The Rules

Thermal Energy Systems and CHP

Version 1.0— December 2024

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Cover photo: Chillers and boilers in a building's mechanical plant room.

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Contents

1 Introduction

1.1 General

This document contains **Rules** for NABERS UK **Assessors** when undertaking assessments for ratings with thermal **energy systems**, such as

a) Combined Heat and Power systems (**CHP system**, including combined cooling, heating and power systems (CCHP) also known as cogeneration/trigeneration system), or

b) Chilled water and hot water systems, or

c) Reversible heat pump or 4 pipe chiller systems,

d) Combinations of the above

where **thermal energy meters** are used to apportion thermal energy between end uses inside and outside the scope of the rating.

In addition, **thermal energy meter** validation requirements are provided at the end of this document (Appendix C Thermal energy metering requirements).

⚠ If all **thermal flow energy** from an energy system is used within the **minimum energy coverage** of the rating, there is no need to use this ruling, as there is no apportionment of **thermal flow energy** required.

1.2 Interpretation of the Rules and Rulings

Assessments for an accredited rating must comply with the version of the **Rules**, and any relevant **rulings**, current on the day the rating application is lodged to NABERS, unless—

a) the **Scheme Administrator** has specifically approved otherwise in writing, or

b) the assessment is conducted under the terms of a NABERS Commitment Agreement which specifies an earlier version of the Rules.

A **ruling** takes precedence if there is any conflict with the Rules. If there is a conflict between rulings, the most recent takes precedence.

In addition to the **Rules**, an **Assessor** is to make use of relevant **rulings** and the **NABERS UK rating input form**. A list of the documentation required in relation to this document is given in Chapter 5.

1.3 Situations not covered by the Rules

These **Rules** are intended to cover most ratings. If an exceptional situation is encountered and the **Rules** are not easily applicable, the **Assessor** must contact the **Scheme Administrator** for assistance.

Where an **Assessor** is unsure how to apply the **Rules**, the **Scheme Administrator** may resolve the issue by making an interpretation of the **Rules** or by advising the use of a specific procedure that aligns with the intention of the **Rules**. Written correspondence from the **Scheme Administrator** is required as evidence if this occurs.

Procedures not contained within these **Rules** may only be used for a particular rating with prior written approval from the **Scheme Administrator**. Approval to use the same procedure must be sought from the **Scheme Administrator** each time it is proposed to be used. Approval is entirely at the discretion of the **Scheme Administrator**.

1.4 How to use this document

1.4.1 General

The Rules allow apportioning of energy flowing from **energy systems** and their associated **thermal flow energy** to separate end uses that are required to be included in a NABERS rating from those that are not.

This document is to be applied in conjunction with the relevant **Rules** and does not replace the provisions of the relevant **Rules**. The following guidance regarding end uses, shared facilities and services applies:

a) End uses: This document does not define the end uses that are required to be included in the rating. The **Assessor** must always refer to the relevant Rules and subsequent rulings to determine the end uses to be included.

b) Shared facilities and services: There are a range of other shared facilities and services with specific **Rules** regarding their apportioning of **energy inputs**. The **Assessor** should refer to the Shared Facilities and Shared Services Rulings.

1.4.2 Formatting conventions and referencing

The term “**Rules”** refers to a body of works produced by NABERS that specify what must be examined, tested and documented when an **Assessor** conducts a rating. Wherever the term is used in this document from Chapter 3 onwards, it refers to this document, *NABERS Thermal Energy Systems and CHP — Dec 2024*. Other **Rules** documents mentioned in the text are distinguished from the present document by the inclusion of their title.

Text appearing **teal** and **bold** is a defined term. Defined terms can be found in Chapter 2 of these **Rules** or in the terms and definitions chapter of the respective **Rules** document.

All main references to documentation requirements appear *italicised* and in **aqua font**.

Internal cross references appear as numbered sections (e.g. Section 4.2) or chapters (e.g. Chapter 3) and are hyperlinked. Cross references to an individual **Rules** text are numbered appropriately together with the title of the specific text.

The following formatting conventions may appear in this text:

> ⚠ Important requirements and/or instructions are highlighted by an information callout box.

Note: Text appearing with a grey background is explanatory text only and is not to be read as part of the **Rules**.

Example: Text appearing with a green background is intended to demonstrate a worked example of the respective **Rules** section or **Ruling** section.

This is a documentation requirement callout box.

1.5 Related documents

The following documents have been referenced within these **Rules**:

NABERS UK The Rules – Energy for Offices, v2.1, 2024

NABERS UK The Rules – Metering and Consumption, v2.1, 2024

NABERS AUS Ruling – Shared Services and Facilities, v1.0, 2022

Heat Network (Metering and Billing Regulations) 2014 (and subsequent amendments)

Measuring Instruments Directive (MID) (2014/32/EU) MI-001

OIML R75-1, Heat Meters Part 1: General Requirements, 2002

Assessors must use the latest version of NABERS **Rules** and **Rulings** that have been referenced within this document.

2 Terms and definitions

This chapter lists the key terms, and their definitions, that are integral to the proper use of this document.

Term	Definition
acceptable data	Data which meets the applicable accuracy and validity requirements of these **Rules**.
Assessor	An accredited person authorised by the **Scheme Administrator** to conduct NABERS ratings.
calculator	A sub-assembly, which receives signals from the **flow sensor** and the temperature sensors and calculates and indicates the quantity of the thermal energy exchanged.
CHP system	A combined heat and power system that uses input energy to generate both electricity and **thermal flows, also known as a cogeneration system**. For the purposes of this document, this is taken to include combined cooling, heating and power systems (CCHP), also known as trigeneration systems.
circulation energy	The energy consumed by a circulation pump used in the process of transferring thermal energy. The energy used by this pump can be apportioned using these Rules. **Note:** If this pump is exclusively used to transfer energy from the **rated premises** to **other users**, then it is considered to be dedicated transfer energy and NOT circulation energy.
dedicated transfer energy	The energy consumed by a dedicated transfer pump exclusively used in the process of transferring thermal energy from the rated **premises** to **other users** or vice versa. **Example:** The energy associated with a secondary chilled water pump circulating chilled water to the rated office as well as the adjacent hotel is **circulation energy** *not* **dedicated transfer energy**. However, if the same office rating had a separate heat exchanger connection to the adjacent hotel, then the tertiary chilled water pumps for the heat exchanger circulating chilled water to the adjacent hotel would be **dedicated transfer energy**.
Electricity equivalent factor (EEF)	The factor used to convert energy measured in kWh to kWh_e.

Term	Definition
energy input	The total energy consumption of all components of the **energy system** being apportioned, including but not limited to: a) Electricity or gas inputs to chillers, boilers, heat pumps, **CHP systems** and heat rejection systems. b) **Circulation energy** for chilled water, heating hot water and condenser water; c) **Thermal flow energy inputs** such as chilled water or hot water entering the **energy system.** **Note:** This definition does not include the energy use associated with building management systems or **dedicated transfer energy**.
energy system	A system that uses input energy consumption (gas, electricity) to act upon one or more **thermal flows**. Includes chillers, boilers, heat pumps, pumps and **CHP systems**.
flow sensor	A flow measuring sub-assembly which indicates the volume, mass or volumetric flow rate of a liquid.
minimum energy coverage	The energy end uses required to be included in a rating assessment as defined in the relevant NABERS **Rules**.
NABERS UK rating input form	The rating input form provided by the **Scheme Administrator** for use by **Assessors** in the calculation of accredited ratings.
other users	A building or space whose services are not included in the **minimum energy coverage** of the rating being conducted.
rated premises	The building or building section to be rated.
rating period	The 12-month base period for the rating, requiring at least 12 continuous months of **acceptable data** upon which the rating is based.
Remote Metering Reading System (RMRS)	System whereby meter readings and other crucial meter data are sent to a data collection system. Such a system provides virtual meter access when physical access is not possible.
Rules	Authoritative document produced by the **National Administrator** that specifies what must be covered by an **Assessor** in order to produce a rating.
Ruling	An authoritative decision by the **National Administrator** which acts as an addition or amendment to the **Rules**.

Term	Definition
Scheme Administrator	The body responsible for administering NABERS UK, in particular the following areas: a) Establishing and maintaining the standards and procedures to be followed in all aspects of the operation of the system. b) Determining issues that arise during the operation of the system and the making of ratings. c) Accrediting **Assessors** and awarding accredited ratings in accordance with NABERS UK standards and procedures. The functions of the Scheme Administrator are undertaken by the Chartered Institute of Building Services Engineers (CIBSE). **Note:** The term "**Scheme Administrator**" applies to the NABERS UK context and should not be confused with the term "National Administrator" that appears in NABERS Australia publications.
thermal energy meter	A combination of a flow meter and a **temperature sensor pair** that can be used to calculate **thermal flow energy**.
thermal flow	A flow of chilled water, hot water or condenser water that is made available for use from an **energy system**. Excludes rejected heat not available for use such as heat rejection and losses from the **energy system**.
thermal flow energy	The thermal energy in the **thermal flow**, measured based on the difference between the thermal energy of the flow leaving the thermal generator and the thermal energy of the same liquid flow as it returns to the **energy system**.
temperature sensor pair	A sub-assembly (for mounting with or without pockets), which senses the temperatures of the heat-conveying liquid at the flow and return of a heat-exchange circuit.

3 Electricity Equivalent Factor calculations

3.1 General

This methodology enables **Assessors** to calculate the **electricity equivalent factor (EEF)** for:

a) **thermal flows**; and
b) electricity generated by **energy systems**.

The methodology requires two types of measurements:

a) **Energy metering**: metering that measures electricity, gas or other **energy inputs** to the **energy system** as well as electricity outputs from the **energy system** in the case of **CHP system**; and
b) **Thermal energy measurements**: **Thermal energy meters** that measure the **thermal flow energy** transferred by the **thermal flows** created by the **energy system**.

⚠ The **EEF** for a simple system such as a central chiller plant is just the kWh_e per unit thermal energy for the plant. However, this methodology also enables calculation of **EEF** in the situation where an **energy system** has more than one form of energy output.

3.2 Process overview

The process for the calculation of electricity equivalent factor is as per Table 3.2.

Table 3.2: Process overview

	Step	Reference
1	Identify the **energy system(s)** and their boundaries.	Section 3.3
2	Determine the total **energy inputs** to the **energy system** during the **rating period.**	Section 3.4
3	Determine all the **thermal flows** and electrical outputs (if applicable) from the **energy system.**	Section 3.5
4	Measure **CHP system** electrical output.	Section 3.6
5	Conduct verification check.	Section 3.7

6	Calculate the **electricity equivalent factor (EEF)** for each **thermal flow** and for the electricity output (if applicable) from the **energy system**.	Section 3.8

3.3 Step 1: Identify energy systems and their boundaries

3.3.1 General

It is important to define the boundaries of **energy systems** to ensure that the correct **energy inputs** and outputs are considered.

For documentation requirements, see Section 5.2.

3.3.2 Boundaries of an individual energy system

For the calculation of the **electricity equivalent factor** of a **thermal flow** to be unambiguous, it is necessary to apply clear **rules** around the boundaries of an **energy system**. In particular:

a) An individual **electricity equivalent factor** can only be calculated for:

1) An output **thermal flow** of one type (e.g. hot water, chilled water, condenser water, electricity), for which

2) All downstream flow branches have the same **energy inputs**, ignoring any **dedicated transfer energy**.

Note 1: As the purpose of the **EEF** calculation is to enable apportionment of energy, it is critical to ensure that the apportionment reflects the energy that is dedicated to each flow path. This requires that all flow paths that the **EEF** applies to have the same physical **energy inputs**.

Note 2: **Dedicated transfer energy** within the **minimum energy coverage** of the rating is directly added to the rated energy use and is therefore ignored in **EEF** calculations.

b) Where the **thermal flow** has streams with different **energy inputs**, additional **energy system(s)** must be added to capture the effect of the additional **energy inputs** until each **energy system** complies with Item a) above.

Note: This process will create a cascade of **energy conversion systems**, each of which can have its **EEF** calculated unambiguously for that **thermal flow**.

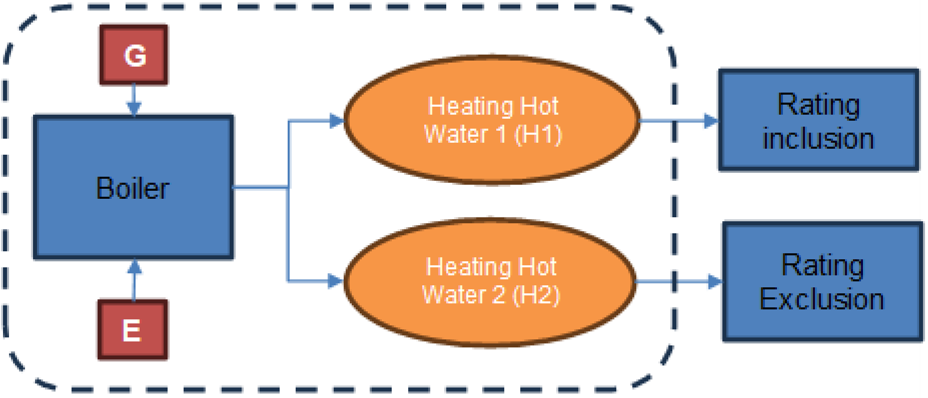
c) The upstream (input side) limit of an individual **energy system** is defined as the sum of all **energy inputs** relevant to the generation of the energy outputs from the **energy system**.

Note: **Thermal flows** of different types may require different configurations of **energy conversion systems** in order to calculate the **EEF** calculated unambiguously for each **thermal flow**.

3.3.3 Examples

Figure 3.3.3(a) is a schematic representation of a simple **energy system**.

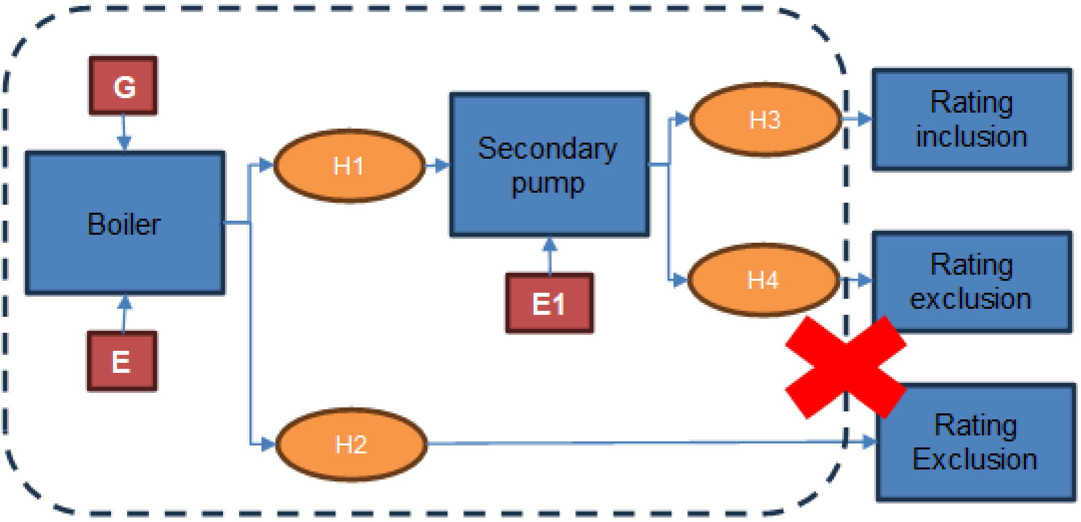
Figure 3.3.3(a): A simple energy system. Gas G and electricity E supply a boiler system (boilers, primary pumps) to produce two hot water flows H1 and H2



It is clear in this situation that the two heating hot water flows H1 and H2 have the same **energy inputs**, being the gas G and electricity E to the boiler and pumps. Thus, the boiler can be treated as a single **energy system** as illustrated by the dashed boundary.

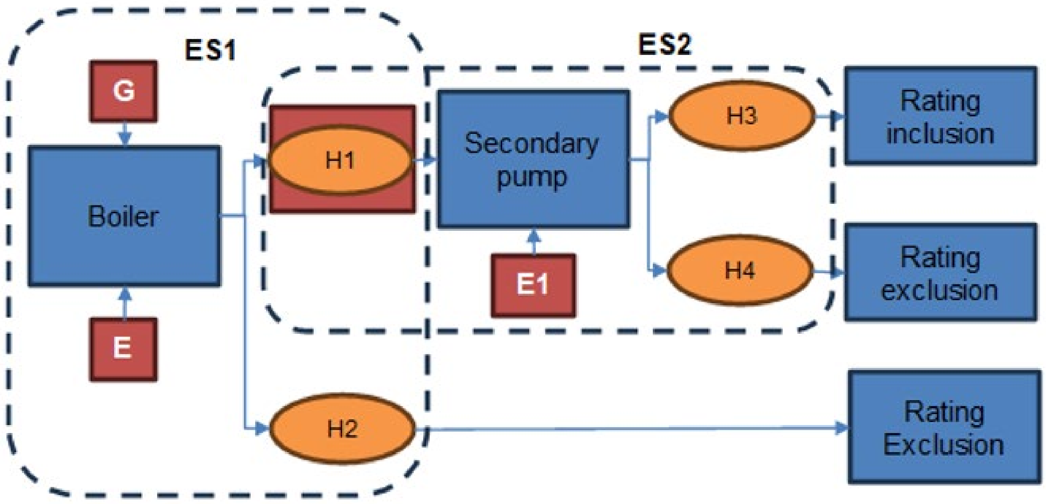
Note: If, instead of a boiler, the heating plant consisted of a combination of boilers and heat pumps, the **energy inputs** would be G, the gas input to the boilers and E, the electricity input to the boilers, heat pumps and pumps.

Figure 3.3.3(b): An incorrect energy system boundary



In the system represented in Figures 3.3.3(b), heating hot water **thermal flows** H3 and H4 have energy input E1 which is not shared by H2. Thus, a single **EEF** that applies to H2, H3 and H4 cannot be calculated. As a result, the **energy system** suggested by the dashed line in Figure 3.3.3(b) is not permitted. This situation can be resolved, however, by introducing an additional **energy system** as shown in Figure 3.3.3(c).

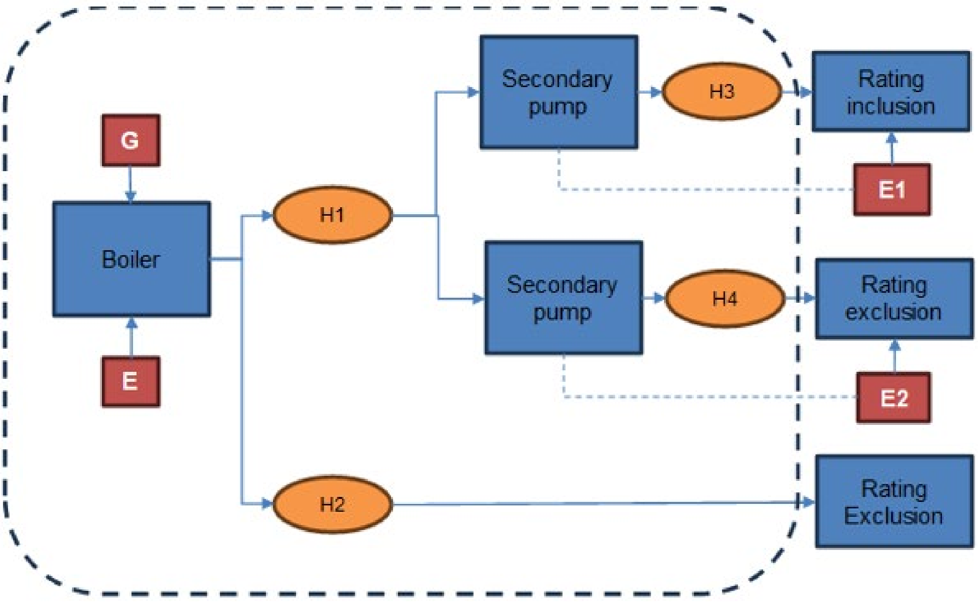
Figure 3.3.3(c): A correctly delineated cascade of two energy systems



In this revised configuration, ES1 has two outputs H1 and H2 with identical **energy inputs**, while ES2 has two outputs H3 and H4 with identical **energy inputs** E1 and H1. Thus, when calculating **EEF**s for this configuration, one would calculate the **EEF**s for ES1, followed by the **EEF**s for ES2.

Finally, consider the following variant of the system above, as shown in Figure 3.3.3(d):

Figure 3.3.3(d): An energy system in the presence of two instances of dedicated transfer energy (the two secondary pumps)



In the system represented in Figure 3.3.3(d), the secondary pump energy E1 and E2 are both **dedicated transfer energy**, to H3 and H4, respectively. E1 and E2 can therefore be allocated 100% to the respective end use, and not as an energy input to the **energy systems** (Section 3.3.2 a) b). Once this has been accounted for, the **energy inputs** of **thermal flows** H1, H2, H3 and H4 are the same (i.e. G and E). Thus, there is no need to define the secondary pumps as separate **energy systems** and the dashed boundary is permitted.

3.4 Step 2: Measure energy inputs

3.4.1 General

The Assessor must determine all **energy inputs** to the **energy system**. For examples of typical energy inputs, see Table 3.4.

Table 3.4: Examples of typical energy inputs

Thermal energy output	Examples of typical energy inputs
Chilled water	Chiller (electricity, gas) Chilled water circulation pumps (electricity) Heat rejection equipment (electricity) **CHP system** equipment (electricity, gas)
Condenser water	Cooling tower fans (electricity) Condenser water circulation pumps (electricity)
Heating hot water	Boiler (gas, electricity) Heat pumps (electricity) Heating hot water circulation pumps (electricity) **CHP system** equipment (gas, electricity)

Note 1: Each **thermal flow** output may also be an energy input to a downstream **energy system**.

The **Assessor** must ensure that all energy use required for the operation of the **energy system** is included. The **energy inputs** are calculated as the total energy use for each input evaluated over the full year of the **rating period**.

See Appendix B for further guidance for **Assessors**.

Note 2: As discussed in Section 3.3, **dedicated transfer energy** is not treated as part of the **energy system** for the purpose of **EEF** calculations.

For documentation requirements, see Section 5.2.

3.4.2 Energy inputs sub-metering requirements

Energy consumption data must be obtained for the entire **rating period** for each **energy input**. Meters used to measure **energy inputs** must comply with the requirements in *NABERS UK The Rules – Metering and Consumption* and the provisions of Appendix C Thermal energy metering requirements.

3.4.3 Heat recovery systems

Heat recovery systems may form part of the **energy inputs** into an **energy system**. For an **energy input** to be considered as a heat recovery system, the following conditions must be met:

a) For a system that transfers heat to the **energy system** being considered:
   1) The system must have no temperature-controlled heating (i.e. heating used with the intent of maintaining a minimum flow temperature).
   2) The system may have heat rejection (i.e. a cooling tower used to maintain a maximum flow temperature)

b) For a system that transfers heat from the **energy system** being considered:
   1) The system must have no temperature-controlled cooling (i.e. cooling used with the intent of maintaining a maximum flow temperature).
   2) The system may have heat input (i.e. heat input used with the intent of maintaining a minimum flow temperature).

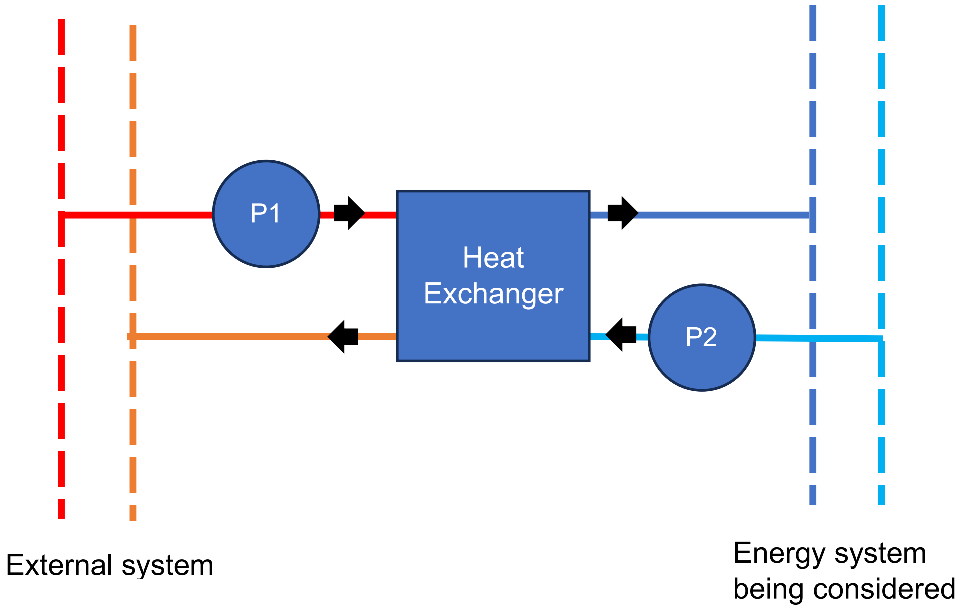
In this situation the **energy inputs** for the heat recovery system are considered to be the pump energy associated with pumping required to overcome pressure drop and create flows though the heat exchanger (on both sides) and associated pipework and valves connecting the heat exchanger to the associated general circulation systems, as shown in Figure 3.4.3.

If the heat recovery system does not have dedicated pumps in a manner similar to the configuration in Figure 3.4.3, the following considerations apply:

a) If there is no pump P1, in the absence of a calculation regime approved by the **Scheme Administrator**, such a heat recovery system must be treated as a case of insufficient metering as discussed in Section 3.4.4.

b) If there is no pump P2, the **Assessor** should ensure that the primary **circulation energy** in the **energy system** being considered is included as an energy input, as this will cover the function of pump P2.

Figure 3.4.3: A heat recovery system, the energy inputs for the heat recovery system are limited to the input energy for pumps P1 and P2.



3.4.4 Systems with insufficient or inadequate energy input metering

If compliant metering is insufficient to determine some or all the **energy inputs** during the **rating period**, the following conditions apply:

a) Where **energy inputs** can be *excluded* from the rating, only the part of the **energy input** that is adequately sub-metered may be excluded.

b) Where the **energy input** is required to be included in the rating, the rating cannot proceed unless metering that includes (but may not be limited to) the **energy input** is used to measure and include the **energy input**.

Example: A **CHP system** provides chilled water and hot water to an office building. The gas input into the **CHP system** is known but the measured electricity input to the **CHP system** includes electricity to an unrelated (excludable) facility.

If the electricity to the unrelated facility is provided with compliant submetering, then it can be excluded from the **energy inputs** for the **EEF** calculations relating to the **CHP system**. If it is not provided with compliant submetering, then either the electricity to the unrelated facility must be included in the **energy inputs** for the **CHP system EEF** calculation, or the rating cannot proceed.

3.5 Step 3: Measure thermal flow energy outputs

3.5.1 Measuring thermal flow energy

The **Assessor** must identify all **thermal flows** from the **energy system**. The **thermal flow energy** for each of these flows must be calculated as per the requirements below.

For documentation requirements, see Section 5.2.

3.5.2 Thermal energy meter requirements

3.5.2.1 Thermal energy meters

Thermal energy meters must be provided to each **thermal flow** from the **energy system**, downstream of any circulation pump counted within the **circulation energy**.

Note: The location of the **thermal energy meter** relative to any dedicated thermal storage is not critical.

3.5.2.2 Validation requirements

All **thermal flows** used in the rating must be measured using compliant **thermal energy meters**, which are meters that comply with Appendix C Thermal energy metering requirements.

3.5.3 Systems with insufficient or inadequate thermal energy meters

If there a **thermal flow** that needs to be used in the rating calculation that is not provided with a compliant **thermal energy meter**, then:

a) No energy exclusion relating to the **thermal flow** is permitted; and

b) Any energy inclusion relating to the **thermal flow** must either:

   1) include all the **energy inputs** to the **thermal flow**; or

   2) be calculated on the basis of subtraction of compliant **thermal energy meters**, but only if the exclusion comprises less than 25% or the total **thermal flow energy** for the **energy system**.

The rating cannot proceed if these requirements are not met.

3.6 Step 4: Measuring electrical output energy (CHP systems)

Electrical energy outputs from a **CHP system** must be measured using an electricity meter or submeter in compliance with *NABERS UK The Rules – Metering and Consumption*.

For documentation requirements, see Section 5.2.

3.7 Step 5: Verification check

The purpose of this verification is to check that the ratio of total energy outputs to total **energy inputs** (known as the Coefficient of Performance or COP) is reasonable for the type of system being assessed.

This is calculated using the following formula:

COP = (Thermal energy outputs (kWh_{th})+Electrical energy outputs (kWh))/(Energy Inputs (kWh))

See Table 3.7 for examples of acceptable COP ranges checks for a common **energy systems**.

Where the calculated COP does not fall within the range of acceptable COP in Table 3.7, the **Assessor** must retain evidence such as equipment technical data and calculations to prove that the COP is reasonable.

For documentation requirements, see Section 5.2.

Table 3.7: Examples of COP checks on some common energy systems (excluding circulation energy)

Energy system	Energy Inputs	Energy Outputs	Range of acceptable COP
Chiller	Chiller electrical consumption	Chilled water	2.0 to 6.5 (Compression chiller)
Heating hot water	Boiler gas consumption	Hot water	0.3 to 0.98
	Heat pump electrical consumption	Hot water	1.0 to 4.5
4 pipe chiller	4 pipe chiller electrical consumption	Chilled water and hot water	2.0 to 9.0
Condenser water	Cooling tower fan electrical consumption	Condenser water	40 to 125
CHP system	Gas and electricity	Chilled water, hot water and electricity	0.7-0.95

3.8 Step 6: Calculating electricity equivalent factors

3.8.1 General

The **energy inputs** for an **energy system** are allocated between the **thermal flows** and electricity generated by that system. The ratio of this allocation is dependent upon the type of energy output. This allocation is then used to calculate the **electricity equivalent factors** for the outputs of the **energy system**.

Note 1: Electricity equivalent factors are used to convert all fuels to a common metric. For NABERS UK, this metric is informed by the ratio of primary energy inputs to the fuel to that of electricity and is expressed in units of kWh_e/kWh. The **EEF** for electricity is $1kWh_e/kWh$, while the **EEF** for gas is 0.75 kWh_e/kWh.

For documentation requirements, see Section 5.2.

3.8.2 Calculation

The kWh equivalent E_{tot} of the energy inputs to the **energy system** is calculated as:

$$E_{tot}\ (kWh_e) = \sum_{j=1}^{N} EEF_j\ e_j$$

Where $j=\{1..N\}$ covers all the types of energy inputs to the **energy system** (e.g. gas, electricity), and energy type j has energy consumption e_j (kWh) in the **rating period** and a kWh_e **electricity equivalent factor** of EEF_j (kWh_e/kWh).

3.8.2.1 Single energy output

For an **energy system** that has only one type of **energy output** (e.g. hot water only, chilled water only, etc).

$$EEF = \frac{E_{tot}}{\varepsilon}$$

Where E_{tot} is the kWh_e equivalent of the **energy inputs** to the system and ε is the energy (in kWh) of the output from the system.

3.8.2.2 Multiple energy outputs

For an **energy system** that has multiple types of **energy output** (e.g. a **CHP system**, a 4-pipe chiller or a heat pump that also works as a chiller), the kWh equivalent A_x (kWh_e) allocated to **energy system** energy output x with **thermal flow energy** or output electricity ε_x in the **rating period** is calculated as:

$$A_x = P_x E_{tot}$$

where

$$P_x = \frac{\alpha_x \varepsilon_x}{\alpha_{HW1}\varepsilon_{HW1} + \alpha_{HW2}\varepsilon_{HW2} + \alpha_{ChW}\varepsilon_{ChW} + \alpha_{CW}\varepsilon_{CW} + \alpha_{Elec}\varepsilon_{Elec}}$$

Noting that:

a) Each of the ε_x factors is the sum of the kWh energy for all outputs of type x; and

b) The factors α are as defined in Table 3.8.

Table 3.8: Weighting factors for energy outputs from an energy system

Energy output type	α value
HW1: Hot water from CHP or boiler	0.83
HW2: Hot water from heat pump	0.37
ChW: Chilled water	0.25
CW: Condenser water	0.01
Elec: Electricity	1

Note that the higher hot water factor applies to all **CHP systems**, irrespective of whether they use gas boilers or heat pumps (or neither) to supplement waste heat recovery.

The electricity equivalent factor for flow *x* is:

$$EEF_x = \frac{A_x}{\varepsilon_x} = \frac{\alpha_x E_{tot}}{\alpha_{HW1}\varepsilon_{HW1} + \alpha_{HW2}\varepsilon_{HW2} + \alpha_{ChW}\varepsilon_{ChW} + \alpha_{CW}\varepsilon_{CW} + \alpha_{Elec}\varepsilon_{Elec}}$$

Note 1: Weighting factors are used only to provide some level of proportionality between different energy outputs. The underlying principle is that the ratio of kWh_e intensity between different energy outputs should remain constant and broadly reflective of what would have occurred had the energy outputs been individually generated. The absolute value however is modulated by the overall efficiency of the whole system. The weighing factors α have been determined based on the following figures:

a) Boiler: seasonal efficiency = 0.9, **EEF**$_{gas}$ = 0.75

b) Chilled water: Seasonal efficiency (SEER/IPLV) = 4, **EEF**$_{elec}$ = 1

c) Heat Pump: Seasonal efficiency (SCOP) = 2.7, **EEF**$_{elec}$ = 1

d) Condenser water, cooling tower fan power 10W/kW, **EEF**$_{elec}$ = 1

e) Electricity: **EEF**$_{elec}$ = 1

4 Thermal flow energy apportionment

4.1 General

This methodology enables **Assessors** to apportion energy, measured in kWh_e, between different uses/users of a single **thermal flow**.

Energy is apportioned between the users of thermal energy based on the quantity used by each end user. The energy consumption allocated to the rating using this methodology is considered **acceptable data** and is not added to the potential error.

4.2 Process overview

The process for apportioning **thermal flow energy** of a single **thermal flow** is as per Table 4.2. For apportioning heating hot water, chilled water or condenser water for a NABERS energy rating, go to Step 1. For apportioning domestic hot water, go straight to Step 5.

Table 4.2: Process overview

	Step	Reference
1	Determine the **electricity equivalent factor (EEF)** of the **thermal flow**.	Section 3
2	Identify all end uses of the **thermal flow**.	Section 4.3
3	Calculate the kWh_e for the **thermal flow energy** to be included in the rating.	Section 4.4
4	Ensure applicable **dedicated transfer energy** is included in the rating.	Section 4.5
5	Apportion domestic hot water energy.	Section 4.6

4.3 Step 1: Identify energy uses of the thermal flow

4.3.1 Thermal energy meter requirements

The **Assessor** must identify all end uses of the **thermal flow**, and further identify which end uses are to be included in the rating and which are to be excluded.

For documentation requirements, see Section 5.3.

4.4 Step 2: Calculate the kWh_e for the thermal flow energy to be included in the rating

The kWh_e to be included in the rating $A_{x,included}$ is the product of the measured total flow energy to be included in the rating $TFE_{included}$ multiplied by the electricity equivalent factor for the **thermal flow** EEF_x, that is:

$$A_{x,included} = EEF_x \times TFE_{included}$$

For documentation requirements, see Section 5.3.

4.5 Step 3: Dedicated transfer energy

Any **dedicated transfer energy** applicable to the rating must be separately metered and 100% allocated to the rating.

Non-utility meters used to measure **dedicated transfer energy** must comply with the general requirements for non-utility meters set out in *NABERS UK The Rules – Metering and Consumption*.

For documentation requirements, see Section 5.3.

4.6 Step 4: Domestic hot water

4.6.1 General

Apportioning domestic hot water (DHW) uses a different methodology as it is an open loop system, making the metering of **thermal flow energy** a challenge. The energy is instead apportioned on the respective end uses for the DHW.

Thermal energy meters are not required for apportioning a shared DHW system, but water meters are required.

For documentation requirements, see Section 5.3.

4.6.2 Measuring total system energy consumption

Determine the total energy consumption of the shared DHW system for the **rating period** using compliant electrical or gas metering.

4.6.3 Measuring domestic hot water use

Several types of water meters are required to complete a water balance of the DHW system. This includes, at a minimum, the following types of meters:

a) Master water meter(s) to measure the total DHW use;

b) Water submeters for all end uses which, when added together, equal the total DHW use; and,

c) Sufficient water submeters to measure the DHW of the included/excluded DHW use.

Virtual water meters must not be used.

The **Assessor** must compare the total DHW production to the total system energy input using the thermal energy formula in Appendix A and confirm that these values are reasonable for the type of DHW system. The basis for accepting these values should be documented and retained for any NABERS audit.

4.6.4 Apportioning energy consumption

The total energy consumption of the shared DHW system is apportioned based on the proportion of the DHW used by the **rated premises** compared to the total DHW use during the **rating period.**

4.6.5 Metering requirements

Non-utility meters used to measure the hot water consumption of a domestic hot water system must comply with the validation, accuracy, frequency of readings and documentation requirements set out in *NABERS UK The Rules – Metering and Consumption*.

The hot water meters must also be appropriately rated for the temperatures of the DHW system. A standard water meter is designed for cold water and will not be accurately installed on a hot water system

5 Documentation required for accredited ratings

5.1 General

5.1.1 Information and documentation requirements

The information in the tables below is required for a rating. Information may be contained in many different formats. The purpose of the documentation is to provide an acceptable, credible source of the required information. In some instances, specific document types may be unnecessary for an individual rating. Or, under different rating circumstances, the specific document types may carry multiple items of information required for the rating. The qualifying factor is not the type of document but that the documentation contains the required information in an acceptable format.

The tables in Section 5.2 onwards are organised based on the divisions of previous chapters (Chapter 3 and Chapter 4). All the required information should be obtained from the premises' owner/manager before a site visit, and then confirmed during the site visit and subsequent assessment. A site inspection helps to verify that the information provided is accurate, current and complete.

Individual ratings may require additional information or documentation depending on the individual circumstances of the **rated premises**.

5.1.2 Documentation retention

Assessors must keep copies of the documentation that contains information on which an assessment is based. Data retained for audit must be in a form which facilitates reviews and makes anomalies easily apparent.

Access to original documents is highly desirable if they are available. Copies of original documents may be used as evidence as long as the **Assessor** is satisfied that they are, or can be verified to be, true and complete records of the original documents or files.

5.2 Documentation required for Chapter 3: Electricity equivalent factor calculations

Topic	Requirements	Documentation
Step 1: Identify **energy systems** and their boundaries	Section 3.3	*Required information* The **Assessor** must retain evidence of the nature of each **energy system**, its **thermal flows**, and other energy outputs and inputs. *Documentation examples* Documentation that can be used as evidence includes the following: a) Hydronic reticulation diagrams (from design documentation or hand drawn schematics) for the **energy system;** b) Energy inputs and outputs diagrams showing electrical and fuel flows for the **energy system.**
Step 2: Measure energy inputs	Section 3.4	*Required information* The **Assessor** must retain evidence of the annual energy consumption of energy inputs of each **energy system** compliant with: a) The requirements of *NABERS UK – The Rules: Metering and Consumption* for electricity and fuel inputs b) The requirements of Appendix C Thermal energy metering requirements. *Documentation examples* Refer to the cross-referenced rules for documentation examples.

Step 3: Measure **thermal flow energy** outputs	Section 3.5	*Required information* The **Assessor** must retain evidence of **thermal flow** metering measurements and calculations compliant with the Requirements of Appendix C Thermal energy metering requirements. *Documentation examples* Refer to the cross-referenced rules for documentation examples.
Step 4: Measuring electrical output energy (**CHP systems**)	Section 3.6	*Required information* The **Assessor** must retain evidence of the annual electricity output from the **CHP system** compliant with the requirements of NABERS UK – The Rules: Metering and Consumption. *Documentation examples* Refer to the cross-referenced rules for documentation examples.
Step 5: Verification check	Section 3.7	*Required information* The **Assessor** must retain evidence including calculations and equipment documentation that demonstrates that the COP of each **energy system** is reasonable. *Documentation examples* Documentation that can be used as evidence includes the following: a) **Assessor** calculations; b) Equipment technical specifications and performance curves, showing gross efficiency; c) Thermal energy outputs metered data and annualised value; d) Energy input metered data and annualised value.

Step 6: Calculating Electricity Equivalent Factors	Section 3.8	*Required information* The **Assessor** must retain evidence of calculations used to derive the **electricity equivalent factors** for each energy output from each **energy system**. *Documentation examples* **Assessor** calculations.

5.3 Documentation required for Chapter 4: Thermal flow energy apportionment

Topic	Requirements	Documentation
Step 1: Identify energy uses of the **thermal flow**	Section 4.3	*Required information* The **Assessor** must retain evidence of **thermal flows**, end uses and metering arrangements. *Documentation examples* Hydronic reticulation diagrams (from design documentation or hand drawn schematics) for the **thermal flows** including identification of end uses and metering locations.
Step 2: Calculate the kWh_e for the **thermal flow energy** to be included in the rating	Section 4.4	*Required information* The **Assessor** must retain evidence of the apportionment calculation based on the **EEF** for the **thermal flow** and the **thermal flow energy** that is relevant to the **rated premises**. *Documentation examples* Documentation that can be used as evidence includes the following:

		a) **EEF** calculations as per the requirements of Section 5.2. b) **Thermal energy meter** data compliant with Appendix C Thermal energy metering requirements.
Step 3: **Dedicated transfer energy**	Section 4.5	*Required information* The **Assessor** must retain evidence compliant with the requirements of *NABERS UK – The Rules: Metering and Consumption* of the annual electricity consumption of each **dedicated transfer energy** item relevant to the **rated premises**. *Documentation examples* Refer to the cross-referenced rules for documentation examples.
Step 4: Domestic hot water	Section 4.6	*Required information* Records demonstrating the apportioning of total DHW energy consumption must be retained. The **Assessor** must retain evidence that the ratio of total DHW thermal energy production to total system energy input is reasonable for the type of DHW system. *Documentation examples* Documentation that can be used as evidence includes the following: a) Technical specifications demonstrating temperature rating of water meters are appropriate; b) Hydronic reticulation of thermal system including location of meters and thermal energy transfer points to the **rated premises** and to **other users**; c) Documentation proving non-utility meters meet the requirements set out in NABERS UK The Rules – Metering and Consumption.

5.4 Documentation required for Appendix D: Thermal Energy Metering Requirements

Topic	Requirements	Documentation
General checks	Section C.1.2	*Required information* The **Assessor** must retain evidence of the general validation checks. *Documentation examples* Documentation that can be used as evidence includes the following: a) **Assessor** site notes and photographs in relation to the metering installation b) **Assessor** recordings of instantaneous **thermal energy meter** site readings and the basis on which they appear reasonable c) Thermal energy balance documentation as per Section 44C.1.6.
Thermal energy meter accuracy requirements	Section C.1.3	*Required information* The **Assessor** must retain written evidence, for each meter showing that: a) The meter has been included in a notification under the Heat Network (Metering and Billing Regulations) 2014 and that the meter is used for billing purposes; or b) Certification of meter as Class 1 or 2 under Measuring Instruments Directive (MID) (2014/32/EU) and evidence that the meter is operated within the boundaries of its minimum and maximum flow and minimum temperature difference; or c) Meter otherwise complies with the maximum permissible error requirements of Section C.1.4, based on measurement in the past 10 years; or d) Thermal energy balance documentation as per Section 44C.1.6.

		Documentation examples Documentation that can be used as evidence includes the following: a) Notification under the Heat Network (Metering and Billing Regulations) 2014 b) Thermal energy bills relating to the meter c) Meter certification documentation d) Calibration certificates for the meter e) On-site measurement-based verification measurements using temporary measurement equipment f) Calibration certificates for any temporary measurement equipment, within 180 days of the measurement date.
Remote Metering Reading system validation	Section C.1.5	*Required information* Documentation must be retained that confirms that 100% of the **thermal energy meters** have been validated within the past 10 years to read on the **RMRS** correctly. The **Assessor** must be able to confirm that the **thermal energy meters** have been installed correctly. *Documentation examples* Documentation that can be used as evidence includes the following: a) **RMRS** validation records as per Appendix A of NABERS UK The Rules – Metering and Consumption; b) Signed statement by a competent person (name, company and qualification) confirming that meters have been installed correctly.

Thermal Energy Balance	Section C.1.6	*Required information* Documentation of the energy balance conducted. *Documentation examples* **Assessor** calculations
Other Requirements	Section C.2	*Required information* The **Assessor** must retain evidence of: a) 15 minute thermal energy readings and calculations b) compliance with *NABERS UK- The Rules: Metering and Consumption* *Documentation examples* Documentation that can be used as evidence includes the following: a) Soft or hard copy records of thermal meter readings on 15 minute basis for duration of the **rating period** b) Documentation as required in NABERS UK- The Rules: Metering and Consumption

Appendix A Examples

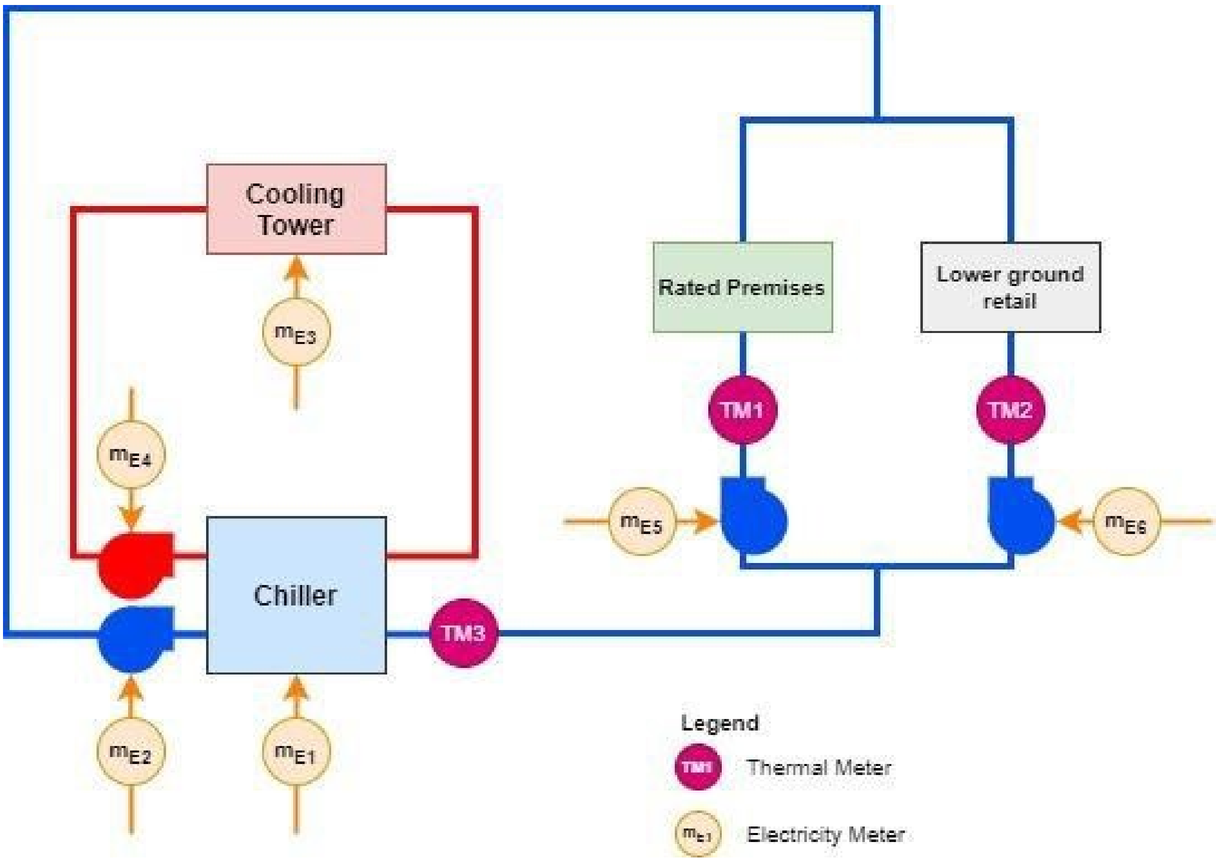
A.1 Example 1: Shared chilled water systems

A.1.1 Site description

A chiller plant operates as an **energy system** providing chilled water to an office Base Building and a small retail tenancy located on the ground floor, as shown in Figure A.1(a). The system also provides heat rejection to both the office and retail spaces through a cooling tower condenser water loop. The **rated premises** has a standalone tenant condenser water system that does not use the same cooling towers as the shared chilled water system. There are no other end users of the shared chilled water or condenser water.

The **Assessor** must determine the proportion of the energy input to be allocated to the **rated premises** from the chilled water and condenser water system.

Figure A.1(a): Example 1 – Chilled water and condenser water schematic

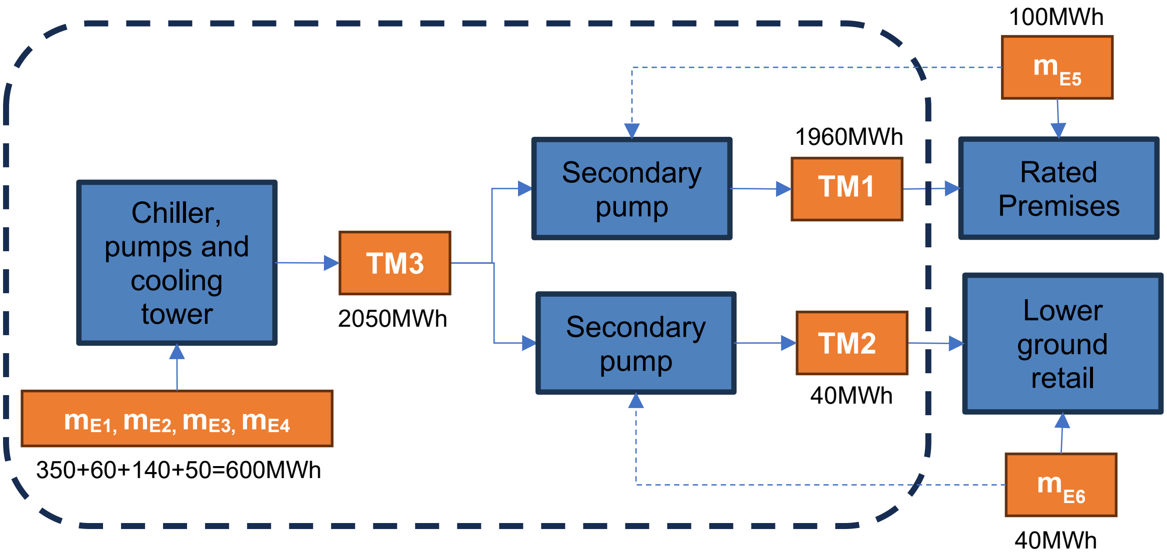


A.1.2 Determine the electricity equivalent factor for the thermal flow

Step 1: Determine the limits of the energy system(s)

The chiller (m_{E1}), cooling tower (m_{E3}) and associated primary pumps (m_{E2}, m_{E4}) form a simple **energy system** that produces chilled water. This is illustrated in Figure A.1(b) below.

Figure A.1(b): Example 1 – Energy system boundary



The secondary pumps to the **rated premises** (m_{E5}) and the lower ground retail (m_{E6}) are both treated as **dedicated transfer energy** and therefore are automatically allocated 100% to their respective end use. As a result, there is no need for either to be treated as a separate **energy system**.

Step 2: Determine the total energy inputs to the energy system

The energy consumption of all system components has been sub-metered for the duration of the **rating period**. These are recorded and exported to spreadsheet format in 15-minute intervals.

The **Assessor** obtains meter readings that meet the metering requirements outlined in *NABERS The Rules – Metering and Consumption*.

The measured energy inputs are as per Table A.1(a).

Table A.1(a): Annual consumption of energy inputs

Meter	Component	Annual consumption (MWh)
m_{E1}	Chillers	350
m_{E2}	Primary chilled water pumps	60
m_{E3}	Cooling tower fans	140
m_{E4}	Condenser water pumps	50

m_{E5}	Secondary chilled water pumps for the **rated premises** chilled water riser	100
m_{E6}	Secondary chilled water pumps for the lower ground retail chilled water riser	40

Following from Step 1:

a) the total energy input to the chiller plant **energy system** is:

$$m_{E1} + m_{E2} + m_{E3} + m_{E4} = 600\ MWh$$

b) the electricity consumption for secondary chilled water pump for the **rated premises** (m_{E5}) is **dedicated transfer energy** for the **rated premises**. As such, it is 100% allocated to the **rated premises**.

c) the electricity consumption for secondary chilled water pump for the lower ground floor retail (m_{E6}) is **dedicated transfer energy**. Therefore, it is 100 % allocated to the lower ground retail and thus is an exclusion from the rating.

Step 3: Determine all the thermal flows and electrical outputs from the energy system

As shown in Figure A.1(a) and Figure A.1(b) the only **thermal flow** from the **energy system** is the chilled water. There are no electrical outputs from the **energy system**.

The **Assessor** confirms that the **thermal energy meters** meet the validation requirements in Appendix C Thermal energy metering requirements.

The measured **thermal flow energy** from the three **thermal energy meters** is as per Table A.1(b). These figures were determined based on a sum of 15-minute readings of thermal energy across the **rating period**.

The chilled water **thermal flow energy** from the chiller plant **energy system** is measured by meter TM3. For the purpose of the **electricity equivalent factor** calculation, this is the only **thermal energy meter** information of interest.

Table A.1(b): Metered thermal flow energy

Meter	End user	Annual thermal energy (MWh_{th})
TM1	Rated office premises	1,960
TM2	Lower ground retail	40
TM3	Total **thermal flow energy**	2050

The **thermal energy meters** do not have the certifications or calibrations required under Appendix C Thermal energy metering requirements. Therefore, the **Assessor** must conduct an energy balance in accordance with Section D.1.6. The annual thermal energy balance is calculated as per Table A.1(c).

Table A.1(c): Calculating the annual thermal energy

Meter	End user	Annual thermal energy (MWh)
TM1 + TM2	Rated office premises + Lower ground retail	2,000
TM3	Total	2,050

The annualised **thermal flow energy** measured by TM3 is within 10 % of the sum of transferred thermal energy (TM1 + TM2) as calculated below:

$$\%\ discrepancy = \frac{TM3 - (TM1 + TM2)}{TM3} = \frac{50}{2050} = 2.4\%$$

This is correct within 10% and is therefore acceptable.

Step 4: Verification check

The energy input for the chillers is 350MWh, while the **thermal flow energy** is 2050 MWh. This gives a COP of 2050/350=5.85 which is within the range of expectation for a chiller plant.

Step 5: Calculate the electricity equivalent factor

The **electricity equivalent factor** for the chilled water plant is calculated as follows:

a) The **EEF** of electricity is 1 and the input energy is 600MWh so the total kWh_e for the energy input is $600MWh_e$.
b) 100% of this is allocated to the chilled water so the total kWh_e for the chilled water **thermal flow energy** is $600MWh_e$.
c) The **EEF** for the chilled water flow is $600MWh_e/2050MWh_{th}=0.29kWh_e$ per kW_{th}.

A.1.3 Thermal flow energy apportionment

Step 1: Identify all uses of the thermal flow

As shown in Figure A.1(a), the only uses of the **thermal flow** are the **rated premises** and the lower ground retail.

The **thermal flow energy** to be included in the rating is measured by **thermal energy meter** TM1 which has an annual **thermal flow energy** of 1960 MWhth.

Step 2: Calculate the kWhe to be included in the rating

The **thermal flow energy**, in kWhe, to be included in the rating is 1960MWhth*0.29=568.4MWhe.

Step 3: Dedicated transfer energy

The **dedicated transfer energy** for the **rated premises** is measured by meter mE5. The electricity consumption in the **rating period** for this is 100MWh, which must be included in the rating.

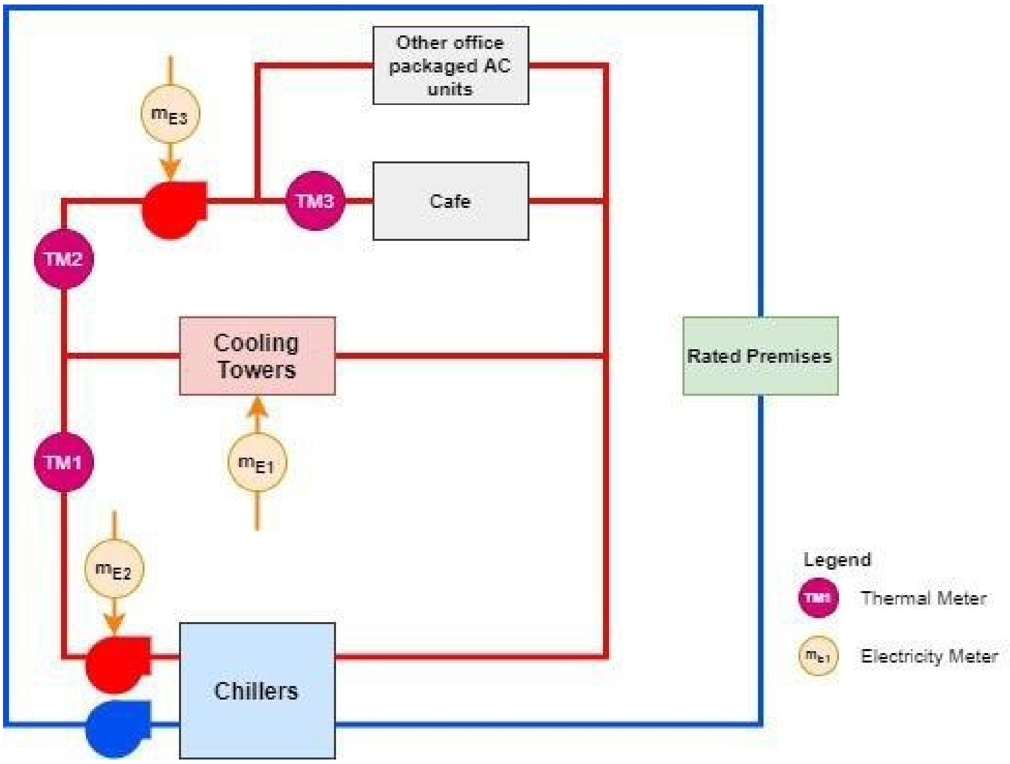
A.2 Example 2: Shared condenser water system

A.2.1 Site description

This example is based on a whole building rating. Heat rejection is provided to an office building (inclusive of the tenant condenser water system) and a small café located adjacent to the foyer of the building, as shown in Figure A.2(a) below. Central chilled water is only provided to the office space and is not provided to the café. The condenser water loop does not serve any other end users beyond the tenant condenser water system and chilled water system. As this is a whole building rating, the tenant condenser water service to the office packaged AC is included in the rating, but the equivalent service to the café is excluded.

The **Assessor** must determine the proportion of the energy input to be allocated to the **rated premises** from the shared condenser water system.

Figure A.2 (a): Example 2 – Condenser water schematic



A.2.2 Determine the electricity equivalent factor for the thermal flow

Step 1: Determine the limits of the energy system(s)

The plant of concern for this analysis encompasses the cooling towers (m_{E1}) and condenser water pumps (m_{E2}, m_{E3}). The chilled water system is not of concern for this case because the chilled water does not serve the café; as a result, the chilled water **energy inputs** are allocated 100 % to the **rated premises**.

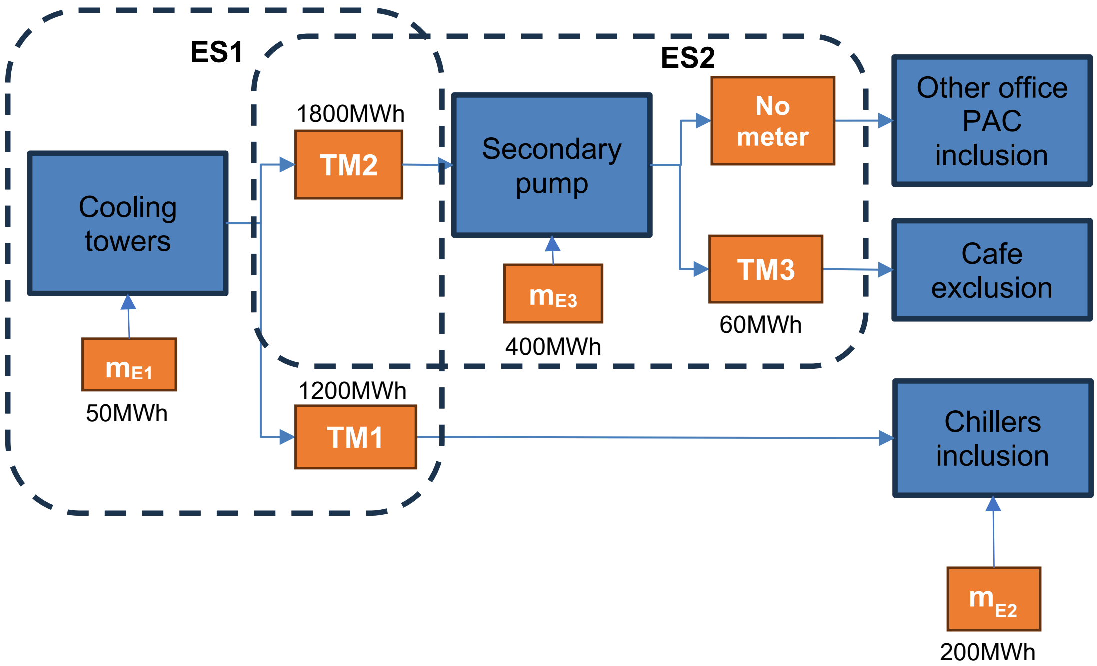
The chiller condenser water pump (m_{E2}) is **dedicated transfer energy** for the **rated premises**, and so is 100% allocated to the **rated premises**. However, the tenant condenser water pump (m_{E3}) is shared between rating inclusions and exclusions and means that the **energy inputs** of the **thermal flows** downstream of the pump are different to those flowing to the chiller.

These factors means that we have to consider two **energy systems** for this site:

a) System ES1: The cooling towers (m_{E1}) are an **energy system** that produces the **thermal flows** measured by TM1 and TM2.
b) System ES2: The tenant condenser water pumps are a separate **energy system** that acts upon the **thermal flow** measured by TM2 using the electricity measured by m_{E3}.

This is illustrated in Figure A.2(b) below.

Figure A.2 (b): Example 2 – Energy system boundaries



Step 2: Determine the total energy inputs to the energy system

The annual energy consumption of all system components has been sub-metered for the duration of the **rating period** according to the metering requirements outlined in *NABERS The Rules – Metering and Consumption*.

The annual consumption figures recorded by the electricity meters are listed in Table A.2(a).

Table A.2(a): Annual consumption of energy inputs

Meter	Component	Annual consumption (MWh)
m_{E1}	Cooling tower fans	50
m_{E2}	Condenser water pump to CHW system	200
m_{E3}	Tenant condenser water system pump	400

TM1, TM2 and TM3 are measured using integrated **thermal energy meters** to the **thermal energy meter** validation requirements.

In addition, the annual **thermal flow energy** figures measured by the **thermal energy meters** are listed in Table A.2(b).

Table A.2(b): Annual thermal energy of end users

Meter	End user	Annual thermal energy (MWh)
TM1	**Rated premises** condenser water for chillers	1,200
TM2	Tenant condenser water system (TCDW)	1,800
TM3	Tenant condenser water to the cafe	60
TM4	Tenant condenser water to the office PACs	1700

As determined in Step 1, we have two **energy systems**:

a) The cooling tower fans **energy system** has energy input m_{E1} = 50MWh of electricity.
b) The tenant condenser water pump **energy system** has two energy inputs, being the pump electricity measured by m_{E3} = 400MWh of electricity and the energy of the **thermal flow** measured by TM2=1800MWh$_{th}$.

In addition, we have **dedicated transfer energy** assigned to the **rated premises** from m_{E2}, being 200MWh.

Step 3: Determine the thermal flows and electrical outputs from the energy system

The **thermal flows** from the cooling tower **energy system** are the chiller condenser water measured by TM1 and the tenant condenser water measured by TM2, a total of 3000MWh$_{th}$. There are no electrical outputs from the cooling tower **energy system**.

The **thermal flow energy** from the tenant condenser water pumps is the same as the flow TM2 (1800MWh$_{th}$).

Step 4: Verification check

The effective COP of the cooling towers is:

$$COP = \frac{TM1 + TM2}{m_{E1}} = \frac{1200 + 1800}{50} = 60$$

This is in the expected range. No verification check is required for the tenant condenser water pumps.

Step 5: Calculate the electricity equivalent factor

The **electricity equivalent factor** for the cooling towers is calculated as follows:

a) The **EEF** of electricity is 1 and the input electricity for the cooling towers is 50MWh so the total MWh$_e$ for the cooling towers is 50MWh$_e$.

b) This acts upon a total **thermal flow energy** TM1+TM2=3000MWh.

c) The **EEF** of cooling towers **energy system** is 50MWh$_e$/3000MWh$_{th}$=0.0167kWh$_e$/kW$_{th}$.

The **electricity equivalent factor** for the tenant condenser water pumps is calculated as follows:

a) The **EEF** of electricity is 1 and the input electricity for the pumps is 400MWh so the total MWh$_e$ for the pumps is 400MWh$_e$.

b) The **EEF** for the input flow is $0.0167kWh_e/kWh$ so the input flow has a MWh_e of $0.0167*1800=30MWh_e$.
c) The output **thermal flow energy** is 1800MWh.
d) The **EEF** of the **thermal flow** leaving the tenant condenser water pumps is $(400+30)MWh_e/1800MWh_{th}=0.238kWh_e/kW_{th}$.

A.2.3 Thermal flow energy apportionment

The **thermal flow** to be apportioned is the flow from the tenant condenser water pumps.

Step 1: Identify all uses of the thermal flow

The **thermal flow** from the tenant condenser water pump **energy system** goes to the office area packaged AC, which is an inclusion to the rating, and the café, which is an exclusion from the rating.

Step 2: Calculate the kWh_e to be included in the rating

The kWh_e of the **thermal flow energy** to be included in the rating is $(1800-60)MWh_{th}*0.238kWh_e/kWh=414kWh_e$. This exclusion is permissible in the absence of a meter on the packaged AC units leg of the condenser water system because it 60/1800= 3.3% of the total **thermal flow** which is less than 25% of the **thermal flow energy** and therefore permitted under Section 3.5.3.

Step 3: Dedicated transfer energy

The **dedicated transfer energy** to be included energy is the chiller condenser pump energy measured by m_{E2} which is $200MWh=200MWh_e$.

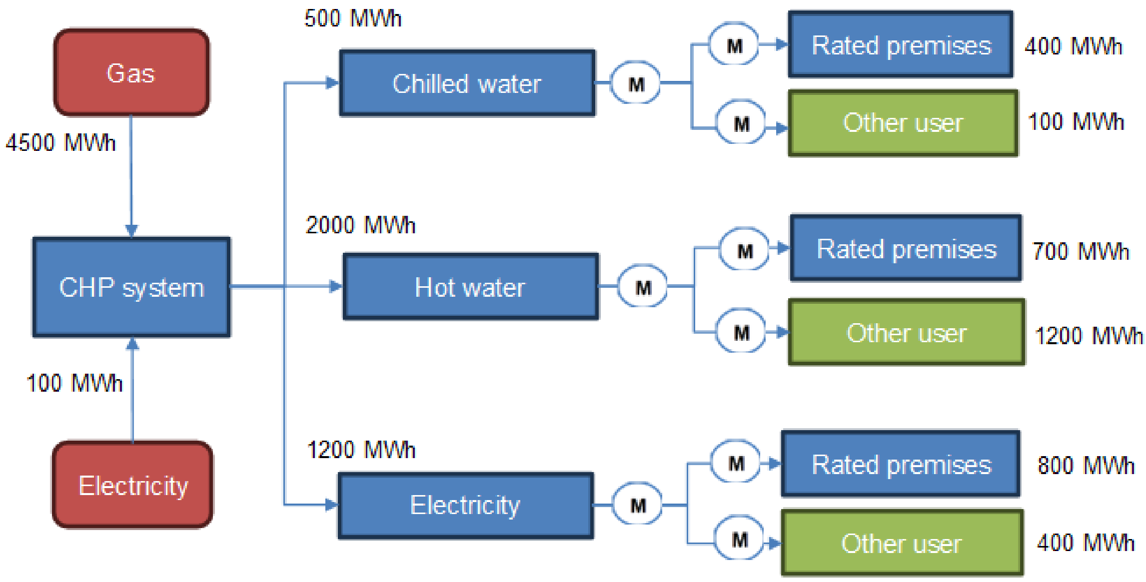
A.3 Example 3: CHP system

A.3.1 Site Description

A **CHP system** uses gas to generate heat, chilled water and electrical outputs which are shared between the **rated premises** and one **other user**, as shown in Figure A.3. Note that there are no dedicated secondary pumps for the **rated premises** or the **other user** on either the chilled water or hot water circuit.

The **Assessor** must determine the kWh_e to be allocated from the **CHP system** to the **rated premises**.

Figure A.3: Example 3 – CHP schematic



A.3.2 Determine the electricity equivalent factor for the thermal flow

Step 1: Determine the limits of the energy system(s)

The **CHP** plant is a single **energy system** as there are no downstream additional energy inputs into the **thermal flows**.

Step 2: Determine the total energy inputs to the energy system

The annual energy consumption of all system components has been sub-metered for the duration of the **rating period** according to the metering requirements outlined in *NABERS The Rules – Metering and Consumption*. The figures are shown on Figure A.3.

Note that the total kWh_e of the inputs is:

$(4500MWh*0.75kWh_e/kWh) + (100MWh*1kWh_e/kWh) = 3475MWh_e$

This figure is E_{tot} in the calculations in Step 5.

Step 3: Determine the thermal flows and electrical outputs from the energy system

The annual **thermal flow energy** figures for the chilled water and hot water **thermal flows** are metered using integrated meters. The figures are shown on Figure A.3.

Step 4: Verification check

The effective COP of the **CHP system** is:

$$COP = \frac{outputs}{inputs} = \frac{500 + 2000 + 1200}{4500 + 100} = 0.8$$

This is in the expected range.

Step 5: Calculate the electricity equivalent factor

The electricity equivalent factor for the three outputs are as follows:

Chilled water

Chilled water

$$EEF_{ChW} = \frac{\alpha_{ChW}E_{tot}}{\alpha_{HW1}\varepsilon_{HW1} + \alpha_{ChW}\varepsilon_{ChW} + \alpha_{Elec}\varepsilon_{Elec}} = \frac{0.25 * 3475}{0.83 * 2000 + 0.25 * 500 + 1 * 1200} = \frac{868.8}{2985}$$

$$= 0.291 kWh_e/kWh_{th}$$

Hot Water

$$EEF_{HW1} = \frac{\alpha_{HW1}E_{tot}}{\alpha_{HW1}\varepsilon_{HW1} + \alpha_{ChW}\varepsilon_{ChW} + \alpha_{Elec}\varepsilon_{Elec}} = \frac{0.83 * 3475}{0.83 * 2000 + 0.25 * 500 + 1 * 1200} = \frac{2884}{2985}$$

$$= 0.966 kWh_e/kWh_{th}$$

Electricity

$$EEF_{Elec} = \frac{\alpha_{elec}E_{tot}}{\alpha_{HW1}\varepsilon_{HW1} + \alpha_{ChW}\varepsilon_{ChW} + \alpha_{Elec}\varepsilon_{Elec}} = \frac{1 * 3475}{0.83 * 2000 + 0.25 * 500 + 1 * 1200} = \frac{3475}{2985}$$

$$= 1.164 kWh_e/kWh_{th}$$

As a cross check:

$$EEF_{HW1}\varepsilon_{HW1} + EEF_{ChW}\varepsilon_{ChW} + EEF_{elec}\varepsilon_{elec} = 0.291 * 500 + 0.966 * 2000 + 1.164 * 1200 = 3474$$

This is equal to E_{tot} (3475MWh$_e$) as calculated in Step 2, to within the accuracy of calculation.

A.3.3 Thermal flow energy apportionment

Step 1: Identify all uses of the thermal flow

As identified in Figure A.3, the chilled water and hot water **thermal flows** are shared between the **rated premises** and one **other user**. Both users are metered.

Step 2: Calculate the kWh$_e$ to be included in the rating

There are three components to be included in the rating:

a) The kWh$_e$ of the chilled water to be included in the rating is 400MWh$_{th}$*0.291kWh$_e$/kWh=116MWh$_e$.

b) The kWh$_e$ of the hot water to be included in the rating is 700MWh$_{th}$*0.966kWh$_e$/kWh=676MWh$_e$.

c) The kWh$_e$ of the electricity to be included in the rating is 800MWh*1.164kWh$_e$/kWh=931MWh$_e$.

The total kWh$_e$ to be included in the rating is therefore 116+676+931=1723MWh$_e$.

Step 3: Dedicated transfer energy

There is no **dedicated transfer energy** to be included in the rating.

Appendix B Additional Guidance for Assessors

B.1 Thermal energy calculations

In most cases, integrated energy meter readings are used to measure thermal energy. Integrated energy meters typically record instantaneous flow and temperature readings (one temperature sensor at least is remote) and use an on-board calculation device or BMS to convert to instantaneous energy demand (kW). The demand is integrated over time to obtain the total thermal energy transferred by the system during a certain period of time.

Integrated energy meters calculate the heat transfer rate (in kW) of a thermal **energy system** using the following formula:

$$Q = mC_p\Delta T$$

Where:

Q is the energy transferred in kW

m is the mass flow rate of the water in kg/s

C_p is the specific heat capacity of water (~4.2 kJ/kg°C)

ΔT is the temperature difference between the supply and return temperature of the water

Where separate flow rate and temperature sensors are used in place of an energy meter, the

Assessor may use the flow rate and temperature readings and calculate the instantaneous energy demand using the formula above. When using the above formula, the following requirements apply

a) If the flows are measured in L/s, they must be converted to kg/s.

b) The flow rate and temperature readings must be taken at the same time and must meet the requirements outlined in Section C.2.

The instantaneous demand readings (kW) at no more than 15-minute intervals must be integrated over time to produce a total annual thermal energy consumption figure (kWh). Calculations may be automated by a meter reading system or performed by the **Assessor**.

B.2 Apportioning shared chilled water systems

This section provides guidance to **Assessors** when apportioning the energy consumption of shared chilled water systems.

The appropriate treatment will depend on—

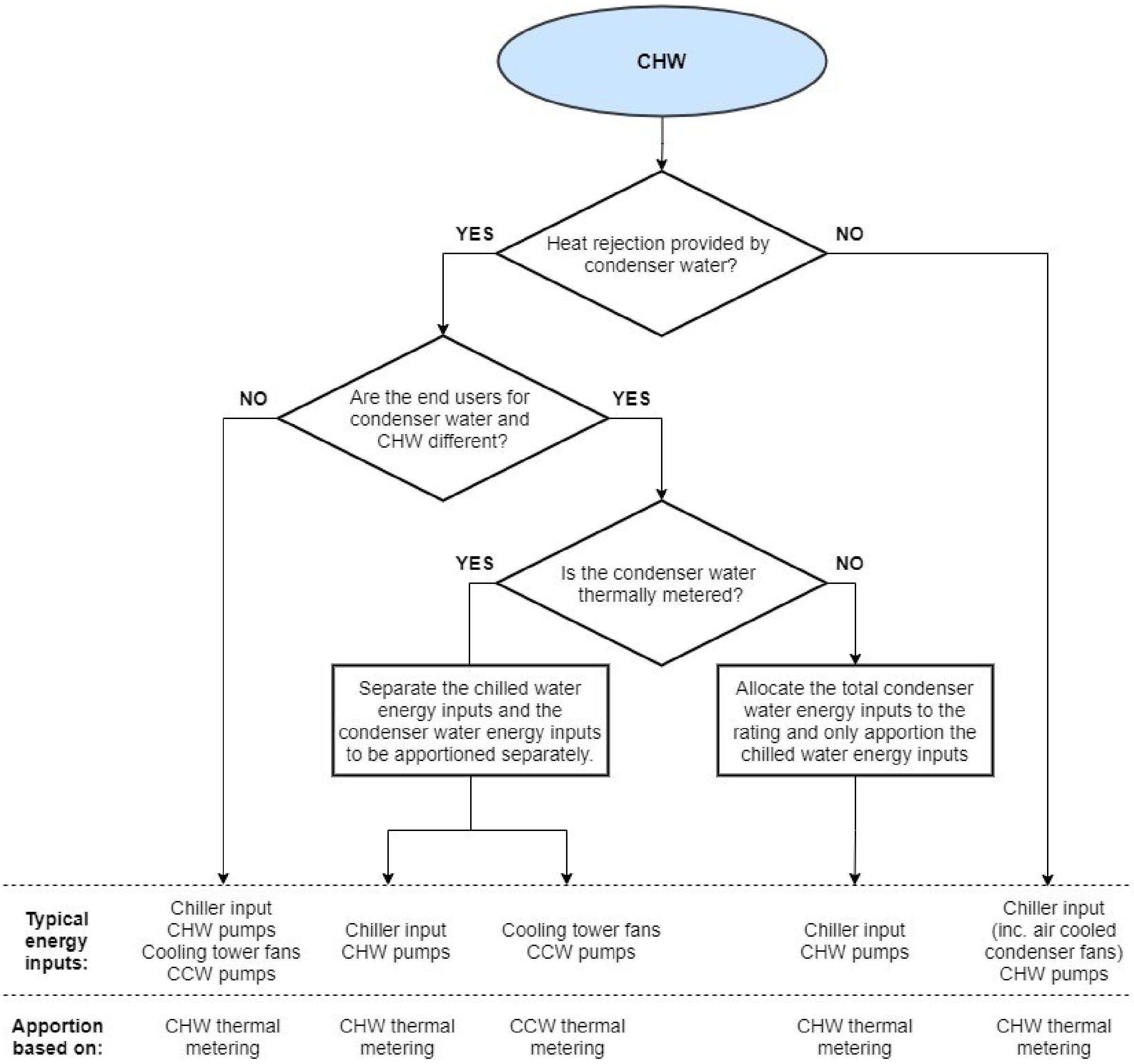
a) the type of chiller (air-cooled or water-cooled),

b) the configuration of **thermal energy meters** though the chilled water system, and

c) the end users of the heat rejection.

Figure B.1 illustrates the process for determining the energy inputs and **thermal energy meter** requirements for shared chilled water systems.

Figure B.1: Apportioning shared chilled water systems for NABERS Energy ratings



Appendix C Thermal energy metering requirements

C.1 Validation of thermal energy meter accuracy

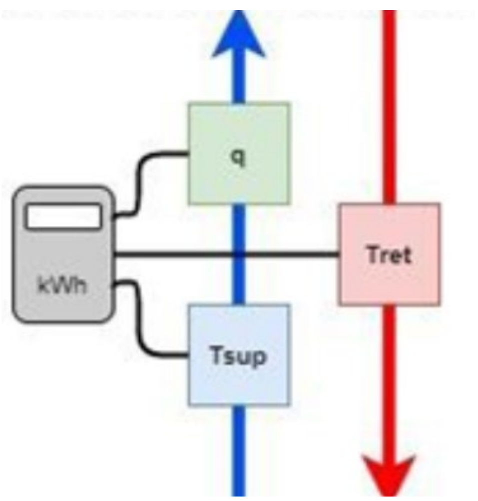
C.1.1 Thermal energy meter installation

Integrated **thermal energy meters** are preferred for reliability and should be installed and validated as per the manufacturer's specifications. Figure C.1 illustrates a typical **thermal energy meter** installation. This consists of temperature measurements of supply and return flow, plus a flow measurement. These factors are integrated within the **thermal energy meter** to calculate the thermal energy change in the **thermal flow**.

Alternatively, a combination of flow meter and two temperature sensors may be used to record readings to manually calculate the thermal energy transfer.

Note: **Thermal flow energy** measurements are typically taken using integrated **thermal energy meters**. Integrated **thermal energy meters** measure the flow rate and difference between the supply and return temperatures. The measurements are integrated over time to determine the **thermal flow energy** (in kWh).

Figure C.1: Typical thermal energy meter configuration



C.1.2 General checks

The **Assessor** shall undertake checks to ensure that the thermal energy metering system is free from obvious faults. This shall include each of the steps below:

a) Inspection of the installed **thermal energy meters** to ensure that the thermal measuring equipment (**temperature sensor pair** and **flow meter**) has been installed correctly in accordance with manufacturer's instructions and is used for the correct working fluid type. Thermal energy measurement accuracy is extremely sensitive to correct **temperature sensor pair** installation. Immersion temperature sensors must be used. The **Assessor** may use a qualified and competent professional to verify the configuration of the **thermal energy meter** installation.

b) Review and documentation of instantaneous meter readings to demonstrate that they are within expected range for the operating conditions at the time of observation.

c) Where a thermal energy balance is possible without the use of virtual meters, a check and documentation of the thermal energy balance to the requirements of Section C.1.6.

The rating cannot proceed if any of these checks are unsatisfactory.

C.1.3 Thermal energy meter accuracy requirements

The **thermal energy meter** accuracy requirements must be demonstrated using one of the following methods in order of priority:

a) Evidence that the meter has been notified as part of a heat network under the Heat Network (Metering and Billing Regulations) 2014 (and subsequent amendments) and is used for billing purposes.

b) Certification of meter as class 1 or 2 under Measuring Instruments Directive (MID) (2014/32/EU) or OIML 75-1 and confirmation by the **Assessor** that:

    1) The limit of minimum flow rate for the meter is less than the minimum flow rate for the application as identified from Table C.1.

    2) The limit maximum flow rate for the meter is larger than the maximum flow rate for the application.

    3) The limit of minimum temperature difference is less than the minimum temperature difference for the application as identified from Table C.1.

c) Confirmation via calibration certificates not more than 10 years old of conformance to the maximum permissible error in Section C.1.4.

d) Confirmation via on-site verification within the past 10 years using secondary in-situ calibrated immersion **temperature sensors pairs** and calibrated **flow sensors** of conformance to the maximum permissible error requirements of Section C.1.4. Any secondary equipment used for on-site verification must be factory calibrated less than 180 days prior to the verification date.

e) A thermal energy balance of the **thermal flow** meeting the requirements of Section C.1.6.

The **Assessor** must retain evidence documenting why a method of higher priority could not be used for the rating. This requirement applies to all the **thermal energy meters** used in the rating.

> For documentation requirements, see Section 5.4

C.1.4 Thermal energy meter maximum permissible error

> **Note:** The requirements in this section have been adapted from OIML R75-1 Heat Meters Part 1: General Requirements, using Class 2 thresholds.

The error for each **thermal metering system** is the arithmetic sum of the errors of all sub-assemblies, as shown below:

$$E_{=} E_{temperature} + E_{flow}$$

Where all values are expressed in percentages (%). $E_{temperature}$ and E_{flow} must be specifically determined for the meter and applicable duty.

The maximum errors must be less than 6% when calculated at the applicable assessment points from Table C.1:

Table C.1: Permissible errors of thermal energy meter sub-assemblies

Case	Assessment points		
Primary circuit with chiller/boiler	Minimum flow at minimum continuous operation of boiler/chiller	&	temperature difference corresponding to minimum flow and minimum continuous thermal output from chiller/boiler
Circuit with pump	Minimum continuous pump flow	&	temperature difference corresponding to 10% of circuit design thermal load at minimum pump flow
Pipework branch without own pump	20% of design flow for the branch	&	50% design temperature difference
		and	
	50% of design flow for the branch	&	20% design temperature difference

C.1.5 Remote metering reading system validation

If the **thermal energy meter** system includes a **Remote Metering Reading System (RMRS)**, including an interface to a Building Management System (BMS) used to transmit meter data, then the **Assessor** must check that all necessary validation requirements in accordance with Section 6.3.3 of *NABERS UK The Rules – Metering and Consumption* have been met.

It cannot be assumed that newly installed non-utility metering systems have been validated. All of the **thermal energy meters** connected to the **RMRS** must be validated, and evidence of their validation obtained by the **Assessor**.

The **RMRS** validation must be repeated at least once every 10 years, or whenever a change in **RMRS** occurs, whichever happens first.

For documentation requirements, see Section 5.4.

C.1.6 Energy balance requirements

Where an energy balance is used to meet the requirements of Section D.1.3, the energy balance shall be calculated as:

$$TFE_{total} = TFE_{included} + TFE_{excluded}$$

Where:

TFE_{total} = the measured total **thermal flow energy** for the **thermal flow**.
$TFE_{included}$ = the measured total **thermal flow energy** to be included in the rating.
$TFE_{excluded}$ = the measured total **thermal flow energy** to be excluded from the rating.

Note that for this purpose, the meter(s) used to calculate TFE_{total} must be separate from the meters used to calculate $TFE_{included}$ and $TFE_{excluded}$. The formula must balance within 10 % of the sum of $TFE_{included}$ and $TFE_{excluded}$. Where this is not achieved, then the accuracy of each meter used for the **energy balance** must be validated using Section C.1.3 (a), (b), (c) or (d). The calculations must be forwarded to the **Scheme Administrator** as part of the rating lodgement.

Note: The energy balance is to be completed based on the figures for the full **rating period**.

For documentation requirements, see Section 5.4.

C.1.7 Treatment of pump energy thermal effects

The default assumption for all calculations is that impact of pump and flow frictional losses causing heating of a **thermal flow** passing through the pumps can be ignored. In systems with exceptionally high ratios of pumping energy to thermal energy, this assumption may not be viable and the **Assessor** may need to submit an alternative calculation methodology to the **Scheme Administrator** for approval.

> **Note:** Conservation of energy dictates that all shaft energy (and in some cases, motor losses) from a pump is dissipated as a heat gain to the **thermal flow**. However, the location of this dissipation is split between frictional losses within the pump and frictional losses in the totality of the pipework. This means that it is not simple to identify where the dissipated energy appears relative to **thermal energy meter** locations. In most cases, the **thermal flows** are far larger than the pump energy, and as a result the pump energy can be ignored without significant impact on the accuracy of calculations.

C.2 Metering and Consumption – other requirements

C.2.1 Measurement frequency

Thermal flow energy calculations for each **thermal energy meter** must be based on either:

a) For integrated **thermal energy meters**, $kW_{thermal}$ calculations; or

b) For non-integrated **thermal flow energy** calculations, simultaneous flow and return temperature measurements combined with flow measurements,

In either case, calculations must be repeated and recorded at least every 15 minutes.

The **thermal flow energy** is calculated as the sum of the short time interval meter readings for the **rating period**.

C.2.2 General Requirements

The requirements of *NABERS UK – The Rules Metering and Consumption* apply to thermal metering systems in all aspects except where contradicted by the provisions of this document.

> For documentation requirements, see Section 5.4.

Contact us

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