NABERSNZ Energy for Offices Ruling for Thermal Energy Exclusions

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Introduction

Document Control

Note: This Ruling was first issued by the Office of Environment and Heritage[1] in July 2008 and is adapted for use in New Zealand with permission.

A growing number of buildings are using innovative solutions to reduce their greenhouse emissions and share their resources. For example chilled water may be generated efficiently in a large system in one building and then pumped to an adjacent smaller building (or to serve a retail component of an office block).

This document aims to provide an effective method of measuring the thermal energy transferred by the water and correctly allocating the associated greenhouse emissions to the rated space to enable a fair rating to proceed. These measurements are designed to fit within the overall accuracy requirements of the NABERSNZ Energy and Water for offices Rules for collecting and using data (the Rules).

The most accurate method of measurement is to meter the instantaneous raw energy inputs to the system and also the thermal energy outputs and then correctly apportion and allocate these to the correct end users. This is the "standard" methodology of this document for large or significant transfers of energy. However, this is costly and time consuming for many buildings and not necessary when dealing with small amounts of energy. For this reason this document is divided into two sections for:

- small end users by means of a simplified method of estimation, and
- large end users by means of the standard method of measurement.

Note that strict compliance with this document is required and is thereby deemed to satisfy the accuracy requirements of the Rules. The assessor must produce complete details of all calculations and assumptions and justify the methodology chosen and detail final calculations.

For small end users and the simplified method the assessor may complete the assessment and include all calculations and justifications in the assessment inputs.

For any ratings using the standard method of measurement for large users, the assessor must contact the Administrator before submitting the rating to ensure that energy balances and calculations are suitable for the installed systems.

[1] The New South Wales Government through the Office of Environment and Heritage (OEH) has licensed EECA to modify and administer NABERS energy and water for offices in New Zealand.

Alternative methods of calculation are possible if they comply with the intent and accuracy limits of this document, but these must be approved in full by the Administrator before the rating is completed.

1. Definition of small end user

Note that the following definitions only apply to the single source as nominated and a single source only. For example you cannot add domestic hot water and heating hot water even if they both are separately defined as small end users, the combined effect is that of a large user.

“Equivalent use” is defined at the end of this document in the “Definitions” section.

The derivations of the percentages used in this section are shown in Appendix A.

A small end user may use the simplified methodology of estimation. If the space and use is not clearly defined or it is not obviously a small end user then it is automatically a large user and the standard methodology must be applied. The assessor must include in the spreadsheet a justification for the reason why the small end user methodology has been selected.

Note that for a small end user “flow” is simply the flow of water in L/s or equivalent units, while for the standard methodology the flow cannot be used on its own but is only one component of the thermal energy calculation including differential temperature. The requirements for measurement are also lower for the simplified method and only require relative flows rather than continuous and instantaneous comparisons.

1.1. Domestic Hot Water

1.1.1. Whole Building Rating

The addition of any amount of domestic hot water is a small end user.

The exclusion of domestic hot water is a small end user only if the building to which it is exported is the same size or smaller and has equivalent use or the exported flow is equal to or less than the flow in the building.

1.1.2. Base Building Rating

The addition of any amount of domestic hot water is a small end user.

The exclusion of domestic hot water is a small end user only if the building to which it is exported is the same size or smaller and has equivalent use or the exported flow is equal to or less than the flow in the building.

1.2. Heating Hot Water

1.2.1. Whole Building Rating

The addition of heating hot water is a small end user only if less than 50% of the building's hot water supply is imported.

The exclusion of heating hot water is a small end user only if:

- the building to which it is exported is less than 50% of the size of the rated building and has equivalent use, or
- the design exported flow is 50% or less than the maximum flow (both defined in the definitions section 3.4), or
- the measured exported flow is 50% or less than the maximum flow.

1.2.2. Base Building Rating

The addition of heating hot water is a small end user only if less than 25% of the building's hot water supply is imported.

The exclusion of heating hot water is a small end user only if:

- the building to which it is exported is less than 25% of the size of the rated building and has equivalent use, or
- the design exported flow is 25% or less than the maximum flow, or
- the measured exported flow is 25% or less than the maximum flow.

1.2.3. Tenancy Rating

The addition or exclusion of heating hot water is never considered a small end user for a tenancy rating because it is likely to be a significant portion of the overall energy consumption.

1.3. Chilled Water

1.3.1. Whole Building Rating

The addition of chilled water is a small end user only if less than 25% of the building's chilled water supply is imported.

The exclusion of chilled water is a small end user only if:

- the building to which it is exported is less than 25% of the size of the rated building and has equivalent use, or
- the design exported flow is 25% or less than the maximum flow, or
- the measured exported flow is 25% or less than the maximum flow.

1.3.2. Base Building Rating

The addition of chilled water is a small end user only if less than 15% of the building's chilled water supply is imported.

The exclusion of chilled water is a small end user only if:

- the building to which it is exported is less than 15% of the size of the rated building and has equivalent use, or
- the design exported flow is 15% or less than the maximum flow, or
- the measured exported flow is 15% or less than the maximum flow.

1.3.3. Tenancy Rating

The addition or exclusion of chilled water is never considered a small end user because it is likely to be a significant portion of the overall energy consumption.

2. Simplified methodology for small end users

2.1. Domestic Hot Water

2.1.1. Whole Building Rating

Addition

For an addition of energy imported into the rated space add an additional 3% to the total benchmarking score[2].

Exclusion

For an exclusion of energy exported from the rated space use the following formula:

$$Exclusion\% = 3 \times \left(\frac{Rateable\ area\ of\ other\ building}{Rated\ Area\ of\ space} \right)$$

Note that a maximum of 3% can be excluded from a whole building rating.

The percentage addition or exclusion is to be applied to the total benchmarking score and a suitable factor can be applied to an energy source or an additional energy source added to create the correct overall adjustment.

2.1.2. Base Building Rating

Addition

For an addition of energy imported into the rated space add an additional 5% to the total benchmarking score.

Exclusion

For an exclusion of energy exported from the rated space use the following formula:

$$Exclusion\% = 5 \times \left(\frac{Rateable\ area\ of\ other\ building}{Rated\ Area\ of\ space} \right)$$

Note that a maximum of 5% can be excluded from a base building rating.

The percentage addition or exclusion is to be applied to the and a suitable factor can be applied to an energy source or an additional energy source added to create the correct overall adjustment.

[2] The benchmarking score is calculated by the NABERSNZ calculator and is the energy intensity of the rated space that has been corrected for the greenhouse gas emission intensity of the energy, relative to electricity.

2.2. Heating Hot Water

2.2.1. Whole Building Rating

Addition

For an addition of heating hot water imported into the rated space use the following formula:

$$Addition\,\% = 5 \times \left(\frac{\%\,of\ imported\ water\,energy}{50\%} \right)$$

Use flow meters, or design parameters, or an alternative method that has been approved to determine the percentage of heating hot water being imported to the space.

Exclusion

For an exclusion of heating hot water exported from the rated space based on flows use the following formula:

$$Exclusion\% = 5 \times \left(\frac{2 \times Actual\ flow}{Maximum\ \ flow} \right)$$

Use flow meters, or design parameters, or an alternative method that has been approved to determine the actual exported flow and the maximum system flow.

For an exclusion of heating hot water exported from the rated space use the following formula if only the relative areas are known:

$$Exclusion\% = 5 \times \left(\frac{2 \times Rateable\ area\ of\ other\,building}{Rated\ \ Area\ of\ \ space} \right)$$

Note that a maximum of 5% can be excluded from any rating. The percentage addition or exclusion is to be applied to the total benchmarking score and a suitable factor can be applied to an energy source or an additional energy source added to create the correct overall adjustment.

2.2.2. Base Building Rating

Addition

For an addition of heating hot water imported into the rated space use the following formula:

$$Addition\,\% = 5 \times \left(\frac{\%\,of\ imported\ water\ energy}{25\%} \right)$$

Use flow meters, or design parameters, or an alternative method that has been approved to determine the percentage of heating hot water being imported to the space.

Exclusion

For an exclusion of heating hot water exported from the rated space based on flows use the following formula:

$$Exclusion\% = 5 \times \left(\frac{4 \times Actual\ flow}{Maximum\ \ flow} \right)$$

Use flow meters, or design parameters, or an alternative method that has been approved to determine the actual exported flow and the maximum system flow.

For an exclusion of heating hot water exported from the rated space use the following formula if only the relative areas are known:

$$Exclusion\% = 5 \times \left(\frac{4 \times Rateable\ area\ of\ \ other\ building}{Rated\ \ Area\ of\ \ space} \right)$$

Note that a maximum of 5% can be excluded from any rating. The percentage addition or exclusion is to be applied to the total benchmarking score and a suitable factor can be applied to an energy source or an additional energy source added to create the correct overall adjustment.

2.3. Chilled Water

2.3.1. Whole Building Rating

Addition

For an addition of chilled water imported into the rated space use the following formula:

$$Addition\,\% = 5 \times \left(\frac{\%\,of\ imported\ water\ energy}{25\%} \right)$$

Use flow meters, or design parameters, or an alternative method that has been approved to determine the percentage of chilled water being imported to the space.

Exclusion

For an exclusion of chilled water exported from the rated space based on flows use the following formula:

$$Exclusion\% = 5 \times \left(\frac{4 \times Actual\ flow}{Maximum\ \ flow} \right)$$

Use flow meters, or design parameters, or an alternative method that has been approved to determine the actual exported flow and the maximum system flow.

For an exclusion of chilled water exported from the rated space use the following formula if only the relative areas are known:

$$Exclusion\% = 5 \times \left(\frac{4 \times Rateable\ area\ of\ other\ building}{Rated\ \ Area\ of\ \ space} \right)$$

Note that a maximum of 5% can be excluded from the rating. The percentage addition or exclusion is to be applied to the total benchmarking score and a suitable factor can be applied to an energy source or an additional energy source added to create the correct overall adjustment.

2.3.2. Base building Rating

Addition

For an addition of chilled water imported to the rated space use the following formula:

$$Addition\,\% = 5\times\left(\frac{\%\,of\ imported\ water\,energy}{15\%}\right)$$

Use flow meters, or design parameters, or an alternative method that has been approved to determine the percentage of chilled water being imported to the space.

Exclusion

For an exclusion of chilled water exported from the rated space based on flows use the following formula:

$$Exclusion\% = 5\times\left(\frac{6.7\times Actual\ flow}{Maximum\ \ flow}\right)$$

Use flow meters, or design parameters, or an alternative method that has been approved to determine the actual exported flow and the maximum system flow.

For an exclusion of chilled water exported from the rated space use the following formula if only the relative areas are known:

$$Exclusion\% = 5\times\left(\frac{6.7\times Rateable\ area\ of\ \ other\,building}{Rated\ \ Area\ of\ \ space}\right)$$

Note that a maximum of 5% can be excluded from any rating. The percentage addition or exclusion is to be applied to the total benchmarking score and a suitable factor can be applied to an energy source or an additional energy source added to create the correct overall adjustment.

Using the Design Flow

When using the simplified method for small end uses and in particular using the design flow, it is important to use the design flow at normal expected conditions rather than the maximum possible capacity. An example of this is condenser water systems that have the capacity designed based on a kW per square metre rating but rarely are installed to even 25% of this theoretical capacity. The design numbers used must reflect the building being rated, not just a theoretical capacity calculation based on what might be installed. An acceptable method of comparison is to use commissioning data to confirm real life performance.

Also, when using the simplified methodology the result must be entered as an error and the rating must comply with the overall error limits. The reason for this is to prevent a building from having 5% of chilled water to retail, 5% of hot water to retail, 5% of chilled water to library, 5% of hot water to library, 5% of chilled water to food court, and 5% of hot water to food court all independently assessed as small end users, along with other assumptions.

3. Standard Methodology for large users

3.1. Determine production process

Determine if the production of the imported or exported water is a primary or secondary process as these will need to be treated differently.

- Primary production is defined when electricity or gas is fed into a machine which is designed to produce water energy of a specific type. This specific energy is then directly shared with another building. For example the production of chilled water from a chiller or hot water from a boiler, both being fed by electricity or gas.
- Secondary production is defined as either a by-product (waste recovery) of the above primary production or a secondary use of the primary source. Examples of the use of a by-product may be the use of waste heat from a chiller or generator. Examples of secondary use may be:
  - the use of chilled water from an absorption chiller that is fuelled by hot water from a boiler, (primary being the hot water and secondary being chilled water)
  - or second stage cooling from an industrial process that is then shared, for example a process may require freezing (first stage) and later warming to room temperature (second stage) – the cooling energy recovered from the second stage would be considered secondary production.

3.2. General procedure:

3.2.1. Primary Production

Primary production requires an energy balance of the whole system. All energy associated with the production of the primary source including all ancillary components is to be included in the energy balance.

1. **For an addition of energy:**
   All raw energy inputs and associated ancillary components and all power required to transfer the thermal energy must be included in the energy balance. Raw energy and ancillary component energy is apportioned based on use, but transfer energy (see definition at end of document in section 3.4) is allocated 100% to the importing building.
2. **For an exclusion of energy:**
   Include all raw energy sources as above and apportion based on use, but do not include energy sources not normally associated with this rating type. For example, condenser water for a tenancy rating. Transfer energy is not apportioned but 100% deducted.

3.2.2. Secondary Production

Secondary production follows a similar process but must be followed all the way back to the raw energy input, rather than just the production step being investigated. This is more difficult to quantify because there is no direct relationship between raw energy input and thermal energy output because there is an additional stage between. In many cases the energy (for example from waste heat) would normally require an additional energy input (cooling tower) to remove it so the transfer acts as a pseudo abatement scheme rather than as a greenhouse gas producer.

The direct effect is very difficult to quantify as it is not a zero emission source so should not be given full status as such, but it is an efficient use of resources so should be rewarded.

It would also be essential to qualify the system as not being primary production and also ensure that it uses normally “wasted” energy and not have the system simply be oversized and use “excess” energy.

3.3. Details of calculation process

Firstly qualify the system as primary or secondary, or even a combination of both systems. Each system of energy transfer will need to be treated separately as follows.

3.3.1. For primary production and energy transfer:

1. Conduct an energy balance of the entire system. This is to be a complete and thorough energy balance. It is to start at the thermal energy being transferred and include its source and all end uses of it. The end uses of the thermal energy are to include all other uses of it in any building and are to include all pumping and transfer devices. From the source of the thermal energy the generation method is to be included with all energy inputs from any source and all outputs including any pumping and transfer devices and any methods of removing waste energy of the process, including all ancillary devices associated with the process. The entire production process is to be captured from beginning to end, with all energy sources and all end uses.
2. Balance the thermal energy against all raw energy inputs at any point in time.
   This balance is to use sub metering for all energy inputs and outputs of any type. If there is no sub metering then the entire meter that the piece of equipment is connected to is to be included. The balance must be checked for accuracy and that all energy sources do in fact balance and

are appropriate for the system installed given the design efficiencies and system losses. A system that does not pass this balancing phase will not be accepted as it indicates either parts of the system are missing from the balance, or errors in the equations, or errors in calibration, or accuracy errors in the equipment.

3. **For an addition of energy** (importing thermal energy to the rated building or space)
   At any point in time:
   a. Energy directly associated with the transfer (pumping etc) of the thermal energy into the space is to be treated separately and 100% allocated to the importer.
   b. Determine the percentage imported thermal energy compared to the total production or total end uses as appropriate. Note that true thermal energy must be used for this calculation and simple flow measurements will not be acceptable.
   c. Apply this percentage to the raw energy input of the entire production system as measured by sub meters. This must contain all raw energy sources required to produce the thermal energy and remove waste production.
   d. This is now the instantaneous energy demand to be allocated to the rated space.
4. **For an exclusion of energy** (exporting thermal energy out of the rated building or space)
   At any point in time:
   a. Energy associated with the transfer (pumping etc) of the thermal energy directly out of the space is to be treated separately and 100% excluded from the exporter's rated energy. Note that circulation pumps are to be included in the energy allocation below.
   b. Determine the percentage exported energy compared to the total production or total end uses as appropriate. Note that actual true thermal energy must be used for this calculation and simple flow measurements will not be acceptable.
   c. Apply this percentage to the raw energy input of the entire production system as measured by sub meters. Energy not normally associated with the type of rating being done is not to be included in the energy balance and must remain with the rated space. (e.g. cooling towers for export to a tenancy)
   d. This is now the instantaneous energy demand to be allocated to the rated space.

3.3.2. For secondary production and/or energy transfer:

1. Conduct an energy balance of the entire system.
   (Notes as per primary production in section 3.3.1)
2. Ensure that the transferred energy is either:
   a. Normally "wasted" and the transfer negates the addition of other energy to remove the unwanted energy, or
   b. Is one step removed from the raw energy input of electricity or gas.
3. For alternative a. of normally wasted energy:
   a. For an addition of energy:
      i. only include 100% of energy associated with the transfer of the thermal energy.
   b. For an exclusion of energy:
      i. An exclusion is not allowed as this is already considered in the negation of the removal of the energy, which had to be done in any case.
4. For alternative b. of secondary use:
   At any point in time:
   a. For an addition of energy:
      i. Energy associated with the transfer (pumping etc) of the thermal energy is to be 100% allocated to the importer.
      ii. Determine the percentage imported energy against the total production. Note: Since this is secondary energy the figure required to produce the secondary energy is defined as the percentage of primary energy being used by the secondary generation multiplied by the percentage of secondary energy being exported. (For example a system where 50% of primary hot water is used in a chiller where 80% of that chilled water is exported has an imported percentage of 50% x 80% = 40%)
      iii. Apply this percentage to the raw energy input of the entire system. This must contain all raw energy sources required to produce the thermal energy including all ancillary services of both the primary and secondary systems.
      iv. This is now the instantaneous energy demand to be allocated to the rated space.

b. For an exclusion of energy:
   i. Energy associated with the direct transfer (pumping etc) of the thermal energy is to be 100% excluded from the exporter.
   ii. Determine the percentage exported energy against the total production. Note: As above for an addition.
   iii. Apply this percentage to the raw energy input of the entire system. This must contain all raw energy sources required to produce the thermal energy including all ancillary services of both the primary and secondary systems.
   iv. This is now the instantaneous energy demand to be allocated to the rated space.

All of the above calculations are an instantaneous measure of demand (kW) and need to be integrated over time to produce energy consumption (kWh). An acceptable method is to record the instantaneous demand (kW) every 15 minutes and multiply by 0.25 (hours) to give a kWh result. This will give a figure of actual kWh consumption over that time period. A time resolution of 15 minutes is considered the maximum allowable to give an accurate reading except for the most stable of industrial systems in which case 30 minutes may be acceptable. In general a resolution of less than 5 minutes is not required.

3.4. Definitions

Water energy or **thermal energy** is defined as the heat energy (in kW) used in the water system. This is calculated through the equation $Q = (m\ C_P\ T_D) / t$ where:

Q is the energy in kW
m is the mass of water in kg
C_P is the specific heat capacity of water (4.19 kJ/kg °C)
T_D is the temperature differential (flow to return) of the water in °C
t is time in seconds

In a pipe system with constant diameter pipes and using water this is better expressed as:

$$\mathbf{Q = V \times 4.19 \times T_D}$$

Where:

Q is the energy in kW
V is the flow of water in litres per second
T_D is the temperature differential (flow to return) of the water in °C

Transfer energy is defined as the pumping energy used solely to directly transfer the thermal energy from one building to the other. It does not include general circulation pumps for the base system but pumps specifically used to transfer the water from one space to another. If the process relies solely on system pressure from circulating pumps then the specific transfer energy is considered to be zero. In this case the pumping energy is treated as part of the overall energy associated with the production of the thermal energy and is to be apportioned.

Equivalent use is defined as an office building with similar hours of operation.

Design flow as used in the simplified method is defined as the flow of the system in litres per second (L/s) as demonstrated by engineering calculations.

Maximum flow as used in the simplified method is defined as the maximum capacity of the system in litres per second (L/s) as demonstrated by engineering calculations. It may also be the maximum reading of a flow meter over a period of 12 months, as long as the meter is recorded continuously. This is not the flow ratings of pumps, but rather the maximum expected capacity during operation.

Actual or measured flow as used in the simplified method is defined as the flow of the system in litres per second (L/s) as measured by a flow meter.

4. Measurement Standards

This section applies only to the standard methodology for large users because it needs to be an accurate calculation. The simple methodology of estimation is more lenient because it falls below the overall accuracy limit of NABERSNZ Energy.

The overriding factor when considering this measurement standard is that the thermal energy calculations are effectively replacing direct energy sub-metering; therefore the overall accuracy of the calculations should be equivalent to the NABERSNZ Energy sub-metering clauses. In order to ensure the accuracy of the final calculations it is essential that the raw data inputs are as accurate as can be realistically measured. The following section is a guide to the minimum standards required for the measurement methods and technologies. In addition to this the assessor must use all reasonable methods (such as the energy balance which is compulsory, or optional on-site calibrations) to ensure that the real readings correspond to the potential accuracy and that data is not missed from the logs.

The principle to be applied is that NABERSNZ Energy only considers the actual error over the range of the expected reading, and both the error and reading must be measured in the same scale. A theoretical % accuracy of a full scale that is not relevant to the actual system being measured will not be considered. For example; a sensor with a specified accuracy of "1% of full-scale" with a sensor range of 0-100℃ represents an actual error of 1℃ anywhere across that 100℃ range. At a measured reading for chilled water of 7℃ this represents a possible error of 1° in 7° or over 14%. This is not acceptable.

The analogue to digital (A/D) conversion should also be taken into account to ensure that the whole system is matched. For example; the sensor itself might fall within the required error range and transmits a 0-5V output to the digital data logger. If the analogue input for the data logger is calibrated for a 1-10V signal with an 8bit A/D conversion (only 255 discreet steps) the overall accuracy might fall below the overall requirement.

An example showing the full system described above from end to end is described here to explain how a seemingly "accurate" system can produce unacceptable errors:

Inputs to the system:

- Temperature sensor with 1% of full scale accuracy over 0-100℃ range, analogue output of 0-5V.
- Data logger analogue input 0-10V (0.5% accuracy) with 8 bit A/D conversion.

The temperature sensor has a sensitivity (S) of:

S = 5V/100℃
= 0.05V/℃
= 50mV per ℃

The data logger analogue input has 0-10V low and high reference points spread over the 8 bits (or 255 discreet counts). Therefore the sensitivity of the A/D converter is:

S = 10V/255bits
= 0.0392 V/bit
= 39.2mV per bit

This corresponds to a temperature resolution of:

R = (39.2mV/bit)/ (50mV/℃)
= 0.784℃ per bit

Alternatively this can be calculated as 100℃ over the 5V range, or 100℃ over half the full 10V range of 255 bits, or 0.784℃ for each available bit.

At a reading of 7℃ (assuming a perfectly accurate reading) this represents a possible A/D conversion error of 1 bit (+/-0.5 bits rounding) or 0.784℃ in 7℃ or about 11% (for a perfectly accurate reading).

The installed system with certified accuracies of 1% and 0.5% has been previously shown to have a measurement error of 14% with an additional conversion error of 11%, which are then doubled in our calculations since we are using the differential temperature. This demonstrates that care should be taken that all components are matched and should be considered end to end as a whole system, and not as separate unrelated components.

4.1. Monitoring Inputs

Temperature

The error of the final result (including sensor, transmitter, cable losses, and A/D conversion) is to be better than 3% over the expected reading range.

Immersion sensors installed in thermowells or their equivalent should be used. “Strap-on” type sensors will not be acceptable. The technology of the sensor itself will not be specified but should be compatible with the recording device with minimal conversion required so that the whole system falls within the accuracy limits. Care should be taken in assessing the error of the actual reading, rather than a % accuracy band (as explained above).

The whole system must be well matched. This applies to all analogue inputs being read by the BMS or monitoring system.

Flow

The error of the final result (including measuring device, sensor, transmitter, cable losses, and A/D conversion) is to be better than 3% over the expected reading range.

The technology of the flow sensor will not be specified but preference will be given to integrated sensors designed specifically for flow measurements such as magnetic flow meters. “Paddle wheel” type sensors or similar mechanical devices must be field tested and calibrated over a wide range of flows to ensure that they are reliable and accurate over the total range of flows.

Differential pressure type sensors linked to an orifice plate or other type of device or probe must be designed for the low pressures expected and any accuracy requirements must include the errors caused by the device as well as the sensor, and the matching of the two.

For example a differential pressure sensor with a certified accuracy of 1% Full-Scale will not be acceptable if the sensor is always reading in the bottom quarter of its range because it is not well matched to the pressure probe. This is amplified when other losses such as the pressure probe itself are taken into consideration.

Integrated thermal energy meters

The same principles apply in that a particular technology will not be specified, but the overall error in the kWh reading must be better than 5% over the expected reading range including all elements involved in recording that measurement. Care must be taken to ensure that the specified accuracy is of the kWh reading and not of individual components.

Any mechanical devices must be field tested for reliability and accuracy over a range of readings.

4.2. Recording and calculation

Intervals

Inputs should be monitored continuously but recording the readings should be done every 15 minutes or more often if required.

Intervals of longer than 15 minutes may be acceptable but only if it can be demonstrated that the system is stable and there will be no significant fluctuations over a greater time period. Longer time periods will not be acceptable for typical chilled or hot water systems in commercial buildings.

Calculation and data logging

There is no stipulation on the data logging and storage of data except to say that all calculations must be performed at the recording interval (typically every 15 minutes). It is not acceptable to average or sum the recordings and use this number as the input to calculations.

It is possible to log all recorded data as the raw inputs and then perform the final calculations on this data. This will require extensive storage capacity and may place a strain on some systems. However, it does allow flexibility if a formula needs to be altered since all the raw data is available for the re-calculation.

It is also possible to perform all of the calculations in the field at every recording interval and then only transmit and log the final result. This places less strain on communications and data storage capacities but has the limitation that without the raw data, no recalculations will be possible.

Appendix A

Derivation of the calculations used in the simplified methodology

The calculations are based on the following general percentages of commercial building energy use break down.

Whole Building		Base Building	
Use	% Energy	Use	% Energy
Heating	10	Heating	17
Cooling	21	Cooling	36
Domestic Hot Water	3	Domestic Hot Water	5
Ventilation	10	Ventilation	18
Lighting	38	Lighting	
Office Equipment	4	Office Equipment	
Other	14	Other	24
Total	100	Total	100

The percentages are used in two separate ways, firstly to determine if the transfer can be considered to be a small end user (less than 5% of overall emissions is transferred) and then secondly to determine the actual amount to be allocated to that space.

Determining a small end user:

The crucial factor is that the overall emissions fall below the NABERSNZ Energy accuracy limit of 5%. Therefore the emissions due to the transfer of energy must be less than 5% of the rated emissions. To simplify the calculations and to take out the unknown of varying technologies and fuel mixes for different buildings, the energy percentage from the table is assumed to have equivalent percentages to the emissions.

For example a whole building has approximately 10% of energy associated with heating so up to half of this can be imported or exported without reaching the overall NABERSNZ Energy 5% accuracy limit. In section 1.2.1 the allowable limit for heating hot water transfer in a whole building rating is 50% of the overall hot water supply.

For a base building rating exporting chilled water, the limit to determine if it is a small end user is defined in section 1.3.2 as 15%. This was calculated by considering that

36% of a base building's energy is used in chilled water production and therefore 15% of this may be exported before reaching the overall 5% limit (15% of 36% is 5% of overall emissions).

Similar principles apply for the other rating types and thermal energy types.

Calculating the amount to be allocated:

In the same way, the 5% accuracy limit is also used as the guiding principle for the calculation of the actual addition or exclusion of each energy type and rating.

We will use a base building rating and an exclusion of cooling water as an example since it will probably be the most common type of situation encountered where the central plant chilled water is exported to a retail centre or small adjacent building.

Once we know that this building complies as a small end user we need to know how to exclude the actual transfer amount. This is given to us in section 2.3.2. If we were calculating an addition we know that a full 15% of imported chilled water energy would give us the 5% emissions so the addition is expressed as the ratio of the percentage of imported energy (cannot be over 15% or it will not be a small end user) over 15% multiplied by the allowable 5% of emissions, or:

$$Addition\,\% = 5 \times \left(\frac{\%\,of\ imported\ water\,energy}{15\%} \right)$$

However, we are considering the exclusion of energy in this example which is expressed as:

$$Exclusion\% = 5 \times \left(\frac{6.7 \times Actual\ flow}{Maximum\ \ flow} \right)$$

In this case we are allowed to export only 15% of the maximum capacity of the system. This is again expressed as a ratio so that at the maximum limit of 15% the ratio is 1 (6.7 x 15% equals 1.005) and we can then exclude the full 5% of emissions. Anything less than the maximum allowable flow gives a reduced export amount.

The other option for transfer to an equivalent use space is based on the same principle and assumes that the consumption per square metre will be uniform in both spaces. This is known to be untrue for all cases but for the sake of the small end user where only a maximum of 5% can be excluded, this is considered acceptable and is why NABERSNZ Energy insists on equivalent use to reduce the risk of errors.

In all cases the ratio is applied to the measured variable (chilled water in this case) but the overall addition or exclusion percentage of emissions is to the total emissions for the rated space, not just the energy used to generate the measured variable. This is due to the fact that the original percentage break-ups in the above table are based on total energy use in the building and also because the 5% NABERSNZ Energy accuracy limit applies.

Appendix B

Examples of systems and how to perform the energy balance:

Note that this applies to the standard methodology of calculation that requires constant measuring of the thermal energy and apportioning of this to the raw energy inputs.

These examples are provided for guidance only and are meant to give an indication of the overall process rather than the exact methodology.

Example A: Chilled water system with constant speed primary pumps and secondary pumps dedicated to transfer water to the other space. This is considered primary production. A similar example can be used for hot water production from a standard boiler. If there is no secondary pump then the primary pump energy is to be apportioned.

Component	**Input**	**Treatment**
Chiller itself	Electricity and/or gas (metered)	To be apportioned
Cooling towers and condenser water pumps	Electricity metered	To be apportioned as required in this document
Primary pump	Metered electricity	To be apportioned
Secondary pump	Metered electricity	100% allocated to importer
Thermal energy of all water	Calculated from flow and differential temp (either single at chiller or summation of “other” uses)	Firstly ensure that overall inputs equate to outputs. Then apportion raw energy according to ratio of exported energy on a continual basis.
Thermal energy of exported water	Calculated from flow and differential temp at the take off point	Used in the calculation of the ratio for apportioning.
Floor controls, valves etc	Too small to individually measure	Not required to be included

At each point in time, the exported energy equals (the sum of the chiller input energy plus primary pumping energy plus heat rejection energy) multiplied by (the ratio of exported thermal energy over total thermal energy) plus (direct pumping energy required to export the thermal energy).

Example B: Chilled water is exported from an absorption chiller that is fed with hot water from a hot water boiler. This is considered secondary production since the exported thermal energy is ultimately derived from the heat energy from the boiler. Single pumping circuits are considered for simplicity but secondary circuits on either the hot or chilled water circuits would be treated as above.

Component	**Input**	**Treatment**
Hot water boiler itself	Gas (metered)	To be apportioned
Primary hot water pump	Metered electricity	To be apportioned
Thermal energy of all hot water	Calculated from flow and differential temp (either single at boiler or summation of “other” uses)	Firstly ensure that heating inputs equate to outputs. Then apportion raw energy according to ratio of exported energy on a continual basis.
Thermal energy of hot water to chiller	Calculated from flow and differential temp at the take off point	Used in the calculation of the ratio for apportioning.
Chiller itself	Electricity metered (thermal energy input already measured above)	To be apportioned
Cooling towers and condenser water pumps	Electricity metered	To be apportioned as required in this document
Primary pump	Metered electricity	To be apportioned
Thermal energy of all chilled water	Calculated from flow and differential temp (either single at chiller or summation of “other” uses)	Firstly ensure that cooling inputs equate to outputs. Then apportion raw energy according to ratio of exported energy on a continual basis.
Thermal energy of exported water	Calculated from flow and differential temp at the take off point	Used in the calculation of the ratio for apportioning.
Floor controls, valves etc	Too small to individually measure	Not required to be included

In example B we need to perform two energy balances simultaneously. Firstly for the hot water circuit and then for the chilled water circuit to ensure that all energy is accounted for, and all meters are reading reliably.

Once we are sure the systems are reading correctly the energy can be apportioned to the correct user. In this case we will start with the hot water circuit. We can derive the instantaneous percentage of energy going to the chiller compared to the

rest of the hot water system. This percentage is then applied to the gas and electrical energy being fed into the boiler. This is our raw kWh energy input into the chiller (aside from direct electrical metering at the chiller itself for ancillary components). This apportioned raw energy is combined with the directly metered raw energy and is apportioned instantaneously based on the percentage of chilled water being exported compared to the entire chilled water production.
In essence the formula becomes similar to example A or:

The exported energy equals (the sum of the chiller input energy plus primary chilled water pumping energy plus heat rejection energy) multiplied by (the ratio of exported thermal energy to total thermal energy).

Where: the chiller input energy equals (the sum of metered boiler input energy plus primary hot water pumping energy) multiplied by (the ratio of hot water thermal energy supplied to the chiller to total hot water thermal energy production).