Department of Energy & Climate Change

RICARDO-AEA

# UK Greenhouse Gas Emissions Estimates: QA/QC Plan

## 1 Introduction

### 1.1 Description and purpose of the datasets

#### Greenhouse Gas Emissions Estimates by Source

The dataset contains emissions of the Kyoto basket of six greenhouse gases (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) on a source basis. This attributes emissions to the sector that emits them directly.

Emissions are reported in National Communication format, and are published as the UK's National Inventory, that is submitted to the EC and UNFCCC, and on the DECC website. The UK Greenhouse Gas Inventory is compiled and maintained by Ricardo-AEA (the Inventory Agency) on behalf of DECC.

#### Greenhouse Gas Emissions Estimates by End User

The dataset contains emissions of the Kyoto basket of six greenhouse gases on an end user basis. This allocates emissions associated with energy supply to the end users of the energy.

Emissions are reported in National Communication format, and are published on the DECC website, and as part of the UK's National Inventory Report. The end user inventory is generated from the source inventory.

The dataset allows a more complete picture of emissions within a given sector, by allocating indirect emissions associated with energy supply to end use sectors. For example, in the domestic sector, emissions associated with electricity use are reallocated from power stations to the domestic users. This allows trends in total emissions from energy consumption in the sector to be assessed.

#### $CO_2$ and non-$CO_2$ Provisional Emissions Estimates

The dataset contains provisional emissions estimates of the six greenhouse gases of the Kyoto basket on a source basis. Carbon dioxide emissions are reported in National Communication format, while emissions from the other gases are reported as total.

Provisional greenhouse gas emissions estimates are published on the last Thursday in March each year, 3 months after the end of the year in question. This coincides with the publication of the March edition of *Energy Trends*, which is the first release of statistics covering UK energy use in the most recent year (i.e. year t-1).

The greenhouse gas provisional emissions estimates are subject to revision when the final estimates are published 13 months later (t+1); however, they provide an early indication of emissions in the most recent full calendar year. In the last 4 years provisional estimates were within 1 per cent of the final figures.

**Local and Regional $CO_2$ Emissions Estimates**

The dataset consists of $CO_2$ emission estimates for each Local Authority in the UK and aggregations of these statistics to Government Office Regions.

The dataset is compiled on a consistent basis across the whole of the UK and is as far as possible consistent with nationally reported emissions to the UNFCCC and under the Kyoto Protocol. The dataset provides a spatial disaggregation of the national $CO_2$ inventory on an End User basis in which emissions from the production and processing of fuels (including electricity) are reallocated to users of these fuels. This then means the total emissions associated with the use of fuel by the end user are quantified and can be presented.

The dataset is produced each year by Ricardo-AEA on behalf of DECC and is published on the DECC website.

There is an increasing need for Local and Regional data on emissions of $CO_2$ because the UK climate challenge needs to be tackled at a local level. In order to do this a consistent evidence base is required, to enable local authorities and other relevant organisations to prioritise and act effectively to reduce emissions. This is necessary for national and regional targets to be met.

## 1.2 Purpose of this QA/QC plan

This QA/QC plan has been developed to describe the Quality Assurance and Quality Control procedures in place to ensure the datasets meet the quality requirements for National Statistics and to explain the data processing steps required for producing the datasets. The 5 key principals for this QA/QC plan are shown in **Table 1** below. These principals are inter-related and apply at various levels in the data compilation and reporting processes. The definitions provided here relate to the compilation of a National Inventory but the principals still apply to the compilation of end user statistics and datasets at a lower geographical resolution and for local/national rather than international purposes.

**Table 1: QA/QC Principals and their application to the end user and Local $CO_2$ datasets**

| **Principal and definition in relation to the national inventory compilation** | **Procedures in place to ensure principals are implemented for the end user dataset** | **Procedures in place to ensure principals are implemented for the Local $CO_2$ dataset** |
|---|---|---|
| **Transparency** means clear documentation and reporting at a level of disaggregation that sufficiently allows individuals or groups other than the designated emission expert or the compiler of the inventory to understand how the inventory was compiled and assure it meets good practice requirements. The transparency of emission reporting is fundamental to the effective use, review and continuous improvement of the inventory. | A detailed data processing manual for internal use. Documentation within the databases and spreadsheets showing data inputs, calculations and outputs. Chapter within the NIR explaining the method used, how the end user emissions relate to the by source emissions and summarising the data set. | A detailed manual for internal use setting out the data processing approaches. Documentation within the databases and spreadsheets showing data inputs, calculations and outputs. Annual Methodology report which includes an explanation of changes in methods between years and the differences between this dataset and other $CO_2$ emissions data for the UK. |
| **Consistency** means that estimates for any different inventory years, pollutants and source categories are made in such a way that differences in the results between years and source categories reflect real differences in emissions. Annual emissions, as far as possible, should be calculated using the same method and data sources for all years, and resultant trends should reflect real fluctuations in emissions and not the changes resulting from methodological differences. | The input data for the end user estimates are compiled as part of the national inventory as reported to the UNFCCC. Updates are made each year to the time series to take account of new methods and data (EFs and activity data). | Updates are made each year to the time series to take account of new methods and data (EFs and activity data). |

| Principal and definition in relation to the national inventory compilation | Procedures in place to ensure principals are implemented for the end user dataset | Procedures in place to ensure principals are implemented for the Local $CO_2$ dataset |
|---|---|---|
| Consistency also means that, as far as practicable and appropriate, the same data are reported under different international reporting obligations. | | |
| **Comparability** means that the national inventory is reported in such a way that allows it to be compared with national inventories of other Parties. This can be achieved by using accepted methodologies and by using the reporting templates and through the use of the harmonized Nomenclature For Reporting (NFR), as specified in Annex III of the Reporting Guidelines. | The total emissions within the dataset are equal to the "by source" emissions for the same geographical coverage. | Comparisons are made with other published datasets (EU-ETS, DA inventories, UK totals).<br>The use of nomenclature to define sectors as outlined in earlier reports on this dataset. |
| **Completeness** means that estimates are reported for all pollutants, all relevant source categories and all years and for the entire territorial areas of Parties covered by the reporting requirements set forth in the provisions of the Convention and its protocols. | Specific checks are made to ensure that the total end user inventory is equal to the total emissions within the source inventory. | Comparison with the UK National Inventory to ensure we have included all relevant sectors.<br>Some sectors are specifically not included because it is not appropriate to report at the LA level e.g. aviation, shipping. |
| **Accuracy** means that emissions are neither systematically overestimated nor underestimated, as far as can be judged and with uncertainties reduced as far as practicable. This implies that Parties will endeavour to remove bias from the inventory estimates and minimize uncertainty. | Uncertainty analysis is undertaken each year.<br>Peer review of methods ensures that the most appropriate and up to date methods are used<br>Emission maps for NOx and PM10 (produced using similar method as for $CO_2$) are verified against measured air pollution concentrations. | Uncertainty analysis is undertaken each year.<br>Peer review of methods ensures that the most appropriate and up to date methods are used<br>Emission maps for NOx and PM10 (produced using similar method as for $CO_2$) are verified against measured air pollution concentrations. |

The $CO_2$ and non-$CO_2$ provisional emissions estimates do not come from the Greenhouse Gas Inventory. $CO_2$ provisional emissions are very simple estimates based on the change in energy use between year t-2 and year t-1. It is assumed that the percentage change in $CO_2$ emissions between year t-2 and year t-1 is the same as the percentage change in energy use between the two years. Non-$CO_2$ provisional emissions are estimated based on a simple approach which assumes that the trend for the other 5 gases of the Kyoto basket1 will be half way between 'no change' on the latest year and a repeat of the trend over recent years. The calculations are conducted by the Climate Change Statistics team.

The March edition of *Energy Trends*, on which the provisional emissions estimates are based, is published by the Energy Statistics team in DECC, who also collect and quality assure the data of this publication. If absolute and percentage differences between the two consecutive years are higher or lower than an agreed value, a further check is required by the Energy Statistics team in order to identify any data processing errors. The calculations are conducted by the Climate Change Statistics team but the results are then submitted to the Energy Statistics team for additional revision.

# 2 The QA/QC Plan

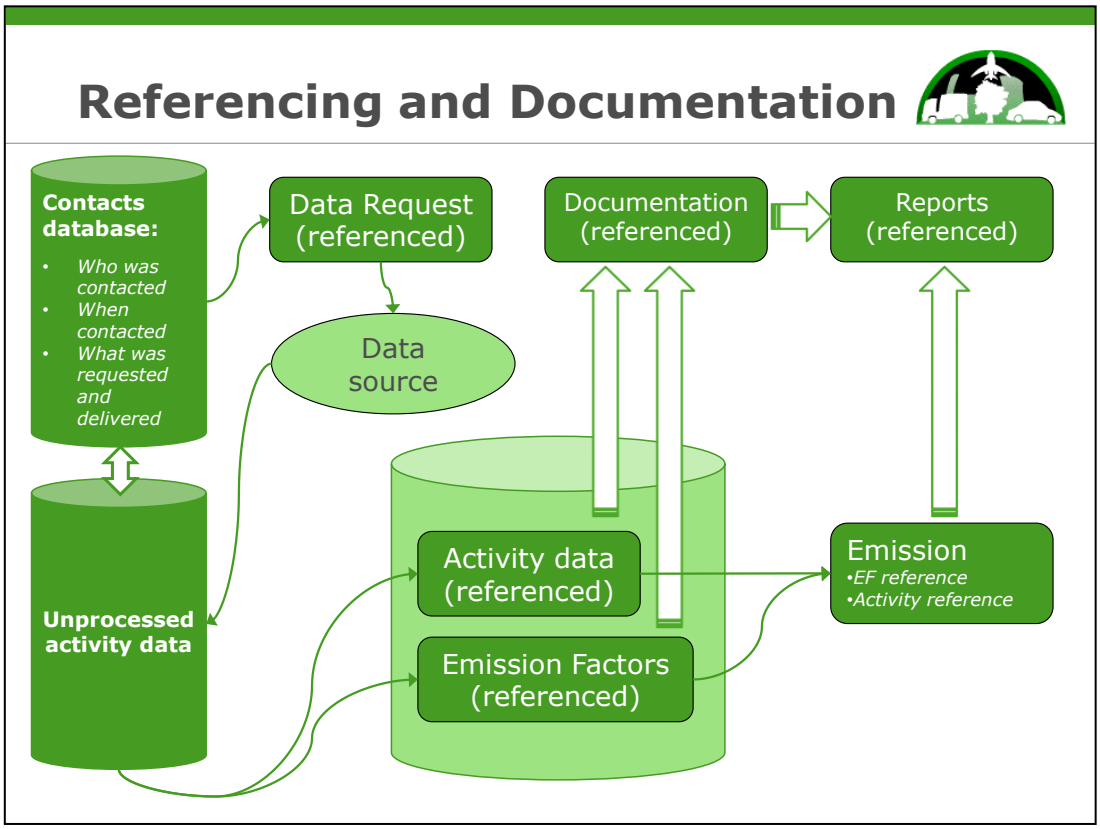
The UK national emission estimates are prepared via a central database of activity data and emission factors, from which the UK emissions are extracted and reported in a variety of formats. The QC within this system has evolved over many years, and is illustrated in **Figure 1** below.

Numerous QA/QC procedures are built into the data processing system. These include checks before activity data, emission factors and other necessary data are entered into the national database of GHG emissions, and when data are extracted from the database. The database contains activity data and emission factors for all the sources necessary to construct the UK GHG inventory.

In addition to the UK's own GHGI specific QA/QC system, through Ricardo-AEA, the Inventory has been subject to ISO 9000 since 1994 and is now subject to BS EN ISO 9001:2008. It is audited by Lloyds and the Ricardo-AEA internal QA auditors. The NAEI has been audited favourably by Lloyds on three occasions in the last 12 years. The emphasis of these audits was on authorisation of personnel to work on inventories, document control, data tracking and spreadsheet checking, and project management. As part of the Inventory management structure there is a nominated officer responsible for the QA/QC system – the QA/QC Co-ordinator. Ricardo-AEA Ltd is currently accredited to BS EN ISO 9001:2008. Lloyds Register Quality Assurance carried out a three yearly recertification audit of AEA in September and October 2011. Ricardo-AEA Ltd successfully passed the recertification, with no major non compliances, and a new certificate was issued. Ricardo-AEA is currently certificated both for the Quality Assurance ISO 9001:2008, including TiCKIT, and Environmental Management System ISO 14001 standard.

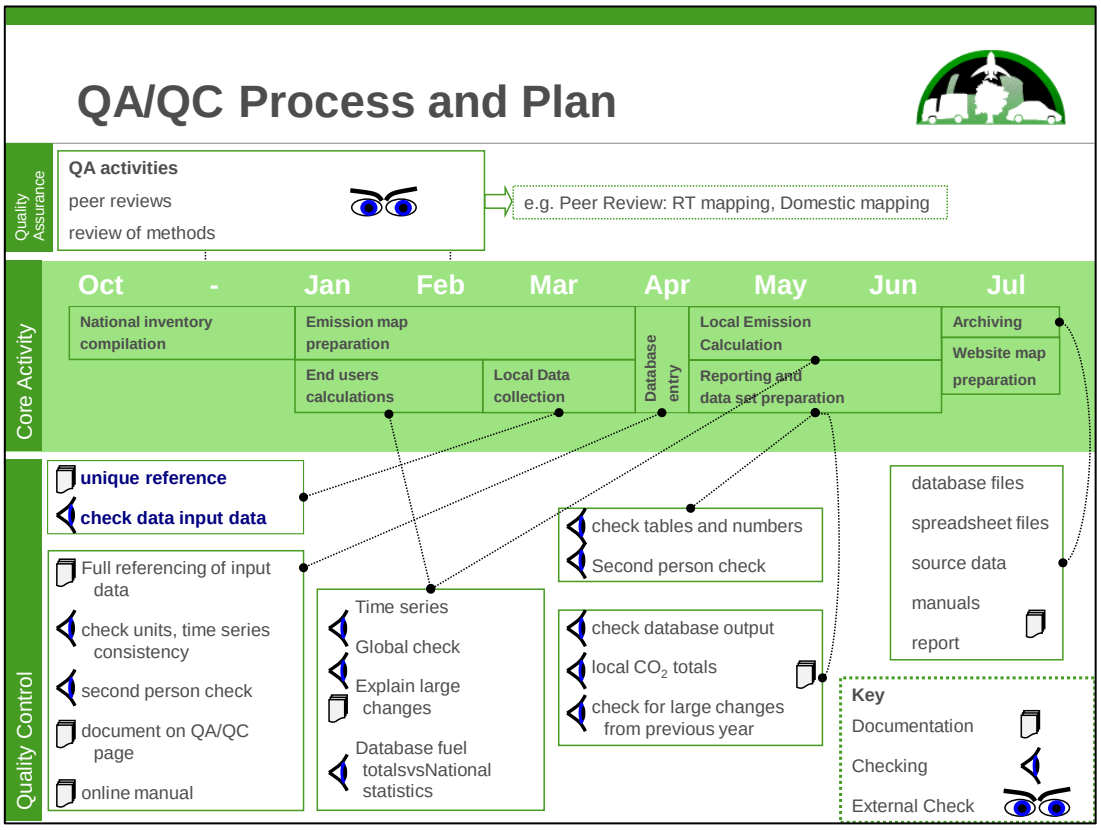
The scope of Ricardo-AEA's Quality Assurance (QA) system includes procedures for preventative actions, the control of non-conforming products and services, corrective actions, and continuous improvement.

**Figure 1: System of referencing and documentation used within UK greenhouse gas inventory**



The QA/QC plan for the Local $CO_2$ estimates mirrors that of the inventory as a whole to ensure the inventory best practice procedures are applied to this work. It includes documentation, checking and peer review across the process of LA $CO_2$ compilation. This is illustrated in **Figure** .

**Figure 2: QA/QC Plan for the compilation of the Local $CO_2$ dataset**




The Plan establishes the minimum requirements for QA/QC across the activities involved in compiling the Local and Regional $CO_2$ estimates and is underpinned by the UK GHG inventory QA/QC as reviewed by the UNFCCC.

# 3 Documentation: Providing Transparency

The following activities ensure that the inventory compilation is transparent:

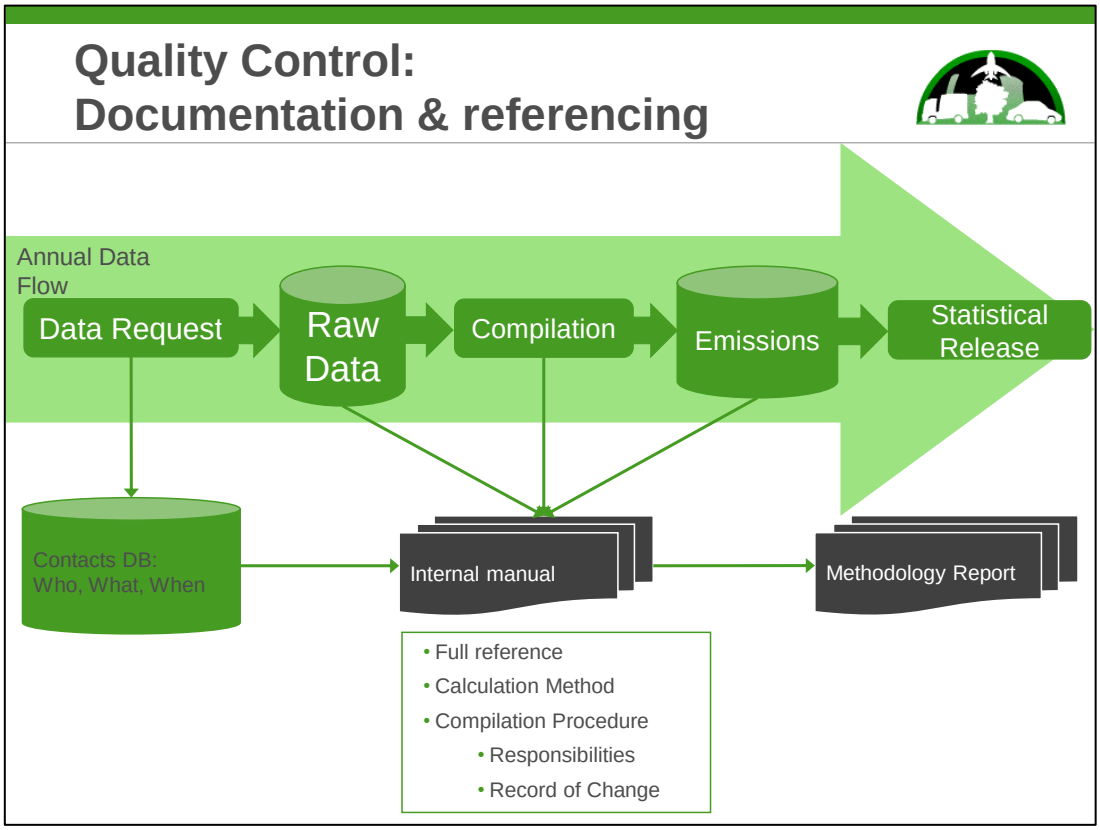
- Source data received by Ricardo-AEA are logged, numbered and are traceable back to their source from anywhere in the compilation system. The mechanisms for this are a contacts database, spreadsheet notes, and an automated system of data referencing within the main NAEI database of activity data and emission factors. These mechanisms are described below.
- A contacts database provides the mechanism by which all incoming and outgoing data from the UK GHG inventory is logged and referenced in a transparent way that enables data flows to be traced back to source from any part of the data pathway. This database provides the central hub for data referencing and archiving and also provides a detailed record of data required for inventory compilation and the data source contacts, thereby ensuring both transparency of inventory data flows and consistency in source data acquisition across inventory cycles.
- Data processing spreadsheets each include a QA sheet in a standard format. This QA sheet provides summary details of source data, data processing activities for each sheet, the scope of activity and emission factor data outputs, relationships with other processing spreadsheets (where inter-dependencies exist), links to internal

consistency checks, plus records of authorship, version control and checking procedures.

- The UK inventory and associated geographical information are held as a database of activity data and emission factors, point source emissions and geographic distributions. Within the database these data fields are referenced to both the data source and the spreadsheet used to process source data. The database is populated via an automated system of querying specific spreadsheets, and data may only be uploaded to the database once it meets specified QAQC criteria of data checking, completion and consistency. The automation routines help to minimise potential human data transcription errors, and are also checked as part of the QA system.
- Annual reports to UNFCCC and UNECE provide full details of inventory estimation methodologies by source sector for the UK totals. Reports on the mapping provide the additional methodology for the mapping activities. These reports include summaries of key data sources and significant revisions to methods and historic data, where appropriate.

**Figure 3** and the paragraphs below provide an outline of the documentation processes.

**Figure 3: Summary of Documentation processes**




### 3.1 Methodology report

Annex 13 of the UK's National Inventory Report contains an overview of the principles of the end user calculation and the database method used, example calculations, and detail of how the end user categories map onto the by source inventory. This is the main, publically available source of information about the end users inventory.

The Local and Regional $CO_2$ Emissions Estimates report is publicly available on the DECC website and includes descriptions of the methods used to compile the emissions estimates for the different sectors listed in the dataset. It also describes the assumptions that we have used in this compilation.

### 3.2 Detailed Manual

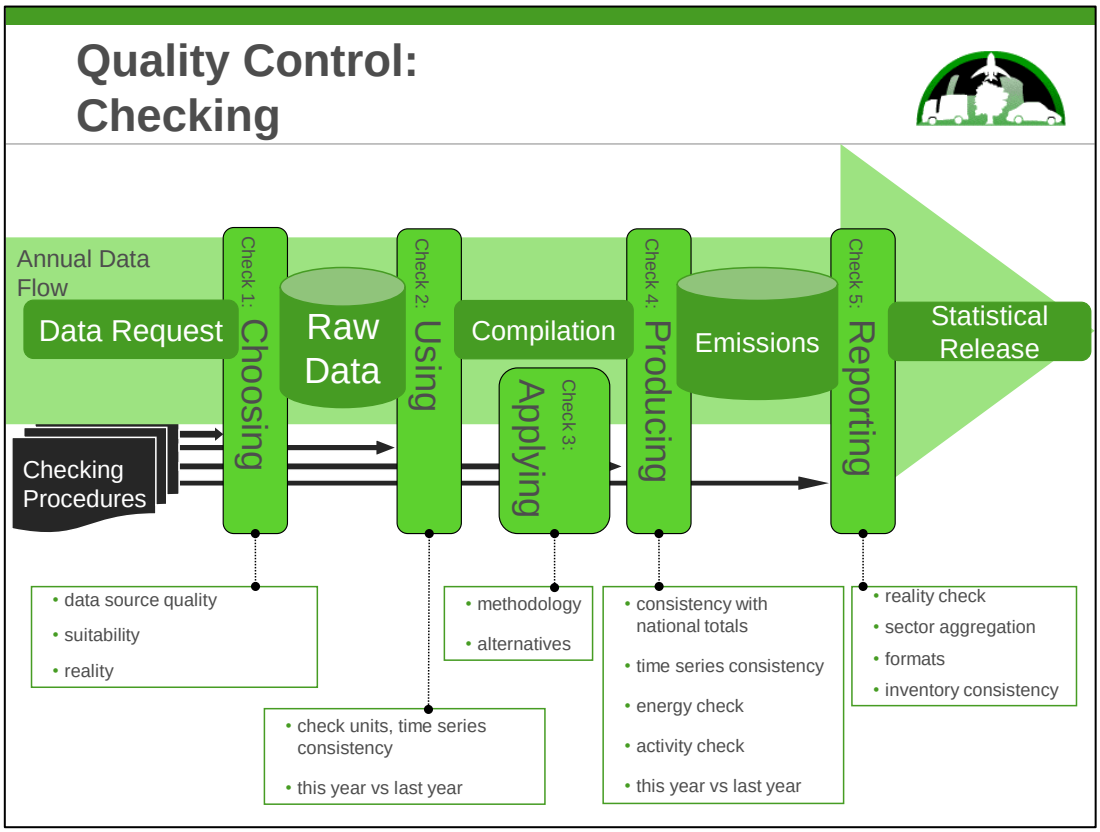
The end user calculations are carried out within a database. This has been fully documented with system diagrams to show the flow of data and the sequence of queries used. An internal manual has also been compiled, detailing how to run the model.

For the Local and Regional $CO_2$ Emissions Estimates this is an internal detailed manual for the reliable production of the data each year; see Annex 1 of this document for a list of the detailed processing steps.

# 4 Checking procedures and QA: Completeness Consistency

Checks are undertaken at each stage of the inventory compilation – on receipt of the data, after each calculation step and at the end of the process before dissemination. These procedures are summarised in **Figure** .

**Figure 4: Summary of QC and checking procedures**




**UK Inventory Checks**

- AEA's QA/QC system requires that calculations are checked and the checks applied are described. Also the data sources used for calculations must be referenced on the spreadsheet or file/database.
- All spreadsheets are subject to second-person checking prior to data uploading to the NAEI database.
- Source data used for calculations are referenced on the spreadsheet QA page with more detailed references (e.g. to a specific table within a referenced publication) noted throughout the processing spreadsheets to ensure transparency of data flows and consistency of inventory compilation.

- Mass balance checks are made to ensure that the total fuel consumptions in the inventory are in accordance with those published in the official UK Energy Statistics from DECC or with other appropriate statics such as Emissions Trading Returns.
- Database and GIS output comparisons between different inventory cycles enable the investigation of the effects of recalculations and help identify any data processing errors. A designated auditor identifies sources where there have been significant changes or new sources. Inventory compilers are then required to explain these changes to satisfy the auditor.
- A final check is made on the inventory comparing the emissions of the latest year with those of the previous year (within the same inventory version).

**End user emissions checks**

The inputs for the end user estimates are mostly the same as those for the national inventory, and the checks applied to the raw data, at the compilation stage and to the emissions outputs are all relevant to the end user estimates. Therefore, the checking procedures relevant to the end user data set, build on those already in place for the by source inventory. Only estimated electricity use, and fuels exported from the UK do not form part of the by source inventories. These data inputs are still checked as part of the overall compilation process – exports data are introduced within the spreadsheets used to compile estimates of fuel use by sector, and electricity is compiled as a separate spreadsheet.

Additional checks made to the end user emissions outputs are:

- Totals check – the total emissions from the end user model, by fuel, must be consistent with the total emissions by source.
- Energy supply – within the model, emission from energy supply should be allocated out to all energy users. This category should therefore be close to zero – if not, this is an indication of a problem with the model.
- Checks vs. the previous year – a cross check of the emissions time series against the previous highlights where there are large differences. These can then be investigated and explained.
- Source vs. end user checks – for all categories (except for energy supply), end user emissions are expected to be greater than or equal to emissions by source. Large variations in the ratio of source to end user emission across the time series may indicate an error in the data processing, and should be explained.
- Trend checks – large inter-annual variations should be investigated, especially where these are not also reflected within the by source inventory.

**Local $CO_2$ emissions checks**

Further checks are undertaken specifically for the Local $CO_2$ emissions dataset to ensure that the emissions estimates are complete and consistent with UK and Devolved Administration totals (and if not then the reason is understood and explained). A summary of specific checks are listed in **Table 2**.

**Table 2: Checking Procedures for the Local $CO_2$ dataset**

| ID(s)* | Checking Procedure |
|---|---|
| Checking data inputs | |
| 1,3 | The $CO_2$ estimates in NAEI databases are checked as part of the GHGI inventory QA system before reporting National emissions to DECC and the UNFCCC. |
| 19,23,24,25 | Check total and sector level fuel consumption for consistency with DUKES data used in NAEI database. These datasets are National Statistics and have therefore already been subjected to appropriate levels of QA/QC. |
| 5,14 | Site-specific and 1km resolution distribution grids inputs are checked by the relevant NAEI data compilers.<br>Site specific emissions by sector are checked for completeness with national |

| ID(s)* | Checking Procedure |
|---|---|
| | emissions by sector and fuel.<br>Emission pattern distributions in 1km maps should add to 1 (each 1km square a fraction of the national total).<br>The NAEI emissions distributions have been verified through modelling of air quality, for example of $NO_x$. |
| 31 | CEH LULUCF data are compared with previous year's estimates and against national and devolved administration totals for consistency. |
| Checking data processing and calculations | |
| 4 – 17 | Checking output of database queries at each stage to ensure completeness of sectors and comparisons with national total emissions.<br>Independent check on output of database queries to ensure correct configuration of the queries. |
| 18 - 28 | Internal checks in spreadsheets to ensure completeness (check sums of activity data etc). |
| 30 – 33 | Checking output of final database queries to ensure completeness. |
| Checking outputs | |
| 33 - 35 | Check sums of output for dataset consistency – LAs add to regions etc.<br>Year on year comparisons for sector totals and for each LA.<br>Reconciliation with National and DA end user totals.<br>Per capita emissions - highs and lows, sense checks.<br>Visual check of mapped distributions – which LAs are in upper and lower quartiles for different sectors. |

* Relates to numbered steps shown in Annex 2

# 5 Review and Comparisons: Completeness & Comparability, Improving Accuracy

The UK inventory cycle includes a programme of continuous improvement applied to all elements of inventory compilation. The end user dataset is based directly on the UK inventory, and therefore improvements made to the source inventory directly feed into the end user dataset. For the Local $CO_2$ emission estimates, in particular, each year elements of the inventory maps are identified for improvements.

# 6 Recalculation

Where changes are made to inventory estimation methodologies, or where source data are revised or errors in previous inventories identified, then the full time-series of emissions are recalculated. Where this occurs (or where a new source is added to the inventory), the database entries of activity and/or emission factors are labelled with a specific change code as appropriate.

# 7 Uncertainties

The uncertainty analysis for the UK greenhouse gas inventory is detailed within the National Inventory Report, which is updated annually.

A specific uncertainty analysis is not currently undertaken for the end user emissions, however the uncertainty by gas detailed in the NIR would also apply to this data set.

The LA $CO_2$ emissions estimates, as with any inventory, are associated with a degree of uncertainty. Overall uncertainties in the emission estimates for each LA have been assessed by combining three variables. Two of these three variables are sets of uncertainty estimates:

- Uncertainty in national emissions: estimates of the percentage error relating to the UK total $CO_2$ emissions by sector;

- Uncertainty in the spatial distribution of emissions: an assessment of the degree of correlation between modelled and real world distributions of fuel consumption, activity and emissions;
- The proportion that each sector contributes to emissions in each LA.

Overall uncertainties are estimated using the sum of the squares method for propagating errors through calculations. This method uses the input data on estimates of component uncertainties. Uncertainty estimates for the national total GHG emissions are calculated in the UK's greenhouse gas inventory.

# 8 Archiving

At the end of each reporting cycle, all the database files, spreadsheets, on-line manual, electronic source data, paper source data, output files are in effect frozen and archived. An annual report outlining the methodology of the inventory and data sources is produced. Electronic information is stored on hard disks that are regularly backed up.

# Annex 1: Manual for Compilation of the Local $CO_2$ emissions

**Figure 2** shows an overview of the data processing steps to generate the Local $CO_2$ emissions dataset and the processing steps are described in **Table 3**.

**Figure 2: Data flows and data processing steps for the Local $CO_2$ dataset**

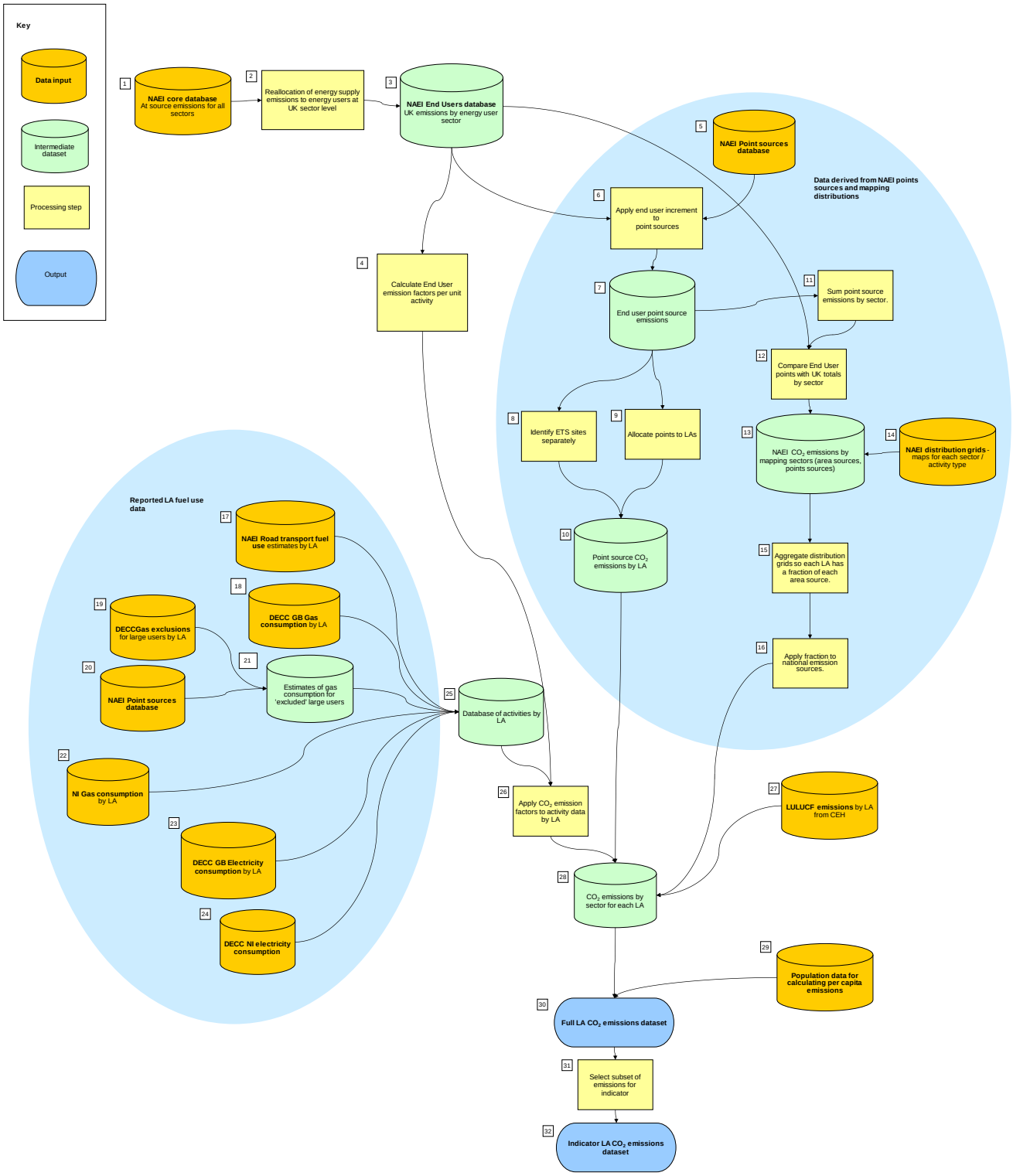


**Table 3: Description of data processing steps for the Local $CO_2$ dataset**

| ID* | Data input / Process | Description |
|---|---|---|
| Initial processing of National Emissions by sector | | |
| 1 | NAEI core database | UK Emissions of $CO_2$ for all sectors as Primary (at source) emissions. |
| 2 | Reallocation of energy supply emissions to energy users at UK sector level | Reallocation of emissions from energy supply industries to each energy user sector in the inventory in proportion to the amount of energy used by these sectors. Some fuel producers use fuel from other producers, for example refineries use electricity. The refineries therefore 'receive' emissions from electricity producers and in turn these emissions are reallocated to the users of the refineries products. This requires that an iterative approach be used to estimate emissions from the end users. The iterations stop when all fuel producers have no more fuel to relocate to End Users. |
| 3 | NAEI End Users database | UK emissions of $CO_2$ by energy user sector.<br>There is an additional step here for the $LACO_2$ work to remove emissions from the crown dependencies so that these emissions are UK only. |
| 4 | End user emission factors per unit activity | Emissions factors back-calculated from activity and emissions data in the end user database: emission / activity = emission factor. |
| Processing of data for site-specific estimates and mapping emissions at 1km resolution | | |
| 5 | NAEI Point source database | Site specific (point source) emissions for energy user sectors for non-gas fuels/activities |
| 6 | Apply end user increment to point sources | Incremental End User factors calculated by sector as ratio of End User to Primary emissions. Incremental factors applied to site-specific emissions to derive End User point source emissions. |
| 7 | End user point source emissions | As calculated in step 6. |
| 8 | Identify ETS sites separately | ETS sites are identified separately in the point sources database in order to be able to exclude them from the indicator dataset (although National Indicator 186 is no longer a legal requirement, the dataset is still produced and presented on the DECC website). |
| 9 | Allocate points to LAs | Using postcodes and grid references each point source is allocated to the Local Authority in which it is located. |
| 10 | Point source $CO_2$ emissions by LA | Non-gas point source emissions aggregated for each Local Authority by fuel / activity type. |
| 11 | Sum point source emissions by sector. | First stage of the calculations to generate 1km resolution emission maps. For each sector it is necessary to compare point source emission totals with national totals. This stage calculates point source emissions for each sector. |
| 12 | Compare End User points with UK totals by sector | Using End User database sector totals and point source emission totals calculate percentage coverage of sectors by point sources. |
| 13 | NAEI $CO_2$ emissions by mapping sectors (area sources, points sources) | For each sector calculate emissions to be distributed as area sources (i.e. not by point sources). |
| 14 | NAEI distribution grids - maps for each sector / activity type | Assign a NAEI distribution grid to each area source sector emission. NAEI distribution grids are calculated using appropriate proxy statistics. |
| 15 | Aggregate distribution grids so each LA has a fraction of each area source. | Bespoke GIS software is used to generate 1km resolution, or better, maps of emissions for the sectors required (non-gas, non-road transport activities). |
| 16 | Apply fraction to national emission sources. | Emissions from area sources assigned to each LA. |
| Processing of other reported fuel use at LA level | | |
| 17 | NAEI Road transport fuel use estimates by LA | Road traffic fuel consumption statistics derived from NAEI 1km modelled estimates. Extra split between A-roads and motorways is required (not available in published data on DECC website). |
| 18 | DECC GB Gas consumption by LA | Data published by DECC. |
| 19 | DECC Gas exclusions for large users by LA | Data obtained from DECC. |

| ID* | Data input / Process | Description |
|---|---|---|
| 20 | NAEI Point sources database | As above (stage 5). |
| 21 | Estimates of gas consumption for 'excluded' large users | Identify sites in the points source database where gas is used, as listed in DECC exclusions. |
| 22 | NI Gas consumption by LA | Data published by DECC. |
| 23 | DECC GB Electricity consumption by LA | Data published by DECC. |
| 24 | NI electricity consumption by LA | Data published by DECC. |
| 25 | Database of activities by LA | Collection of all data from stages 17 to 24. |
| Aggregation of emission estimates for final results | | |
| 26 | Apply $CO_2$ emission factors to activity data by LA | Multiplication of activity data from stage 25 with emission factors from stage 4. |
| 27 | LULUCF emissions by LA from CEH | Aggregation of detailed LULUCF emissions into categories for reporting. |
| 28 | $CO_2$ emissions by sector for each LA | Compilation of emissions from all sectors. |
| 29 | Population data for calculating per capita emissions | Data published by ONS |
| 30 | Full LA $CO_2$ emissions dataset | Final output dataset. |
| 31 | Select subset of emissions for indicator | Exclusion of motorway emissions and ETS sites. |
| 32 | Indicator LA $CO_2$ emissions dataset | Final indicator dataset. |

* Relates to numbered steps shown in Annex 2