtraction of carbon stored from the carbon emission as estimated from the energy supply balance, following the guidance in chapter 6 of volume 2 Energy of the 2006 GLs.

From the above we recommend the following approach for each commodity that is reported to be used for non-energy applications in the UK energy demand statistics as described in **Error! Reference source not found.** below.

Table A1. 2: Comparison of the quantitative reporting of Carbon Stored by Parties (CRF table 1.A(d); data from the 2013 CRFs as available from the UNFCCC website

Commodity	GBR	AUS	AUT	BEL	BGR	BLR	CAN	CZE	DEU	DNK	ESP	EST	FIN	FRA	GRC	HRV	HUN	IRL	ISL	ITA	JPN	KAZ	LTU	LUX	LVA	NLD	NOR	NZL	POL	PRT	ROU	RUS	SVK	SVN	SWE	USA	Average	Stdev	Min	Max
Blast Furnace Gas																					80%																80%	0%	80%	80%
Butane			75%																																		75%	0%	75%	75%
Coal			50%						80%																		100%									59%	72%	19%	50%	100%
Coal Oils																					80%																80%	0%	80%	80%
Coke			1%								5%		47%																								17%	21%	1%	47%
Coke Oven Gas																											100%								100%		100%	0%	100%	100%
Gasoline & Kerosene			50%						85%																	78%	100%								100%		83%	18%	50%	100%
Naptha	14%		75%	100%	75%		75%	80%	55%		80%		100%	100%	75%	80%	100%			62%	75%					78%			75%	80%	75%		80%		100%	119%	83%	15%	55%	119%
Other non-specified																	100%																				100%	0%	100%	100%
Other Petroleum products			75%						75%		80%		100%	75%	50%											78%											76%	13%	50%	100%
Pentanes Plus																																				59%	59%	0%	59%	59%
Petroleum Coke	100%								85%					75%	100%		100%		100%								100%								100%	30%	86%	23%	30%	100%
Refinery feedstocks																																			100%		100%	0%	100%	100%
Refinery Gas									55%																												55%	0%	55%	55%
Residual Fuel Oil									95%				100%													78%	89%								100%		92%	8%	78%	100%
Solvents		75%																																			75%	0%	75%	75%
Waxes														75%									100%		100%										58%	83%	18%	58%	100%
White Spirit										100%				75%											100%												92%	12%	75%	100%
Coke Lignite									90%																												90%	0%	90%	90%
Coke Hard coal									90%																												90%	0%	90%	90%
Other Bituminous coal											4%																										4%	0%	4%	4%
Iron and Steel Coal																												100%								100%	0%	100%	100%
Other Oils	98%																																		100%		100%	0%	100%	100%
,Gas/Diesel Oil	100%		50%			50%			55%					100%		50%	100%			24%	50%	50%				78%	50%			50%	50%	78%	80%	100%	100%	50%	65%	23%	24%	100%
Bitumen	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	78%	100%	100%	100%	100%	100%	100%	100%	100%	100%		99%	4%	78%	100%
Coal Oils and Tars (from Coking Coa	100%	75%	75%					73%			90%			75%		75%				100%	75%					58%				75%	75%	16%	75%		100%	10%	70%	25%	10%	100%
Lubricants	54%	60%	50%	50%	50%		50%	50%	90%	100%	50%	50%	33%	100%	50%	50%		50%	50%	86%	50%		50%	50%	50%	78%	80%		50%	50%	50%	63%	50%	100%	100%	9%	60%	21%	9%	100%
LPG	14%		100%	80%		80%	80%		55%				100%	100%			100%				80%	80%				78%	100%		80%	80%	80%	78%	80%	100%	100%	59%	85%	13%	55%	100%
Ethane	14%													100%		80%														80%			80%		100%		88%	10%	80%	100%
Natural Gas	41%			33%	33%	33%	98%		90%				100%	33%	100%	33%	100%			100%	33%	33%	100%			39%	100%		100%	33%	33%	72%	33%	100%	100%	59%	66%	31%	33%	100%

Table A1.3: Recommended NEU reporting procedure by commodity

Commodity	Approach	Other Party's approaches
Natural gas	The DUKES reported non-energy use of natural gas seems to be OK and the emissions from it seem to be appropriately accounted for under IPPU for ammonia production.	• Austria: (NIR-76) Manufacture: emissions from the use of natural gas as a feedstock in ammonia production are accounted for in the industrial processes sector (category 2.B.1). • Netherlands: (NIR-56) production of silicon carbide, carbon black, methanol and ethylene from the combustion of residual gas (a by-product of the non-energy use of fuels) are included in 1A2c (chemicals). Although these CO2 emissions are more or less process-related, they are included in 1A2 for practical purposes: consistency with Energy statistics that account for the combustion of residual gases. Their inclusion in 1A2 is justified since there is no strict IPCC guidance on where to include those emissions.
LPG	DUKES reports a fraction (about half of the LPG) that is used for non-energy applications. These might be the production of such chemicals as ethylene, propylene, butylene, butadiene, etc. In these cases the carbon in LPG will be stored in these products. LPG might also provide part of the heat needed for the chemical reactions. However the GHGI assumes a very low (and varying) % stored (14%). • Apply the DUKES data or corrected DUKES data using additional information (e.g. from EUETS, operators) with additional justification for the low carbon stored estimates. • Analyse what processes use this feed stock (ethylene, other chemicals) and report any emissions from this fraction in the relevant IPPU source category. • The emissions of the other part of the LPG (energy use) should be reported in the appropriate source category within sector 1.A • The fraction of LPG used for NEU can directly be used in table 1.A(b) of the CRF (column carbon stored)	• Most other Parties reporting data on Carbon stored for LPG have between 55% and 100% assumed stored (used in products). i.e. they assume that more than half and possibly all of the carbon in the LPG ends up in the products.

Commodity	Approach	Other Party's approaches
Naphtha	DUKES reports 100 % NEU of naphtha. This equals the default value as provided by the 2006 GLs (Vol 3 chapter 5). As the UK uses a different number, this will need a clear explanation why it is different. If a fraction of the naphtha appears to be combusted for energy: • Emissions from this fraction need to be estimated and reported under the appropriate source category within sector 1.A fuel combustion. • If non-energy use of naphtha leads to process emissions, these need to be reported under process emissions from the chemical industry. The IPCC default assumption is that this is not the case. The easiest way of doing this is to correct the DUKES data prior to using it in RA and SA. Given the IPCC default and the other Part data, the current reported fraction of naphtha use as a fuel appears to be improbable – possibly due to the approach adopted to aggregate across feedstock chemicals. Combustion might also occur as a waste treatment or as a safety option in flares. • Tables 1.A(b) and 1.A(d) should be completed accordingly	• Most other Parties reporting data on Carbon stored for Naphtha have between 60% and 100% assumed stored (used in products). • USA: (NIR A-85) Because reformed naphtha is used to make motor gasoline (hydrogen is released to raise aromatics content and octane rating), "straight-run" naphtha is assumed to be used as a petrochemical feedstock.
Refinery gas	DUKES reports 100 % NEU of refinery gas. There are various production processes that could convert RFG into feed stocks into the petrochemical industry, and RFG has been used as a feedstock in UK sites. The EUETS and operator data provides data on what refinery gas is used for and any emissions should be reported in the appropriate source category • Tables 1.A(b) and 1.A(d) should be completed using this (corrected if necessary) information.	• Carbon stored in refinery gas is only reported by Germany (55% stored). No other Parties refer to Refinery Gas explicitly in their CRF reports.
Gas/diesel oil	DUKES (Table 1) reports a very small fraction of gas/diesel oil as NEU. This fraction is labelled "transport diesel" as a sub-commodity under "gas/diesel oil". The GHG inventory assumes this is all stored which is consistent with many Parties. However, we do not have information on what this commodity is used for in non-energy applications. Any emissions from NEU use of "transport diesel' then should be reported under the appropriate source category. It might be that such emissions do not occur. • Tables 1.A(b) and 1.A(d) should be completed using this (corrected if necessary) information	• There is a large range in the % carbon stored for other Parties (table 2) from 25% - 100%.

Commodity	Approach	Other Party's approaches
Bitumen	Given the normal use of bitumen, a carbon stored fraction of 100% is reasonable	• Austria: (NIR A-75) Use: indirect CO2 emissions from the use of bitumen for road paving and roofing that should be reported in categories 2.A.5 and 2.A.6 are included in sector 3 solvent and other product use. Disposal: CO2 emissions from the disposal from bitumen are assumed to be negligible. Recycling is not considered. • Denmark: (NIR-324) The indirect emission of CO2 from asphalt roofing and road paving has been estimated from production statistics compiled by Statistics Denmark and default emission factors presented by IPCC (1997) and EMEP/CORINAIR (2004).
Lubricants	Given the normal use of lubricants, a carbon stored fraction of 100% is reasonable. A small fraction of lubricants might be oxidized during use, but it most frequently is not combusted for energy. For Lubricants the IPCC 2006 recommends assuming 20% oxidation (80% stored) during use (see section 5.2 of volume 3). UK (page 104 of NIR) suggests 13-16% oxidation (84-87% stored) which is broadly consistent with IPCC (see above). However, CRF data table 1.A(b) suggests between 34 and 59% oxidation (41% - 66% stored). This needs to be clarified in the NIR to explain the data available on use of waste lubricants in specific sectors (e.g. power, cement). Lubricants might be incinerated as end-of-life treatment. This then should be reported in the energy sector (if incinerated with energy recovery) or waste sector. Activity data will normally be derived from waste statistics, rather than from the energy demand statistics. • If incineration is reported in the energy sector this might lead to an underestimate of the emissions in the RA. That is not a problem and should be explained in the section of the NIR comparing RA and SA. • If incineration is reported in the waste sector, the RA, assuming 100% C stored will not estimate these emissions either.	• Most other Parties assume between 50% and 100% carbon stored in lubricants (see table 2). • Austria: (NIR 75) Use: emissions from the use of motor oil are included in CO2 emissions from transport. VOC emissions from lubricants used in rolling mills are considered in category 2.C.1. It is assumed that other uses of lubricants do not result in VOC or CO2 emissions due to the low vapour pressure of lubricants. Disposal: emissions from incineration of lubricants (waste oil) are either included in categories 1.A.1.a and 1.A.2 if waste oil is used as fuels or in category 6 C respectively if energy is not recovered.

Commodity	Approach	Other Party's approaches

Petroleum coke	DUKES reports 100 % carbon stored for petcoke. Additional data suggest that at least part of petcoke is combusted in the cement industry. The UK GHGI has two options here:
	• If petcoke is used as an additive to influence the cement specifications,
	  ○ this petcoke use could be interpreted as NEU, despite the fact that the oxidation of petcoke will provide some process heat. The CO2 emissions from this petcoke then should be included in the country specific emission factor for cement production and the associated emissions should be reported under source category Cement in the IPPU sector.
	  ○ The carbon stored fraction in the RA could be assumed to be 100% as reflected in DUKES
	• If petcoke is used primarily for energy in the cement industry, the DUKES data would need to be corrected prior to their use in the inventory. Both the SA for energy and the RA should be completed in accordance with these updated DUKES statistics.
		• 8 Parties reporting % stored report between 30% (USA) and 100% stored (see table 2)

White and Industrial Spirit	Given the normal use of white spirit, a carbon stored fraction of 100% is reasonable. It is hardly ever combusted for energy and hence will not be included in the SA of the energy sector. If there is country-specific information that it is combusted for energy in some companies or industries, the DUKES data need to be corrected for this and the RA tables in the CRF have to be completed in accordance with this correction, but there appears to be no such evidence. For White Spirit IPCC 2006 recommends accounting for this in calculations for CO2 from NMVOCs under sector 3 solvent use (see section 5.5 of volume 3)	• 3 Parties reporting % stored report between 75% and 100% stored (see table 2)
Paraffin waxes	Given the normal use of paraffin waxes, a carbon stored fraction of 100% is reasonable. Candles are hardly ever burnt for energy and emissions from this will normally not be included in the SA for the energy sector. Hence assuming 100% carbon stored in the RA is correct. However, For PARAFFIN WAX USE the IPCC 2006 recommends assuming 20% oxidation during use (see section 5.3 of volume 3). The UK assumes 58% carbon stored consistently between the SA and the RA, and therefore there should be no reporting inconsistency.	• 4 Parties reporting % stored report between 58% and 100% stored (see table 2)

Commodity	Approach	Other Party's approaches
Other oil products	These might include a range of other intermediate refinery products. Using a carbon stored fraction of 100% seems to be reasonable. The NAEI team could try to assess in more detail what these NEU commodities are. Any other oil product included in this energy demand entry could be treated similarly.	• Parties reporting % stored report between 50% and 100% stored (see table 2)
Any other commodity not reported in the NEU entry of the DUKES	Correct the DUKES statistics and apply these in the inventory calculations. • NGLs are not reported as final energy use in the UK energy statistics. Its use apparently only occurs in refineries and is seen as feedstock into the refining process, where it is distilled (not combusted); • Coal tars and benzole are not reported in the energy demand statistics and are reported as 100% fuel use, in energy sector. This is known to be an error in DUKES; some of this is contributing to the UK anode value and should be considered a feedstock to IPPU, otherwise the carbon is stored.	

Annex 2: Requirements of the 2006 IPCC Guidelines

Compared to the 1996 Guidelines the treatment of emission from non-energy use of fossil commodities is much more clearly described in the 2006 Guidelines. Chapter 5 of Volume 3 (Industrial Processes and Product Use) provides clear and complete guidance on how to treat emissions from non-energy use of fossil commodities in the Sectoral Approach. NEU of fossil commodities is by definition not reported in the energy sector. However, it is relevant as a correction in the Reference Approach and provides a cross check for the total carbon in fossil commodities which are stored in products or used as feedstock.

To apply the IPCC guidance correctly, the following is recommended:

1. The SA estimates energy combustion emissions, using understanding of the chemistry of fuels actually used in all combustion processes. Activity data here must be taken from energy sales (or demand in statistical terms) data (1.A.2, 1.A.3, 1.A.4) and from energy[2] input into energy transformation industries (1.A.1). Part of the inputs into these transformation processes is used as fuel to provide the energy necessary for the processes and part is used as feedstock. This is particularly the case for refineries.
2. The RA estimates energy combustion emissions, using understanding of the primary production of, and trade in, fossil primary and secondary commodities. In the UK, the DUKES Commodity Balance tables provide this information. Using carbon contents for all commodities, this trade balance is first converted into a carbon balance. The full fossil carbon balance for the country then is converted into an emission estimate.
3. The gross national consumption, derived from the balance between primary production, imports, exports, marine bunkers and a few minor entries, is used for the Reference Approach as an independent estimate of CO_2 emissions from fossil fuel as a QA/QC procedure.
4. Differences between RA and SA will occur and if not too large (a few per cent) are fully acceptable. In fact these differences are expected to be in the order of magnitude of the so-called statistical differences.
5. Since the energy supply balance data and the energy demand data are independently collected and the methods are essentially different, SA and RA provide two independent methods to estimate emissions. Therefore the RA can be used to QA/QC the SA.
6. The RA uses statistical trade data on amounts of fuels prior to any energy transformation process, whereas the SA uses statistical demand data on inputs into the transformation and final demand of secondary and primary (mainly natural gas and coals) fuels.
7. Some commodities are partly used for non-energy use (NEU) applications. These are not recognized in the RA data and hence the RA needs to be corrected for this NEU before a comparison with the SA can be made. Demand statistics do provide information on the amount of (secondary) products that are NEU and hence these data can be used to subtract the carbon not oxidised (for energy) from the RA.
8. Finally, since the national total emissions must be calculated from the SA, any flaws in the RA do not influence UK's accounting. We cannot however exclude the possibility that in UK's submissions until now the emissions related to the use of non-energy use of fuels are misallocated, underestimated or overestimated in the relevant source categories in industrial processes, product use and waste.

[2] Please note that "energy" here means any fuel used for process heat, needed for the transformation processes; it excludes fossil commodities (primary or secondary) that are transformed in other fossil commodities such as crude oil and feed stocks.

For the Sectoral approach, the 2006 IPCC Guidelines (as do the IPCC 2000 GPG) require the Parties to use data on final energy demand (1A2, 1A3, 1A4) and energy input into the energy (transformation) industry (1A1) as the activity data for the sectoral approach of the energy sector. In the UK the starting point is the DUKES data. Since the inventory team has information that the DUKES data deviate from real world fuel use, either through misallocations or through lack of sufficient detail, the DUKES data should be corrected prior to its use as both activity data in SA and balance data in RA.

The IPPU volume (2006 GLs Volume 3) includes a separate chapter on accounting for some of commodities used as feed stocks (chapter 5, NON-ENERGY PRODUCTS FROM FUELS AND SOLVENT USE). This chapter provides methods for estimating emissions from the first use of fossil fuels as a product for primary purposes other than i) combustion for energy purposes and ii) use as feedstock or reducing agent. Emissions from the latter two uses are accounted for by methods described in the chemical industry (IPCC 2006 GLs, Volume 3 Chapter 3) and in metal industry (IPCC 2006 GLs, Chapter 4). Chapter 5 of the IPPU volume proposes methods for lubricant use (section 5.2), paraffin wax use (section 5.3), asphalt production and use (section 5.4) and solvent use (section 5.5).

[The view of the Lead Reviewers engaged on this review is that these chapters are fully consistent with what was meant by the 1996 Guidelines but was not very clearly explained.]

More details about the recommended approaches to reporting NEU of fuels is provided in the Annex 1 table 3, which presents the recommended approach alongside the summary of how other Parties report their NEU data.

Annex 3: Commodity-specific reference sources for UK data and methods

Natural Gas

Personal Communication: Darren Leng, the EA's Site Inspector for the Yara International ammonia plant at Saltend. (October 2013). Clarification of plant ownership and provision of ammonia production data for recent years in the time series.

Coal Tars and Benzole

Personal Communication: Bob Lewis, Tata Steel, (Sept. 2013). Clarification of fate of products within coke oven and effluent.

Personal Communication: Mick Briggs, Tata Steel, (Sept. 2013). Clarification of content of EAF and LAF electrodes, the UK and imported sources for needle coke.

Personal Communication: Glyn Currie, Koppers UK Ltd. (September 2013). Confirmation that the UK GHGI assumptions used in the 2013 submission regarding fate of coal tar and benzole materials and products are still applicable.

Ethane, Propane, Butane, Naphtha

Some data related to the use of process gases as fuels were collected as part of the GHGI improvement research detailed in the report "GHG Inventory Research: Use of EUETS Data - Iron and Steel Sector"

Personal Communication: Andy Roberts, Director - Environment, Health and Safety, UK Petroleum Industry Association. Summary of the petrochemical production facilities that account for the majority of feedstock materials reported as NEU. Clarified the feedstock used in each UK plant and the products.

Gas Oil

Personal Communication: Vicky Holloway, CEMHD 7 (Chemicals, Explosives and Microbiological Hazards Division - Unit 7), Explosives Inspectorate. (October 2013). Clarified that no sites under the HSE regulation utilise gas oil or fuel oil in the manufacture of explosives. No such activities exist in the UK.

Personal Communication: Andy Roberts, Director - Environment, Health and Safety, UK Petroleum Industry Association. Identified the main UK petrochemical production plant that use gas oil as a feedstock.

Bitumen

Personal Communication: Chris Southwell, Refined Bitumen Association, 3/10/13. Confirmed that the assumption that 100% of carbon from bitumen is stored in UK products, as assumed within the 2013 submission.

Petroleum Coke

Personal Communication: Andy Roberts, Director - Environment, Health and Safety, UK Petroleum Industry Association. Clarified the UK sources of petroleum coke, the main consumers and provided insight into the import / export balance.

White spirit and SBP solvents, Lubricants (and greases), Waxes, Miscellaneous Products

Personal Communication: Andy Roberts, Director - Environment, Health and Safety, UK Petroleum Industry Association. For all of these commodities, provided clarification of the main applications in the UK and the UK producers. Where possible provided validation of the current assumptions in the 2013 submission, and provided context as regards the significance of each commodity for potential emissions.

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