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# Technical Paper | Explanation of the Uncertainty Assessment in *Our Impacts*

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**Definition of uncertainty**

Uncertainty is the estimated amount or percentage by which an observed or calculated value may differ from the true value. Uncertainty is usually expressed as a range of values and the probability that the true value falls within that range. For example, the uncertainty for a company's annual GHG emissions may be expressed as +/- 30%, at the 95% confidence level (i.e. there is a 95% chance that the true value is within a range 30% above or below the calculated value for annual emissions).

**Using the uncertainty assessment in *Our Impacts***

The uncertainty assessment in *Our Impacts* gives an indication of the *relative* uncertainty associated with activity data (depending on whether the data is actual or estimated) and the emission or conversion factors (depending on whether the factors have more or fewer built-in assumptions), and can be used to reduce uncertainty by encouraging reporting companies to improve the type and quality of data collected. The uncertainty score for an assessment can be reduced by:

1. Providing actual data rather than estimated data.
2. Providing data for the whole assessment period rather than extrapolating data.
3. Increasing the level of detail provided for emission sources (e.g. specifying "small", "medium" or "large" vehicle rather than "average").
4. Providing transportation data in energy, mass or volume units for fuel consumed rather than providing data for distance travelled (as calculating emissions from distance travelled requires an assumption about fuel economy).
5. Providing energy consumption data in energy, mass or volume units rather than providing data for energy costs or floor area occupied (as calculating emissions from cost data or floor area requires additional assumptions and conversions).
6. Providing waste data in mass units rather than by volume or number of bin bags (as calculating emissions from volume data requires an assumption about the density of waste).

The uncertainty assessment is best used as a tool for improving the type and quality of data provided rather than as an objective measure of the amount by which true GHG emissions differ from estimated GHG emissions.

**Overview of uncertainty method used in *Our Impacts***

The method for the uncertainty assessment used in *Our Impacts* is the first order error propagation method, and this involves combining the uncertainties for each of the parameters or values used in the greenhouse gas calculations. The parameters used in greenhouse gas calculations are the activity data, conversion factors, emission factors, and global warming potentials, and each will have an associated uncertainty (i.e. the true value for each parameter may be different by a certain amount from the value which is used in the calculations)[1].

To give a simple example, calculating the $CO_2$ emissions from diesel combustion involves multiplying activity data (e.g. 1 litre of diesel) by an emission factor (e.g. 2.648 $kgCO_2$/litre) – but the true values for both the activity data and the emission factor may be different from "1 litre" and "2.648 $kgCO_2$/litre". The activity data may not be correct for a number of reasons such as faulty measuring equipment or rounding errors, and through calibration and statistical analysis we can find the range within which the true value is likely to fall, e.g. we might find that there is a 95% chance that the true value is within the range +/- 5% of the estimated value. Similarly with the emission factor, the amount of carbon released from combusting a litre of diesel may vary, perhaps due to variations in the density of diesel or the technology used to combust the fuel, and through empirical measurement and statistical analysis we might find that there is a 95% chance that the true value lies within the range +/- 7% of the estimated value. The first order error propagation method can be used to combine these two uncertainty values to give the overall uncertainty for the combustion of 1 litre of diesel, in this case the combined uncertainty is +/-8.6% at the 95% confidence level[2].

Figure 1 shows an example of uncertainty values used in *Our Impacts.* All the uncertainty values used are shown in the "calculations" option on the "reporting" page.

[1] The Carbon Disclosure Project (CDP) requires information on the uncertainty associated with activity data only, as this is considered to be the only source of uncertainty that reporting companies can control. The automated CDP report from *Our Impacts* therefore provides an uncertainty estimate for activity data only.

[2] The individual parameter uncertainties are combined by squaring and summing the values, and then finding the square root of the result. The uncertainty from individual emissions sources can be aggregated by multiplying the emissions from each source by their uncertainty value and then squaring the result. The results for each emission source are then summed, the square root is taken, and divided by total emissions.

Figure 1. Example of uncertainty calculation in OI.

| GHG | GWP | tGHG | $tCO_2e$ | Factors |
|---|---|---|---|---|
| $CO_2$ | 1 | 0.0026 | 0.0026 | |

| Name | Coefficient | Unit | Uncertainty |
|---|---|---|---|
| Entered Data Uncertainty | | | ±5% |
| Diesel, stationary combustion (Defra/DECC 2010) Locations: Europe, Turkey, United Kingdom | 2.6413 | $kgCO_2/l$ | ±7% |
| Overall Uncertainty | | | ±8.6% |

| GHG | GWP | tGHG | $tCO_2e$ | Factors |
|---|---|---|---|---|
| $CH_4$ | 25 | 7.1400e-08 | 0.000002 | |

| Name | Coefficient | Unit | Uncertainty |
|---|---|---|---|
| Entered Data Uncertainty | | | ±5% |
| Diesel, stationary combustion (derived from Defra/DECC 2010) Locations: Europe, Turkey, United Kingdom | 0.000071 | $kgCH_4/l$ | ±55% |
| Overall Uncertainty | | | ±55% |

| GHG | GWP | tGHG | $tCO_2e$ | Factors |
|---|---|---|---|---|
| $N_2O$ | 298 | 9.4200e-08 | 0.000028 | |

| Name | Coefficient | Unit | Uncertainty |
|---|---|---|---|
| Entered Data Uncertainty | | | ±5% |
| Diesel, stationary combustion (derived from Defra/DECC 2010) Locations: Europe, Turkey, United Kingdom | 0.000094 | $kgN_2O/l$ | ±35% |
| Overall Uncertainty | | | ±35% |

| GHG | GWP | tGHG | $tCO_2e$ | Factors |
|---|---|---|---|---|
| $CO_2e$ | 1 | 0.0027 | 0.0027 | |

Assumed uncertainty for activity data

Assumed uncertainty for the emission factor

Combined uncertainty calculated from the values above

**Assumptions used in *Our Impacts'* uncertainty assessment**

There are a number of key assumptions to be aware of with the uncertainty assessment in *Our Impacts*:

1. The uncertainty values for activity data are assumed to be +/- 5% if "actual" data is entered, e.g. complete data from meter readings or company records, and +/- 30% if "estimated" data is used, e.g. data which are extrapolated or approximate. These uncertainty values are "directional", i.e. data from meter readings and company records are assumed to have a lower uncertainty than data which are assumed or estimated, but the magnitude of the uncertainty values is not based on empirical or statistical analysis. The reason that assumed uncertainty values are used rather than undertaking source-specific analysis is that the data requirements for determining bespoke uncertainty values are very onerous and most reporting companies are not able to provide uncertainty values for the data they collect.

2. The uncertainty values for the majority of emission and conversion factors are assumed, as most sources of published factors do not provide uncertainty values. Again, the assumed uncertainty values are "directional" so that emission factors which involve relatively few assumptions are assumed to have a lower uncertainty than emission factors which involve more assumptions. For example, the vehicle.km emission factors for cars where the engine size is known are assigned a lower uncertainty value (e.g. +/-20%) than the vehicle.km factors for cars where the engine size is unknown (+/-50%). The values +/-20% and +/-50% are assumed and are not derived from statistical analysis.

**Interpreting the uncertainty assessment in *Our Impacts***

It is important to recognise that the uncertainty assessment in *Our Impacts* gives an indication of uncertainty, i.e. an assessment which uses estimated data and emission factors with implicit assumptions (such as assumed engine size or assumed passenger loading) will be given a higher uncertainty score than the same assessment using actual data and emission factors with fewer implicit assumptions. However, because the uncertainty values for activity data and the majority of conversion and emission factors are not based on empirical and statistical analysis the results are not an objective or exact measure of uncertainty.

One implication of this is that the estimated uncertainty for one company's GHG accounts should not be compared to the estimated uncertainty for another company's GHG accounts as any difference may be an artifice of the assumed values used in the assessment, rather than the true amount by which actual GHG emissions may differ from the estimated GHG emissions. It should be noted that this limitation exists for almost all uncertainty assessments which use "expert opinion" or contain other forms of subjective judgement, and is not a limitation specific to the assessment in *Our Impacts*[3].

[3] The WBCSD/WIR guidance note on uncertainty states that "Except in highly restricted cases, uncertainty estimates cannot be interpreted as objective metrics that can be used as an unbiased measure of quality to compare across source categories or different companies", p3. http://www.ghgprotocol.org/calculation-tools/all-tools