The Lab

Technical Briefing Note

CHP: Custom GHG Factors



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Methodology: Custom GHG Emission Factors for District Energy Networks with CHP

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About This Technical Methodology Note (TMN)

Context & Purpose

This document forms part of the Carbon Advisory Open Source Library. It contains the specific technical formulas, boundary definitions, and calculation hierarchies used by our internal consultants to deliver high-level carbon management advice.

For over 20 years, these methodologies have been applied across the NHS, central government, police forces, and blue-chip corporations. We have released them into the public domain to ensure that rigorous, accurate measurement is accessible to every sustainability professional, regardless of budget.

How to Use This Document

This note is designed for Sustainability Practitioners with a working knowledge of GHG Protocol and ISO 14064 principles. It provides the "Consultancy-Grade" approach to specific, complex scenarios where standard average conversion factors may be insufficient.

Need Technical Support?

While this methodology provides the theoretical framework, applying it to unique operational data can be complex. If you require a second pair of eyes to validate your calculations, or a "Power Hour" to adapt this methodology to your specific site, Carbon Advisory offers paid technical support services.

1. Introduction

1.1 Purpose

This methodology paper establishes a standardised approach for calculating greenhouse gas (GHG) emission factors for district heating networks that incorporate both conventional boiler plant and Combined Heat and Power (CHP) generation. The methodology is designed to be consistent with international GHG accounting standards and UK Government guidance, while providing transparent and verifiable emission factors for use in organisational carbon footprint reporting.

The calculated emission factors enable customers of district heating networks to accurately report their Scope 2 emissions from purchased heat, cooling, electricity while maintaining clear separation between actual emissions and avoided emissions (Scope 4) in accordance with GHG Protocol requirements.

1.2 Scope of Application

This methodology applies to district energy schemes that supply heat, cooling, electricity to multiple customers from a centralised energy centre. It is specifically designed for schemes that include:

- Gas-fired boiler plant for heat generation
- Gas-fired Combined Heat and Power (CHP) engines
- Heat distribution networks with associated thermal losses
- Export of CHP-generated electricity to customers or the grid
- Chilled water for cooling, etc.

1.3 Regulatory and Standards Framework

This methodology is consistent with the following standards and guidance:

- GHG Protocol Corporate Accounting and Reporting Standard
- GHG Protocol Scope 2 Guidance
- ISO 14064-1:2018 Specification for quantification and reporting of GHG emissions
- UK Government GHG Conversion Factors for Company Reporting
- Digest of UK Energy Statistics (DUKES) CHP allocation methodology

2. CHP Emission Allocation Methodology

2.1 The Efficiency Method (67/33 Allocation)

Emissions from the Combined Heat and Power (CHP) plant have been allocated between heat and electricity outputs using the **Efficiency Method** (also widely known as the **2/3rds – 1/3rd method**). This approach is consistent with Method 1 of the UK Government's Digest of UK Energy Statistics (DUKES) and the 2025 Government Greenhouse Gas Conversion Factors for Company Reporting methodology.

By allocating two-thirds (67%) of the fuel emissions to electricity and one-third (33%) to heat, this calculation reflects the higher carbon intensity associated with electricity generation compared to thermal heat production. This allocation recognises that:

- Electricity is a higher-grade energy form than heat (based on exergy principles)
- Generating electricity from fuel requires more primary energy per unit of useful output
- Heat can be considered a by-product of electricity generation in many CHP applications

2.2 Rationale for the 67/33 Split

The 67/33 allocation ratio is derived from typical conversion efficiencies:

- **Electricity generation:** UK Government statistics for A modern gas-fired power station achieves 48.9% efficiency (DUKES 2025). Taking a reference efficiency of 50%, this means 2 kWh of gas is required to generate 1 kWh of electricity.

- **Heat generation:** A modern condensing boiler achieves approximately 90% efficiency, meaning approximately 1.1 kWh of gas is required to generate 1 kWh of heat.

> *"Gas condensing boilers with effective rated output of 4 to 400 kW must achieve a useful efficiency of ≥91 + 1 log Pn at rated output (70°C average boiler-water temperature), and ≥97.1 + 1 log Pn at 30% part load."*
>
> ***Source**: The Boiler (Efficiency) Regulations 1993, SI 1993/3083, Schedule 2*

The ratio of these efficiencies (2:1 or approximately 67%:33%) forms the basis for allocating CHP emissions. This approach ensures that heat from CHP receives an appropriate emissions credit for being co-produced alongside electricity, without understating the emissions associated with electricity generation.

2.3 Application of the Allocation

The 67/33 allocation is applied at the point of determining emission intensity factors, not at the point of energy flow. The calculation determines:

1. Total gas consumed by the CHP unit (fiscal meter / invoices)
2. Total combustion emissions from CHP gas consumption (kWh x EF Gas)
3. Allocation of 33% of emissions to heat output
4. Allocation of 67% of emissions to electricity output
5. Division by respective energy outputs to derive emission factors

2.4 Calculating CHP Fuel Use Formulae

$$Fuel\ for\ Heat\ Output\ =\ \left(\frac{Total\ Fuel\ Input}{(2\ x\ Power\ Output)\ +\ Heat\ Output}\right)\ x\ Heat\ Output$$

$$Fuel\ for\ Power\ Output\ =\ \left(\frac{2\ x\ Total\ Fuel\ Input}{(2\ x\ Power\ Output)\ +\ Heat\ Output}\right)\ x\ Power\ Output$$

The methodology in section 4 describes the calculation of custom greenhouse gas (GHG) emission factors that accurately reflect the specific performance characteristics of the energy centre's equipment, rather than relying on generic published factors.

2.5 Outputs Produced

The methodology produces the following emission factors (all expressed in $kgCO_2e/kWh$):

Output	Scope 2	Scope 3 (T&D)	Scope 3 (WTT)	Scope 4
CHP Electricity	✓	N/A	✓	✓
Blended Heat	✓	✓	✓	✓
Cooling	✓	N/A	✓	✓

3. Input Data Requirements

3.1 Measured Operating Data (Variables)

These values must be obtained from actual metered performance data for the specific installation:

Parameter	Symbol	Unit	Description
Proportion of heat from gas boilers	H_boiler	%	Annual share of total heat output from standalone boilers
Proportion of heat from CHP	H_chp	%	Annual share of total heat output from the CHP unit
Heat distribution losses	L_heat	%	Losses in the heat distribution network
Gas boiler efficiency	η_boiler	%	Gross thermal efficiency of the gas boiler(s)
CHP thermal efficiency (Gross)	η_chp_th	%	Gross thermal efficiency of the CHP unit
CHP electrical efficiency (Gross)	η_chp_el	%	Gross electrical efficiency of the CHP unit
Parasitic electricity factor	P_elec	kWh / kWh heat	Electricity consumed per kWh of heat delivered
Cooling losses	L_cool	%	Losses in the cooling distribution network
COP (Coefficient of Performance)	COP	ratio	Efficiency of the absorption chiller
% CHP electricity for cooling	CHP_cool	%	Proportion of chiller electricity from CHP

3.2 Official Data (Constants)

These values are taken from official UK Government sources and should be updated annually:

Parameter	Value	Source
CHP allocation to electricity	66.67% (2/3)	DUKES Method 1 / UK GHG Reporting
CHP allocation to heat	33.33% (1/3)	DUKES Method 1 / UK GHG Reporting
Natural Gas factor	0.18296 $kgCO_2e/kWh$	UK GHG Conversion Factors 2025
Grid Electricity	0.177 $kgCO_2e/kWh$	UK GHG Conversion Factors 2025
Grid Marginal (Gas CCGT)	0.382775 $kgCO_2e/kWh$	DUKES 2025 / UK GHG CF 2025
Grid Electricity T&D	0.01853 $kgCO_2e/kWh$	UK GHG Conversion Factors 2025
Grid Marginal T&D	0.033799 $kgCO_2e/kWh$	DUKES 2025 / UK GHG CF 2025
Natural Gas WTT	0.03021 $kgCO_2e/kWh$	UK GHG Conversion Factors 2025
Grid Electricity WTT	0.0459 $kgCO_2e/kWh$	UK GHG Conversion Factors 2025
Grid Electricity WTT T&D	0.00397 $kgCO_2e/kWh$	UK GHG Conversion Factors 2025
Grid Marginal WTT	0.063106 $kgCO_2e/kWh$	DUKES 2025 / UK GHG CF 2025
Grid Marginal WTT T&D	0.005572 $kgCO_2e/kWh$	DUKES 2025 / UK GHG CF 2025

4. Calculation Methodology

4.1 CHP Fuel Allocation (67/33 Method with Efficiency Adjustment)

The standard 67/33 allocation method prescribes that two-thirds of CHP fuel input is allocated to electricity generation and one-third to heat generation. However, this methodology applies an **efficiency-adjusted allocation** that accounts for the actual thermal and electrical efficiencies of the CHP unit.

4.1.1 CHP Energy Outputs (per 1 kWh gas input)

From the measured CHP efficiencies:

```
Gross CHP Heat Generation = η_chp_th  [kWh heat per kWh gas]

CHP Electricity Generation = η_chp_el  [kWh electricity per kWh gas]

Heat Distribution Losses = η_chp_th × L_heat  [kWh heat per kWh gas]

Net CHP Heat = η_chp_th - (η_chp_th × L_heat)  [kWh heat per kWh
gas]
```

4.1.2 Efficiency-Adjusted Fuel Allocation

The allocation of gas input between heat and electricity uses the following formulas, which weight the standard 67/33 split by the relative efficiencies:

Gas allocated to Gross Heat generation:

```
Gas_heat = 1 / ((2 × η_chp_el) + η_chp_th) × η_chp_th
```

Gas allocated to Heat Distribution Losses:

```
Gas_heat_losses = Gas_heat × L_heat
```

Gas allocated to Net Heat generation:

```
Gas_net_heat = Gas_heat - Gas_heat_losses
```

Gas allocated to Electricity generation:

```
Gas_elec = 2 / ((2 × η_chp_el) + η_chp_th) × η_chp_el
```

> **Note:** This allocation method applies the 67/33 (2:1) ratio but adjusts it based on the actual efficiency of each output. This ensures that a CHP unit with higher electrical efficiency relative to thermal efficiency will have a greater proportion of gas allocated to electricity generation, and vice versa.

4.2 CHP Emission Factors

4.2.1 Combustion Factors (Scope 2)

CHP Gross Heat Emission Factor:

```
EF_chp_gross_heat = (Gas_heat × EF_gas) / η_chp_th
```

CHP Heat Distribution Losses Emission Factor:

```
EF_chp_heat_losses = EF_chp_gross_heat × L_heat
```

CHP Net Heat Emission Factor (Scope 2):

```
EF_chp_net_heat = EF_chp_gross_heat - EF_chp_heat_losses
```

CHP Electricity Emission Factor (Scope 2):

```
EF_chp_elec = (Gas_elec × EF_gas) / η_chp_el
```

4.2.2 Well-to-Tank Factors (Scope 3)

The same allocation methodology is applied using the Natural Gas WTT factor:

CHP Gross Heat WTT Factor:

```
EF_chp_gross_heat_wtt = (Gas_heat × EF_gas_wtt) / η_chp_th
```

CHP Net Heat WTT Factor:

```
EF_chp_net_heat_wtt = EF_chp_gross_heat_wtt - (EF_chp_gross_heat_wtt × L_heat)
```

CHP Electricity WTT Factor:

```
EF_chp_elec_wtt = (Gas_elec × EF_gas_wtt) / η_chp_el
```

4.2.3 T&D Factors

There are no Transmission, Distribution and Theft (T&D) factors for CHP electricity as it is generated and consumed on-site, not delivered through the National Grid.

4.3 Boiler Emission Factors

For heat generated by standalone gas boilers, the calculation is straightforward:

4.3.1 Fuel Use (per kWh heat output)

Gas for Gross Heat:

```
Gas_boiler_gross = 1 / η_boiler
```

Gas for Heat Distribution Losses:

```
Gas_boiler_losses = Gas_boiler_gross × L_heat
```

Gas for Net Heat:

```
Gas_boiler_net = Gas_boiler_gross - Gas_boiler_losses
```

4.3.2 Boiler Emission Factors

Boiler Gross Heat (Scope 2):

```
EF_boiler_gross = Gas_boiler_gross × EF_gas
```

Boiler Heat Distribution Losses (Scope 3):

```
EF_boiler_losses = EF_boiler_gross × L_heat
```

Boiler Net Heat (Scope 2):

```
EF_boiler_net = EF_boiler_gross - EF_boiler_losses
```

Boiler Heat WTT (Scope 3):

The same approach applies for WTT factors using EF_gas_wtt.

```
EF_boiler_gross_wtt = Gas_boiler_gross × EF_gas_wtt

EF_boiler_losses_wtt = EF_boiler_gross_wtt × L_heat

EF_boiler_net_wtt = EF_boiler_gross_wtt - EF_boiler_losses_wtt
```

4.4 Blended Heat Emission Factors

The blended heat factors combine CHP and boiler heat factors, weighted by the actual proportion of heat delivered from each source. The calculation also includes the parasitic electricity consumption for heat delivery.

Blended Gross Heat (Scope 2):

```
EF_blended_gross = (EF_chp_gross_heat × H_chp) + (EF_boiler_gross × H_boiler) + (P_elec × EF_chp_elec)
```

> **Note:** The parasitic electricity term accounts for pumps and other ancillary equipment that consume electricity to deliver heat. This electricity is assumed to come from the CHP unit.

Blended Heat Distribution Losses (Scope 3):

```
EF_blended_losses = EF_blended_gross × L_heat
```

Blended Net Heat (Scope 2):

```
EF_blended_net = EF_blended_gross - EF_blended_losses
```

Blended Heat WTT (Scope 3):

The WTT factors follow the same blending approach but exclude the parasitic electricity component (WTT are upstream emissions, parasitics apply to downstream transmission):

```
EF_blended_gross_wtt = (EF_chp_gross_heat_wtt × H_chp) +
(EF_boiler_gross_wtt × H_boiler)
```

```
EF_blended_losses_wtt = EF_blended_gross_wtt × L_heat
```

```
EF_blended_net_wtt = EF_blended_gross_wtt - EF_blended_losses_wtt
```

4.5 Cooling Emission Factor

Cooling is produced by chillers powered by a combination of CHP-generated electricity and grid electricity.

4.5.1 Electricity Requirement

Total Cooling (including losses):

```
Cooling_total = Cooling_delivered × (1 + L_cool)
```

Electricity for Cooling:

```
Elec_cooling = Cooling_total / COP
```

Electricity from CHP:

```
Elec_chp = Elec_cooling × CHP_cool
```

Electricity from Grid:

```
Elec_grid = Elec_cooling - Elec_chp
```

4.5.2 Cooling Emission Factor (Scope 2)

```
EF_cooling = (Elec_chp × EF_chp_elec) + (Elec_grid × EF_grid_gen)
```

4.5.3 Cooling WTT Factor (Scope 3)

```
EF_cooling_wtt = (Elec_chp × EF_chp_elec_wtt) + (Elec_grid × EF_grid_wtt)
```

4.6 Scope 4 Avoided Emissions

The GHG Protocol requires that avoided emissions are reported separately from Scope 1, 2, and 3 emissions. Avoided emissions (sometimes referred to as Scope 4) represent the emissions that would have occurred if the CHP outputs had instead been produced by conventional means (i.e., grid electricity and boiler heat). They represent emission reductions that occur outside an organisation's value chain.

> **Critical Compliance Point:** Avoided emissions must **never** be netted against or embedded within Scope 1, 2, or 3 emission factors. Customers reporting district heat consumption as Scope 2 emissions cannot claim avoided emissions credits within their Scope 2 reporting boundary.

4.6.1 CHP Electricity Avoided Emissions

The avoided emissions from CHP electricity are calculated against the grid marginal generation (Gas CCGT) rather than average grid:

```
EF_avoided_elec = (EF_grid_marginal + EF_grid_marginal_td + EF_grid_marginal_wtt + EF_grid_marginal_wtt_td) - (EF_chp_elec + EF_chp_elec_wtt)
```

4.6.2 Blended Heat Avoided Emissions

The avoided emissions represent the efficiency benefit of CHP heat versus boiler heat, weighted by the CHP proportion:

```
EF_avoided_heat = ((EF_boiler_gross + EF_boiler_gross_wtt) -
(EF_chp_gross_heat + EF_chp_gross_heat_wtt)) × H_chp
```

4.6.3 Cooling Avoided Emissions

```
EF_avoided_cooling = EF_avoided_elec × Elec_chp
```

5. GHG Protocol Scope Classification

5.1 Scope Assignment for Connected Buildings

Emission Factor	Reporting Scope	Rationale
CHP Electricity (combustion)	Scope 2	Purchased energy from third-party supplier
CHP Electricity (WTT)	Scope 3	Upstream emissions from fuel supply chain
Blended Heat (combustion)	Scope 2	Purchased energy from third-party supplier
Blended Heat (T&D losses)	Scope 3	Losses occurring outside building boundary
Blended Heat (WTT)	Scope 3	Upstream emissions from fuel supply chain
Cooling (combustion)	Scope 2	Purchased energy from third-party supplier
Cooling (WTT)	Scope 3	Upstream emissions from fuel supply chain
Avoided emissions	Scope 4	Outside of scopes (reported separately)

5.2 Notes on T&D Factors

- **CHP Electricity** has no T&D factor because it is generated and consumed on-site without transmission through the National Grid.
- **Blended Heat** includes a T&D factor representing distribution losses within the heat network.
- **Cooling** has no separate T&D factor; distribution losses are incorporated into the cooling calculation via the COP and loss factors.

6. Verification and Audit Trail

6.1 Internal Consistency Checks

Verifiers should perform the following consistency checks on submitted data:

1. **Energy balance:** Total gas consumed should equal boiler gas plus CHP gas
2. **Heat balance:** Heat generated should equal heat delivered plus distribution losses
3. **CHP efficiency:** Combined thermal and electrical efficiency should be consistent with CHP technology type (typically 75-85% for gas engines)
4. **Efficiency reasonableness:** Boiler efficiency typically 80-95%, CHP thermal 35-45%, CHP electrical 30-40%

6.2 Common Errors to Identify

Verifiers should be alert to the following common calculation errors:

- **Embedded CHP credits:** Emission factors that include avoided emissions credits within the headline factor (non-compliant with GHG Protocol)
- **Inconsistent gas inputs:** CHP gas calculated from electricity output rather than heat output
- **Missing distribution losses:** Emission factors expressed per kWh generated rather than per kWh delivered
- **Incorrect allocation:** Energy-based allocation instead of standard 67/33 efficiency method
- **Outdated emission factors:** Use of previous year's conversion factors

6.3 Documentation Requirements

The following documentation should be obtained and retained as verification evidence:

- Gas invoices or fiscal meter readings for the reporting period
- Heat meter readings (generation and delivery points)
- Electricity meter readings (CHP output, parasitic consumption, export)
- Equipment specifications confirming CHP and boiler types
- Calculation spreadsheet with all formulae visible
- Source reference for emission factors used

6.4 Annual Review

This methodology should be reviewed annually to:

- Update official emission factors from UK Government sources
- Recalculate based on updated measured performance data
- Verify continued applicability of assumptions

6.5 ISO 14064-3 Compliance

When these factors are used for verified carbon reporting under ISO 14064-1, the following should be documented:

- Completeness of data coverage
- Estimation methods for any data gaps
- Uncertainty assessment for key parameters

7. Worked Example

Input Values

Parameter	Value
H_boiler	61.3%
H_chp	38.7%
L_heat	6.5%
η_boiler	76.39%
η_chp_th	38.48%
η_chp_el	36.35%
P_elec	0.032 kWh/kWh
L_cool	7.0%
COP	3.0
CHP_cool	54.11%

Calculated Emission Factors

Factor	Scope	Value ($kgCO_2e/kWh$)
CHP Electricity	Scope 2	0.3291
CHP Electricity (WTT)	Scope 3	0.0543
Blended Net Heat	Scope 2	0.2067
Blended Heat (T&D)	Scope 3	0.0144
Blended Heat (WTT)	Scope 3	0.0325
Blended Heat WTT (T&D)	Scope 3	0.0023
Cooling	Scope 2	0.0925
Cooling (WTT)	Scope 3	0.0180
CHP Electricity Avoided	Scope 4	0.1018
Blended Heat Avoided	Scope 4	0.0338
Cooling Avoided	Scope 4	0.0196

8. References

1. UK Government GHG Conversion Factors for Company Reporting 2025
2. DEIS, DESNZ (2025) *Digest of UK Energy Statistics (DUKES)*
3. GHG Protocol Corporate Standard
4. ISO 14064-1:2018 Specification with guidance for quantification and reporting of greenhouse gas emissions and removals
5. CIBSE Technical Memorandum TM46: Energy Benchmarks

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