The Lab

Technical Briefing Note

Scope 4: Avoided Emissions



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FAQs

1. **What are Scope 4 emissions?**
   Scope 4 emissions, also known as avoided emissions, are reductions in greenhouse gas (GHG) emissions that occur outside an organization's direct operational boundaries or value chain. These reductions are a direct result of using a product, service, or technology that allows others to reduce their emissions compared to a conventional alternative.

2. **Are Scope 4 emissions mandated by the GHG Protocol?**
   No, Scope 4 emissions are not formally mandated within the GHG Protocol. However, they are increasingly important for companies to demonstrate the positive climate impacts of their investments in low-carbon technologies.

3. **What is the focus of this Scope 4 emissions methodology?**
   This methodology focuses on the operational emissions reductions achieved when a low-carbon technology or solution replaces a higher-carbon alternative within the UK. It explicitly excludes life cycle emissions from both the low-carbon solutions and the conventional sources they displace.

4. **What types of low-carbon technologies are covered by this methodology?**
   This procedure applies to a range of low-carbon technologies and solutions, including renewable electricity generation (solar PV, wind power), low-carbon heating solutions (heat pumps), efficient energy systems (CHP), and low-emission transport (HEVs, BEVs).

5. **How are Scope 4 emissions calculated under this methodology?**
   The calculation involves quantifying the operational impact of the low-carbon solution, determining the baseline emission factor of the displaced conventional alternative, calculating baseline emissions, and then calculating the net avoided operational emissions.

6. **What is the importance of the baseline emission factor?**
   The baseline emission factor is crucial for a realistic assessment of avoided emissions. It represents the operational carbon intensity of the specific conventional energy source or activity that the low-carbon solution displaces.

7. **What baseline emission factor is used for renewable electricity generation?**
   The 2024 baseline factor used is the Gas (Combined Cycle) emission factor of 0.394 kg CO2e/kWh, as it is the predominant marginal fuel in the UK grid. The WTT factor is 0.06508 kg CO2e/kWh.

8. **Why is it important to exclude life cycle emissions in this methodology?**
   This procedure focuses on the direct operational displacement effect of low-carbon technologies, providing a more realistic assessment of immediate emission reductions.

9. **How should Scope 4 emissions be reported?**
   Scope 4 avoided emissions must be reported distinctly and separately from Scope 1, Scope 2, and Scope 3 GHG emissions. They do not reduce or offset an organization's direct or indirect emissions inventory.

10. **Why is quality control and verification important for Scope 4 emissions calculations?**
    Internal review and external verification (recommended) ensure the accuracy, consistency, and adherence to the procedure, especially for external reporting or high-stakes claims.

11. **What is the most significant Scope 4 emission avoidance achieved by the example technologies provided?**
    Solar power offers the most significant Scope 4 emission avoidance due to the elimination of fossil fuel combustion.

12. **Where can I find official UK government emissions factors?**
    Official UK government publications such as those from the Department for Energy Security and Net Zero (DESNZ) or the Department for Environment, Food & Rural Affairs (DEFRA) are primary sources. A 20 year history of these factors can be found on the FREE Carbon Saver Carbon Factors Database.
    https://www.carbonsaver.org/tools/carbon_factors_database.php

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Calculating Scope 4 Emissions

Low-Carbon Technologies in the UK

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1.0 Executive Summary

This document provides a standard methodology for calculating Scope 4 (avoided) greenhouse gas (GHG) emissions in the UK, focusing on the operational impacts of low-carbon technologies. While not formally part of the GHG Protocol, Scope 4 emissions are key to showing the positive climate impacts of these investments.

The methodology quantifies the environmental benefit when a low-carbon solution replaces a higher-carbon alternative, considering only operational emission reductions and excluding life cycle emissions. It covers technologies like renewable electricity, low-carbon heating, efficient energy systems, and low-emission transport.

The calculation involves determining the low-carbon solution's operational impact, identifying the baseline emission factor of the displaced alternative, calculating baseline emissions, and then the net avoided operational emissions. Realistic baseline emission factors, such as the UK's marginal grid carbon intensity (mainly gas-fired) or fuel combustion emission factors, are crucial.

Clear responsibilities are assigned for data collection, calculation, review, and approval. Reporting requires thorough record-keeping, transparency, separate reporting of Scope 4 emissions, and a narrative explaining their significance. Quality control includes internal reviews and recommends external verification.

Examples for solar power and CHP systems illustrate the calculation process and the significant avoidance potential of renewables. This methodology offers a robust and conservative approach to quantifying and reporting Scope 4 emissions for UK climate change mitigation efforts.

2.0 Purpose

This document establishes a standardized methodology for calculating Scope 4 (avoided) Greenhouse Gas (GHG) emissions. While Scope 4 emissions are not formally recognized within the GHG Protocol, they are gaining increasing importance as companies strive to demonstrate the positive climate impacts of their investments in low-carbon technologies.

This methodology quantifies the environmental benefit achieved when a low-carbon technology or solution displaces a more conventional, higher-carbon alternative within the UK.

This procedure focuses exclusively on operational emissions reductions, providing a realistic assessment of the direct displacement effect of low-carbon technologies. It explicitly excludes life cycle (embodied) emissions from both the low-carbon solutions and the conventional sources they displace.

3.0 Scope

This procedure is applicable to the assessment of Scope 4 avoided emissions for a range of low-carbon technologies and solutions implemented in the UK, including but not limited to:

- **Renewable Electricity Generation**: Solar PV, Wind Power.
- **Low-Carbon Heating Solutions**: Heat Pumps.
- **Efficient Energy Systems**: Combined Heat and Power (CHP).
- **Low-Emission Transport**: Hybrid Electric Vehicles (HEVs), Battery Electric Vehicles (BEVs/EVs).

It encompasses the calculation of avoided carbon dioxide equivalent (CO2e) emissions, based on verifiable data regarding the operational performance of the low-carbon solution and appropriate operational carbon intensity factors for the displaced conventional alternatives.

This methodology focuses solely on the operational phase of the low-carbon solution and its direct displacement effect on emissions.

4.0 Definitions

- **Scope 4 Emissions (Avoided Emissions)**: Reductions in GHG emissions that occur outside an organization's direct operational boundaries or value chain. These reductions are a direct consequence of the use of a product, service, or technology that enables others (e.g., consumers, other businesses) to reduce their own emissions compared to a conventional alternative.
- **Baseline Activity/Energy Source:** The conventional, higher-carbon activity or energy source that is directly replaced or avoided by the operational implementation of the low-carbon technology. The operational emission factor of this baseline is crucial for calculating avoided emissions.
- **Marginal Grid Carbon Intensity:** The specific CO2e emission factor associated with the fuel/power source that typically sets the wholesale electricity price and is most often brought online (or taken offline) to balance supply and demand. In the UK, this is predominantly Gas (Combined Cycle) generation, which was utilized in UK electricity generation continuously during all half-hour periods in 2024.
- **CO2e (Carbon Dioxide Equivalent):** A metric measure used to compare the emissions from various GHGs based on their global warming potential (GWP), converting them to the equivalent amount of carbon dioxide.
- **kWh (Kilowatt-hour):** A fundamental unit of energy, commonly used for electricity consumption or heat output.
- **MWh (Megawatt-hour):** A unit of energy equal to 1,000 kilowatt-hours (kWh).
- **Litre (L):** A unit of volume, commonly used for liquid fuels.
- **Km (Kilometre):** A unit of distance, used for transport efficiency.
- **WTT**: "Well-to-Tank" emissions, which fall under Scope 3, represent the greenhouse gases emitted throughout the fuel supply chain—from extraction to delivery. Neglecting WTT emissions can substantially underestimate an organization's overall environmental impact.

5.0 Responsibilities

- **Data Collection Team:** Responsible for accurate and timely collection of raw operational performance data for the low-carbon solution (e.g., meter readings, vehicle logs).
- **Calculation Team:** Responsible for processing collected data, identifying and applying the specified baseline carbon intensity factors, performing all calculation steps as per this procedure, and maintaining comprehensive calculation records. This team may include internal personnel or be supported by external consultants with specialized expertise in carbon accounting, eg. carbonsaver.org.
- **Environmental/Sustainability Department:** Responsible for reviewing and validating the accuracy, completeness, and consistency of the calculated Scope 4 emissions, ensuring adherence to this procedure and relevant reporting standards.
- **Management:** Responsible for approving the methodology and ensuring adequate resources are allocated for its implementation and ongoing compliance.

6.0 Procedure: Calculation Methodology

The calculation of Scope 4 avoided emissions under this "realistic displacement" methodology involves comparing the operational impact of the low-carbon solution against a baseline derived from the conventional alternative it displaces, eg. solar power versus grid electricity.

This procedure explicitly excludes life cycle (embodied) emissions from both the low-carbon solutions and the conventional sources they displace.

6.1. Quantify the Operational Impact/Output of the Low-Carbon Solution and Emissions

- **Action:** Accurately measure and record the total energy generated, energy saved, or activity performed by the low-carbon solution for the specified reporting period (e.g., calendar month, quarter, or year). The unit will depend on the technology.
- **Data Source:** Primary data from calibrated meters, vehicle logs, or verified operational performance models.
- **Examples** of Quantifiable Operational Impact:
    - **Solar PV/Wind**: Total gross electricity generated (kWh).
    - **Heat Pump**: Total heat energy supplied (kWh of heat output).
    - **Hybrid/EV**: Distance travelled (km), fuel used (litres) or electricity consumed (kWh).
    - **CHP**: Total electricity generated (kWh) and total heat supplied (kWh of heat).

Formula:

Low-Carbon Solution Emissions (kg CO2e)
=
Quantified Operational Output (kWh)
x
Emissions Factor of Low-Carbon Solution (kg CO2e per kWh)

Real-world examples are provided in the Appendix.

6.2. Determine the Operational Baseline Emission Factor of the Displaced Conventional Alternative

- **Action**: Identify and obtain the most recent and appropriate operational carbon intensity factor for the specific conventional energy source or activity that the low-carbon solution is realistically displacing. This is the critical step for a realistic assessment.

  Data Sources:

  - **Official UK Government Publications**: Department for Energy Security and Net Zero (DESNZ) or Department for Environment, Food & Rural Affairs (DEFRA) annual "Greenhouse Gas Reporting: Conversion Factors" are primary sources for various fuels and activities.
  - **National Grid Electricity System Operator (NESO)**: For electricity-specific marginal factors and fuel/power source carbon intensities.
  - **Carbon Saver FREE Carbon Factors Database:** www.carbonsaver.org for various fuel and energy types with historical factors covering 20 years.
  - **NESO Power Generation** Source Intensities (kg CO2e/kWh):
    - Biomass: 0.120
    - Coal: 0.937
    - Dutch Imports: 0.474
    - French Imports: 0.053
    - Gas (Combined Cycle): 0.394
    - Gas (Open Cycle): 0.651
    - Hydro: 0
    - Irish Imports: 0.458
    - Nuclear: 0
    - Oil: 0.935
    - Other: 0.300
    - Pumped Storage: 0
    - Solar: 0
    - Wind: 0

Selection of Baseline Factor based on Technology

Renewable Electricity Generation (Solar PV, Wind)

- **Rationale**: New renewable electricity generation in the UK primarily displaces marginal fossil fuel generation.
- **2024 Factor to Use**: Gas (Combined Cycle): 0.394 kg CO2e/kWh (as it is the predominant marginal fuel in the UK grid). WTT factor = 0.06508 kg CO2e/kWh.
- **Unit**: kg CO2e/kWh

Heat Pumps

- **Rationale**: Heat pumps typically displace operational emissions from conventional fossil fuel heating, most commonly natural gas boilers in the UK.
- **2024 Factor to Use**: Emission factor for Natural Gas combustion = 0.18290 kg CO2e/kWh. WTT factor = 0.03021 kg CO2e/kWh.
- **Unit**: kg CO2e/kWh (of heat)

Hybrid Electric Vehicles (HEVs) / Battery Electric Vehicles (BEVs/EVs)

- **Rationale**: These vehicles displace operational emissions from petrol or diesel consumption.
- **2024 Factor to Use**: Operational emission factor for Petrol or Diesel combustion:
  - Petrol = 2.084400 kg CO2e/litre. WTT = 0.580940 kg CO2e/litre.
  - Diesel = 2.512790 kg CO2e/litre. WTT = 0.611010 kg CO2e/litre.
- **Unit**: kg CO2e/litre or kg CO2e/km (if average fuel economy is applied).
- **Note for BEVs**: While BEVs displace petrol/diesel, their electricity consumption has associated Scope 2 emissions. The Scope 4 calculation here is the avoided fuel emissions - Scope 2 Electricity Emissions = Net Scope 4 avoided emissions.

Combined Heat and Power (CHP) Systems

- **Rationale**: CHP systems simultaneously generate electricity and heat, displacing both grid electricity and conventional heat generation.
- **Approach**: Utilize the "Carbon Saver CHP Custom Factors Spreadsheet" which employs a Total System Efficiency principle to produce specific operational emission factors for both the CHP's electricity and heat outputs.
- **Note**: This requires a detailed understanding of the CHP system's inputs, outputs, and the specific factors derived from the Carbon Saver methodology for accurate calculation of displaced electricity and heat emissions.
- **Unit**: Custom factors will typically be in kg CO2e/kWh (electricity) and kg CO2e/kWh (heat).

Heat & Boiler Efficiency

For calculating the heat output of a conventional boiler, to enable comparison with a Heat Pump, an efficiency factor of 91% GCV (gross calorific value) for natural gas boilers can be used.

This figure is suggested as it represents the minimum seasonal efficiency required for new direct-fired water heaters (which include many commercial boilers) in England, as mandated by the UK government's Building Regulations Part L as of June 15th, 2022.

While older or non-condensing boilers may operate at significantly lower efficiencies, using this higher, regulated efficiency for the boiler baseline aligns with the principle of "professional conservatism" often referenced in standards like PAS 2060.

Alternatively, if the actual efficiency of the replaced conventional alternative is known, that value should be used.

For CHP the UK Government factors for Heat and Steam should be used = 0.17965 kg CO2e/kWh heat (WTT = 0.17965 kg CO2e/kWh heat).

This approach ensures that any calculated avoided emissions attributed to the CHP Heat output are robust and not overestimated, as it compares the CHP to official UK factors..

6.3. Calculate Baseline Emissions

- **Action**: Calculate the hypothetical GHG emissions that would have been released if the equivalent energy/activity from the low-carbon solution had been provided by the conventional baseline alternative.

Formula:

```
Baseline Emissions (kg CO2e)
=
Estimated Conventional Baseline Operational Output (kWh)
x
Emissions Factor of the Displaced Conventional Alternative (kg CO2e per kWh)
```

6.4. Calculate Net Scope 4 (Avoided) Operational Emissions

- **Action**: The final Scope 4 avoided emissions are equivalent to the calculated Baseline Emissions minus the Low-Carbon Solution Emissions, as this procedure focuses solely on operational displacement and explicitly excludes life cycle emissions from both the low-carbon solution and the conventional sources.

Formula:

```
Scope 4 (Avoided) Operational Emissions (kg CO2e)
=
Baseline Emissions (kg CO2e)
-
Low-Carbon Solution Emissions (kg CO2e)
```

- **Result**: The final value represents the net kg CO2e emissions prevented by the low-carbon solution's operation during the reporting period, based on the displacement of the specified conventional alternative.

7.0 Reporting and Documentation

- **Record Keeping:** Maintain comprehensive and auditable records of all input data, calculation steps, and final results. This includes operational performance data of the low-carbon solution, the specific baseline carbon intensity factor used (with its source and version), and any assumptions made.
- **Transparency:** Clearly articulate the methodology, the specific low-carbon technology assessed, the chosen baseline scenario, the relevant operational carbon intensity factor used, and the explicit exclusion of life cycle emissions (from both the low-carbon solution and the conventional sources) in all public or internal reports. It is crucial to distinguish this approach from calculations that include life cycle impacts or different displacement assumptions.
- **Separate Reporting:** Scope 4 avoided emissions must be reported distinctly and separately from Scope 1, Scope 2, and Scope 3 GHG emissions. They do not reduce or offset an organization's direct or indirect emissions inventory.
- **Narrative:** Provide a concise narrative explaining the significance of the avoided emissions, the rationale for selecting the specific baseline displacement factor for the technology, and its contribution to climate change mitigation efforts within the UK context.

8.0 Quality Control and Verification

- **Internal Review:** All calculations shall undergo an independent internal review by qualified personnel not directly involved in the initial calculation to ensure accuracy, consistency, and strict adherence to this procedure.
- **External Verification (Recommended):** For external reporting or high-stakes claims, consider seeking third-party verification of the Scope 4 emissions calculation. Experts such as those at carbonverification.org can provide cost effective independent assurance.
- **Factor Review:** Periodically review analyses of the UK energy and transport markets to confirm that the chosen baseline displacement factors remain realistic and representative of current conditions. If market dynamics or fuel mixes shift significantly, the baseline factor assumption may need to be updated. Updated official government factors are added to the FREE Carbon Saver Factors database each year https://carbonsaver.org/tools/carbon_factors_database.php

9.0 References

- Provided list of UK power source carbon intensities for individual fuel types (from National Grid Electricity System Operator (ESO), where applicable).
- UK Government (Department for Energy Security and Net Zero / Department for Environment, Food & Rural Affairs) – "Greenhouse Gas Reporting: Conversion Factors".
- Carbon Saver FREE Carbon Factors Database: https://carbonsaver.org/tools/carbon_factors_database.php
- Academic research and industry reports supporting the identification of marginal generators in the UK electricity market (e.g., Carbon Brief, National Grid ESO analyses).
- CHP Custom Factors (refer to specific documentation for this methodology for detailed CHP calculations).
- Greenhouse Gas Protocol – Product Life Cycle Accounting and Reporting Standard (for general guidance on avoided emissions principles, noting the operational focus of this document).

10.0 Appendix - Real World Examples

On-Site Solar Power

When solar power systems are installed on-site, the electricity they produce typically substitutes for grid electricity usage.

Low Carbon Solution Operational Emissions

Electricity for solar panels does not emit Greenhouse Gases. Therefore the operational emissions are 0 kg CO2e

Baseline Emissions from Displaced Conventional Alternative

When a solar installation generates electricity, it typically displaces grid electricity consumption. To calculate the avoided emissions, determine the total electricity produced by the solar panels in kWh and multiply that by the emissions factor of the marginal fuel most likely displaced from the grid.

Grid Electricity Marginal Fuel 2024 Factor:

- Gas (Combined Cycle): 0.394 kg CO2e/kWh (as it is the predominant marginal fuel in the UK grid).
- WTT factor = 0.06508 kg CO2e/kWh.
- **Grid Electricity Marginal Fuel Total = 0.45908 kg CO2e/kWh**

```
Solar Generation = 1,000,000 kWh
x
Gas (Combined Cycle) inc WTT: 0.45908 kg CO2e/kWh
/
1000 to convert to tonnes CO2e
=
Scope 4 Avoided Emissions Solar Power 459.1 t CO2e
```

CHP Power

When electricity and heat are produced by combined heat and power (CHP) systems, this process results in a displacement of conventional energy generation. Specifically, the electricity generated by CHP units reduces the demand for electricity supplied by the national or local power grid. Simultaneously, the heat produced by CHP displaces the heat that would otherwise be generated by dedicated heating systems such as boilers.

Low Carbon Solution Operational Emissions

The "Carbon Saver CHP Custom Factors Spreadsheet" employs a methodology grounded in the Total System Efficiency principle to determine operational emission factors. These factors are specifically calculated for both the electrical and thermal energy outputs generated by a Combined Heat and Power (CHP) system.

Critically, the calculation encompasses a comprehensive lifecycle assessment, including Well-to-Tank (WTT) emissions. This ensures that the emission factors account for all upstream activities associated with the fuel supply chain, from extraction and processing to transportation and delivery, in addition to the direct emissions from the CHP unit's operation.

The spreadsheet enables a more accurate and holistic evaluation of the environmental performance of CHP systems compared to using generic or less comprehensive emission factors.

CHP Electricity Emissions Calculation

- CHP Electricity = 0.33501 kg CO2e/kWh
- CHP Electricity WTT= 0.05533 kg CO2e/kWh
- **CHP Electricity Total = 0.39034 kg CO2e/kWh**

```
CHP Electricity = 1,000,000 kWh
x
CHP Electricity Total = 0.39034 kg CO2e/kWh
/
1000 to convert to tonnes CO2e
=
Low Carbon Solution CHP Electricity 390.3 t CO2e
```

CHP Heat Emissions Calculation

- CHP Heat = 0.16725 kg CO2e/kWh
- CHP Heat WTT = 0.02763 kg CO2e/kWh
- CHP Heat T&D Losses = 0.00836 kg CO2e/kWh
- CHP Heat T&D Losses WTT = 0.00138 kg CO2e/kWh
- **CHP Heat Total = 0.20462 kg CO2e/kWh**

```
CHP Heat = 1,000,000 kWh
x
CHP Heat Total = 0.20462 kg CO2e/kWh
/
1000 to convert to tonnes CO2e
=
Low Carbon Solution CHP Heat 204.6 t CO2e
```

Baseline Emissions from Displaced Conventional Alternative

Combined heat and power (CHP) units reduce the demand for electricity from the grid, thereby decreasing the use of the marginal fuel source typically employed. Additionally, the heat generated by CHP systems substitutes for heat produced by standalone heating systems such as boilers.

Baseline Electricity Emissions Calculation

Grid Electricity Marginal Fuel 2024 Factor:

- Gas (Combined Cycle): 0.394 kg CO2e/kWh (as it is the predominant marginal fuel in the UK grid).
- WTT factor = 0.06508 kg CO2e/kWh.
- **Grid Electricity Marginal Fuel Total = 0.45908 kg CO2e/kWh**

CHP Electricity = 1,000,000 kWh
x
Gas (Combined Cycle) inc WTT: 0.45908 kg CO2e/kWh
/
1000 to convert to tonnes CO2e
=
Baseline Emissions CHP Electricity 459.1 t CO2e

Baseline Heat Emissions Calculation

UK Government Heat & Steam 2024 Factor:

- Heat = 0.17965 kg CO2e/kWh
- Heat WTT = 0.03341 kg CO2e/kWh
- Heat T&D Losses = 0.00946 kg CO2e/kWh
- Heat T&D Losses WTT = 0.00176 kg CO2e/kWh
- **Heat Total = 0.22428 kg CO2e/kWh**

CHP Heat = 1,000,000 kWh
x
UK Government Heat & Steam Total: 0.22428 kg CO2e/kWh
/
1000 to convert to tonnes CO2e
=
Baseline Emissions CHP Heat 224.3 t CO2e

Calculate Avoided Emissions

CHP Electricity

```
Baseline Emissions CHP Electricity 459.1 t CO2e
-
Low Carbon Solution CHP Electricity 390.3 t CO2e
=
Scope 4 Avoided Emissions CHP Electricity 68.8 t CO2e
```

CHP Heat

```
Baseline Emissions CHP Heat 224.3 t CO2e
-
Low Carbon Solution CHP Heat 204.6 t CO2e
=
Scope 4 Avoided Emissions CHP Heat 19.7 t CO2e
```

Summary of Examples

Utilizing Low Carbon Solutions to generate 1,000 MWh of energy yields the following Scope 4 emission reductions, according to real-world data:

- Solar Power: **459.1** t CO2e
- CHP Electricity: **68.8** t CO2e
- CHP Heat: **19.7** t CO2e

Renewable energy sources, such as solar power, offer the most significant Scope 4 emission avoidance by eliminating the combustion of fossil fuels.

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Carbon Advisory | Consultancy-Grade Methodologies. Open Sourced.

We provide the detailed technical methodologies and guidance notes that sustainability professionals need to calculate correctly—completely free of charge.

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