Interim Methodology for the treatment of Cogeneration and Trigeneration Systems in NABERS ratings.

Date: 12 July 2013 (version: 1.1)

1 Purpose and Principles

The purpose of this interim methodology is to provide guidance to NABERS Assessors in undertaking ratings which receive energy from co/tri generation systems. This methodology provides the principles for the apportioning of energy and allocation of greenhouse gas emissions to end users, in accordance with the NABERS National Steering Committee decision of 25 October 2012. This methodology will apply until a suitable industry standard for cogeneration systems is established by the industry working group.

Guidance has been included to assist assessors on:

- Determining whether a cogeneration system is considered onsite or offsite.
- Apportioning energy inputs to the users of electricity, heating hot water and chilled water outputs of a co/trigeneration system.

2 Coverage of this methodology

This document applies to most situations involving cogeneration or trigeneration systems in a NABERS Energy rating. It is relevant to all classes of buildings rated under NABERS and overrides the provisions of the relevant 'Rules for collecting and using data' (the Rules) or 'Validation Protocol for Accredited Ratings' for each building class current at the date of publication of this document, as well as the Validation Protocol for Thermal Energy Exclusions (version 2.0) (except where specifically referenced), for systems involving cogeneration and trigeneration.

Grid supply

On 25 October 2012, the NABERS National Steering Committee agreed to recognise low emissions electricity supplied from off-site co/trigeneration plants, and transparently recognise it in a NABERS rating. When energy is supplied via the national grid or a similar network, a robust technical and auditing standard is needed to be able to reliably use this information in a NABERS Energy rating. An expert industry working group is currently developing this standard. This methodology is not a substitute for this standard and is not suitable for use when energy is transferred across the grid or similar network.

Case assessment

Ratings that include co/trigeneration systems are to follow the provisions of this Interim Methodology. Alternative methodologies can be proposed to the National Administrator by using the Ruling Request function within the NABERS website www.nabers.gov.au to amend this Interim Methodology.

Note that, in order to ensure all buildings are rated on equitable grounds, a proposed methodology cannot be used until it has been approved by the National Administrator and an updated Interim Methodology has been published. The National Administrator

may take these proposals to the expert industry working group to seek their comment. Only proposals which comprehensively address the principles of the NABERS National Steering Committee decision 25 October 2012 will be considered. The National Administrator reserves the right to refuse to rate any proposal which doesn't accurately and transparently account for the energy used and its associated carbon footprint by the building.

Update from version 1.0 (released on 19 June 2013)

A minor amendment was made to the definition of **Supplementary Fuel**, to remove wording that appeared to contradict the definition of a **Cogeneration System**.

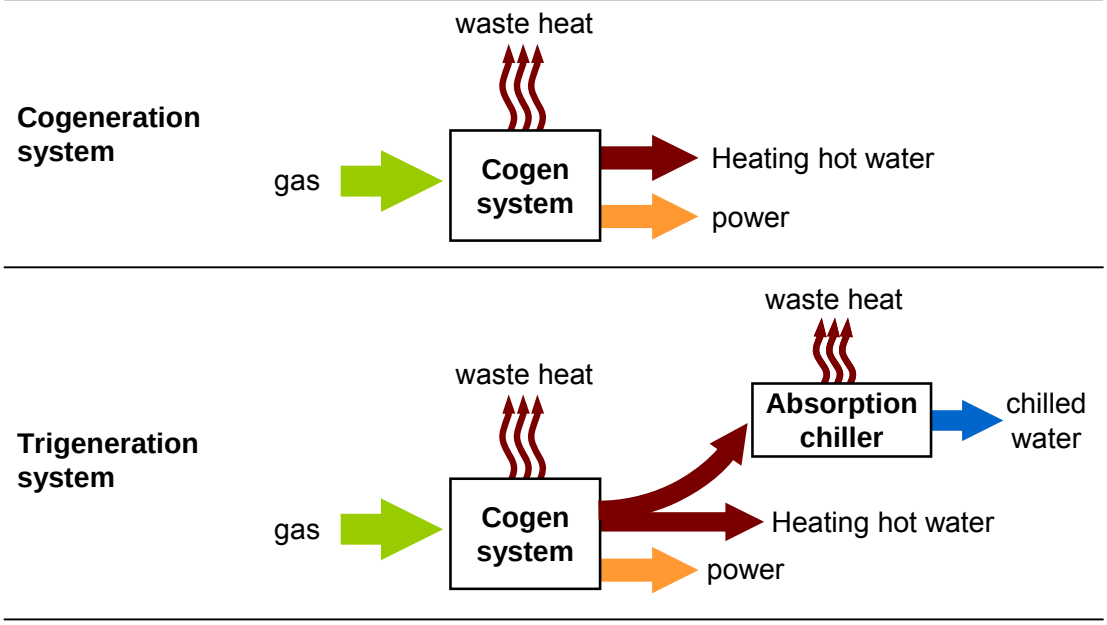
Methodology

2.2 3.1 Definitions

Term	Definition
Auxiliary Energy	Energy required for controlling equipment and other devices directly attached to cogeneration or trigeneration system components. Energy inputs included in this definition include, but are not limited to: ■ Jacket heating to the generator. ■ Pumps used to reject heat from the generator and absorption chiller for both utilised and rejected heat streams. ■ Pumps required to circulate/transport waste heat or absorption chiller output from the cogeneration or trigeneration plant to the primary or third party clients. ■ Electrical inputs to the absorption chiller. ■ On-board controls and variable speed drives (VSDs) for cogeneration or trigeneration plant items. Note: this definition does not include the energy use associated with building management systems, or with supplementary fuels used to boost the heat or chilled water outputs.
Cogeneration System	A system that uses fuel, usually gas, to generate electricity and heating hot water. The system includes the generator and pumps for the transport of heat from the system to the building systems, but excludes the supplementary boilers used to boost heat outputs from the cogeneration system.
Offsite cogeneration electricity	Electricity supplied to the rated premises from an offsite co/trigeneration system, as determined under Section 2.4 *Step1: Determining the system location*. Note: offsite electricity has been included as a new energy source in the NABERS Online Calculator. Further details on how offsite cogeneration electricity is accounted for in a NABERS rating can be found under Annex I: Further clarifications.
Shared Switchboard	An electric switchboard that: ■ Is fed by electricity from the co/trigeneration plant as well as from the grid, and ■ Serves the rated premises and at least one other user.

Term	Definition
Supplementary Fuel	Supplementary fuels used to boost the waste heat or absorption chiller outputs. Note: This includes, but it is not limited to, boilers used to supplement heating hot water and gas usage for direct firing of the trigeneration absorption chiller.
Trigeneration System	A **Cogeneration System** that uses part of the heating hot water to operate an absorption chiller, which produces chilled water. This system includes the generator and pumps for the transport of heat from the system to the building systems, the absorption chiller and associated pumps for the transport of chilled water to the building systems, but excludes the supplementary boilers and chillers used to boost the heat or chilled water outputs from the system.
Heating hot water	Heating hot water or steam generated by the co/trigeneration plant which is used directly by the rated premises or other users. This definition excludes heat rejection, and hot water or steam for the purposes of generating chilled water. Note: The generation of heating hot water and chilled water are treated separately throughout this Methodology.

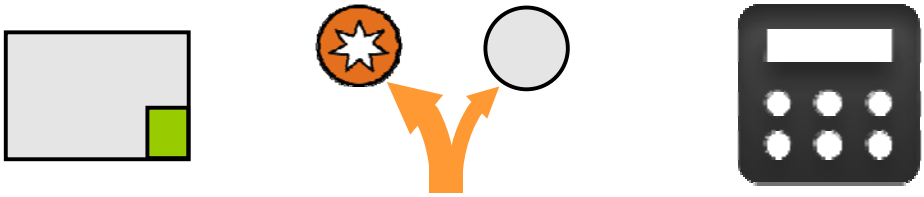
Figure 1: Illustration of a typical cogeneration and trigeneration system



2.3 Process Summary

	Step	Reference
1	Determine whether the co/trigeneration system is located onsite or offsite	Section 2.4 *Step1: Determining the system location*.
2	Determine the system's energy inputs and the final users of its energy outputs	Section 2.5 *Step 2: Measuring energy use and generation products*
3	Calculate the allocation of energy inputs and emissions to the rated premises	Section 2.6 *Step 3: Allocating energy and emissions to users*

Figure 2: Process steps for assessing co/trigeneration systems



Step 1: Determine if the system is onsite or offsite

Step 2: Measure the system's energy inputs and determine the final users of its outputs

Step 3: Calculate energy allocated to the rating

2.4 Step1: Determining the system location

In a NABERS Energy rating, co/trigeneration systems are assessed as being located either onsite or offsite. Determining the system's location is an important part of the assessment of cogeneration systems, which determines the way these systems are treated under Section 3.5 *Step 3: Allocating energy and emissions to users*.

Figure 3: Determining the location of a cogeneration system

Office Tenancy & Data Centres IT Equipment ratings Co/trigeneration systems always considered offsite.		Offsite
All other Energy ratings Co/trigeneration systems considered onsite when they are physically located within the building and/or its grounds.		Onsite Offsite

2.4.1 Tenancy and IT Equipment ratings

Co/trigeneration systems are always considered to be offsite for the purposes of a NABERS Energy for offices tenancy or NABERS Energy for IT Equipment ratings.

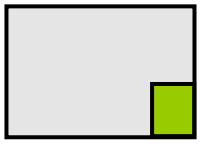
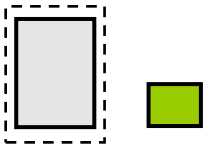
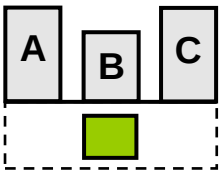
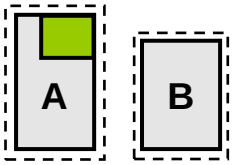
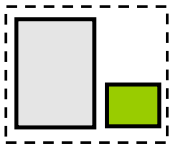
2.4.2 Other NABERS Energy rating types

A co/trigeneration system is considered to be onsite when it is located within the physical boundaries of the building where the rating is being conducted and/or its grounds (as shown on the title of the building). Where this is not the case, the co/trigeneration system must be considered as being offsite.

Co/trigeneration systems located on grounds shared with other buildings

Where a co/trigeneration system is located in facilities that are physically shared with other buildings and form part of the building asset, the system is considered to be onsite for all buildings sharing the facilities.

2.4.3 Examples for ratings other than Tenancy and IT Equipment

Example	Treatment
	The co/trigeneration system is located within the physical boundaries of the building and its grounds. The system is considered **onsite**.
	The co/trigeneration system is not located within the physical boundaries of the building. The system is considered **offsite**.
	Three buildings are supplied with services from a cogeneration system, which is located in a shared basement. The system is considered **onsite** for all three buildings.
	Two buildings are supplied with services from a cogeneration system, which is physically located in building A. The system is considered **onsite** for Building A, and **offsite** for Building B.
	The co/trigeneration system is located within the legal grounds of the building. The system is considered **onsite**.

2.5 Step 2: Measuring energy use and generation products

When assessing a co/trigeneration system, its energy inputs during the Rating Period must be measured. Assessors must also determine the energy outputs of the system, and who used these energy services during the Rating Period.

2.5.1 Step 2a: Measuring energy consumption

Assessors must determine all energy inputs to the co/trigeneration system for the entire Rating Period using compliant metering. This includes the following:

- The total gas and electrical inputs to the generator
- The total **Auxiliary Energy** inputs where metered

Treatment of Auxiliary Energy

If the Auxiliary Energy is separately metered, it must be included in the proportioning calculation and apportioned to the end users of the cogeneration system. If part or all of the Auxiliary Energy is not separately metered, then this unmetered auxiliary energy must be included in the rating, except in the case of:

- NABERS Energy ratings for office tenancies, and
- NABERS Energy ratings for IT Equipment

Treatment of supplementary fuel used to boost thermal outputs

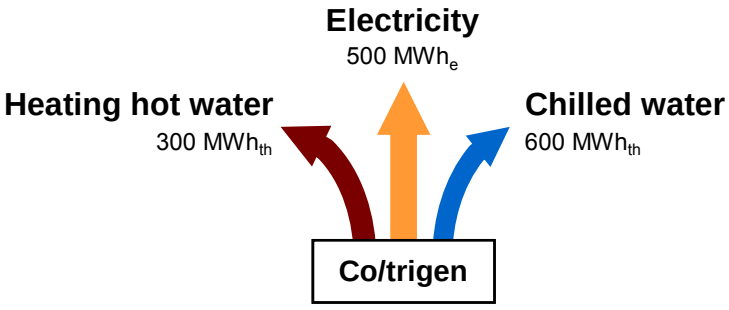
Supplementary fuels used to boost the **heating hot water** or chilled water outputs are considered as being outside the co/trigeneration system, and are directly attributable to the end-users of the thermal energy. This includes boilers used to supplement useful heat and the use of gas for direct firing of the trigeneration absorption chiller.

2.5.2 Step 2b: Determining energy generation outputs

If a cogeneration or trigeneration system supplies electricity or thermal energy to the rated premises and at least one more user, then the Assessor must:

- Determine the total electrical output from the co/trigeneration system for the Rating Period using compliant metering, and
- Determine the total **heating hot water** and chilled water output from the co/trigeneration system for the Rating Period, using compliant thermal metering.

Figure 4: Example energy outputs of a co/trigeneration plant during the Rating Period



Systems with insufficient or inadequate electricity metering

Where compliant electricity metering is not available or insufficient to determine the generation of electricity by the co/trigeneration plant during the Rating Period, the following considerations apply:

- Where co/trigeneration electricity is directly supplied to the rated premises (not through a shared switchboard), then all co/trigeneration energy inputs and auxiliary energy are allocated to the rated premises.
- Where electricity from the co/trigeneration system is supplied to the rated premises through a **shared switchboard**, then:
  - All co/trigeneration energy inputs and auxiliary energy are allocated to the rated premises, and
  - All grid inputs to the shared switchboard are allocated to the rated premises.

Systems with insufficient or inadequate thermal energy metering

Where compliant thermal metering is not available or insufficient to determine the production of heating hot water and chilled water by the co/trigeneration plant during the Rating Period, the following considerations apply:

- The generation of heating hot water is considered to be zero, and
- The cogeneration plant is assumed to convert 75% of the gas consumption into generation outputs. All energy not converted to electricity is deemed to be chilled water.

As a result, the production of chilled water by the co/trigeneration plant over the Rating Period is calculated as following:

$$CHW = G \times 0.75 - E$$

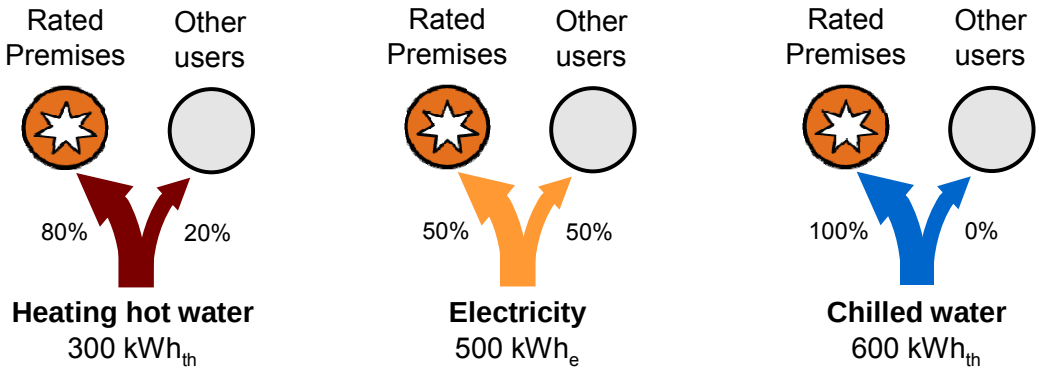
Where CHW is the annual production of chilled water in kWh_{th}, G is the system's annual fuel input in kWh and E is the electricity generation in kWh_e.

2.5.3 Step 2c: Determining the users of the energy generation outputs

Once the annual outputs of the co/trigeneration plant have been obtained, Assessors must determine what fraction of such services were used by the rated premises.

Note that any electricity exported to other buildings or the electricity grid, as well as to internal building users not included in the rating (e.g. tenants in a base building rating), is considered as exported energy and must be excluded from the rating.

Figure 5: Example – Determining the users of a trigeneration plant's outputs during the Rating Period.



Electricity generation

Assessors must determine how much of the total electrical output from the co/trigeneration system determined in *Step 2b*, was used by the rated premises during the Rating Period. If the system's electricity generation was used by more than one user, compliant sub-metering is required to determine how much electricity was used by the premises as compared to other users.

Where electricity from a co/trigeneration system is supplied to the rated premises through a **shared switchboard** also feeding other users, the electricity inputs to the switchboard must be allocated to its end users. Where this is the case, the grid and cogeneration electricity inputs to the switchboard must be allocated on the basis of:

- Contractual agreements that clearly document:
  - That the sum of generator electricity allocated to each end user served by the shared switchboard is equal to the total co/trigeneration electricity input to the switchboard, and
  - The allocation of electricity supplied from the generator (as opposed to the grid) to the party being assessed.

  Retrospective agreements, within the stated constraints, are permitted; or, if not available,
- The relative total consumption of the parties served by the shared switchboard over the Rating Period.

Note: When using contractual agreements, Assessors should ensure that these are consistent with the allocation of electricity to end users during the Rating Period.

Assessors are reminded to differentiate between on-site and off-site supplies when considering contractual allocations.

Figure 6: Electricity directly transferred from the co/trigeneration system to the rated premises

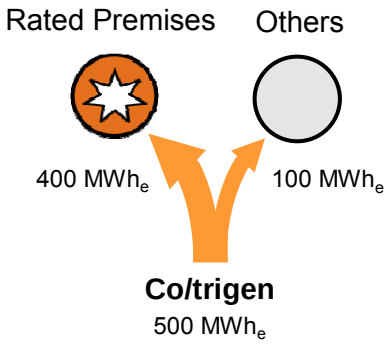
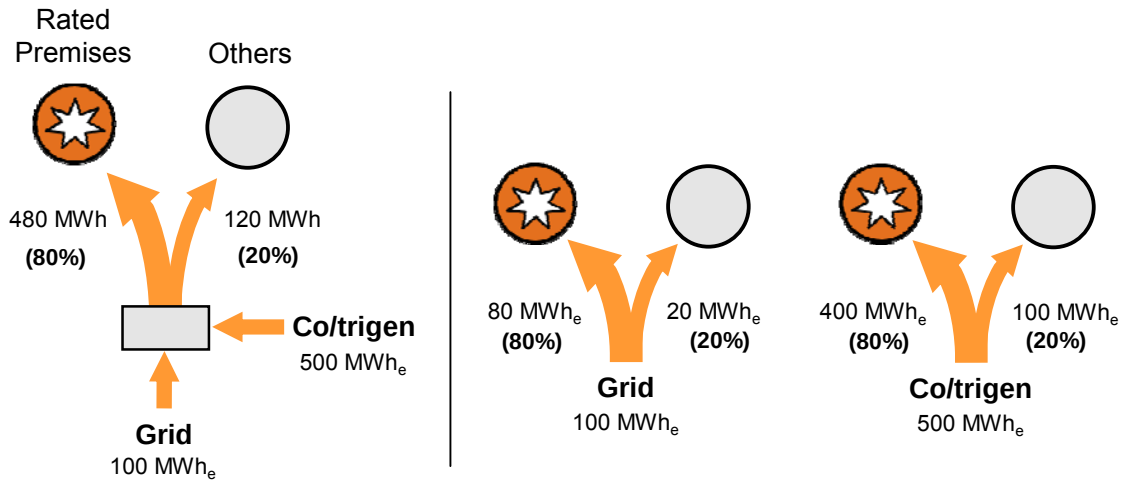


Figure 7: Apportioning grid and co/trigeneration electricity inputs to the users of a shared switchboard.



Thermal energy generation

Assessors must determine how much of the total heating hot water and chilled water generated by the co/trigeneration system was used by the rated premises during the Rating Period.

If the system's thermal energy generation was used by the rated premises as well as other users, metering that complies with the provisions of the Validation Protocol for Thermal Energy Exclusions (version 2.0) is required to determine the amount of heating hot water and chilled water used by the premises.

Incomplete metering

Some co/trigeneration systems may have insufficient electrical or thermal metering to determine what fraction of the electricity and/or thermal energy outputs from the cogeneration system were used by the rated premises over the rating period. In such cases, a rating may still be possible, by applying the following rules:

- If sub-metering is insufficient to determine the fraction of co/trigeneration electricity output used by the rated premises, then all generated electricity is allocated to the rated premises.

- If thermal energy metering is insufficient to determine the fraction of heating hot water or chilled water used by the rated premises, then all gas allocated to heating hot water and chilled water under Step 3a is allocated to the rated premises.

2.6 Step 3: Allocating energy and emissions to users

The energy inputs to a co/trigeneration system are apportioned among the users of its electricity, heating hot water and chilled water outputs.

2.6.1 Step 3a – Allocating energy inputs to thermal and electricity outputs

Energy inputs and emissions are allocated to the electricity and thermal energy outputs of the co/trigeneration system. The apportioning is performed by calculating the emissions at which electricity, heating hot water and chilled water are generated by standard industry equipment. A more detailed explanation of the rational behind these calculations can be found under Annex I: Further clarifications.

The energy inputs identified under Step 2a must be allocated to the users of the electricity, heating hot water and chilled water outputs of a cogeneration plant. The percentage of emissions allocated to the electricity (**P_E**), heating hot water (**P_H**) and chilled water (**P_{CHW}**) are calculated as following:

$$P_E = \frac{E \times EF_e}{(E \times EF_e) + \left(\frac{H \times 3.6}{0.75} \times EF_{gas}\right) + \left(\frac{CHW}{4} \times EF_e\right)}$$

$$P_H = \frac{\frac{H \times 3.6}{0.75} \times EF_{gas}}{(E \times EF_e) + \left(\frac{H \times 3.6}{0.75} \times EF_{gas}\right) + \left(\frac{CHW}{4} \times EF_e\right)}$$

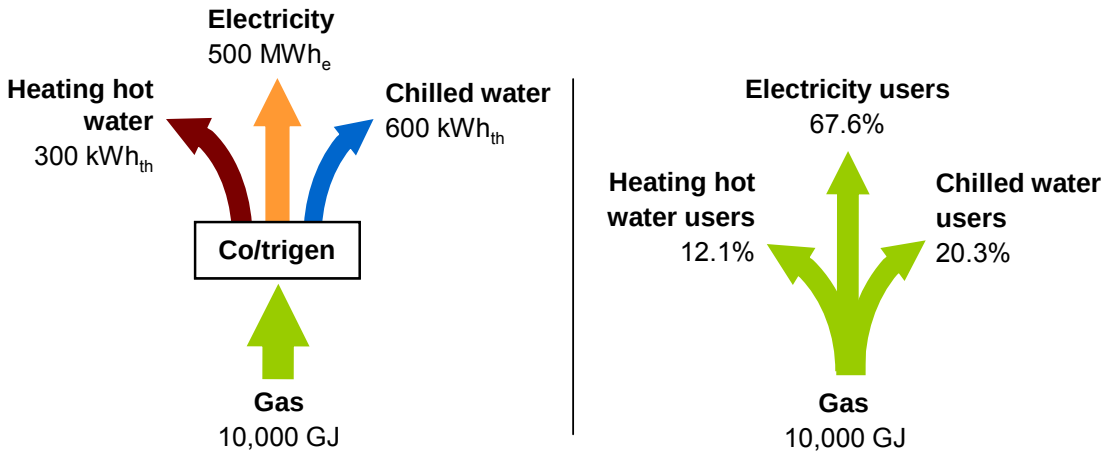
$$P_{CHW} = \frac{\frac{CHW}{3.6 \times 4} \times EF_e}{(E \times EF_e) + \left(\frac{H \times 3.6}{0.75} \times EF_{gas}\right) + \left(\frac{CHW}{4} \times EF_e\right)}$$

Where,

- E is the electricity outputs as determined in Step 2b (kWh_e),
- H is the heating hot water outputs as determined in Step 2b (kWh_{th}),
- CHW is the chilled water outputs as determined in Step 2b (kWh_{th}),
- EF_e is the NGA emission factors for electricity ($kgCO_2/kWh_e$), and
- EF_{gas} is the NGA emission factors for natural gas ($kgCO_2/MJ_{th}$).

Note: all the calculations in this section are performed automatically by the NABERS Cogeneration Calculator. Assessors are not required to perform these manually.

Figure 8: Example – allocating energy inputs to heating hot water and electricity users.



2.6.2 Step 3b – Allocating energy to the rated premises

Thermal energy

The input fuel allocated to the **heating hot water** and chilled water outputs of the co/trigeneration system in Step 3a must be apportioned among the users of this energy. Apportioning should be performed based on the relative use of the thermal energy outputs generated, as determined under Step 2b.

Figure 9: Example – apportioning energy inputs among heating hot water users.

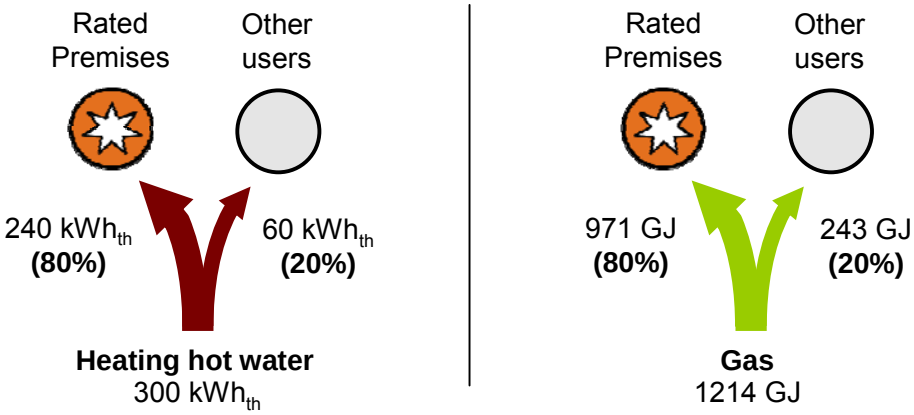
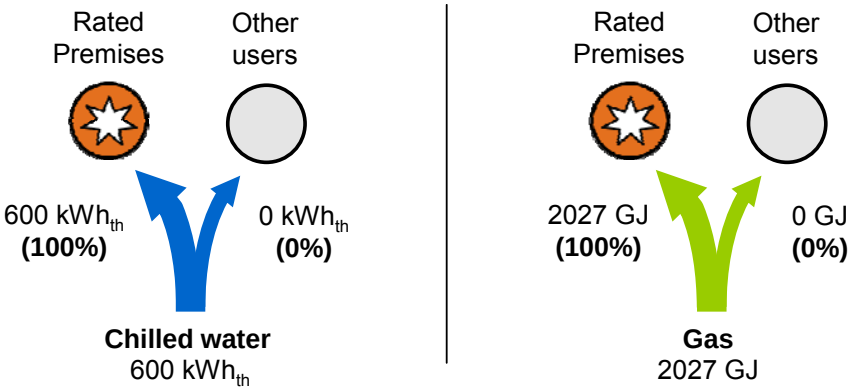


Figure 10: Example – apportioning energy inputs among chilled water users.

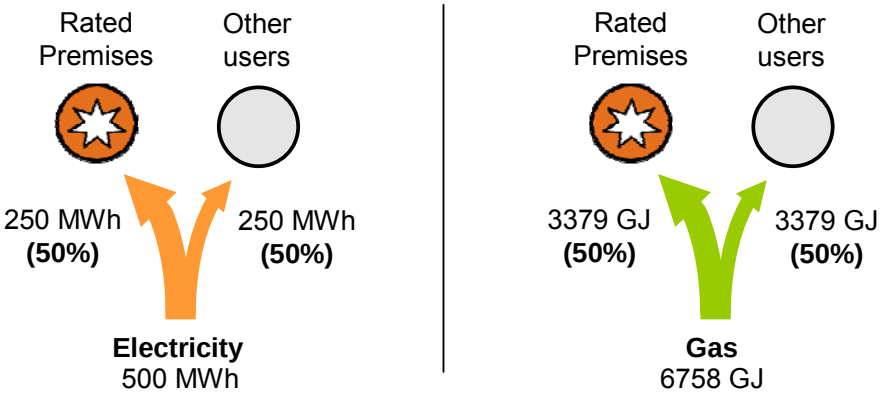


Note: under to circumstances is fuel input allocated to heat rejection.

Electricity – Onsite systems

The input fuel allocated to the electricity outputs of the co/trigeneration system in Step 3a must be apportioned among the users of this energy. Apportioning should be performed based on the relative use of the electricity generated, as determined under Step 2b.

Figure 11: Example – apportioning gas consumption to electricity users of onsite co/trigeneration systems.



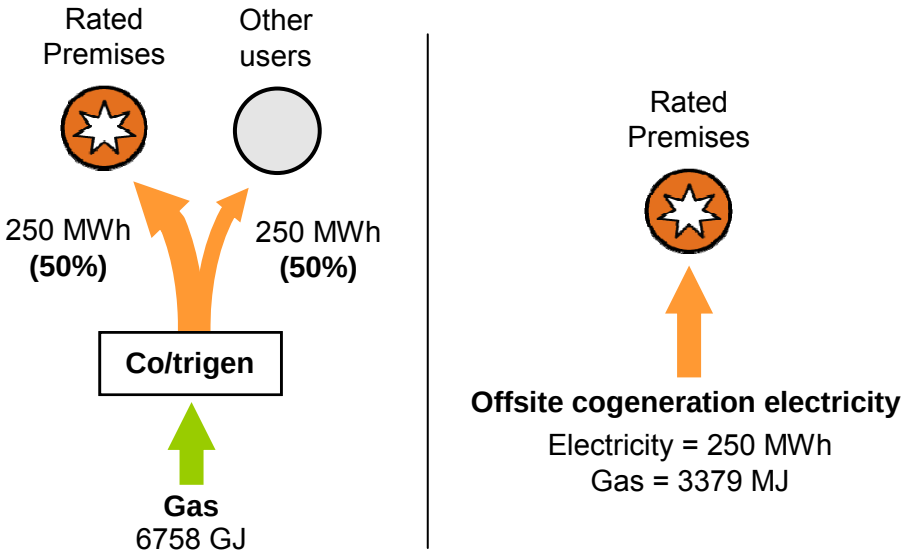
Electricity – Offsite systems

Where electricity is supplied from an offsite co/trigeneration system to the rated premises (such as in a tenancy rating), this energy is considered to be **offsite cogeneration electricity**. The following two parameters are associated with this type of energy supply:

- The amount of electricity supplied by the offsite co/trigeneration system to the rated premises, as calculated in Step 2c, and
- The input fuel used to generate this electricity. This is calculated using the same methodology than for Electricity – Onsite systems above.

Note: Offsite cogeneration electricity has been included as a new energy source in the NABERS Online Calculator. Assessors must enter both, the electricity supplied to the rated premises and the quantity of input fuel used to generate this electricity, into the calculator. A more detailed explanation of how offsite cogeneration electricity is accounted for in a NABERS rating can be found under Annex I: Further clarifications.

Figure 12: allocating offsite cogeneration electricity to electricity users of offsite systems.



2.7 Compliant metering

All metering must meet the requirements of the NABERS Rules that are relevant for the building type being rated. Virtual meters, i.e. additions or subtractions of multiple physical meters, can be used to meet the requirements of this Interim Methodology within the constraints of the general Rules.

Thermal meters used must comply with the provisions of the Validation Protocol for Thermal Energy Exclusions (version 2.0).

2.8 Annex I: Further clarifications

On 25 October 2012, the NABERS National Steering Committee made a number of decisions regarding the treatment of cogeneration and trigeneration systems in a NABERS Energy rating. In order to implement these, a new fuel source (**offsite cogeneration electricity**), as well as an interim methodology to apportion the energy inputs of a co/trigeneration system to its power and thermal energy outputs, have been introduced.

This Annex provides further details on how these are applied in a NABERS rating.

2.8.1 Offsite cogeneration electricity

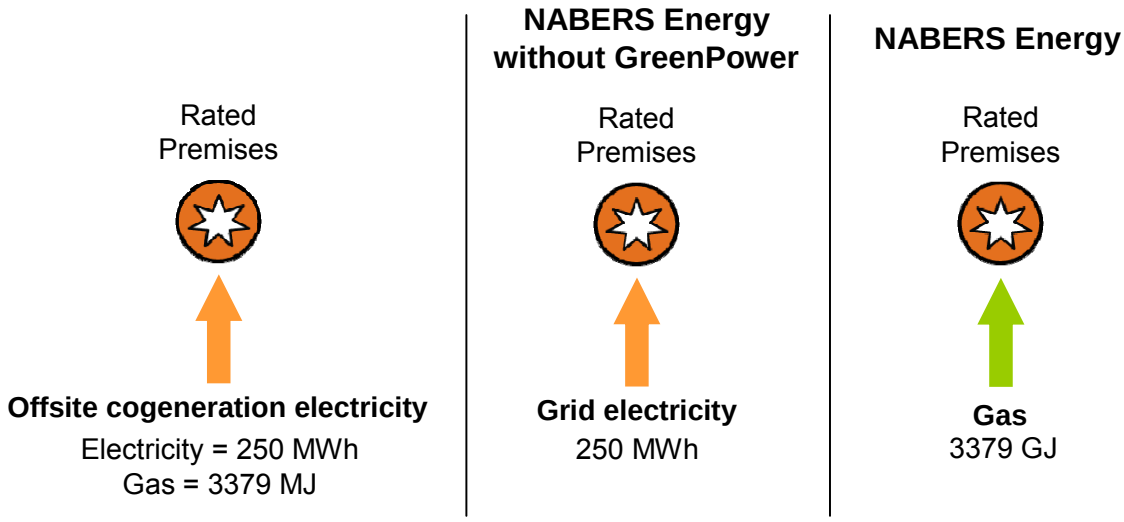
The NABERS National Steering Committee agreed to recognise the emissions from electricity provided from offsite cogeneration systems, in a manner consistent with the current treatment of GreenPower.

In order to implement this decision, this document introduces a new type of energy supply called **offsite cogeneration electricity**. Two parameters are associated with this energy source: the electricity supplied from the offsite cogeneration system to the rated premises, and the input fuel (usually gas) used to generate this electricity. The supply of offsite cogeneration electricity will be treated in as:

- **Grid electricity** in a *NABERS Energy without GreenPower* rating, in line with the treatment of GreenPower, and
- **Gas consumption** in a *NABERS Energy* rating, allowing the rating to accurately capture the emissions generated to produce this electricity.

This treatment is further explained in the following Figure:

Figure 13: Treatment of offsite cogeneration electricity under NABERS Energy and NABERS Energy without GreenPower ratings.



2.8.2 Apportioning emissions to electricity and thermal energy outputs

The NABERS National Steering Committee agreed to allocate emissions values to both, the electricity and thermal energy outputs of cogeneration systems. All calculations required to perform such apportioning are provided under Section 2.6.1 *Step 3a – Allocating energy inputs to thermal and electricity outputs*. The rational behind these calculations is explained in this Annex.

Energy input cannot be directly apportioned to measured electricity, **heating hot water** and chilled water, as these are not directly comparable. In order to apportion fuel inputs to each of these energy outputs, they must be first converted to comparable units. In this document, the following three-step methodology is used to achieve this:

Step a: calculate displaced energy

The measured heating hot water and chilled water outputs are first converted to an equivalent amount of displaced gas and electricity, respectively.

- **Heating hot water:** the amount of gas that would have been used to generate the same amount of heating hot water by a conventional boiler is calculated. A typical boiler thermal efficiency of 75% is assumed.
- **Chilled water:** the amount of electricity that would have been used to generate the same amount of chilled water by a compression chiller is calculated. An Integrated Part Load Value of 4 is assumed, to represent a typical performance of a compression chiller across the year.

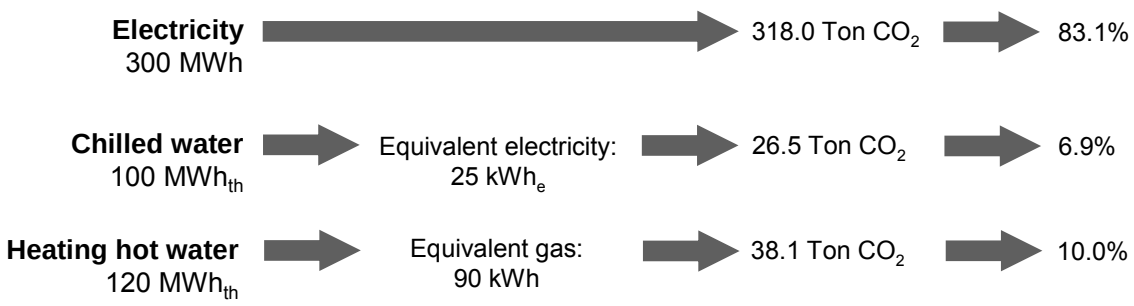
Step b: convert to displaced emissions

The electricity produced by the co/trigeneration system, as well as the equivalent energy calculated under 'Step a', are converted to equivalent CO_2 emissions, using NGA emission factors.

Step c: Calculate apportioning percentage

Calculate the percentage of fuel input and auxiliary energy to be apportioned to electricity, heating hot water and chilled water outputs based on the relative CO_2 emissions calculated in 'Step b'.

Figure 14: Step 1 – convert HHW and CHW to equivalent electricity and gas.



2.9 Annex II: Examples

2.9.1 Example 1

- ☑ Base building rating
- ☑ Onsite System
- ☑ Users: base building, tenants and grid exports
- ☑ Generates: power and **heating hot water** (HHW)

Step 1

The cogeneration system is located on the plant room of the building being assessed. The system is considered to be an onsite system under Step 1.

Step 2a

The gas consumption during the Rated Period was 10,000 GJ. Auxiliary Energy was not sub-metered, and was included in the Base Building electricity consumption.

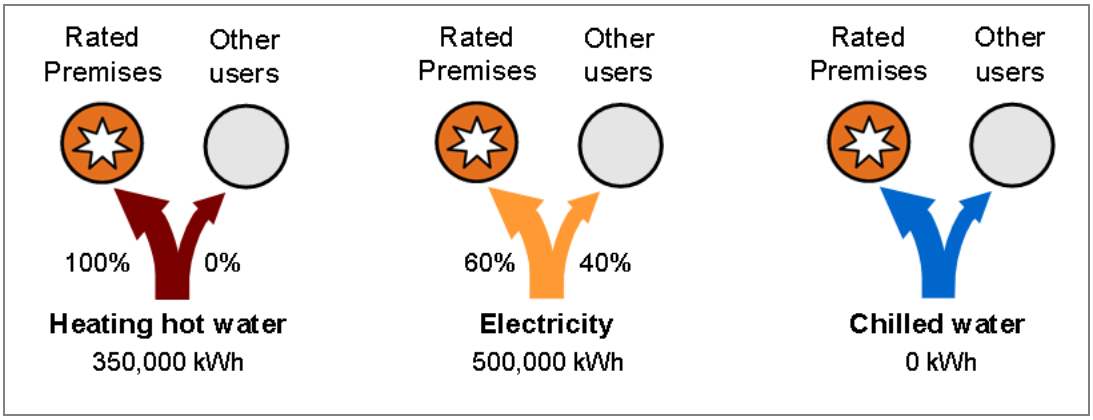
Step 2b

The cogeneration system's production of electricity and heating hot water were electrically and thermally metered, respectively. Over the Rating Period, the system produced 500 MWh_e of electricity and 350 MWh_{th} of heating hot water.

Step 2c

Electrical sub-metering showed that the 300MWh_e of electricity were used by the base building. The rest of the electricity generation (200 MWh_e) was used by tenants and exported to the electricity grid. All heating hot water was used by the base building.

Figure 15: Result after completion of Step 2



Step 3a

The gas consumption from the cogeneration system is apportioned to electricity and heating hot water users using the calculations detailed in Step 3a. Electricity users are allocated with 82.7% of the gas use from the cogeneration system, while heating hot water users are allocated with the reminder 17.3%.

Step 3b

The base building was the only user of heating hot water during the Rating Period. All gas use associated with heating hot water under Step 3a is allocated to the base building:

$$10{,}000\ \text{GJ} \times 17.3\% = 1730\ \text{GJ}$$

The cogeneration plant is onsite, and the base building used 60% of all electricity it produced during the Rating Period. Consequently, 60% of all gas use associated with electricity under Step 3a is allocated to the base building:

$$(10{,}000\ \text{GJ} \times 82.7\%) \times 60\% = 4960\ \text{GJ}$$

Result:

The following energy usage is allocated to the base building:

- Gas = 1,730 + 4,960 = 6,690 GJ

2.9.2 Example 2

- ☑ Tenancy rating
- ☑ Offsite System
- ☑ Users: base building and tenants
- ☑ Generates: power and chilled water (CHW)

Step 1

Tenancy rating; the trigeneration system is considered offsite system under Step 1, regardless of its location.

Step 2a

The gas consumption during the Rated Period was 10,000 GJ. Auxiliary Energy was not sub-metered, and does not need to be included in a Tenancy rating.

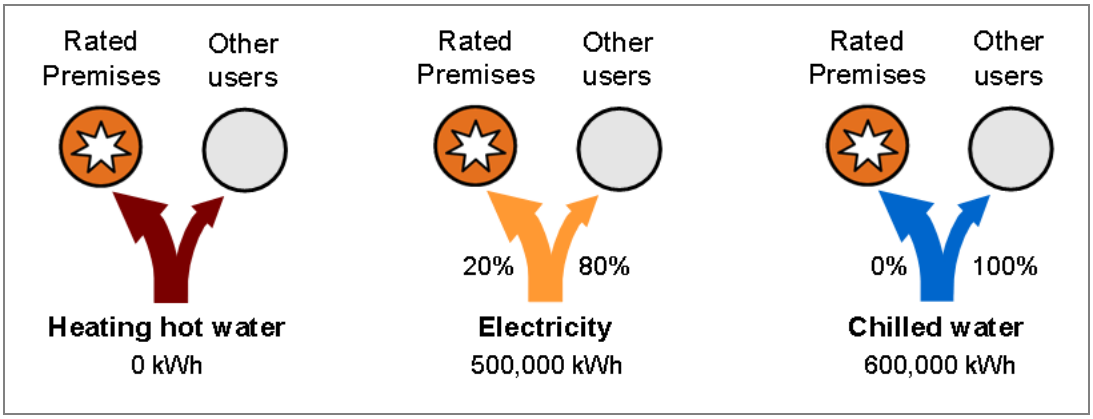
Step 2b

The cogeneration system's production of electricity and chilled water were electrically and thermally metered, respectively. Over the Rating Period, the system produced 500 MWh_e of electricity and 600 MWh_{th} of chilled water.

Step 2c

Electrical sub-metering showed that the 200MWh_e of electricity were used by the tenant being rated. The rest of the electricity generation (400 MWh_e) was used by the base building and other tenants. No chilled water was directly used by the tenant.

Figure 16: Result after completion of Step 2



Step 3a

The gas consumption from the trigeneration system is apportioned to electricity and chilled water users using the calculations detailed in Step 3a. Electricity users are allocated with 76.9% of the gas use from the cogeneration system, while chilled water users are allocated with the reminder 23.1%.

Step 3b

The tenancy does did not use any chilled water during the Rating Period. No gas use associated with chilled water under Step 3a is allocated to the tenancy:

The cogeneration plant is offsite. Consequently, the amount of **offsite cogeneration electricity** used by the tenancy is equal to 100MWh$_e$. The amount of gas used to generate this electricity is calculated as following:

$$(10{,}000\ \text{GJ} \times 76.9\%) \times 20\% = 1538\ \text{GJ}$$

Result:

The following energy usage is allocated to the tenancy:

- Gas = 0 GJ
- Offsite cogeneration electricity = 100 MWh$_e$ (associated gas = 1538 GJ)

2.9.3 Example 3

☑ Base building rating
☑ Onsite System
☑ Auxiliary energy metered
☑ No thermal metering

Step 1

The cogeneration system is located on the plant room of the building being assessed. The system is considered to be an onsite system under Step 1.

Step 2a

The gas consumption during the Rated Period was 10,000 GJ. Auxiliary Energy was sub-metered and equal to 10 MWh$_e$ of electricity during the Rating Period.

Step 2b

The cogeneration system's production of electricity was sub-metered and equal to 500 MWh_e. The production of heating hot water or chilled water was not thermally metered, and therefore is estimated as following:

$$\text{Heating hot water} = 0\ \text{MWh}_{\text{th}}$$

$$\text{Chilled water} = \left(\frac{10{,}000\ \text{GJ}}{3.6} \times 0.75\right) - 800 = 1{,}283\ \text{MWh}_{\text{th}}$$

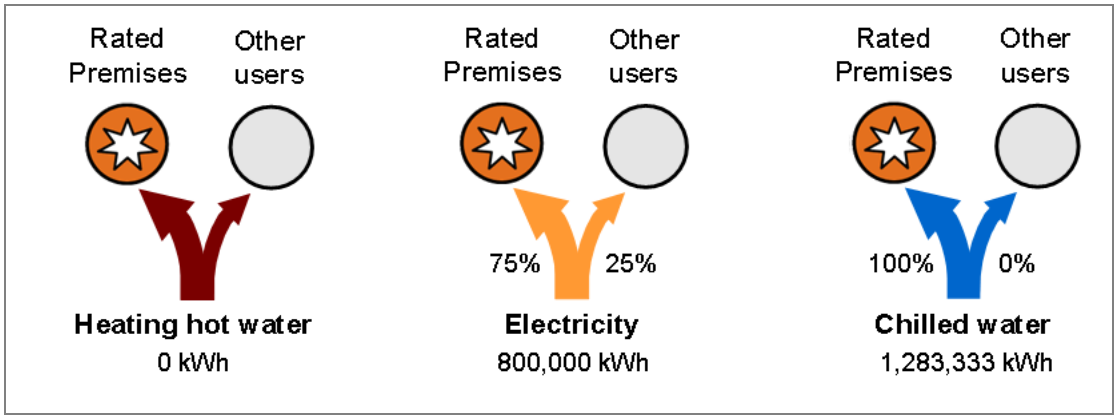
Note: the 3.6 term above is used to convert the gas usage from GJ to kWh units, as required in Step 2b.

Step 2c

Electrical sub-metering showed that the 600MWh_e of electricity were used by the base building. The rest of the electricity generation (200 MWh_e) was used by tenants.

The base building uses some of the thermal outputs from the trigeneration system, but there is insufficient thermal metering to determine exactly how much. Consequently, all heating hot water and chilled water determined under Step 2b is allocated to the base building.

Figure 17: Result after completion of Step 2



Step 3a

The gas consumption from the trigeneration system is apportioned to electricity and chilled water users using the calculations detailed in Step 3a. Electricity users are allocated with 71.4% of the gas use from the cogeneration system, while chilled water users are allocated with the reminder 28.6%.

Step 3b

All chilled water was considered to be used by the base building. As a result, all gas use and auxiliary energy associated with chilled water under Step 3a is allocated to the base building:

$$\text{Gas input} = 10{,}000\ \text{GJ} \times 28.6\% = 2{,}860\ \text{GJ}$$

$$\text{Auxiliary Energy} = 10\ \text{MWh} \times 28.6\% = 2.8\ \text{MWh}_{\text{e}}$$

The cogeneration plant is onsite, and the base building used 75% of all electricity it produced during the Rating Period. Consequently, 75% of all gas use and auxiliary energy associated with electricity under Step 3a is allocated to the base building:

$$\text{Gas input} = (10{,}000\ \text{GJ} \times 71.4\%) \times 75\% = 5{,}355\ \text{GJ}$$

$$\text{Auxiliary Energy} = (10\ \text{MWh} \times 71.4\%) \times 75\% = 5.3\ \text{MWh}_{e}$$

Result:

The following energy usage is allocated to the base building:

- Gas = 2,860 + 5,355 = 8,215 GJ
- Auxiliary energy = 2.8 + 5.3 = 8.1 MWh_{e}