Education and Industrial Energy Calculation Guide

July 2009

This document was prepared on behalf of the NZGBC by Beca with funding from the Energy Efficiency Conservation Authority (EECA).

Acknowledgement

The New Zealand Green Building Council thanks everyone who contributed content, time and effort in the development of the Green Star NZ – Education and Industrial Calculation Guide.

In particular, the New Zealand Green Building Council acknowledges the extraordinary input by members of the Technical Working Group:

Alan Barbour, Beca

Quentin Jackson, Ecubed

Ben Masters, Beca

Mark Ogilvie, Norman Disney Young

Neil Purdie, Aurecon

Scott Smith, Aecom

The New Zealand Green Building Council would also like to acknowledge the patience, time and effort given by all pilot projects using this calculation guide. A special thank you is extended to pilot project team members from Lincolne Scott, Ecubed and Aecom who assisted with the testing and verification of the calculation guide.

The New Zealand Green Building Council also wishes to thank the Energy Efficiency Conservation Authority (EECA) for their generous funding contribution to this project.

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1 Executive Summary

This document has been prepared to provide guidance on the energy calculation approach for projects seeking to be assessed under the Green Star NZ – Education or Industrial rating tools.

Under the Green Star ENE-1 Credit, there are two options with which projects can demonstrate compliance:

- a ‘Two-model’ energy calculation

OR

- a ‘Schedule Method’ option

Using the Two-model energy calculation approach there are two aspects awarded points under the ENE-1 and ENE-2 Credits:

- ENE-1 Energy improvement
- ENE-2 Greenhouse gas emissions improvement

The process of carrying out both the two model calculation and the schedule method calculation are described in this guide.

2 Energy Calculation Methodology

There are two options under ENE-1 of the Green Star NZ – Education and Industrial Tools for the purposes of benchmarking the energy performance of a building's design. These are summarised as follows:

2.1 'Two-model' Approach

The Two-model energy calculation approach compares the improvement between the computer simulated annual energy target of the Actual (specified) building design over the simulated annual energy target of a Reference building design. The Reference building generally reflects the project building's physical parameters although the building envelope performance and building services efficiencies are intended to represent current industry 'Typical Practice'. The flowchart in Figure 1 (over page) outlines the steps involved in carrying out the Two-model calculation.

Using the Two-model energy calculation approach there are two aspects awarded points under the ENE-1 and ENE-2 Credits:

- ENE-1 Energy improvement
- ENE-2 Greenhouse gas emissions improvement

It is has been the intention of the energy calculation guide to promote the following:

- Building designs that are energy efficient compared to current industry 'Typical' Practice
- Building designs and the use of building energy sources that result in low carbon dioxide equivalent emissions

The guidelines for carrying out the Two-model energy calculation are described in Section 3 of this guide.

The definition of the Actual and Reference Building Model inputs are described in Section 4 of this guide.

2.2 'Schedule Method' Approach

For Green Star NZ – Education and Industrial there is also the option of a 'Schedule Method' approach for selected project types that do not wish to undertake energy simulation modelling.

This method can only be used where the project type is able to meet the schedule method requirements and the installed process power load for the building does not exceed 30W/m^2.

Guidelines for carrying out the Schedule Method approach are described in Section 5 of this guide.

The limit for internal design power load is 30W/m^2. This includes the sum of tenant small power and installed process power load in any individual space in the building.

5 points are available under ENE-1 using the 'Schedule Method' option.

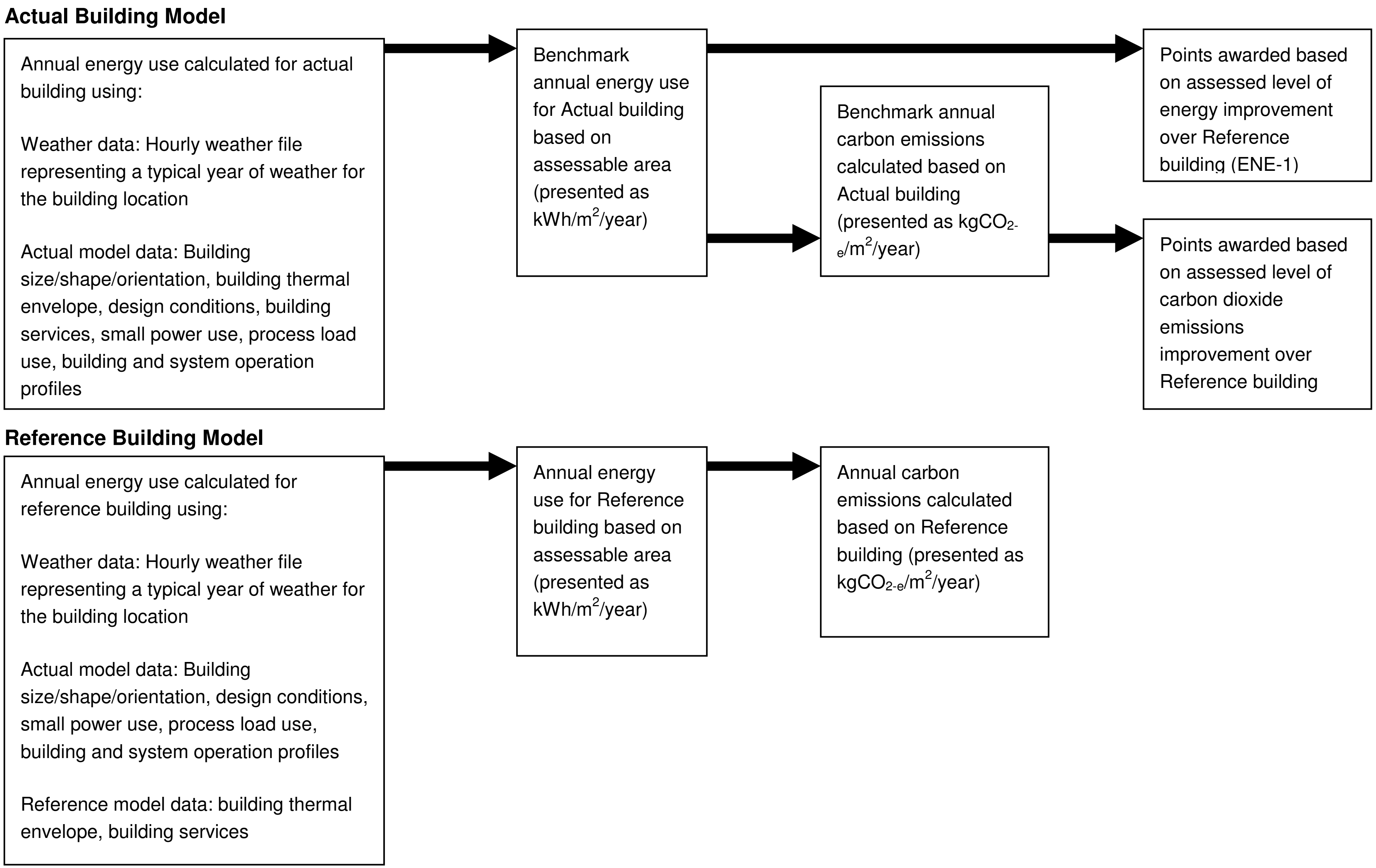

FIGURE 1 – Steps involved in Two-model energy calculation approach

3 Two-Model Energy Calculation Approach

The steps involved in the Two-model energy calculation approach are as follows:

3.1 Assessable Area

- Input the Usable Floor Area[1] (UFA) for Education projects and Gross Floor Area[2] (GFA) for Industrial projects into the Green Star Building Input Sheet of the Green Star spreadsheet

3.2 Actual Building Model HVAC[3] and lighting energy use

Calculate the annual HVAC and lighting energy use for the specified building design:

- Use Actual building model input data described in Section 4
- Apply the appropriate operation and usage schedules to all different space types[4] within the building described in Section 4
- Calculate the annual HVAC and lighting energy use (annual small power usage and process load usage is to be included in the HVAC energy calculation)
- Input annual HVAC and annual lighting energy use into Green Star Energy and GHG Emissions Calculator – separated for each different energy source e.g. Electricity, natural gas, biomass, coal etc

3.3 Actual Building Model energy use for other building services

Calculate the annual energy use for building services other than HVAC and lighting:

- Use manual calculation procedures to calculate energy use for other building services in the Actual building described in Section 6
- Input annual energy use for other building services into Green Star Energy and GHG Emissions Calculator – separated for each different energy source

3.4 Actual Building Model energy benchmark

- The Green Star spreadsheet will sum together the annual HVAC, lighting and other services annual energy use to form the Actual Building Model energy benchmark in kWh/m^2/year based on the assessable area

3.5 Reference Building Model HVAC and lighting energy use

Calculate the annual HVAC and lighting energy use for the Reference Building Model:

- Use Reference Building Model input data described in Section 4
- Apply the same operation and usage schedules as used in the Actual Building Model to each different modelled space types within the building
- Calculate the annual HVAC and lighting energy use (annual small power usage and process load usage is to be included in the HVAC energy calculation)

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[1] UFA is defined in the Introduction section to the Education Technical Manual

[2] GFA is defined in the Introduction section to the Industrial Technical Manual

[3] Heating ventilating and air conditoning designed to control environmental conditions in an internal space

[4] Space type in this document refers to internal spaces intended for a different type of use e.g. warehouse, manufacturing, office, circulation etc

- Input annual HVAC and lighting energy use into Green Star Energy and GHG Emissions Calculator – Separated into electrical and combustible heating energy demands (combustible heating demands are given a $CO_{2\text{-}e}$ factor of 0.25 kg $CO_{2\text{-}e}$/kWh)

3.6 Reference Building Model energy use for other building services

Calculate the annual energy use for building services other than HVAC and lighting:

- Use manual calculation procedures to calculate energy use for other building services in the Reference Building Model described in Section 6
- Input annual energy use for other building services into Green Star Energy and GHG Emissions Calculator – separated for each different energy source

3.7 Reference Building Model energy benchmark

- The Green Star spreadsheet will sum together the annual HVAC, lighting and other services annual energy use to form the Reference Building Model energy benchmark in kWh/m^2/year based on the assessable area

3.8 ENE-1 Compliance

- In order to comply with ENE-1 the energy benchmark of the Actual Building Model must be less than the energy benchmark of the Reference Building Model
- The Green Star spreadsheet will indicate whether ENE-1 compliance has been achieved or not

3.9 ENE-1 Points allocation

The determination of ENE-1 points using the Two-model approach is as follows:

- The Green Star spreadsheet will calculate percentage reduction in energy benchmark of the Actual Building Model over the Reference Building Model
- The Green Star spreadsheet will then determine number of points achieved based on improvement over the Reference Building Model in Table 1 below:

TABLE 1 – ENE-1 points allocation

Percentage Reduction in Energy benchmark compared to Reference Building Model	Green Star points for ENE-1 Credit
0%	5
20%	6
40%	7
60%	8
80%	9
100%	10

3.10 On-site energy generation and on-site renewable energy generation

Take account of any on-site electricity generation (e.g. co-generation) and/or any on-site renewable energy generation (e.g. photovoltaics, wind turbine) but excluding any solar thermal hot water heating or waste heat water heating (this will be taken account of in manual domestic hot water heating calculation in Section 6) as follows:

- Calculate annual electricity generation solely for the proposed building from any on-site generation

- Calculate annual electricity generation solely for the proposed building from any renewable on-site generation
- Provide documentation to accompany the energy calculations including at a minimum:
  - On-site/on-site renewable energy installed capacity
  - On-site/on-site renewable annual energy calculation methodology including all assumptions
- Input annual on-site energy generation into the Green Star spreadsheet energy calculator based on energy source and separate into combustible and non-combustible generation
- Input annual on-site renewable energy generation into Green Star energy and GHG emissions calculator

3.11 ENE-2 Points allocation

The determination of ENE-2 points using the Two-model approach is as follows, the Green Star Spreadsheet will:

- Subtract any contribution from on-site renewable energy generation from the Actual Building Model energy benchmark
- Then convert the adjusted Actual Building Model energy benchmark to annual carbon dioxide emissions based on annual kWh/m^2 for each energy source and associated emission factor
- Then convert any on-site energy generation to annual carbon dioxide emissions based on annual kWh/m^2 for each energy source and associated emission factor
- Then sum together annual carbon dioxide emissions and any carbon dioxide emissions from on-site energy generation
- Convert the Reference Building Model energy benchmark to annual carbon dioxide emissions based on annual kWh/m^2 for each energy source
- Then calculate the percentage reduction in carbon dioxide emissions of the Actual Building Model over the Reference Building Model
- Then determine number of points achieved based on improvement over the Reference Building Model in Table 2 below:

TABLE 2 – ENE-2 GHG emissions reductions points allocation

Percentage Reduction in CO_{2-e} emissions compared to Reference Building Model	Green Star points for ENE-2 Credit
0%	0
10%	1
20%	2
30%	3
40%	4
50%	5
60%	6
70%	7
80%	8
90%	9
100%	10

4 Actual and Reference Building Model Description

The required model inputs for the Actual and Reference building models and documentation is described as follows:

TABLE 3 – Actual and Reference Building Model inputs for HVAC simulation

Model Input	Actual Building Model	Reference Building Model	Documentation Required
Thermal simulation software	▪ The software must be of the dynamic thermal modelling type with the ability to model thermal mass effects employing either the response factor or finite difference thermal calculation method AND ▪ Must be capable of modelling representative building attributes, building elements, and building services systems and controls AND ▪ Must be capable of modelling all Actual and Reference Building Model inputs described in this guide AND ▪ Must have been independently verified to meet the Building Energy Simulation and Diagnostic Method (BESTEST) benchmark for energy simulation programs AND/OR	▪ Same as the Actual Building Model	Verification Documents: ▪ Confirmation that the software meets either BESTEST or ANSI/ASHRAE Standard 140-2004 performance criteria Energy Report: ▪ Brief description of the software package including thermal calculation method ▪ Brief description of how the software represents building services systems and controls

Model Input	Actual Building Model	Reference Building Model	Documentation Required
	▪ Must have been independently verified to meet ANSI/ASHRAE Standard 140-2004 (Building Thermal Envelope and Fabric Test Loads)		
Weather file	▪ Must be hourly weather data for the site based on either IWEC source data created by ASHRAE or NIWA source data in TMY format (or other file sanctioned by NZGBC) and represent an average year's conditions for a weather station. ▪ In the absence of actual weather data for the site a weather file for a climate representative of the local climate to the building must be used.	▪ Same as the Actual Building Model	Verification Documents: ▪ N/A Energy Report: ▪ Hourly weather file used ▪ Weather station location ▪ If weather station is not site location justification as to how the weather file used is representative of the local climate for the building (to be checked by NZGBC during registration of the project for Green Star)
Site orientation	▪ As building design	▪ Same as the Actual Building Model	Verification Documents: ▪ Design or as-installed (where appropriate) relevant drawings showing building orientation Energy Report: ▪ Details of how the orientation has been defined within the model
Building overshadowing	▪ Include the affect of overshadowing from the surrounding environment for annual energy simulation	▪ Same as the Actual Building Model	Verification Documents: ▪ Design or as-installed (where appropriate) relevant drawings showing elements of the surrounding environment causing overshadowing

Model Input	Actual Building Model	Reference Building Model	Documentation Required
			(existing buildings, existing trees etc) Energy Report: ■ Details of how overshadowing from the external environment has been represented in the model
Building geometry	■ As building design	■ The same geometric form as the proposed building ■ Same total assessable area, roof and wall area ■ Same number of stories and overall dimensions ■ Same room layouts and adjacencies	Verification Documents: ■ Design or as-installed (where appropriate) drawings ■ Summary of the assessable area calculation for the whole building Energy Report: ■ Details of how the building's physical characteristics have been accurately represented in the model ■ Details of simplifications (if any) made to the physical characteristics in the model and their effect on the accuracy of the outputs
Modelled spaces	■ Must account for all conditioned[5] and unconditioned spaces in the building ■ Use the appropriate area for each space type	■ Same as the Actual Building Model	Verification Documents: ■ N/A Energy Report: ■ Description of all the modelled

[5] That part of a building within the building thermal envelope, including all space types, that may be directly heated or cooled (via either mechanical cooling, mechanical ventilation or natural ventilation) to control internal environmental conditions

Model Input	Actual Building Model	Reference Building Model	Documentation Required
			conditioned and unconditioned spaces ■ Description of the modelled usable area for each modelled space type and a description of the variance between the actual measured usable area
Thermal zoning	■ All conditioned spaces must be zoned to reflect the system design performance and layout with regard to solar orientation	■ Same as the Actual Building Model	Verification Documents: ■ N/A Energy Report: ■ Description of design zoning and how thermal zoning has been defined within the model
Building thermal envelope	■ As specified	■ Building thermal envelope to meet equivalent NZBC minimum thermal requirements for large buildings[1] **for all conditioned spaces only** ■ Use the NZS:4243 schedule method to determine R-values for each associated building element in the Reference Building Model ■ Where reference glazing R-value is not listed use 0.18 m^2.K/W to represent single glazing	Verification Documents: ■ Design or as-built (where appropriate) drawings showing building thermal envelope materials ■ Materials schedule or specification extracts listing material properties or limits for all thermal envelope materials ■ Materials schedule or specification extracts listing R-values for each building thermal envelope element Energy Report: ■ Details of how the Actual and Reference Building Model building thermal envelope have been modelled ■ Description of R-values modelled for

Model Input	Actual Building Model	Reference Building Model	Documentation Required
			the Reference Building Model thermal envelope in line with the NZS:4243 schedule
Building Construction	▪ As specified	▪ Fast thermal response or 'Lightweight' construction. See Appendix B for definition of each lightweight construction element	Verification Documents: ▪ Design or as-built (where appropriate) drawings showing building structure materials Energy Report: ▪ Details of how the Actual and Reference Building Model Building structure has been modelled
External surface Solar Reflectance	▪ As specified or if unknown use the same as the Reference Building Model	▪ Solar Reflectance = 0.3 (ASHRAE) ▪ To be assigned to all external surfaces	Verification Documents: ▪ Design or as-built Solar Reflectance for applicable external surfaces Energy Report: ▪ Details of how the Actual and Reference Building Model building solar reflectance has been modelled
Area of glazing	▪ As building design	▪ Low height space types (e.g. offices, circulation): Glazing window to wall ratio (WWR) shall equal 50% of the above grade perimeter external wall area of conditioned spaces, and shall be distributed uniformly across each external wall where glazing is present in the Actual Building Model	Verification Documents: ▪ Design or as-built (where appropriate) relevant drawings showing all glazing to the above grade perimeter external wall area Energy Report: ▪ Calculation of the glazing WWR for the Actual Building Model

Model Input	Actual Building Model	Reference Building Model	Documentation Required
		OR ▪ Tall space types (e.g. Warehouse, manufacturing space): Glazing WWR shall equal that of the Actual Building Model or 50% of the above grade perimeter external wall area of conditioned spaces, whichever is smaller, and shall be distributed uniformly across each external wall where glazing is present in the Actual Building Model AND ▪ The WWR calculation should be based on external wall area adjacent only to conditioned spaces	▪ Details of the glazing WWR modelled in the Reference Building Model ▪ Details of the areas of glazing on each façade for both the Actual and Reference Building Model

Model Input	Actual Building Model	Reference Building Model	Documentation Required
Glazing G-value[6]	▪ As specified	▪ 0.87	Verification Documents: ▪ Materials schedule or specification extracts listing glazing G-value OR ▪ Materials schedule or specification extracts listing glazing Shading Coefficient, Solar Heat Gain Coefficient or Solar Factor and the resulting glazing G-value Energy Report: ▪ Details of how the glazing G-value has been represented in the model
Area of skylight	▪ As building design	▪ Skylight area shall equal that of the proposed building or 5% of the gross roof area, whichever is smaller (ASHRAE)	Verification Documents: ▪ Design or as-built (where appropriate) relevant drawings showing total area of skylight Energy Report: ▪ Calculation of the skylight area as a percentage of the gross roof area for the Actual Building Model ▪ Details of the skylight area modelled in the Reference Building Model
Skylight G-value	▪ As specified	▪ 0.87	Verification Documents:

[6] The G-value is defined as the sum of the direct solar transmittance and the heat transferred by radiation and convection into the space (CIBSE). This is also known as the solar factor or solar heat gain coefficient

Model Input	Actual Building Model	Reference Building Model	Documentation Required
			▪ Materials schedule or specification extracts listing skylight G-value OR ▪ Materials schedule or specification extracts listing skylight Shading Coefficient, Solar Heat Gain Coefficient or Solar Factor and the resulting skylight G-value Energy Report: ▪ Details of how the skylight G-value has been represented in the model
Fixed external solar shading device[7]	▪ As building design	▪ None	Verification Documents: ▪ Design or as-installed (where appropriate) relevant drawings showing all fixed external shading device Energy Report: ▪ Details of how the fixed external shading device have been represented in the Actual Building Model
Manually controlled internal shading device e.g. curtains, blinds etc	▪ Not modelled unless daylight harvesting control taken account of in Actual Building Model	▪ Not modelled	N/A

[7] This includes any fixed building element providing solar shading e.g. louvers, roof overhangs, and balconies etc

Model Input	Actual Building Model	Reference Building Model	Documentation Required
Manually controlled external shading device e.g. solar control blinds, external louvers/screens	▪ As specified ▪ Controlled to be in closed position when incident solar radiation measured at the building element to be shaded > 150 W/m^2 and open when incident solar radiation < 150 W/m^2	▪ Not modelled	Verification Documents: ▪ Design or as-installed (where appropriate) relevant drawings showing all manually controlled external shading device ▪ Specification extracts listing control description for manually controlled shading device Energy Report: ▪ Details of how the manually controlled shading device have been represented in the Actual Building Model ▪ Description of how the manually controlled shading device is controlled in the Actual Building Model
Automatically controlled shading device e.g. solar control blinds, external louvres	▪ As specified ▪ Controlled to be in open/closed position determined by incident solar radiation as specified.	▪ Not modelled	Verification Documents: ▪ Design or as-installed (where appropriate) relevant drawings showing all automatically controlled external shading device ▪ Specification extracts listing control description for automatically controlled shading devices Energy Report: ▪ Details of how the automatically controlled shading device have been represented in the Actual Building Model

Model Input	Actual Building Model	Reference Building Model	Documentation Required
			▪ Description of how the automatically controlled shading device is controlled in the Actual Building Model
Design space temperature and humidity conditions	▪ As specified for each space type in the building, including specified control range and dead-bands	▪ Same as the Actual Building Model	Verification Documents: ▪ Specification extracts listing design space temperature and humidity conditions for each conditioned space type in the building Energy Report: ▪ Description of design space temperatures and humidity for each conditioned space type in both the Actual and Reference Building Model
Manually controlled natural ventilation openings	▪ As specified ▪ Must be controlled to achieve NZBC minimum outdoor air rates for each space type during operating hours including heating season ▪ Modelled to control using actual free opening areas ▪ Opening control must take into account control lag through increase in control deadband; 2°C increase above design cooling temperature and 2°C below design heating temperature	▪ Not modelled	Verification Documents: ▪ Specification extracts listing opening sizes and control mechanism Energy Report: ▪ Details of how the natural ventilation system has been modelled including control strategy
Automatically controlled natural ventilation openings	▪ As specified. Energy saving controls specified (e.g. night purge) can be included but the model must	▪ Not modelled	Verification Documents: ▪ Specification extracts listing opening sizes and control mechanism

Model Input	Actual Building Model	Reference Building Model	Documentation Required
	take account of any effects these may have on other Credit Criteria (e.g. thermal comfort) ■ Must be controlled to achieve NZBC minimum outdoor air rates for each space type during operating hours including heating season ■ Opening control modelled as specified using actual free opening areas		Energy Report: ■ Details of how the natural ventilation system has been modelled including control strategy
HVAC system type	■ As specified	■ As defined in Appendix C, Figure 1 for each conditioned space type	Verification Documents: ■ Drawings or schematics showing all HVAC systems in the building ■ Specification extracts describing all HVAC system types for all conditioned spaces in the building Energy Report: ■ Description of all HVAC system types modelled in both the Actual and Reference Building Model
HVAC system definition	■ As specified system design and components ■ Heating plant COP calculated and modelled at applicable design operating conditions at a minimum of 25%, 50%, 75%, and 100% part load efficiencies ■ Cooling plant EER calculated and	■ HVAC system must be modelled as described in Appendix C ■ All HVAC system components must be modelled as described in Appendix D	Verification Documents: ■ Specification extracts describing all HVAC system components Energy Report: ■ Description of all HVAC system components modelled in both the Actual

Model Input	Actual Building Model	Reference Building Model	Documentation Required
	modelled at applicable design operating conditions at a minimum of 25%, 50%, 75%, 100% part load efficiencies ▪ All HVAC components must be modelled as described in Appendix D		and Reference Building Model. At a minimum the requirements described in Appendix D
Minimum outdoor air rate	▪ As specified and claimed in IEQ-2 Ventilation Rate Credit for each space type ▪ Outdoor air rate for each space type must be achieved during operating hours	▪ NZBC minimum for each space type ▪ If space type not covered under NZBC use the same outdoor air rate as in the Actual Building Model	Verification Documents: ▪ IEQ-2 Credit submission Energy Report: ▪ N/A
Heating and cooling plant capacity	▪ As specified	▪ Sized for the Reference Building Model	Verification Documents: ▪ Specification extracts describing the specified heating and cooling plant capacities Energy Report: ▪ Description of the heating and cooling plant capacities modelled for the Actual and Reference Building Model
Piping/duct heat losses/gains	▪ 5%	▪ 5%	Energy Report: ▪ Description of piping/duct heat losses/gains modelled for both the Actual and Reference Building Model
HVAC plant operating schedule	▪ As specified	▪ Same as the Actual Building Model	Verification Documents: ▪ Specification extracts describing the proposed HVAC plant operating schedule

Model Input	Actual Building Model	Reference Building Model	Documentation Required
			Energy Report: ▪ Description of the modelled HVAC plant operating schedule for all conditioned space types for both the Actual and Reference Building Model
Heating plant energy source	▪ As specified	▪ 0.25kg CO_{2-e}/kWh/year carbon emission factor	Verification Documents: ▪ Specification extracts describing the heating plant energy source Energy Report: ▪ Description of the heating plant energy source for both the Actual and Reference Building Model
Cooling plant energy source	▪ As specified	▪ Grid supplied electricity	Verification Documents: ▪ Specification extracts describing the cooling plant energy source
Lighting power density	▪ As specified for each space type	▪ For each space type use lighting power density limits defined in NZS:4243.2 Table 1 ▪ For any space types not listed in NZS:4243.2 Table 1 use lighting power density calculation (NZS:4243.2 Section 3.4.9) with reference to AS/NZS 1680.2 maintained illuminance levels to determine lighting power density limit ▪ If the exact space type isn't listed in AS/NZS 1680.2, select	Verification Documents: ▪ As specified design lighting levels which will be provided for each space type ▪ Luminaire schedule ▪ Reflected ceiling plans clearly showing each typical lighting layout and the types of luminaires used Energy Report: ▪ Calculations showing the modelled lighting power density for each space type in the Actual and Reference

Model Input	Actual Building Model	Reference Building Model	Documentation Required
		most appropriate space type and associated maintained illuminance level	Building Model ■ Justification for selection of appropriate space types and associated maintained illuminance level for any that are not listed in AS/NZS 1680.2
Lighting schedule	■ As specified and taking account of daylight harvesting control where specified ■ Daylight harvesting control must take into account the operation of any internal blinds and affect of resulting lighting levels	■ Same as the Actual Building Model but excluding any daylight harvesting control	Verification Documents: ■ Specification extracts describing the proposed lighting operating schedule ■ Specification extracts describing any daylight harvesting control and control settings Energy Report: ■ Description of the modelled lighting operating schedule for both the Actual and Reference Building Model ■ Description of how the effect of any daylight harvesting control has been incorporated into the energy calculation ■ Justification for selection of appropriate lighting power densities for space types that are not listed.
Small power density	■ As specified for each space type	■ Same as the Actual Building Model	Verification Documents: ■ Schedule or specification documents describing the installed small power density in each space type Energy Report: ■ Description of the mean small power density modelled for each space type in

Model Input	Actual Building Model	Reference Building Model	Documentation Required
			both the Actual and Reference Building Model
Small power schedule	▪ As specified	▪ Same as the Actual Building Model	Verification Documents: ▪ Specification extracts describing the designed small power operating schedule for each space type Energy Report: ▪ Description of the modelled small power operating schedule for each space type in both the Actual and Reference Building Model
Process load density	▪ As specified for each space type	▪ Same as the Actual Building Model	Verification Documents: ▪ Schedule or specification documents describing the installed process load density in each space type Energy Report: ▪ Description of the mean process load density modelled for each space type in both the Actual and Reference Building Model
Process load schedule	▪ As specified	▪ Same as the Actual Building Model	Verification Documents: ▪ Specification extracts describing the designed process load operating schedule for each space type Energy Report: ▪ Description of the modelled process

Model Input	Actual Building Model	Reference Building Model	Documentation Required
			load operating schedule for all spaces in both the Actual and Reference Building Model
Occupancy density	▪ As specified for each space type	▪ Same as the Actual Building Model	Verification Documents: ▪ Schedule or specification documents describing the design occupancy density for each space type Energy Report: ▪ Description of the intended activities and associated occupant sensible and latent gains for each space type ▪ Occupancy density modelled for each space type in both the Actual and Reference Building Model
Occupancy schedule	▪ As specified	▪ Same as the Actual Building Model	Verification Documents: ▪ Specification extracts describing the designed occupancy schedule for each space type Energy Report: ▪ Description of the modelled occupancy schedule for each space type in both the Actual and Reference Building Model
Infiltration	▪ Infiltration must be modelled to reflect façade design specification for different space types. These would vary based on space type e.g. clean rooms and freezers are likely to have	▪ 0.5 ACH 24 hours/day/7 days a week for all spaces	Verification Documents: ▪ Design or as-installed (where appropriate) relevant drawings showing façade design specification for each

Model Input	Actual Building Model	Reference Building Model	Documentation Required
	highly controlled infiltration rates compared to warehouses ■ External openings larger than 2m^2 (typical door) must be explicitly modelled with applicable operation profile		space type Energy Report: ■ Description of the infiltration rate modelled for each space type in both the Actual and Reference Building Model ■ Description of how any significant external openings have been modelled ■ Description of how any measures to reduce infiltration effect just as door curtains and heating systems have been modelled

5 Schedule Method Approach

5.1 Performance Benchmarks

In order to meet the alternative Schedule Method option under ENE-1 each building element must meet the performance benchmarks described in Table 3 below:

TABLE 4 – Performance benchmarks required for ENE-1 Schedule Method approach

Item Number	Building Element	Performance Benchmark	Documentation Required	Comment
1	Building thermal envelope	▪ Building Thermal Envelope to meet equivalent NZBC minimum requirements for large buildings for all conditioned spaces ▪ Where proposed WWR ≤ 50% use the NZS:4243 schedule method to determine minimum R-values required ▪ Where proposed WWR > 50% use the NZS:4243 calculation method to determine minimum R-values required	Verification Documents: ▪ Design or as-installed (where appropriate) relevant drawings showing building thermal envelope materials specified ▪ Materials schedule or specification extracts listing R-values for each building thermal envelope element Schedule Method report: ▪ Description of how the building complies with the NZS:4243 schedule method	Refer to NZS:4243 Energy Efficiency – Large Buildings, Part 1: Building Thermal Envelope
2	Glazing G-value	▪ ≤ 0.87	Verification Documents: ▪ Materials schedule or specification extracts listing glazing G-value OR ▪ Materials schedule or specification extracts listing glazing Shading Coefficient, Solar Heat Gain Coefficient or Solar factor and the	

Item Number	Building Element	Performance Benchmark	Documentation Required	Comment
			resulting glazing G-value Schedule Method report: ■ Brief summary of glazing G-values specified	
3	Skylight area	■ ≤ 5% gross roof area	Verification Documents: ■ Design or as-installed (where appropriate) relevant drawings showing all skylight area Schedule Method report: ■ Calculation of the skylight area as a percentage of the gross roof area	
4	Skylight G-value	■ ≤ 0.87	Verification Documents: ■ Materials schedule or specification extracts listing skylight G-value OR ■ Materials schedule or specification extracts listing skylight Shading Coefficient, Solar Heat Gain Coefficient or Solar factor and the resulting skylight G-value Schedule Method report: ■ Brief summary of skylight G-values specified	
5	HVAC system	■ Each applicable HVAC system component must meet Reference Building Model HVAC system	Verification Documents: ■ Specification extracts describing all HVAC system components	

Item Number	Building Element	Performance Benchmark	Documentation Required	Comment
		description as described in Appendix C in terms of: a) Heating system seasonal efficiency b) Cooling plant EER's c) Supply fan absorbed power d) Return fan absorbed power e) Chilled water pump absorbed power f) Heating water pump absorbed power g) Exhaust air heat recovery h) Economiser	Schedule Method report: ▪ Description of all HVAC system components with reference to each performance criteria	
6	Outdoor air	▪ Minimum outdoor air rates must achieve the NZBC minimum requirements for each space	Verification Documents: ▪ IEQ-1 Credit submission Schedule Method report: ▪ Brief summary of outdoor air rates supplied to each space type	
7	Lighting	▪ The design lighting power density for each space type must not exceed lighting power density limits defined in NZS:4243.2 Table 1 ▪ For any space types not listed in NZS:4243.2 Table 1 use lighting power density calculation (NZS:4243.2 Section 3.4.9) with reference to AS/NZS 1680.2 maintained	Verification Documents: ▪ As specified design lighting levels which will be provided for each space type ▪ Luminaire schedule ▪ Reflected ceiling plans clearly showing each typical lighting layout and the types of luminaires used	

Item Number	Building Element	Performance Benchmark	Documentation Required	Comment
		illuminance levels to determine lighting power density limit ■ If the exact space type isn't listed in AS/NZS 1680.2, select most appropriate space type and associated maintained illuminance level	Schedule Method report: ■ Calculations showing the lighting power density for each space type ■ Justification for selection of appropriate space types and associated maintained illuminance level for any that are not listed in AS/NZS 1680.2	
8	Domestic hot water heating system thermal efficiency	■ ≥ 80% thermal efficiency	Verification Documents: ■ Schedule or specification extract describing the domestic hot water heating system type and thermal efficiency Schedule Method report: ■ Brief description of DHW heating system and the thermal efficiency	
9	Domestic hot water sanitary fittings	■ A maximum of 9 litres/min for showers ■ A maximum of 6 litres/min for hot water taps	Verification Documents: ■ Schedule or specification documents describing the flow rates for specified shower and hot water tap fittings Schedule Method report: ■ Brief description of sanitary fittings specified and their flow rates or Wat-1 Credit documentation	
10	Domestic hot water Pipe insulation	■ All domestic hot water pipework must be insulated to provide a total R-value	Verification Documents: ■ Schedule or specification extract describing the level of insulation	

Item Number	Building Element	Performance Benchmark	Documentation Required	Comment
		≥ 0.3m^2.K/W	required for domestic hot water pipework Schedule Method report: ■ Brief description of DHW pipework insulation specified and R-value	
11	Chilled water flow and return pipework insulation	■ Minimum total R-value for cooling system ≥ 65 kWr capacity but ≤ 250 kWr capacity: a) Located internally = 0.9 b) Located within a wall space, an enclosed sub-floor area or an enclosed roof space = 1.0 c) Located outside the building or in an unenclosed sub-floor area or an unenclosed roof space = 1.1 ■ Minimum total R-value for cooling system > 250 kWr capacity: a) Located internally = 1.2 b) Located within a wall space, an enclosed sub-floor area or an enclosed roof space = 1.3 c) Located outside the building or in an unenclosed sub-floor area or an unenclosed roof space = 1.4	Verification Documents: ■ Schedule or specification extract describing the level of insulation required for chilled water pipework Schedule Method report: ■ Brief description of chilled water pipework insulation specified and R-value	

Item Number	Building Element	Performance Benchmark	Documentation Required	Comment
12	Heating water flow and return pipework insulation	■ Minimum total R-value for heating system ≤ 65 kW capacity: a) Located internally = 0.2 b) Located within a wall space, an enclosed sub-floor area or an enclosed roof space = 0.45 c) Located outside the building or in an unenclosed sub-floor area or an unenclosed roof space = 0.6 ■ Minimum total R-value for heating system > 65 kW capacity: a) Located internally = 0.6 b) Located within a wall space, an enclosed sub-floor area or an enclosed roof space = 0.7 c) Located outside the building or in an unenclosed sub-floor area or an unenclosed roof space = 0.8	Verification Documents: ■ Schedule or specification extract describing the level of insulation required for heating water pipework Schedule Method report: ■ Brief description of heating water pipework insulation specified and R-value	
13	Ductwork insulation	■ Minimum total R-value for ductwork and fittings for systems ≤ 65 kWr cooling capacity and 65 kW heating capacity: a) Evaporative cooling system = 0.6 b) Heating-only system or refrigerated cooling system = 1.0 c) Combined heating and refrigerated cooling system = 1.5 d) Fittings for each system type = 0.4	Verification Documents: ■ Specification extracts describing the levels of insulation for ductwork serving air conditioned spaces Schedule Method report: ■ Brief description of all ductwork insulation specified and R-value	

Item Number	Building Element	Performance Benchmark	Documentation Required	Comment
		▪ Minimum total R-value for ductwork and fittings for systems > 65 kWr cooling capacity and 65 kW heating capacity: a) Evaporative cooling system within a conditioned space = Nil b) Evaporative cooling system in all other locations = 0.9 c) Heating system or refrigerated cooling system within a conditioned space = 1.3 d) Heating system or refrigerated cooling system in all other locations = 1.8		

6 Manual calculations for services other than HVAC and lighting

6.1 Actual Building Model

6.1.1 Mechanical ventilation

- Calculate annual energy use for mechanical ventilation not already accounted for in the energy model e.g. toilet extract
- Use specified fans, fan total efficiencies (product of fan and motor efficiency), flow rates and total pressure (static and dynamic)
- Use specified mechanical extract operation schedules
- Provide verification documentation:
  - Design or as-installed (where appropriate) relevant drawings or schematics showing all mechanical extract
  - Schedule or specification extract describing all mechanical extract
  - Specification extracts describing the proposed mechanical extract operating schedule
- Include in energy report:
  - Manual calculation methodology for mechanical extract

6.1.2 Domestic hot water

- Calculate annual energy use for **domestic** hot water use e.g. Bathrooms and Kitchenettes, wash hand basins, showers etc with reference to water consumption calculated in Wat-1 Credit. **Do not include any hot water required for any Education or Industrial process**
- Use specified domestic hot water generation system efficiency
- Use actual domestic hot water heating energy source
- Take account of any waste heat recovery
- Take account of any solar thermal hot water generation
- Provide verification documentation:
  - Schedule or specification extract describing domestic hot water generation system
- Include in energy report:
  - Manual calculation methodology for domestic hot water
  - Manual calculation methodology for any waste heat recovery water heating
  - Manual calculation methodology for any solar thermal hot water generation

6.1.3 Hydraulics pumps

- Calculate annual energy use for all hydraulics pumps not already accounted for in the energy model. **Do not include any pump energy required for any industrial process**.
- Use specified pumps, pump efficiencies, flow rates and total pump head
- Use specified operation schedules
- Provide verification documentation:
  - Design or as-installed (where appropriate) relevant drawings or schematics showing all hydraulics pumps
  - Schedule or specification extract describing all hydraulics pumps
  - Specification extracts describing the proposed mechanical extract operating schedule
- Include in energy report:
  - Manual calculation methodology for hydraulics pump energy

6.1.4 Lifts

- Calculate the annual energy use due to lifts (where installed)
- Either use the calculation methodology described in Appendix E or use alternative methodology
- Take account of any regenerative lift technology installed
- Provide verification documentation:
  - Lift data sheets
- Include in energy report:
  - Manual calculation for lift energy

6.1.5 Standby generators

Calculation of the energy use for standby generators is not required where these are installed for energy or outage periods only. Should generators be used for on-site power or heat generation these must be accounted for in the building energy use carbon emissions calculator.

6.2 Reference Building Model

6.2.1 Mechanical ventilation

- Calculate annual mechanical ventilation for all spaces not modelled in the Energy model
- Use mechanical extract fan power:
  - Mechanical extract volume < 9,400 L/s = 1.9 W/L/s (ASHRAE)
  - Mechanical extract volume ≥ 9,400 L/s = 1.7 W/L/s (ASHRAE)
- Use the same mechanical extract operation schedules as in the Actual Building Model
- Include in energy report:
  - Manual calculation methodology for mechanical extract for Reference Building Model

6.2.2 Domestic hot water

- Use a domestic hot water generation system thermal efficiency of 80%
- Use carbon factor of 0.25kg CO_2/kWh/year for hot water heating energy source
- Use the same domestic hot water consumption as assumed for the Actual Building Model
- Do not include any waste heat recovery
- Do not include any solar thermal hot water generation
- Include in energy report:
  - Manual calculation methodology for domestic hot water for the Reference Building Model

6.2.3 Hydraulics pumps

- Calculate annual pumping energy for all hydraulics pumps not modelled in the energy model
- Use pump power:
  - 0.30 W/Litres/s
- Use the same pumping flow rates as in the Actual Building Model
- Use the same hydraulics pumps operation schedules as in the Actual Building Model
- Include in energy report:
  - Manual calculation methodology for hydraulics pump energy for Reference Building Model

6.2.4 Lifts

- Use standard values of:
  - 4 kWh/m^2 of assessable area for low rise buildings where lifts serve up to 4 storeys
  - 6 kWh/m^2 of assessable area for buildings where lifts serve up to 10 storeys
  - And additional 0.5 kWh/m^2 of for each additional storey over 10 storeys

6.2.5 Standby generators

Calculation of the energy use for standby generators is not required.

7 Example Energy Calculation

The following table describes the actual and reference model inputs for an example industrial facility located in Whangarei:

TABLE 5 – Description of Actual and Reference Building model inputs for example energy calculation

Model Input	Actual Building Model	Reference Building Model
Weather file	▪ Facility is in the Greater Auckland region so Auckland NIWA weather file used as most representative of the weather files available	▪ Auckland NIWA weather file used
Site Orientation	▪ 10° W of N	▪ 10° W of N
Overshadowing	▪ Overshadowing from an adjacent building and hill modelled	▪ Overshadowing from an adjacent building and hill modelled
Geometry	▪ Single storey ▪ L-shaped floor plate ▪ 2,000 m^2 assessable area	▪ Single storey ▪ L-shaped floor plate ▪ 2,000 m^2 assessable area
Modelled spaces	▪ Warehouse ▪ Office ▪ Manufacturing space ▪ Store rooms (unconditioned space) ▪ Corridors (unconditioned space)	▪ Warehouse ▪ Office ▪ Manufacturing space ▪ Store rooms (unconditioned space) ▪ Corridors (unconditioned space)
Thermal zoning	▪ Warehouse = 1 no. thermal zone ▪ Office = 2 no. thermal zones	▪ Warehouse = 1 no. thermal zone ▪ Office = 2 no. thermal zones

Model Input	Actual Building Model	Reference Building Model
	■ Manufacturing space = 1 no. thermal zone	■ Manufacturing space = 1 no. thermal zone
Building thermal envelope	■ Warehouse uninsulated ■ Office: - Single glazed - Wall insulation - Roof insulation ■ Manufacturing space uninsulated ■ Store rooms uninsulated ■ Corridors uninsulated	■ Warehouse thermal envelope meets NZS:4243 schedule method as a conditioned space ■ Office thermal envelope meets NZS:4243 schedule method as a conditioned space ■ Manufacturing space thermal envelope meets NZS:4243 schedule method as a conditioned space ■ Store rooms uninsulated as not a conditioned space ■ Corridors uninsulated as not a conditioned space
Building Construction	'Heavyweight' construction for all space types: ■ Concrete block external walls ■ Concrete block partition walls	■ 'Lightweight' construction as per Appendix B for all space types
External surface Solar Reflectance	■ Roof = 0.7 ■ External walls = 0.3	■ Roof = 0.3 ■ External walls = 0.3
Area of glazing	■ Warehouse: 20% WWR ■ Office: 30% WWR ■ Manufacturing space:5% ■ Store rooms: 0% WWR ■ Corridors: 10% WWR	■ Warehouse (Tall space type): 20% WWR distributed uniformly across each external wall where glazing is present in the Actual Building Model ■ Office (Low height space type): 50% WWR distributed uniformly across each external wall where glazing is present in the Actual Building Model ■ Manufacturing space (Tall space type): 5% WWR distributed uniformly across each

Model Input	Actual Building Model	Reference Building Model
		external wall where glazing is present in the Actual Building Model ■ Store rooms: 0% WWR ■ Corridors: 0% WWR (As unconditioned space)
Glazing G-value	■ 0.5	■ 0.87
Area of skylight	■ 8% of the gross roof area	■ 5% of the gross roof area
Skylight G-value	■ 0.5	■ 0.87
Fixed external solar shading device	■ Fixed external horizontal solar shading to North facade	■ Not modelled
Manually controlled internal shading device e.g. curtains, blinds etc	■ Not modelled	■ Not modelled
Manually controlled external shading device e.g. solar control blinds, external louvers/screens	■ Not specified	■ Not modelled
Automatically controlled shading device e.g. solar control blinds, external louvres	■ No automatically controlled shading device	■ Not modelled
Design temperature conditions	■ Warehouse = Heating only 16°C ■ Office = 21°C/22°C +/- 1.5°C ■ Manufacturing space = Cooling only 22°C ■ Store room = Unconditioned space ■ Corridors = Unconditioned space	■ Warehouse = Heating only 16°C ■ Office = 21°C/22°C +/- 1.5°C ■ Manufacturing space = Cooling only 22°C ■ Store room = Unconditioned space ■ Corridors = Unconditioned space

Model Input	Actual Building Model	Reference Building Model
Manually controlled natural ventilation openings	▪ Warehouse = High level ventilation louvers ▪ Office = None specified ▪ Manufacturing space = None specified	▪ Not modelled
Automatically controlled natural ventilation openings	▪ None specified	▪ Not modelled
HVAC system type	▪ Warehouse = Electric radiant heating ▪ Office = Fan coil units (Chiller/heat pump) ▪ Manufacturing space = CAV system (Chiller/heat pump)	▪ Warehouse = CAV multizone system ▪ Office = CAV multizone system ▪ Manufacturing space = CAV multizone system
HVAC system definition	▪ Electric radiant heating = 95% thermal efficiency ▪ Air source heat pump = 200 kW ▪ Air source chiller = 300 kW ▪ 200kWr air source heat pump serving fan coil units and CAV system: - Heating plant EER @ 100% load = 3.1 - Heating plant EER @ 75% load = 3.3 - Heating plant EER @ 50% load = 3.6 - Heating plant EER @ 25% load = 3.5 ▪ 300kWr air source chiller serving fan coil units and CAV system: - Cooling plant EER @ 100% load = 3.0 - Cooling plant EER @ 75% load = 3.2 - Cooling plant EER @ 50% load = 3.5 - Cooling plant EER @ 25% load = 3.4	▪ One CAV multizone System serving all conditioned spaces ▪ Heating plant seasonal COP = 80% thermal efficiency ▪ As cooling capacity in Actual Building Model ≤ 525kWr: - Cooling plant EER @ 100% load = 2.2 - Cooling plant EER @ 75% load = 3.0 - Cooling plant EER @ 50% load = 3.0 - Cooling plant EER @ 25% load = 3.0 ▪ Heat recovery with 50% effectiveness ▪ Economiser with 18°C high level shut-off as Whangarei falls within NZS:4243 climate zone 1

Model Input	Actual Building Model	Reference Building Model
	▪ Heat recovery system With 65% effectiveness ▪ Economiser with 18℃ high level shut-off	
Minimum outdoor air rate	▪ Warehouse = Naturally ventilated ▪ Office space = 1 point under IEQ-2 ▪ Manufacturing space = No outdoor air	▪ Warehouse = No outdoor air ▪ Office space = NZBC minimum of 10lit/s/person ▪ Manufacturing space = No outdoor air
Pipe/duct heat losses/gains	▪ 5%	▪ 5%
HVAC plant operating schedule	▪ Warehouse = 24 hours ▪ Office = 10 hours/day, weekdays ▪ Manufacturing space = 10 hours/day, weekdays	▪ Warehouse = 24 hours ▪ Office = 10 hours/day, weekdays ▪ Manufacturing space = 10 hours/day, weekdays
Heating plant energy source	▪ Electricity	▪ 0.25kg $CO_{2\text{-}e}$/kWh/year carbon emission factor
Cooling plant energy source	▪ Electricity	▪ Electricity
Lighting power density	▪ Warehouse = 7 W/m^2 ▪ Office = 8 W/m^2 ▪ Manufacturing space = 15 W/m^2 ▪ Store rooms = 5 W/m^2 ▪ Corridors = 5 W/m^2	▪ Warehouse – 8 W/m2 ▪ Office – 12 W/m2 ▪ Manufacturing space – 18 W/m2 ▪ Store rooms – 8 W/m2 ▪ Corridors – 8 W/m2
Lighting schedule	▪ Warehouse = 10 hours/day, weekdays ▪ Office = 10 hours/day, weekdays ▪ Manufacturing space = 10 hours/day, weekdays ▪ Store rooms = 2 hours/day, weekdays	▪ Warehouse = 10 hours/day, weekdays ▪ Office = 10 hours/day, weekdays ▪ Manufacturing space = 10 hours/day, weekdays ▪ Store rooms = 2 hours/day, weekdays

Model Input	Actual Building Model	Reference Building Model
	▪ Corridors =10 hours/day, weekdays	▪ Corridors =10 hours/day, weekdays
Small power density	▪ Warehouse = 5 W/m^2 ▪ Office = 10 W/m^2 ▪ Manufacturing space = 5 W/m^2	▪ Warehouse = 5 W/m^2 ▪ Office = 10 W/m^2 ▪ Manufacturing space = 5 W/m^2
Small power schedule	▪ Warehouse = 24 hours ▪ Office = 10 hours/day, weekdays ▪ Manufacturing space = 10 hours/day, weekdays	▪ Warehouse – 24 hours ▪ Office =10 hours/day, weekdays ▪ Manufacturing space = 10 hours/day, weekdays
Process load density	▪ Manufacturing space = 200 W/m^2	▪ Manufacturing space = 200 W/m^2
Process load schedule	▪ Manufacturing space =10 hours/day, weekdays	▪ Manufacturing space = 10 hours/day, weekdays
Occupancy density	▪ Warehouse = 1 person/100m^2 ▪ Office = 1 person/10m^2 ▪ Manufacturing space = 1 person/100m^2	▪ Warehouse = 1 person/100m^2 ▪ Office = 1 person/10m^2 ▪ Manufacturing space = 1 person/100m^2
Occupancy schedule	▪ Warehouse =10 hours/day, weekdays ▪ Office = 10 hours/day, weekdays ▪ Manufacturing space = 10 hours/day, weekdays	▪ Warehouse = 10 hours/day, weekdays ▪ Office = 10 hours/day, weekdays ▪ Manufacturing space = 10 hours/day, weekdays
Infiltration	▪ Warehouse = 1 ACH ▪ Office = 0.25 ACH ▪ Manufacturing space = 0.5 ACH	▪ Warehouse = 0.5 ACH ▪ Office = 0.5 ACH ▪ Manufacturing space = 0.5 ACH

7.1 Actual Building Model energy benchmark

Calculate the annual energy use for HVAC and lighting, other building services and any on-site energy generation or on-site renewable energy generation for the Actual Building Model:

Electricity:

- HVAC and lighting = 520,000 kWh
- Other building services = 10,000 kWh

- Actual Building Model energy benchmark = (520,000 kWh + 10,000 kWh)/2000m^2
  = 530,000 kWh / 2000m^2
  = **265 kWh/m^2/year**

7.2 Reference Building Model energy benchmark

Calculate the annual energy use for HVAC and lighting energy use, and other building services or the Reference Building Model:

Electricity:

- HVAC and lighting = 622,500 kWh
- Other building services = 30,000 kWh

Heating energy source:

- HVAC and lighting = 100,000 kWh
- Other building services = 10,000 kWh

- Reference Building Model: Electricity = (622,500 kWh + 30,000 kWh)/2000m^2
  = 652,500 kWh / 2000m^2
  = 326 kWh/m^2/year Electricity

- Reference Building Model: Heating energy source = (100,000 kWh + 10,000 kWh)/2000m^2
  = 110,000 kWh/2000m^2
  = 55 kWh/m^2/year Heating energy source

- Reference Building Model energy benchmark = 326 kWh/m^2/year Electricity + 55 kWh/m^2/year Heating energy source
  = **381 kWh/m^2/year**

7.3 ENE-1 Compliance

Compliance achieved as the Actual Building Model energy benchmark < the Reference Building Model energy benchmark

7.4 ENE-1 Points allocation

61 kWh/m^2/year difference between Actual and Reference Building Model

Percentage saving over the Reference Building Model = 61 kWh/m^2/year / 381 kWh/m^2/year

= 16%

16% saving over the Reference Building Model = **5 points under ENE-1**

7.5 Actual Building Model on-site energy generation and on-site renewable energy generation

- On-site energy generation = 0 kWh
- On-site renewable energy generation = 40,000 kWh

7.6 ENE-2 Points allocation

- Adjusted Actual Building Model energy use with on-site renewable energy = 530,000 kWh/m^2/year – 40,000 kWh/m^2/year
  = 490,000 kWh/m^2/year
- Adjusted Actual Building Model energy use benchmark = 490,000 kWh/m^2/year/2000m^2
  = 245 kWh/m^2/year
- Actual Building Model annual carbon dioxide emissions: 245 kWh/m^2/year Electricity = **41.65 kg CO_2/m^2** (0.17 kg $CO_{2\text{-}e}$/kWh carbon factor)

- Reference Building Model annual carbon dioxide emissions: 326 kWh/m2/year Electricity = 55.42 kg CO2/m^2 (0.17 kg CO_2/kWh carbon factor)
  55 kWh/m^2/year Heating energy source = 13.75 kg CO_2/m^2 (0.25 kg CO_2/kWh carbon factor)
  Total = **69.17 kg CO_2/m^2**

27.52 kg CO_2/m^2 difference between Actual and Reference Building Model

Percentage saving over Reference Building Model = 27.52 kg CO_2/m^2/69.17 kg CO_2/m^2
= 39.8%

40% percentage saving over the Reference Building Model = **3 points under ENE-2**

Appendix A

Example Project Registration Proforma

Appendix A – Example Project Registration Proforma

Projects shall complete this registration from and submit to the NZGBC as part of the Project registration process:

TABLE 1 – Example Project Registration Proforma

Building information	Required Project Information
Building type	▪ Type of Education or Industrial Building
Space types	▪ Description of all space types in the building e.g. warehouse, office, data centre
Assessable Area	▪ Assessable area for the whole building ▪ Assessable area for each space type in the building
Location	▪ Site location in New Zealand
Weather file	▪ Proposed weather file if 'Two-model' approach is proposed
Design conditions	▪ Proposed design temperature and humidity conditions for each space
HVAC Systems	▪ Description of all proposed HVAC systems in the building and spaces served
HVAC system operating schedule	▪ Proposed HVAC system operating schedule for each space
Small power load	▪ Description of proposed small power density for each space in the building (W/m^2) based on client brief
Small power operation	▪ Proposed small power operating schedule for each space based on client brief
Process load	▪ Description of proposed process load density for each space in the building (W/m^2) based on client brief
Process load operation	▪ Proposed process load operating schedule for each space based on client brief
ENE-1 calculation option	▪ Proposed energy calculation option - Either 'Two-model' or 'Schedule Method'

NOTE: If the Two-model approach is proposed, projects should identify any additional aspects in the design of the actual building which may affect the modelling approach e.g. process load sharing energy source with HVAC system, process load sharing HVAC system etc

Appendix B

Reference Building Model Construction Definition

Appendix B – Reference Building Model Construction Definition

Each of the Reference Building Model construction elements must be defined as described in Table 1:

Table 1 - Reference Building Model Constructions

Construction element	Construction make-up from outside to inside
External walls	20mm timber cladding, Insulation, 13mm plasterboard
Roof	Insulated steel roof
Ground floor and suspended floors	150mm concrete, 10mm carpet/underlay
Intermediate floors/ceilings	20mm ceiling tiles, air cavity, 100mm concrete, 10mm carpet/underlay
Partition walls	13mm plasterboard, air cavity, 13mm plasterboard

NOTE: Refer to Section 4 Table 3 for minimum R-value requirements

Appendix C

Reference Building Model HVAC System Definition

Appendix C – Reference Building Model HVAC System Definition

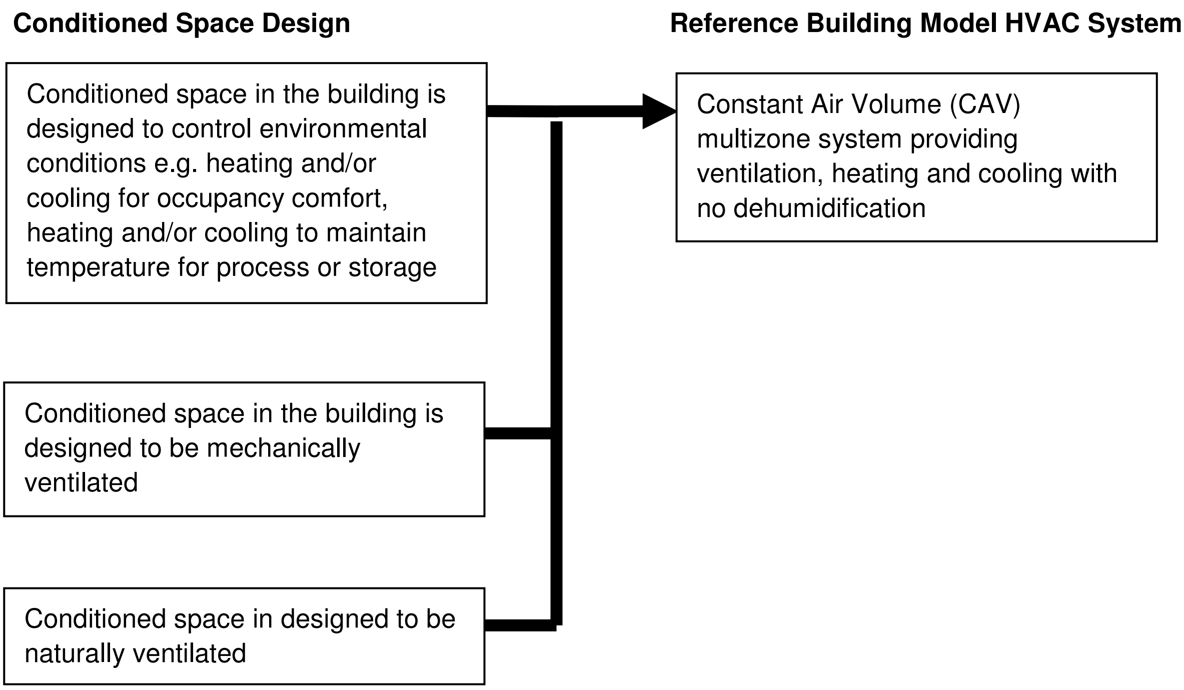

FIGURE 1 – Reference Building Model HVAC system determination

The Reference Building Model HVAC system must be defined as follows for each applicable system parameter:

TABLE 1 – Reference Building Model HVAC system components

HVAC System Component	Actual Building Model attributes	Reference Building Model HVAC System Description
HVAC system type	▪ One or multiple HVAC system types serving different conditioned spaces	▪ One CAV multizone system serving all conditioned spaces in the Reference Building Model ▪ Hot water reheat provided for each system zone in the Reference Building Model to achieve design heating space temperature ▪ Cooling provided via cooling coil for each system zone in the Reference Building Model to achieve design cooling space temperature
System zoning	▪ As specified	▪ The same as the Actual Building Model
Outdoor air rate	▪ As specified	▪ NZBC minimum outdoor air rate for each conditioned space ▪ If space type not covered under

HVAC System Component	Actual Building Model attributes	Reference Building Model HVAC System Description
		NZBC use the same outdoor air rate as in the Actual Building Model
Supply air temperature cooling	▪ As specified	▪ 10℃ less than design cooling space temperature for each conditioned zone ▪ Supply air cooling temperature shall operate as defined above during all operating hours
Supply air temperature heating	▪ As specified	▪ 10℃ more than design heating space temperature for each conditioned zone ▪ Supply air heating temperature shall operate as defined above during all operating hours
Supply air flowrate	▪ As specified	▪ To achieve design conditions in each conditioned zone using the supply air temperatures listed above; OR ▪ Additional supply air flowrate that is required to balance extraction
Exhaust air flowrate	▪ As specified	▪ 80% of Reference Building Model Supply air flowrate
Heating plant seasonal efficiency	▪ As specified	▪ 80% thermal efficiency
Cooling plant EER	▪ ≤ 525 kWr	▪ 100% cooling load = 2.2 ▪ 75% cooling load = 3.0 ▪ 50% cooling load = 3.0 ▪ 25% cooling load = 3.0
	▪ > 525 kWr	▪ 100% cooling load = 2.5 ▪ 75% cooling load = 3.1 ▪ 50% cooling load = 3.1 ▪ 25% cooling load = 3.1
Supply and Return Fan absorbed Power	▪ Building assessable area ≤ 500m^2	▪ 12 W/m^2 of building assessable area
	▪ Building assessable area > 500m^2	▪ 15 W/m^2 of building assessable area
Fan system operation	▪ As specified	▪ Supply and return fans shall operate continuously during operating hours
Chilled water and heating water pumps absorbed power	▪ Building assessable area ≤ 500m^2	▪ 3.0 W/m^2 of building assessable area
	▪ Building assessable area > 500m^2	▪ 4.0 W/m^2 of building assessable area
Chilled water and heating	▪ As specified	▪ Constant speed

HVAC System Component	Actual Building Model attributes	Reference Building Model HVAC System Description
water pumps operation		▪ Chilled water and heating water pumps shall operate continuously during operating hours
Exhaust air heat recovery	▪ Design supply air capacity of 2400 L/s or greater and has a minimum outdoor air supply of 70% or greater of the design supply air	▪ Heat recovery system ▪ Fifty percent sensible heat recovery effectiveness (ASHRAE)
Economiser	▪ As specified	▪ An economiser must be modelled
Economiser high-limit shutoff	▪ As specified	Dependent on NZS 4243 climate zone: ▪ NZS:4243 Climate zone 1 = 18℃ (ASHRAE) ▪ NZS:4243 Climate zone 2 = 21℃ (ASHRAE) ▪ NZS:4243 Climate zone 3 = 21℃ (ASHRAE)

NOTE: Where reference not indicated minimum system performance values derived from NZBC Clause H1, Guidelines for energy efficient HVAC plant[2]

Appendix D

HVAC Modelling Requirements

Appendix D – HVAC Modelling Requirements

The HVAC system must be modelled for both the Actual and Reference Building Model as follows:

TABLE 1 – HVAC modelling requirements

HVAC Modelling Parameter	Modelling Requirements
Chilled water and condenser water pumping	▪ Where applicable, demonstrate that chilled water pumping and condenser water pumping is calculated using the applicable cooling load, the static pressure of the chilled water pumps and the flow rate
Heating hot water	▪ Where applicable, demonstrate that heating hot water pumping is calculated using the applicable heating load, the static pressure of the heating hot water pumps and the flow rate
Chiller plant	▪ Demonstrate that the chiller plant size is accurately reflected in the model ▪ Demonstrate that the actual efficiency curves of the installed plant are used in the model ▪ Water cooled equipment: Demonstrate that chiller data is specified under conditions that reflect the intended condenser water temperature controls ▪ Air cooled equipment: Demonstrate that the air cooled chiller COP profiles have been accurately modelled with regard to loading and ambient conditions
Heating plant	▪ Demonstrate that the heating plant type, size, thermal efficiency and distribution efficiency are accurately reflected in the model.
Supply air and exhaust fans	▪ Demonstrate that fan performance curves are accurately represented in the model ▪ Demonstrate that index run pressure drops are accurately represented to include the total static inclusive of filters, coils and diffusers ▪ Ensure that the calculated fan energy uses the total fan pressure (static + dynamic) ▪ Ensure that the fan efficiency is the product of the motor and fan efficiency
Heat rejection fans	▪ If applicable, demonstrate that allowance for energy consumption from heat rejection fans has been made, based upon the annual cooling load of the building and the supplementary cooling load for tenancy air conditioning
Cooling tower and condenser water pumping	▪ If applicable, demonstrate that allowance for energy consumption from cooling tower and condenser water pumping has been made, based upon the annual cooling load of the building
Outdoor air	▪ Demonstrate that outdoor air flows have been modelled as documented in the mechanical design drawings and specifications, and in compliance with the appropriate standards

HVAC Modelling Parameter	Modelling Requirements
	■ Demonstrate that the minimum outdoor air rate claimed in IEQ-2 Credit is achieved in the model
Economiser	■ Demonstrate that any economy cycles have been modelled to reflect system specification noting any enthalpy/temperature cut-off and control point
Primary duct temperature control	■ Constant Volume Systems: Demonstrate that modelling has allowed supply air temperatures to vary to meet loads in the space ■ Variable Volume Systems: Demonstrate that modelling has allowed supply air volumes to vary to meet loads in the space ■ Demonstrate that set-points have been rescheduled as specified. Note that simplifications may be made to consider average zone temperature in lieu of high/low select
Airflow Control	■ Demonstrate that control logic describing the operation of the dampers to control outside and recirculated airflow is inherent in the model and accurately reflects the airflow characteristics of the system
Minimum turndown	■ Demonstrate, where relevant, that the minimum turndown airflow of each air supply is accurately reflected in the model while still achieving the minimum outdoor air claimed in IEQ-2 Credit
Chiller/compressor staging	■ Demonstrate that for systems that employ multiple chillers with a chiller staging strategy, the correct controls are modelled to reflect the actual relationship between the chillers. ■ For refrigeration systems that use a cascading series of compressors, demonstrate that the COP incorporated is representative of the entire series.
Temperature and humidity control bands	■ Demonstrate that the thermal model accurately reflects the temperature and humidity control bands of the system

Appendix E

Lift Energy Use Calculation

Appendix E – Lift Energy Use Calculation

Please Note that the description below demonstrates the method of calculation only. The actual figures for standard number of trips per year and time for each trip for the facility modelled should be provided and justified. Also the number of trips and typical time for each trip would vary based on if the lifts are intended for passenger use or to ferry goods. If both types of lifts are incorporated then each would need to be calculated separately.

To calculate lift energy use:

- Determine the lift power ratings **R** in kW from supplier specifications;
- Determine the **St**andby power from car lights and lift control system in kW from supplier specifications; and then
- Calculate the annual **Energy** usage using the following formula

E = (R x S x T (100% + P)/3600 + (St x Hrs x 260)) x No. Lifts

Where:

E = Annual **Energy** usage (kWh/year)

R = Power **R**ating of the motor (kW)

S = Number of **S**tarts per year (S=300,000 for the purposes of the Green Star – Education or Industrial 2009 lift energy calculations)

T = Typical **T**rip time (seconds) (T=5s for the purposes of the Green Star – Education or Industrial 2009 lift energy calculations)

P = **P**enalty factor

- Where lifts with speeds over 2.5 m/s have regenerative brakes, P=0%
- Where lifts with speeds over 2.5 m/s do not have regenerative brakes, P=15%

St = **St**andby power – car lights and lift control systems (kW)

Hrs = number of **hours** per day lifts are operating

- Where lift has a power off feature, hrs = 18
- Where lift does not have a power off features, hrs = 24

No. Lifts = Number of lifts of this type in the project under assessment.

Note that:

- The figure of 3600 converts the first half of the equation, which is in kWs, into kWh.
- The hours x 260 takes the standby power and multiplies it by operational hours and days in a year to get annual energy consumption.
- If a lift only services three floors, is to solely be used as a disabled lift and is labelled as such, the energy consumption of this lift can be discounted by 90%.

References

[1] NZS:4243 Energy Efficiency – Large Buildings, Part 1: Building Thermal Envelope

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