IPART

Independent Pricing and Regulatory Tribunal

New South Wales

Project Impact Assessment with Measurement & Verification

Method Guide

Energy Savings Scheme

September 2017

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1 About this document

The NSW Energy Savings Scheme (**ESS**) seeks to reduce energy consumption in NSW by creating financial incentives for organisations to invest in energy saving projects.

The other objects of the ESS are to:

- assist households and businesses to reduce energy consumption and energy costs
- make the reduction of greenhouse gas emissions achievable at a lower cost, and
- reduce the cost of, and need for, additional energy generation, transmission and distribution infrastructure.[1]

Electricity retailers and other mandatory participants (**Scheme Participants**) are obliged to meet energy saving targets. Energy savings can be achieved by installing, improving or replacing energy saving equipment. Persons that become Accredited Certificate Providers (**ACPs**) can create energy savings certificates (**ESCs**) from these activities and then sell those ESCs to Scheme Participants. The Independent Pricing and Regulatory Tribunal of NSW (**IPART**) is both the Scheme Administrator and Scheme Regulator of the ESS.[2]

This document provides guidance about how the Project Impact Assessment with Measurement and Verification (**PIAM&V**) method of the ESS operates, some of the key requirements that must be met when using the method, and how to calculate energy savings for a Recognised Energy Saving Activity (**RESA**) and create ESCs. This document should be used by:

- applicants seeking accreditation as a certificate provider, to assist them in completing their application,[3] and
- those persons who are already ACPs, to assist them in accurately calculating energy savings using this method.

Specifically, this guide provides information on the calculation of energy savings and creation of ESCs using clause 7A of the ESS Rule[4] for:

- forward creation of ESCs from a single site model calculated from a Baseline Energy Model and Operating Energy Model (modelling energy performance before and after project implementation)[5] (section 4.1 of this guide)
- annual creation or top-up of ESCs based on actual performance of a project following implementation, and compared to a Baseline Energy Model (sections 4.2 and 4.3 of this guide), and
- multiple site ESC creation based on a multiple site model, and using a sampling method (section 3.7 of this guide).

1 *Electricity Supply Act 1995*, section 98(2)
2 *Electricity Supply Act 1995*, sections 153(2) and 151(2)
3 A full explanation of the application process is provided in the Application Guide www.ess.nsw.gov.au/How_to_apply_for_accreditation/The_application_process. Applicants should read this document and the Application Guide in full before applying for accreditation.
4 *Energy Savings Scheme Rule of 2009*, as amended from time to time.
5 A RESA may involve multiple sites, where each site has its own energy model.

In addition to this guide, the following references are recommended reading when using this method:

- the *Measurement and Verification Operational Guide* published by the NSW Office of Environment and Heritage (**OEH**),[6] and
- the *International Performance Measurement and Verification Protocol, Core Concepts*, October 2016 (**IPMVP**), published by the Efficiency Valuation Organization.[7]

Legislative requirements

This document is a guide only and is not legal advice. The legal requirements for ACPs participating in the ESS are set out in:

- Part 9 of the *Electricity Supply Act 1995* (**Act**)
- Part 6 of the *Electricity Supply (General) Regulation 2014* (**Regulation**), and
- the *Energy Savings Scheme Rule of 2009* (**ESS Rule**).

ACPs are also required to meet any additional accreditation conditions as set out in their Accreditation Notice.

2 Method overview

The PIAM&V method requires the measurement and verification of energy savings from implementing equipment that is more energy-efficient than the original equipment being replaced, or from modifying the existing equipment to improve its energy efficiency. It also allows new end-user equipment (**EUE**) to be installed where the specific conditions of the ESS Rule are met.[8]

By using measurement and verification techniques to predict and then verify energy savings, the method can assist decision-makers to evaluate funding proposals and make investment decisions. The method accounts for changes in operating conditions, which means that energy savings from different activities can be reasonably compared.

A key feature of this method is that it allows energy savings to be calculated (deemed) for a maximum period of 10 years after the implementation date. Discounting is applied to the calculated energy savings based on the quality of the measured data and how well it fits with predicted energy models. The discounted energy savings are then used to forward create ESCs for up to 10 years after the implementation date.

ESCs that are forward created can also be 'topped-up'[9] if additional energy savings beyond those calculated from forward creation can be demonstrated.[10] For more information on topping-up, see section 4.2 of this guide.

6 Available at: www.environment.nsw.gov.au
7 Available at www.evo-world.org
8 *ESS Rule*, cl 5.3B
9 'Topping-up' refers to ACPs being able to create ESCs in addition to the ESCs created from the original calculation for the deemed energy savings. These 'top-up' ESCs are created from the difference between the actual energy savings that are verified at the end of each year through ongoing measurement, and those used to create the ESCs from the original calculation.

2.1 Types of energy models

There are three acceptable types of energy models that may be used to model the energy use and calculate energy savings:[11]

- *Estimate of the Mean*: to be based on measurements of energy consumption, independent variables and site constants and, where relevant, specifying a measurement period. The coefficient of variation of the energy consumption over the measurement period must be less than 15%.
- *Regression Analysis*: to be based on measurements of energy consumption, independent variables and site constants and specifies a measurement period. The number of independent observations for each site must be at least six times the number of model parameters in the energy model.
- *Computer Simulation*: must use a commercially available software package approved by the Scheme Administrator for use in modelling the relevant type of EUE, and that is calibrated against measurements taken from the actual EUE being simulated to meet any requirements as published by the Scheme Administrator.

There are two ways to develop energy models:

- *Single site*: based on measurements taken from that site.
- *Sampling method (multiple sites)*: based on measurements taken from sample sites using a sampling method. For more information, refer to section 3.7 of this guide.

2.2 Calculating gas savings

For implementations on or after 15 April 2016 the PIAM&V method may be used to calculate either electricity savings or gas savings or both. Where both gas and electricity savings are being calculated, different energy models must be created for each energy type. The term 'energy savings' is used throughout this document and means electricity savings or gas savings or both.

Under clause 5.3(e)(ii) of the ESS Rule, a gas efficiency project may be an eligible activity if it increases the efficiency of gas consumption, where the gas is combusted for stationary energy.

Under clauses 5.3(e)(iii) and 5.4(j) of the ESS Rule, fuel switching from electricity to gas, or gas to electricity may be an eligible activity if (all other requirements being met) it:

- increases the efficiency of the overall energy consumption at the site, and
- does not increase greenhouse gas emissions.

Where a project involves a fuel switching activity, greenhouse gas emissions must be calculated using electricity savings, gas savings and full fuel cycle emissions factors and equations from the current version of the National Greenhouse Accounts Factors. More information on fuel switching can be found in Appendix C of this guide.

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10 *ESS Rule*, cl 7A.14
11 *ESS Rule*, cl 7A.2

Measurements of gas must be made in accordance with the requirements set out in either:

- the *National Greenhouse and Energy Reporting (Measurement) Determination 2008*,[12] or
- the National Measurement Institute standard for gas meters *NMI R 137 Gas Meters*.[13]

Gaseous fuels that are eligible in the ESS are set out in the definition of 'Gas' in clause 10 of the ESS Rule.

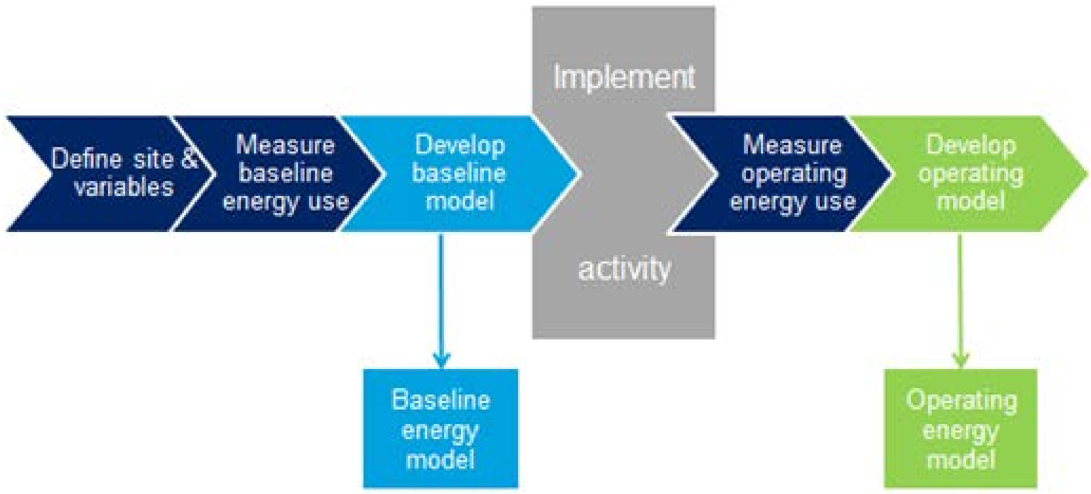
ACPs with an existing PIAM&V accreditation for electricity savings can submit an application for amendment of their conditions of accreditation to the Scheme Administrator to include gas saving activities in their RESA.[14]

2.3 Measurement and verification method

The calculation of energy savings under this method is based on comparing the results of a baseline energy model with those from an operating energy model, as shown in Figure 2.1 below. This requires:

- baseline and operating energy use to be measured and modelled before and after an implementation, and
- independent variables and site constants to be determined and included in the energy models.

Figure 2.2.1 Development of baseline and operating energy models from measurements



12 Refer: www.legislation.gov.au/Details/F2013C00661
13 Refer: www.measurement.gov.au/Pages/Gas-Meters-Comment-Sought-on-NMI-R-137.aspx
14 Refer: www.ess.nsw.gov.au/Accredited_Certificate_Providers/Accreditation_Notice_and_Amendments

3 Requirements that must be met

The information below is guidance about the requirements of the method. This is not an exhaustive list of requirements, and ACPs should ensure they are familiar with the obligations under the Act, Regulation, ESS Rule and any conditions of accreditation.

3.1 Energy saver

An ACP can only calculate energy savings and create ESCs if the ACP is the 'energy saver' under the ESS Rule. The ACP must be the energy saver as at the implementation date. An energy saver can be either:

- **the original energy saver** – which, under the PIAM&V method, is the purchaser (discussed below), or
- **the nominated energy saver** – which is someone the original energy saver has nominated as the energy saver by completing a Nomination Form.[15]

An ACP that is the original energy saver must be accredited as an ACP prior to the implementation date in order to create ESCs from an implementation.

An ACP that is a nominated energy saver must:

- be **accredited** as an ACP **prior** to the implementation date and before the nomination is made[16]
- have a documented procedure for obtaining the nomination from the original energy saver, and
- be **nominated** by the original energy saver **on or before** the implementation date. The nomination is taken to occur on the date that the nomination form is signed by the original energy saver.

3.2 Purchaser

In general, the purchaser is the person who purchases or leases the goods or services that enable the relevant energy savings to be made. However, the following persons cannot be a 'purchaser' and therefore cannot be an original energy saver under the PIAM&V method:

- an ACP who is not the owner, occupier or operator of the relevant site,[17]
- a person who purchases or leases the goods or services for the purpose of reselling the EUE, unless the resale will be an inclusion in a contract for the sale of land or a strata scheme lot.[18]

15 Available at: www.ess.nsw.gov.au/Accredited_Certificate_Providers/Templates
16 The ESS website provides information on applying to become an ACP at: www.ess.nsw.gov.au/How_to_apply_for_accreditation.
17 ACPs that are nominated Energy Savers will typically fall under this category.
18 Wholesalers will typically fall under this category.

Box 3.1 Evidence for the energy saver

The original energy saver (purchaser) may be evidenced by a document showing who purchased or leased the goods or services that enabled the energy savings to be made, such as a tax invoice or sales ledger extract, that:

- shows the completion date and address
- identifies the recipient
- identifies the supplier (including their ABN), and
- provides a brief description of the equipment or service provided (itemised if possible).

3.3 Implementation and implementation date

The ESS Rule defines 'implementations', 'implementation dates' and 'site' (explained below). These concepts are used to determine the number of ESCs, and from when they can be created.

3.3.1 Implementation

An implementation is the delivery of an energy saving activity (called a 'RESA' in the ESS Rule)[19] at a site.

3.3.2 Implementation date

For ACPs that use the PIAM&V method, the implementation date is the date that the implementation commenced 'normal operations'.[20] Normal operations are considered to commence when the installation of the EUE is complete, or when a new service commences. They may commence after a commissioning period or after fine-tuning the performance of the equipment or process. If normal operations are to commence after a commissioning period, details of the commissioning process should be included in the nomination form or other formal project documentation.

Box 3.2 Evidence of the implementation date

The implementation date may be evidenced by a completion/commissioning report that:

- is produced by the party responsible for the design and commissioning of the equipment
- clearly identifies the location where the implementation occurred, and
- shows the implementation date and is signed by an appropriately qualified and responsible person.

The report can be an internal document that demonstrates the completion of process improvements by internal staff.

19 A RESA must meet all of the criteria set out in clauses 5.3 and 5.4 of the ESS Rule.
20 *ESS Rule*, cl 7A.17

3.4 Production and service levels

Energy savings cannot be calculated from a reduction in production or service levels. For example, closing down a manufacturing plant is not an eligible activity. However, turning off redundant machinery, whilst maintaining production or service levels, is an eligible activity.

To address this issue, production or service levels must be included as independent variables or site constants and accounted for in the energy models. Their inclusion must be done in a way that allows direct comparison of performance before and after an implementation.

Evidence of maintenance of production and service levels

This may be evidenced by a document showing the calculation of a production or service metric for each site, before and after an implementation.

3.5 Efficiency requirement for installing new end-user equipment

If new end-user equipment[21] is being installed, it must be more efficient than the average energy efficiency of end-user equipment that provides the same type, function, output or service. The average energy efficiency may be estimated by reference to:

- product-weighted averages of products registered as complying with an Australian / New Zealand Standard (AS/NZS) that defines how energy efficiency is to be measured for that class of end-user equipment
- sales-weighted market data for that class of end-user equipment collected from installers, retailers, distributors or manufacturers, or
- baseline efficiency for that class of end-user equipment which may, from time to time, be published by the Scheme Administrator.

3.6 Developing an energy model

The ESS Rule requires that the following parameters be considered and established to support the development of the baseline and operating energy models:

- measurement boundary, choice of independent variables and site constants (for each model)[22]
- effective range, and
- implementation date.

21 'New end-user equipment' is defined as end-user equipment where no end-user equipment of the same type, function, output or service was previously in its place (but does not include additional components installed in the course of modifying existing end-user equipment).

22 Baseline and operating energy models may be based on the same or different variables and constants. Refer to section D.3.3 of this guide for more details.

Also, the following factors are required to determine the energy savings:

- normal year
- interactive energy savings
- accuracy factor
- decay factor, and
- counted energy savings.

More details on how each of these parameters and factors is considered and established for an implementation are provided in Appendices A and D of this guide.

The development of energy models is represented in Figure 3.2.[23] These are represented by the dashed lines across the tops of the graphs for energy consumption, which emulate the energy consumption changes in the baseline and operating periods.

The energy models must also account for *non-routine events* to ensure that a reasonable comparison can be made between the energy consumption measurements before and after an implementation. Non-routine adjustments are made to the measured data to account for unexpected changes in energy use that occur due to non-routine events, such as unscheduled maintenance. Time periods corresponding to non-routine events may be removed, however, the percentage of time removed must be less than twenty percent of the measurement period.[24]

When establishing energy models, the *measurement boundary* needs to be established (see Figure 3.1). This determines what equipment and parameters will be included and excluded from the energy savings calculations. It effectively sets a boundary for the energy models.

Setting the correct measurement boundary is important as the energy models also need to account for interactive energy savings. These are changes to a site's energy consumption that are due to the implementation, but that occur outside of the measurement boundary.

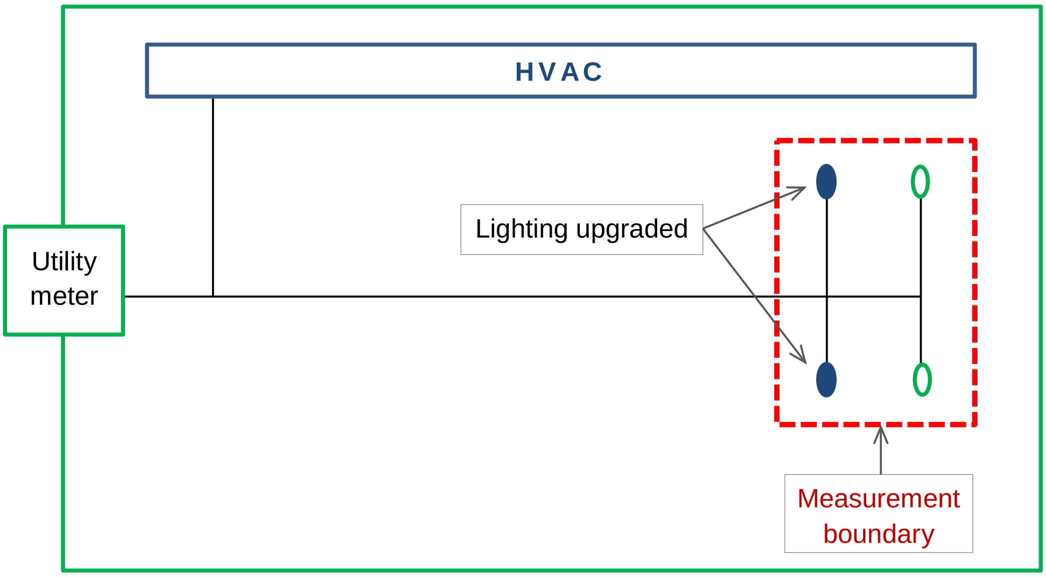
In a simple example provided in Figure 3.1, a lighting upgrade with more efficient lamps reduces the heat load for a building. This may reduce demand for cooling[25] from the heating, ventilation and air-conditioning (**HVAC**) system and therefore reduce the overall energy consumption for the measurement period, as measured by the utility meter. Any energy savings arising from the changes to HVAC demand need to be estimated and taken into account when determining the normal year energy savings (see Figure 3.2).

Box 3.4 Evidence of the RESA boundary

ACPs must collect documents to demonstrate they have adequate metering in place to define the RESA boundary. This can be evidenced by an electrical line diagram or piping and instrumentation diagram (**P&ID**) showing the location of the meter(s) used in measuring the energy consumption.

23 An operating energy model is not required when calculating energy savings and creating ESCs annually.
24 *ESS Rule*, cl 7A.5(g)
25 There may be a corresponding increase in heating requirements during colder periods.

Figure 3.3.1 Example of the measurement boundary showing equipment outside the measurement boundary that may result in interactive energy savings



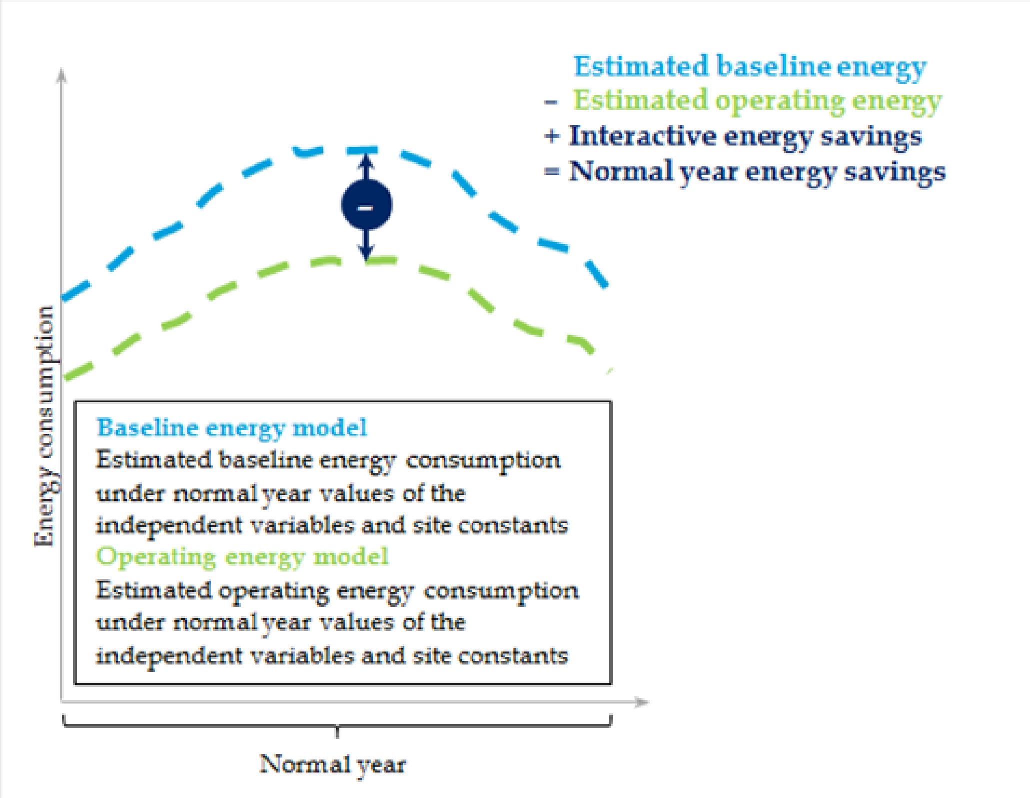
To establish a working energy model, the time period over which measurements are taken must also be established, including the start date and end date of the measurement periods. The values for *energy consumption*, *independent variables* and *site constants* must be within these measurement periods.

The energy savings from an implementation are calculated for savings over a *normal year* (normal year energy savings), as shown in Figure 3.2. This figure shows the difference in energy consumption of the baseline and operating energy models for a normal year. A normal year is defined as a typical year of operation of the EUE at a site, after the implementation date.[26]

The *interactive energy savings* must be estimated and added when determining the normal year energy savings. While the interactive savings are not shown on the below figure, the formula in the diagram explains how they are accounted for to determine energy savings.

26 Clause 7A.12 of the ESS Rule defines the maximum time period for forward creation.

Figure 3.3.2 Baseline energy model and operating energy model with normal year input conditions (plus any interactive energy savings) defines the normal year energy savings



The calculation of energy savings also requires the use of a decay factor, which accounts for the degradation in equipment operation over time.[27]

The decay factor and the interactive energy savings may be influenced by the measurement boundary, the type of EUE that is the subject of the implementation, as well as the site conditions where the implementation occurs. These additional parameters are also explained in further detail in Appendices A and D of this guide.

3.7 Sampling method

The sampling method is designed to reduce measurement costs while maintaining the accuracy of energy savings estimates. Energy measurements may only be taken at eligible representative sample sites to establish energy models. The energy models developed for the sample sites can then be applied to all sites in the population.

Key definitions and requirements under the sampling method are described in the sections below. Information on the development of a Sampling Plan can be found in section 7.1.

27 The decay factor may be applied using a default value from Table A16 of the ESS Rule, or estimated from a persistence model in accordance with clause 7A.13 of the ESS Rule.

3.7.1 Population eligibility requirements

The population is a set of sites that have similar characteristics, where similar implementations are taking place. There is no limit on the maximum number of sites that may be included in the population, as long as they meet the population eligibility requirements (refer to clause 7A.20(a) of the ESS Rule).

The population eligibility requirements are a set of requirements that must be defined and documented in the Sampling Plan. These requirements are in place to ensure that only sites with similar characteristics are included in the population. The Sampling Plan should be developed for the whole population, rather than for each individual site.

The Sampling Plan must clearly explain the process for determining whether each site in the population meets the population eligibility requirements, which must be defined based on:

- the existing EUE at the site
- end-use services being provided by the EUE
- the RESA to be undertaken
- site constants, and
- any additional requirements as published by the Scheme Administrator.

3.7.2 Sample sites and the representativeness test

Samples sites are sites where energy measurements are taken to develop an energy model of the population. The process of selecting samples sites should minimise bias.

A representativeness test must be defined and used to ensure that the distribution of the site constant among the sample sites is representative of the distribution of the site constant across the whole population.

The minimum number of sample sites per population must be at least six times the number of site constants. The site constant(s) is a parameter that affects energy consumption and varies between sites, but does not vary over time under normal operating conditions.

Additional statistical requirements (such as confidence levels, precision and coefficient of variation) should be applied to determine the minimum number of sample sites for large, unknown populations. Refer to section 7.1.6 for more details.

Where possible, the same sample sites should be selected to conduct baseline and operating measurements. If this is not feasible, ACPs must document the reasons for selecting different sites for baseline and operating samples.

3.7.3 Implementation and implementation date

ESCs must be calculated for each individual implementation. Under the sampling method, each site is considered an implementation, and the population consists of multiple implementations.

The implementation date for each implementation must be evidenced, including implementations on sample sites and non-sample sites. Each implementation can have a different implementation date. Each sample site can also have a different start and end date for measurement periods.

Energy savings cannot be calculated until the operating energy model is established, which is determined by the latest end date of all the measurement periods for the sample sites. The example provided in Table 3.1 shows how the earliest ESC creation date, for sites in the sample and other sites in the population, is influenced by the operating energy model measurement period.

Table 3.3.1 Implementation date and ESC creation under sampling

Implementation no.	Type of site	Implementation date	Operating model measurement period end date	Earliest ESC creation date
1	Sample	1 January 2017	1 June 2017	11 July 2017
2	Population	1 December 2016	N/A	11 July 2017
3	Sample	1 February 2017	1 July 2017	11 July 2017
4	Sample	11 February 2017	11 July 2017 (latest)	11 July 2017
5	Population	1 August 2017	N/A	1 August 2017
6	Population	1 May 2017	N/A	11 July 2017

Note: this is not the complete list of implementations for this population. Implementation no. 4 has the latest measurement end date among all sample sites.

3.7.4 Adding new sites to the population

Additional sites can be added to the population after the sampling plan has been implemented and the energy model developed, as long as they meet the population eligibility requirements. ACPs must keep records of the procedures they undertake to ensure that all additional sites meet the population eligibility requirements.

As sites are added to the population, the representativeness test must be applied to check if existing sample sites are still representative of the population. In cases where the existing sample sites fail the representativeness test, new sample sites must be selected.

If new sample sites are selected as a result of additional sites being added to the population, measured data from the new sample sites must be used to update the energy models.

ACPs must use the updated energy models to calculate energy savings for all new sites added to the population. For sites in the original population, the original energy models may be used until the updated energy models are developed. Only one set of energy models can be valid for a population at any time.

3.8 Recycling requirements

ACPs are responsible for ensuring that lighting equipment removed or replaced during an implementation is disposed of appropriately. If the post code of the implementation is in a Metropolitan Levy Area with a postcode listed in Table A25 of the ESS Rule, any lighting equipment containing mercury must be recycled in accordance with the recycling requirements of a product stewardship scheme such as Fluorocycle or equivalent.[28]

Similarly, any refrigerants that are removed or replaced during a refrigeration equipment upgrade must be disposed of in a manner that is compliant with the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989*.[29]

The ESS Rule also requires that removed equipment cannot be refurbished, re-used or resold.[30] ACPs should consider using recycling certificates, or other proof of disposal, to add auditable records verifying end of life for removed equipment.

3.9 Requirement to use a Measurement & Verification Professional

The ESS Rule requires that an M&V Professional deems as appropriate, the following aspects of the M&V approach for each implementation:

- the parameters used when measuring energy consumption, independent variables, site constants and any other relevant parameters
- the method for selecting independent variables and site constants
- the measurement procedures
- the normal year (not required for annual creation or top-up)
- the effective range
- the interactive energy savings
- the accuracy factor
- use of a persistence model
- the baseline energy model
- the operating energy model (except for annual creation or top-up), and
- the sampling method (if applicable).

M&V Professionals must produce an M&V Professional Report with validation and detailed explanatory reasoning for each of the above items. Additional information and a template for the M&V Professional Report can be found on our website.

3.9.1 What is an M&V Professional

An M&V Professional is a person who has been approved by the Scheme Administrator on the basis that they have satisfactorily demonstrated they meet the minimum requirements outlined in clause 7A.15 of the ESS Rule.

The *Guide for Measurement & Verification Professionals*[31] outlines these requirements and how interested parties can apply to be approved as an M&V Professional.

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28 *ESS Rule*, cl 5.3A(b)(i)
29 *ESS Rule*, cl 5.3A(b)(ii)
30 *ESS Rule*, cl 5.3A(a)

3.9.2 How to find an M&V Professional

A list of approved M&V Professionals is available from the ESS website.[32]

A person may not meet all of the M&V Professional requirements for all types of EUE or energy model types. The list of approved M&V Professionals includes the relevant EUE and energy model types. In choosing an M&V Professional to assess the M&V approach, ACPs will need to ensure that they select someone who:

- has relevant skills and experience relating to the particular energy saving activity, and
- is able to conduct an independent assessment of the M&V approach. This means that ACPs will need to use an M&V Professional that has not been involved in developing or implementing the project (including the development of the energy models).

3.9.3 When to use an M&V Professional

ACPs should consider engaging an M&V Professional at multiple stages for each implementation, rather than only at the end of the project. Involving an M&V Professional at various stages may reduce the risk of the M&V approach for the implementation not meeting the requirements of the ESS Rule, and also may reduce the risk of invalid ESC creation. Engaging an M&V Professional only at the end of the project could result in the M&V Professional not validating aspects of the M&V approach that could have been corrected if identified earlier.

IPART monitors the performance of the M&V Professionals and addresses any identified M&V Professional non-compliance in accordance with the guidance outlined in the *Guide for Measurement & Verification Professionals*.[33] However, ACPs remain responsible for the quality of the M&V Professional Report that is prepared for each implementation. As such, ACPs are expected to conduct their own quality assurance of the work of the M&V Professionals with whom they work.

3.10 Minimum requirements for conduct of representatives

The Scheme Administrator has established minimum requirements for the conduct of ACPs and their representatives. This includes ACP responsibilities for:

- training representatives
- maintaining a register of representatives
- ensuring there is a formal, documented, signed and enforceable (legally binding) contract or agreement in place for each representative, and
- providing appropriate customer service.

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31 Refer: www.ess.nsw.gov.au/Methods_for_calculating_energy_savings/Project_Impact_Assessment_with_MV

32 Refer: www.ess.nsw.gov.au/Methods_for_calculating_energy_savings/Project_Impact_Assessment_with_MV/List_of_approved_Measurement_Verification_Professionals

33 Refer: www.ess.nsw.gov.au/Methods_for_calculating_energy_savings/Project_Impact_Assessment_with_MV

ACPs are accountable for all ESS activities conducted by employees, third parties and other representatives. This includes all aspects of an activity for which they create ESCs, from the initial engagement with customers, through to the final quality assurance of documents. ACPs will be held responsible for all actions, omissions and information provided by representatives acting on their behalf under the ESS – regardless of any contract or agreement with other parties. For more information, refer to *ESS Notice 01/2013 (amended July 2014) Minimum requirements for conduct of persons acting on behalf of ACPs.*[34]

4 Calculating energy savings

The energy savings that can be claimed using this method are limited to:

- a maximum period of 10 years after the implementation date,[35] and
- when using forward creation, a maximum of 50,000 ESCs, for each implementation. [36]

Energy savings can be calculated, and ESCs created, using the following equations from clause 7A of the ESS Rule:

- Equations 7A.1 and 7A.2 for forward creation for a single site model
- Equations 7A.1 and 7A.5 for forward creation based on a multiple site model using a Sampling Method
- Equations 7A.3 and 7A.4 for top-up of energy savings using, and
- Equations 7A.3 and 7A.4 for creation based on measured annual energy savings.

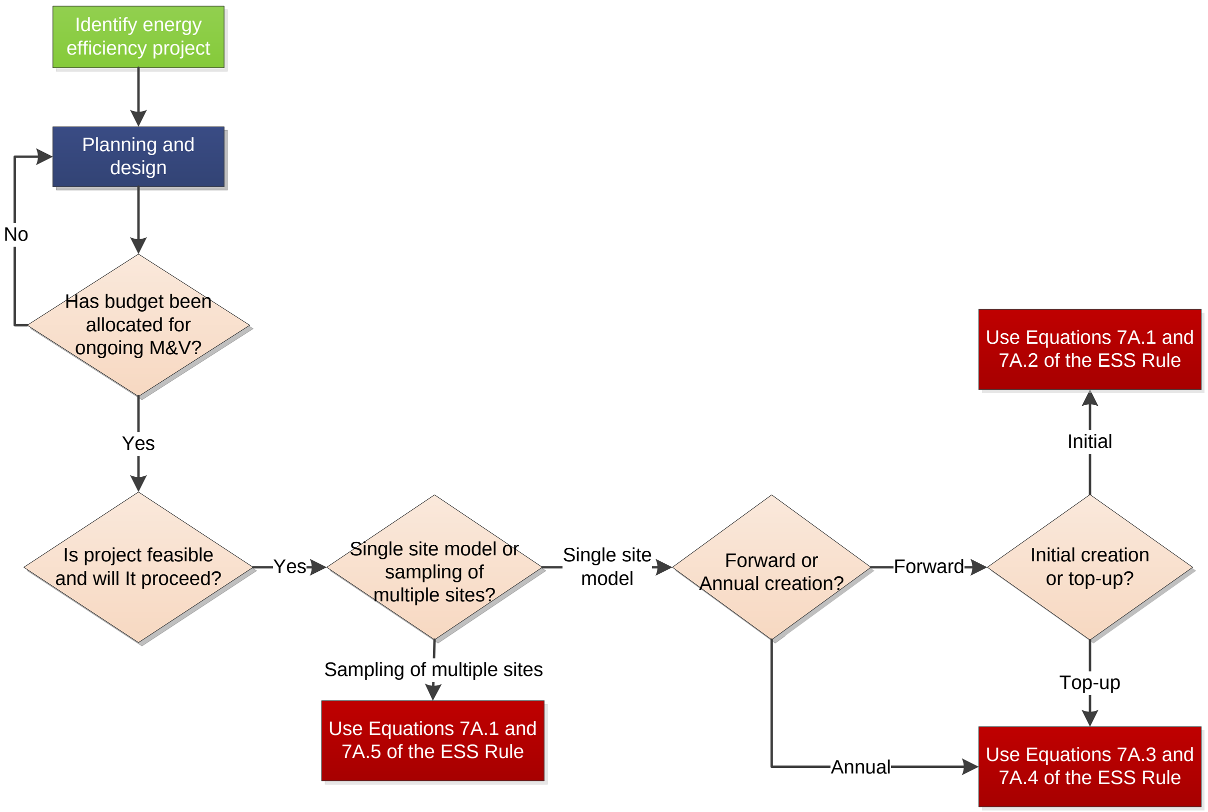
If gas and electricity savings are being calculated, they must be calculated separately for each implementation. Where fuel switching occurs, the total number of ESCs (after energy savings are converted to ESCs) must be a positive number (in order to register ESCs).[37]

The equation to calculate electricity savings includes a regional network factor. The applicable regional network factor is based on the post code of the implementation and can be found in Table A24 of the ESS Rule.

See Figure 4.1 below for a flowchart to assist in determining which equations from the ESS Rule to use for the calculation of energy savings. The four options outlined above are detailed in the following sections.

34 Refer: www.ess.nsw.gov.au/ESS_Notices_and_Updates
35 *ESS Rule*, cl 7A.12.
36 *ESS Rule*, cl 7A.11.
37 In some gas-to-electricity switching activities, despite total net energy savings being a positive number (ie, the increase in electricity consumption does not offset gas savings), the resulting total ESCs may be a negative value. This is due to the fact that the ESS Rule has a lower ESC conversion factor for gas (0.39) than for electricity (1.06). Refer to Appendix C for more details on fuel switching activities.

Figure 4.4.1 Determining which equation to use for calculating energy savings using the PIAM&V method



4.1 Forward creation of ESCs (for single and multiple site models)

Appendix B of this guide describes the steps required to develop the energy models when using forward creation.

Energy savings are calculated using equations 7A.1 and 7A.2 (or 7A.5 if using sampling) from the ESS Rule. Equation 7A.2 is used to calculate the normal year energy savings for a single site model. Similarly, Equation 7A.5 is used to calculate the normal year energy savings for a multiple site model developed using the Sampling Method. The normal year savings, calculated using either equation 7A.2 or 7A.5, is then used as an input into equation 7A.1 to calculate the overall energy savings from an implementation.

The process for forward creation of ESCs is outlined in Figure 4.2.

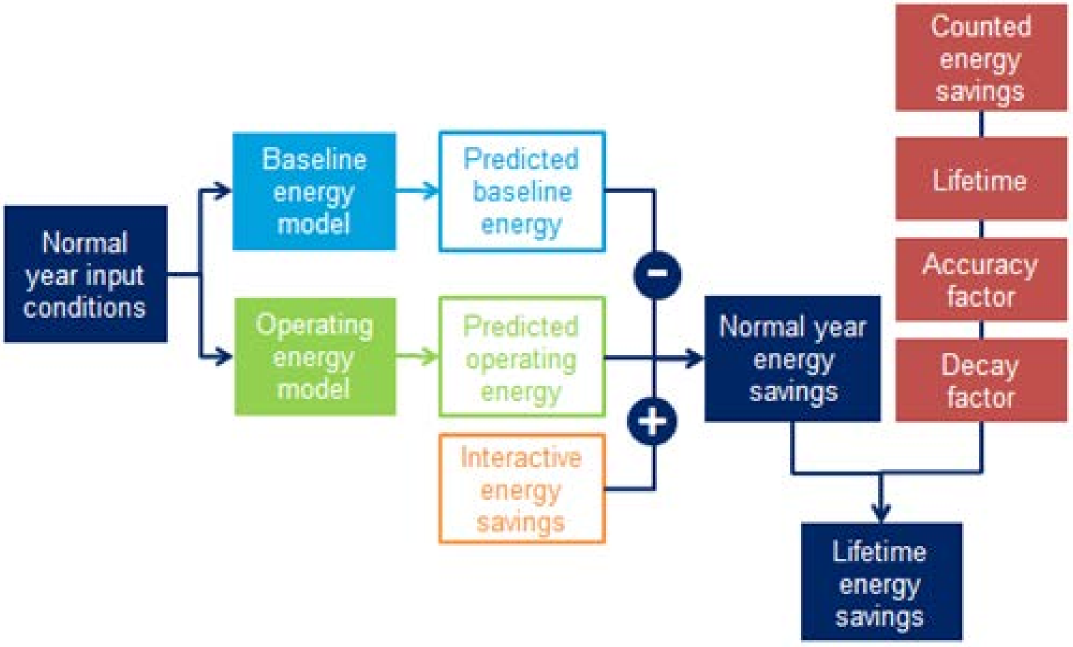
Once the normal year energy savings are determined, the 'lifetime' energy savings need to be calculated, for example, over 10 years. The lifetime energy savings are based on the expected life of the EUE (to a maximum of 10 years after the implementation date) and the following additional factors:

- an *accuracy factor*, with a value between 0 and 1, is used to discount the energy savings according to the relative precision of the calculation of the energy savings[38]

[38] This is estimated from the predicted energy consumption derived from an energy model.

- a *decay factor*, either from a persistence model[39] or from default values, is used to discount the normal year energy savings to calculate the lifetime energy savings, and
- any *counted energy savings* from previous ESC creation for the RESA or at the same site from another RESA (or corresponding scheme),[40] which must also be deducted.

Figure 4.4.2 Process for determining lifetime energy savings for forward creation



4.2 Top-up after forward creation of ESCs

Top-up refers to creating ESCs from the difference between the predicted (deemed) energy savings and the actual measured operating energy savings for a year. Top-up is allowed where energy savings can be demonstrated beyond those calculated for the lifetime energy savings, discounted by an accuracy factor and reduced by any counted energy savings, as shown in Figure 4.3. This option is only available where ESCs have already been created for the site through forward creation.

Appendix A.2 of this guide describes the steps required to top-up ESC creation.

The site, activity and boundary must be the same as already defined in step 1 for the forward creation approach, which is described in Table A.1 of this guide. If using the sampling method (refer to section 3.7), ESCs can be topped-up for both sample and other population sites.

39 A persistence model is essentially a model that forecasts the continuation of energy savings from a RESA (ie installed energy-efficient equipment) over its useful lifetime. When a persistence model is used to calculate the decay factor, the persistence model must also estimate the expected lifetime of the end-user equipment (refer clause 7A.13(b)(i) of the ESS Rule).

40 Clause 53(2) of the Regulation gives the Scheme Administrator the power to require the surrender of ESCs for which a benefit was obtained under a corresponding scheme, such as the Commonwealth Government's Emission Reduction Fund (ERF).

ACPs must check if there have been any changes to EUE within the defined measurement boundary following the implementation of the RESA. If changes have occurred, for example the addition of new EUE as part of a brownfield expansion,[41] a non-routine adjustment may be required to adjust the energy consumption for the effect of the change in EUE.

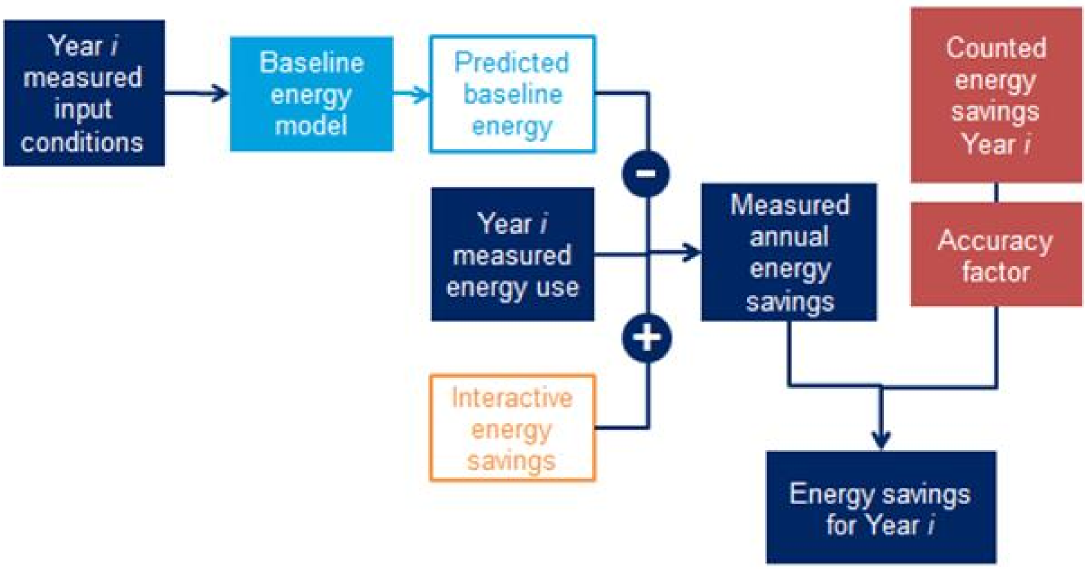
Energy savings are calculated using equations 7A.3 and 7A.4 from the ESS Rule. Equation 7A.4 is used to calculate the measured annual energy savings, which is then used as an input into equation 7A.3 to calculate the uncredited energy savings from the implementation.

The calculation of top-up energy savings includes:

- actual values used as inputs to the baseline energy model, including the actual non-routine adjustments and interactive energy savings
- updating the accuracy factor, which may increase if the relative precision of energy savings increases, and
- determining energy savings from any previous ESC creation for the RESA, either under forward creation or from other RESAs at the same site.

The baseline energy model must be based on a measurement period that has an end date no more than ten years prior to the end date of the measurement period for which energy savings are being claimed.

Figure 4.4.3 Process for top-up of ESCs



4.3 Annual creation of ESCs

Table A.3 of this guide describes the steps required to develop the energy models when using annual creation.

41 A brownfield expansion refers to the expansion of a facility at a site, as opposed to a new build on a site with no previous facility, which is referred to as a greenfield site.

In order to create ESCs using this approach, ACPs must first check if there have been any changes to EUE within the defined measurement boundary following the implementation of the RESA. If changes have occurred, for example the addition of new EUE as part of a brownfield expansion, a non-routine adjustment is required to adjust the energy consumption for the effect of the change in EUE.

Energy savings are calculated using equations 7A.3 and 7A.4 from the ESS Rule. Equation 7A.3 is used to calculate the energy savings from the implementation. Equation 7A.4 is used to calculate the measured annual energy savings.

ESCs can be calculated annually for an implementation, by measuring the actual operating energy consumption for a full year after an implementation, against energy consumption that is estimated using a baseline energy model. Unlike forward creation, no operating energy model is used. The calculation of energy savings are based on:

- an accuracy factor, with a value between 0 and 1, which is used to discount the energy savings according to the relative precision of the calculation of the energy savings determined, and
- any counted energy savings from previous ESC creation for the RESA or at the same site from another RESA, (or corresponding scheme), which must also be deducted.

The equations used are the same as for calculating energy savings from top-up (see section 4.2 of this guide).

The baseline energy model must be based on a measurement period that has an end date no more than ten years prior to the end date of the measurement period for which energy savings are being claimed.

5 Calculating and creating ESCs

Equation 1 of the ESS Rule is used to calculate the number of ESCs that may be created from an implementation or implementations. Note that ESCs can only be created where Equation 1 has a result that is greater than zero.

Equation 1

Number of Certificates = $\Sigma_{Implementations}$ *Electricity Savings x Electricity Certificate Conversion Factor + Gas Savings x Gas Certificate Conversion Factor*

Certain information must be submitted to the Scheme Administrator before an ACP applies to register ESCs created from energy savings arising from an implementation or implementations.[42] ACPs are to provide the required information by completing an Implementation Data Sheet[43] and submitting it through the ESS Portal.[44] The Implementation Data Sheet will include a calculation of the number of ESCs to be created in accordance with Equation 1 in the ESS Rule.

42 *ESS Rule*, cl 6.8
43 Available at: www.ess.nsw.gov.au/Registry/Registering_certificates
44 Information and access to the portal can be found here: www.ess.nsw.gov.au/ESS_Portal

This calculation involves:

- multiplying the electricity savings from the implementation or implementations by the electricity certificate conversion factor (1.06)[45]
- multiplying the gas savings from the implementation or implementations by the gas certificate conversion factor (0.39),[46] and
- adding the two figures together.

The result is the total number of ESCs that ACPs may apply to register from the implementation or implementations. If the result is not a whole number, it is rounded down to the nearest whole number.

There are no restrictions on how many implementations can be bundled together in the same Implementation Data Sheet. However:

- ACPs must apply to register all ESCs included in an Implementation Data Sheet in a single application
- ACPs cannot split energy savings calculated from a single implementation across two or more Implementation Data Sheets, and
- each Implementation Data Sheet must only include the calculation of energy savings that are taken to have occurred in the same calendar year (commonly referred to as 'vintage').

When determining how many implementations to bundle in the same Implementation Data Sheet, ACPs should consider:

- the ESC creation limit specified in their Accreditation Notice, as they must be able to register all the ESCs in the bundle at the same time, and
- the cost of registering the ESCs.[47]

When calculating energy savings using the sampling method, you must ensure that the implementation date for each implementation in the population is accurately recorded. ESCs for each implementation may be created separately or be bundled together. Refer to section 5.3 for more details regarding earliest possible creation date for each implementation

More information on applying to register the creation of ESCs can be found on the ESS website.[48]

The maximum number of ESCs that can be brought forward for any one implementation is 50,000.[49]

45 *Electricity Supply Act 1995*, section 130(1)
46 *Electricity Supply Act 1995*, section 130(1)
47 The ESC registration fee must be paid in a single payment for all ESCs registered in a single bundle. Payment for a single bundle cannot be split into two payments. Refer: www.ess.nsw.gov.au/Registry/Registering_certificates
48 Available at: www.ess.nsw.gov.au/Registry/Creating_certificates
49 As required by clause 7A.11(c) of the ESS Rule.

6 Applying for accreditation

A completed application for this method is required for a person or organisation to become an ACP and create ESCs. An application has multiple parts, which is explained in the Application Guide.[50]

6.1 Application pathways

Developing an application for accreditation for the PIAM&V method can be costly and time consuming. As such, two application pathways are available for applicants:[51]

- Application pathway A can be used by those applying for accreditation in relation to an identified site or sites and requires less information to be provided in the application for accreditation.[52] Refer section 6.1.1 for details of the information that must be provided in the application.
- Application pathway B can be used by those applying for accreditation in relation to multiple unidentified sites and requires one or more fully worked project examples to demonstrate the capability of the applicant to apply the PIAM&V method to those sites. Refer section 6.1.2 for details of the information that must be provided in the application.

6.1.1 Application pathway A

Applicants may use application pathway A when their application relates to implementations at identified sites, ie, sites where the address or other unique identifier can be listed in the Accreditation Notice at the time of accreditation.

Applicants using this pathway must include the following in the application:

- details of the specific implementation (site) or implementations that will be included in their RESA (in terms of EUE, energy saving activity and site)
- an M&V Plan and baseline energy model for at least one site, and
- if using the sampling method, a Sampling Plan (the baseline energy model must also then be provided for the sample).

ACPs accredited under this option will have certain conditions placed on their accreditation that may limit their ability to create ESCs until they either:

- provide further information to the Scheme Administrator (eg, the operating energy model, M&V Report, energy savings and ESC calculations, and M&V Professional Report), or
- successfully complete an audit.

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50 Refer: www.ess.nsw.gov.au/How_to_apply_for_accreditation/Apply_now_-_guides_and_application_forms

51 PIAM&V application options 1, 2 and 3 no longer apply for new applications. Refer to V3.1 of the Method Guide available in the document archive.

52 'Identified sites' means the address(es) or other unique site identifier(s) will be listed in the accreditation notice.

The types of conditions applied to the accreditation will depend on the complexity of the RESA and the number of sites. Once the conditions are met, ACPs may then submit an application for amendment of their conditions to the Scheme Administrator to enable ESC creation.[53]

ACPs accredited via this pathway may also apply to amend their accreditation to add additional sites or EUE at a later stage. Any such application would have to include additional project documents for the additional sites and EUE (ie, M&V Plan, baseline energy model).

6.1.2 Application pathway B

Applicants seeking accreditation to implement a RESA at multiple unidentified sites may use application pathway B.

Applicants using this pathway must include one or more fully worked project examples to demonstrate their capability to apply the PIAM&V method to sites where the RESA will be implemented. The project example(s) must cover the energy model types and EUE included in the application and must include:

- an M&V Plan
- baseline energy model
- operating energy model
- M&V Report, and
- energy savings and ESC calculations (tools, spreadsheets).

The project example may be for a historical project. For example, applicants can apply for accreditation using information from an implementation that has already occurred – to demonstrate their ability to calculate energy savings in accordance with the requirements of the PIAM&V method. However, ESCs would not be able to be created for this implementation, as ESCs can only be created for implementations with an implementation date that is after the date of accreditation.[54]

6.2 Scope of RESA

Those wanting to implement multiple activities that cover different technologies or industries, should group the activities by industry or technology type. The scope of each accreditation needs to be specific enough so that the methodology can be applied to all implementations under the accreditation.

For example, the energy models developed to account for compressed air energy savings (dependent on production) are likely to be significantly different from energy models dealing with HVAC (dependent on weather). Keeping these different scenarios separate makes it easier to develop discrete M&V plans and energy models. The more complexity

53 Refer: www.ess.nsw.gov.au/Accredited_Certificate_Providers/Accreditation_Notice_and_Amendments
54 Refer clause 6.2(a) of the ESS Rule.

that is built-in, by trying to combine different technologies and industry types, the greater the risk of invalid ESCs being found at audit.

6.3 Existing Project Impact Assessment Method accreditations

Those accredited to use the Project Impact Assessment Method (**PIAM**)[55] can apply to have the PIAM&V method added to their existing accreditation if they are interested in using the PIAM&V method to calculate additional energy savings for past implementations. They may also want to add the PIAM&V method to an existing PIAM accreditation for future implementations of an activity for which they are already accredited. In both cases, ACPs will need to complete an application for amendment of their conditions of accreditation and include a completed PIAM&V Application Form Part B to demonstrate their ability to calculate energy savings using the PIAM&V method.[56]

Once an application for amendment is received, the Scheme Administrator will consider the information provided and will determine if the PIAM&V method can be added to the existing PIAM accreditation. Depending on the application, additional information may be requested, and audits may be required before ESCs can be registered.

7 Minimum required records

ACPs are required to keep records in respect of a RESA, including records of:

- the location in which the RESA occurred
- the energy savings arising from that RESA
- the methodology, data and assumptions used to calculate those energy savings, and
- any other records specified by the Scheme Administrator.[57]

ACPs must retain records for at least six years, in a form and manner approved by the Scheme Administrator. Each ACP's Accreditation Notice may include a condition requiring that the ACP's record keeping arrangements are consistent with the ESS Record Keeping Guide.[58]

The boxes throughout this document and the tables in the appendices provide some guidance as to the minimum information that should be kept as a record of the energy savings from each implementation. Those applying for accreditation, however, will need to provide detailed information in their application as to the records they intend to keep to support ESC creation. From 25 May 2017, ACPs must develop the following documents for each implementation (or population, if using the sampling method):[59]

- Measurement & Verification Plan (**M&V Plan**) with a Sampling Plan (if applicable)

55 *ESS Rule*, cl 7

56 Refer: www.ess.nsw.gov.au/How_to_apply_for_accreditation/Apply_Now_-_Guides_and_Application_Forms

57 *Electricity Supply (General) Regulation 2014*, cl 46

58 Available at: www.ess.nsw.gov.au/Accredited_Certificate_Providers/Record_keeping_arrangements

59 Refer fact sheet: www.ess.nsw.gov.au/ESS_Notices_and_Updates/Updates/20171_Consultation_PIAMV_Application_Process

- Measurement & Verification Report (**M&V Report**), and
- spreadsheets / tools to develop energy models and calculate energy savings.

A short description of each document is provided in the following sections.

7.1 M&V Plan

Development of a detailed M&V Plan is central to the successful use of M&V for estimating energy savings. The M&V Plan is typically used to:

- set out the measurement approach
- explain the parameters used (and not used) in the energy models, and,
- explain the approach that will be used to calculate energy savings resulting from an activity.

The OEH *Measurement and Verification Operational Guide*, and the IPMVP (both referenced above) provide detailed guidance on the development and use of M&V Plans. Additional guidance is also provided in Appendix D of this document. An example M&V Plan can be found in Appendix E.

If using the sampling method, ACPs must also develop a Sampling Plan. It should describe the planned sampling approach and how it meets the requirements of clauses 7A.7(e) and 7A.20 of the ESS Rule.

The sampling method described in the Sampling Plan must be reviewed and deemed appropriate by an M&V Professional with their written explanatory reasoning provided.

The Sampling Plan must include the information outlined in the following sections.

7.1.1 Sampling plan – population eligibility requirements

Table 7.1 lists the elements that should be included in the population eligibility requirements.

Table 7.1 Population eligibility requirements

Population eligibility requirements	Description
a. Existing end-user equipment	▼ The sampling plan must describe the type and operational characteristics of existing EUE prior to each implementation. ▼ The description must be precise and cover the common characteristics of the existing EUE throughout the population and the technical specifications of the new EUE. For example, it could be 'a domestic electric resistance hot water system', or 'a refrigerated display cabinet that is not rated as high-efficiency within the meaning of AS 1731.14'. ▼ Any site with existing EUE that does not fit within the defined requirements must not be included in the population.

Population eligibility requirements	Description
b. End-use services being provided	▼ The sampling plan must describe the end-use services being provided at the site. It may include one or more items from Table A17 of the ESS Rule. ▼ Any site that includes EUE that does not provide the services as defined under this requirement must not be included in the population.
c. RESA to be undertaken	▼ The sampling plan must include a concise description of the RESA by: – describing the activity and explaining how the activity will reduce the consumption of energy, and – providing details of the EUE that will be in place after the implementation of the RESA (including technical details and specifications of the new or modified equipment). ▼ Any site that does not meet this requirement must not be included in the population.
d. Site constant	▼ All site constants that are used to develop energy models must be described in the sampling plan. The sampling plan should include the values (or the range of values) of each site constant that will be included in the energy model. ▼ For example, if the site constant is BCA Climate Zone, and the values of BCA Climate Zone are 2, 4 or 5, these values should be included in the population eligibility requirements. Any site that is located in a different BCA Climate Zone will not be eligible to be included in the population.

7.1.2 How to apply the population eligibility requirements

The sampling plan must describe the process that will be implemented to ensure that only sites that meet the population eligibility requirements are included in the population. This process must describe the tests that will be applied to determine which sites are eligible.

For instance, ACPs could create a template with a list of population eligibility requirements and steps for project managers to test if a site meets these requirements.

7.1.3 Distribution of site constants

The sampling plan must describe the expected distribution of site constants across the population.

For example, if the site constant is BCA Climate Zone, and the values of BCA Climate Zone are 2, 4 or 5 (as defined in the population eligibility requirements), ACPs must estimate the distribution of the population among these values. The estimation can be in the form of either percentage or number of sites.

7.1.4 Representativeness test

The sampling plan must define a representativeness test to determine if the sample sites are representative of the whole population. Sample sites are representative if the distribution of the site constant among sample sites is similar to the estimated distribution of the site constant among the population.

For example, if it is estimated that 50% of the population is located in Climate Zone 3, then approximately 50% of the sample sites should be located in this zone.

7.1.5 Additional sample sites

The sampling plan must define conditions under which additional sites are included in the sample to ensure they are representative (as defined in the representativeness test). These conditions are usually a deviation between the estimated and the actual distribution of the site constant among the population.

For example, the sites in the original sample (based on the estimated distribution of the site constant in the population) may have the following distribution:

Climate Zone	Percentage of total sample sites
3	50%
5	50%

If it was later determined that 90% of the sites in the actual population were from Climate Zone 5, then additional sample sites would have to be selected from Climate Zone 5 to ensure that sample sites are representative of the population.

7.1.6 Minimum sample size

The sampling plan must show that the minimum number of sample sites will be at least six times the number of site constants. For large, undefined[60] populations, a sample size determination method developed in accordance with the IPMVP or equivalent M&V standards should be used to calculate the initial number of sample sites.

7.1.7 Bias minimisation

There are a number of sources from which bias might be introduced to sampling. For example, an ACP may only measure energy consumption where metering equipment is in place.

The sampling plan must describe how bias will be minimised in the sample site selection process.

7.1.8 Normal year determination procedure

The sampling plan must include a procedure to determine normal year values for the population. The procedure must be applied to each site of the population, as the normal year values may differ from site to site.

For example, if the independent variable used in the energy models is Cooling Degree Days (**CDDs**), the procedure to calculate normal year CDD values for each site may consider use of typical meteorological year data from the closest weather station.

60 Where the size, mean and standard deviation of the population is unknown.

To satisfy the requirements under clause 7A.7(e) of the ESS Rule, the M&V Professional must deem the procedure appropriate for the implementation and provide written explanatory reasoning.

7.1.9 Interactive energy savings and persistence model determination procedure

Similar to the normal year procedure, the sampling plan should describe the process to determine interactive energy savings, persistence models, counted energy savings and any other relevant M&V parameters for each site of the population when calculating the energy savings for that site.

7.2 M&V Report

ACPs must also develop an M&V Report summarising the outcomes of the implementation. It should describe project implementation details, energy models used (and their development process) and calculation of energy savings, including all M&V parameters and assumptions used in the calculations.

The M&V Report can be used to record how energy models meet the requirements of the ESS Rule, by including sub-headings to check off that each of the ESS Rule requirements has been addressed.

The M&V Report should describe how each of the parameters used in the energy models was derived, so that all assumptions and inputs to the calculation spreadsheets can be referenced and verified by the M&V Professional (see section 3.9) or at audit if required.

The M&V Report should also include information regarding implementation of the Sampling Plan (if applicable) including any changes to the original plan, eg, addition of extra sites to the population.

7.3 Calculation tools

Spreadsheets and tools used in the calculation of energy savings and development of energy models (eg, regression analysis) must be developed and maintained, as supporting information for the M&V Report.

Calculation of energy savings must be done in accordance with the relevant PIAM&V equations outlined in the ESS Rule. Refer to section 4 and Appendix A for more details on how to calculate energy savings. The PIAM&V Tool developed by OEH can assist in the calculation of energy savings with forward creation for a single site model. [61]

61 Available at www.environment.nsw.gov.au/business/piamv-tool.htm

8 Glossary

Term	Definitions
ACP	Accredited Certificate Provider
Accredited Certificate Provider	A person accredited under the ESS to create ESCs for Recognised Energy Saving Activities.
Accuracy factor	A number between 0 and 1, used to discount energy savings according to the relative precision of normal year energy savings at a 90% confidence level.
Coefficient of variation	The sample standard deviation expressed as a percentage of the sample mean.
Computer simulation	A method to establish an energy model that uses software to simulate energy consumption by EUE and can be tested against statistical requirements published by the Scheme Administrator.
Decay factor	A number between 0 and 1 which quantifies the decay of the energy savings due to equipment degradation over time.
Effective range	The range over which values of each independent variable for which a baseline energy model or operating energy model (as the case may be) is valid.
Electricity savings	The reduction of the amount or equivalent amount of electricity consumption (in MWh) arising from the implementation, may be negative for fuel switching activities.
Energy model	A mathematical model describing the energy use profile before an implementation (baseline) and after an implementation (operating) occurs.
Energy saver	Refer to section 3.1 of this guide.
Energy savings	Electricity savings or gas savings or both
ESC	Energy Savings Certificate
ESS	Energy Savings Scheme
ESS Rule	Energy Savings Scheme Rule of 2009
Estimate of the mean	A method in PIAM&V that can be used to establish an energy model.
Gas	Any fuel listed in National *Greenhouse and Energy Reporting (Measurement) Determination 2008* (Cth) Schedule 1 Part 2—Fuel combustion—gaseous fuels or liquefied petroleum gas.
Gas savings	The reduction of the amount of gas combusted for stationary energy (in MWh) arising from the implementation, may be negative for fuel switching activities.
Implementation	The delivery of a Recognised Energy Saving Activity at a site.
Implementation date	Refer to section 3.3 of this guide.
Independent variable	A parameter that varies over time, that can be measured and affects the EUE's energy consumption at a site.
Interactive energy savings	A change in a site's energy consumption due to interactions with EUE for which energy consumption is not measured.
Measurement and verification professional	Refer to section 3.9 of this document.
Measurement boundary	The area of a site that is subject to the implementation, where the energy consumption by any EUE located within it is directly affected by the implementation.

Term	Definitions
Measurement period	The duration of time over which measurement of energy consumption will be taken for the purposes of calculating the energy savings.
Non-routine events	Events which affect energy use, within the chosen measurement period, that are not modelled by any independent variables or site constants. They are required to be removed from the measurement period to enable like-for-like comparison of before and after energy savings scenarios. They are typically due to static factors that may include fixed, environmental, operational and maintenance characteristics.
Normal operations	Typical operating conditions of EUE, excluding commissioning.
Normal year	A typical year for the operation of the EUE at the site after the implementation date.
Number of model parameters	In relation to an energy model, means the number of parameters required to unambiguously define the functional form of the energy model. In a linear energy model, it is the number of coefficients or the number of independent variables and site constants that are used to explain energy consumption variation.
Persistence model	A model used to forecast the continuation of energy savings from an implementation over its useful lifetime.
Population eligibility requirements	The set of defined requirements that a site must meet to be included in the population, set out in Table A.1 of this guide (as required under clause 7A.20 of the ESS Rule).
Pre-implementation period	The measurement period prior to the implementation period.
Purchaser	Refer to section 3.2 of this guide.
Regression analysis	A method in PIAM&V used to establish an energy model that determines a mathematical function for approximating the relationship between energy consumption and independent variables and / or site constants and includes, but is not limited to, linear regression, and mixed models.
Relative precision	A measure of the relative range within which a true value is expected to occur with some specified confidence level.
Representativeness test	A test that can be applied to the set of site constants across the sample sites to test whether they are distributed in a way that represents the expected distribution of those site constants across the population.
RESA	Recognised Energy Saving Activity
Sample site	A site in the population where measurements are taken for inclusion in a multiple site model
Sampling method	The statistical method for conducting measurements on a subset of a population to estimate the characteristics of the entire population.
Site constant	A parameter for a site, which does not vary over time under normal operating conditions, and affects the EUE's energy consumption.

Appendices

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A Guidance for calculation of energy savings

This section of the guide provides more detail on applying the ESS Rule to calculate energy savings. The tables step out key requirements of the ESS Rule, but are guidance only, so care must be taken to ensure all ESS Rule requirements are met.

The tables reference the OEH PIAM&V Tool[62] that steps through the requirements of the ESS Rule for forward creation with a single site model utilising regression analysis. Use of the tool is recommended, but is not required.

The M&V Plan and the M&V Report (or other supporting documents) developed for each implementation are expected to address each section of the tables below relevant to the energy model being developed. More information on developing M&V Plans can be found in Appendices D and E of this document.

A.1 Forward creation at an individual site

Table A.1 provides a step-by-step approach to developing energy models for use with forward creation at a single site; to meet the requirements of clause 7A.1(a) of the ESS Rule. Each of the steps in Table A.1 matches the sections of the OEH PIAM&V Tool.

A.2 Top-up after forward creation at an individual site

Table A.2 provides a step-by-step approach to top-up after forward creation at a single site; to meet the requirements of clause 7A.1(b) of the ESS Rule. The calculation of ESCs using this approach is not included in the OEH PIAM&V Tool.

A.3 Annual creation at an individual site

Table A.3 provides a step-by-step approach to annual creation at a single site; to meet the requirements of clause 7A.1(b) of the ESS Rule. The calculation of ESCs using this approach is not included in the OEH PIAM&V Tool.

A.4 Forward creation at multiple sites using sampling

Table A.4 provides a step-by-step approach to forward creation at multiple sites; to meet the requirements of clause 7A.1(c) of the ESS Rule. The calculation of ESCs using this approach is not included in the OEH PIAM&V Tool.

62 Refer: www.environment.nsw.gov.au/business/piamv-tool.htm%20

Table A.1 Detailed calculation steps when using forward creation at an individual site

Step	Description and PIAM&V Tool reference	Details
1	Define implementation, site and measurement boundary ▼ Step 1 in the *Boundaries and variables* sheet	▼ Describe the equipment or process that will comprise the RESA, including: – performance characteristics of the EUE, including that used to modify the system, and – consideration of Australian certification, performance and safety standards applicable to the equipment. ▼ The measurement boundary must include all EUE whose energy consumption will be effected by the RESA, where feasible: – consider setting the measurement boundary to minimise the proportion of measured energy consumption that is unrelated to the project. ▼ Define the measurement boundary with reference to: – the business / operating cycle – independent variables impacting energy use within the boundary, and – site constants impacting energy use at the boundary.
2	Define energy model data frequency and variables ▼ Steps 2a and 2b in the *Boundaries and variables* sheet	▼ For each energy model, define the data frequency for measurements of: – energy consumption – independent variables – site constants, and – any other relevant parameters. ▼ The frequency of these measurements must be consistent to allow them to be used in the energy models. ▼ For each variable, site constant and energy consumption, include: – name, description and units – measurement procedure, including responsibility for recording and reporting measurement equipment – how any measurements were converted to a different frequency for use in the energy model – any calculations performed on measurements to derive each input – the value of a site constant or independent variable during normal operating conditions, and – measurement accuracy (relative error or absolute error). ▼ To further support the energy model development process, identify and define variables that are neither independent variables nor site constants (ie, will not be used in an energy model), including details of: – assigned name, description and units – measurement procedure

Step	Description and PIAM&V Tool reference	Details
		– typical value or range of values, and – reason they have been excluded from the model. ▼ This may include any number of variables that were considered as inputs to the energy model, but were not included in the final energy model, for example due to finding that the variable had very little influence in describing variations in energy use.
3	Establish normal year of operating conditions ▼ Step 3a on the *Data - Normal year* sheet to enter normal year values for each independent variable and site constant ▼ Step 3b on the *Normal year* sheet for all other information	▼ Define values for independent variables and site constants over a normal year of operation, representing a typical year of operation for the EUE over the maximum time period for forward creation. ▼ When defining a normal year, ACPs must: – consider future 'typical' operating conditions of the site, which may differ from the baseline period. Operating conditions may include typical weather conditions, operating days per year, maintenance periods, changes in site activities (ie, production levels), etc, – use actual data rather than estimates, where practical (typically, data should not be older than 3 years to be indicative of current/predicted performance), – describe how the normal year is constructed, noting any adjustments, calculations or manipulations, and – where the operating cycle of the system is less than one year, the normal year may be constructed by combining values from multiple operating cycles to make up one year.
4	Establish baseline energy model ▼ Step 4a on the *Data - baseline* sheet to enter normal year values for each independent variable and site constant ▼ Step 4b on the *Baseline Energy Model* sheet to define the model	▼ Establish the baseline energy model to estimate the energy consumption in the absence of the implementation, as a function of independent variables and site constants measured under normal operating conditions and based on a normal year. ▼ The baseline energy model may be established by: – estimate of the mean that is based on measurements of energy consumption, independent variables and site constants, where relevant, specifies a measurement period, and where the coefficient of variation of the energy consumption over the measurement period is less than 15% – regression analysis that is based on measurements of energy consumption, independent variables and site constants, specifies a measurement period, and where the number of independent observations for each site when calculated in accordance with clause 7A.6 of the ESS Rule is at least six times the number of model parameters in the energy model (refer section B.2 of this guide), or – computer simulation using a commercially available software package determined to be acceptable by the Scheme Administrator (refer section B.3 of this guide). ▼ For new-end user equipment, the baseline energy model may be established by one of the above methods, by using average energy performance of the same type of EUE, to transform the measurements of energy consumption, independent variables and site constants into inputs, used to establish the operating energy model.

Step	Description and PIAM&V Tool reference	Details
5	Implement and commission activity ▼ Step 5 on the *Implementation* sheet	▼ Define and record the implementation date. ▼ Determine the length of the measurement period for the operating energy model, with a start date occurring after the implementation date.
6	Establish operating energy model ▼ Step 6a on the *Data-operating* sheet ▼ Step 6b on the *Operating model* sheet	▼ Establish the operating energy model to estimate the energy consumption following implementation, as a function of independent variables and site constants measured under normal operating conditions and based on a normal year. ▼ The operating energy model may be established by: – estimate of the mean that is based on measurements of energy consumption, independent variables and site constants, where relevant, specifies a measurement period, and where the coefficient of variation of the energy consumption over the measurement period is less than 15% – regression analysis that is based on measurements of energy consumption, independent variables and site constants, specifies a measurement period, and where the number of independent observations for each site when calculated in accordance with clause 7A.6 of the ESS Rule is at least six times the number of model parameters in the energy model (refer section B.2 of this guide), or – computer simulation using a commercially available software package determined to be acceptable by the Scheme Administrator (refer section B.3 of this guide).
7	Calculate interactive energy savings ▼ Step 7 on the Interactive Energy Savings sheet	▼ Identify and define interactive effects, which lead to interactive energy savings, by including all EUE outside of the measurement boundary that will have its energy consumption affected by the RESA. ▼ Include a written explanation as to why the measurement boundary has not been modified to include this equipment. ▼ An example of an interactive effect is a decrease in the energy requirements for a cooling system, located outside of the measurement boundary, which occurs as a result of a project that installs high efficiency lights that emit less heat. ▼ When estimating interactive energy savings, they cannot represent more than 10% of total energy savings respectively, unless they are estimated in accordance with a guidance document published by the Scheme Administrator.
8	Calculate normal year energy savings ▼ Step 8 on the *Normal Year Energy Savings* sheet, based on previously entered values	▼ Calculate normal year energy savings, in MWh, using Equation 7A.2 by substituting the value of independent variables from the normal year into the baseline energy model and operating energy model, and using the interactive energy savings calculated in step 7. ▼ Any time periods for which any of the normal year values for the independent variables are less than the lower limit or greater than upper limit[a] of the effective range for either the baseline energy model or operating energy model must be excluded from the energy savings calculation. ▼ Additionally, any time periods where the site constants are not their standard value must be excluded from the savings calculation.

Step	Description and PIAM&V Tool reference	Details
9	Apply accuracy factor ▼ Step 9 on the *Accuracy Factor* sheet, based on previously entered values	▼ The accuracy factor (as specified in Table A23 of the ESS Rule or as otherwise determined by another process published by the Scheme Administrator) that corresponds to the relative precision[b] of the energy savings estimate at a 90% confidence level must be applied. ▼ The relative precision of the energy savings estimate must take into account model uncertainty, input and output measurement uncertainty[c], and where relevant, sampling uncertainty. ▼ Depending on the measurement frequency, the relative precision may also need to be adjusted for autocorrelation effects.
10	Determine lifetime and decay factors ▼ Step 10 on the *Decay Factor* sheet, to either use decay factors or the built-in persistence model	▼ The expected lifetime of the EUE determines the maximum time period for forward creation, to a maximum of ten years after the implementation date (or five years for RESAs previously created under PIAM). ▼ In addition, a decay factor is used to estimate the decay of the energy savings due to equipment degradation over its lifetime. **Decay factors** ▼ A decay factor can be estimated by either using a persistence model or specified default values from Table A16 of the ESS Rule. **Persistence model** ▼ If a persistence model is being applied, it must take into account: – the business classification of the site (from Table A18 of the ESS Rule), if known and relevant – the EUE type, – the operating hours (as determined by measurements) for the EUE, and – typical ambient conditions for that site, including temperature, humidity and salinity. ▼ It also needs to: – estimate the expected lifetime of the EUE in whole years – estimate the decay factor for each future year within the maximum time period for forward creation, and – be publicly accessible and accepted for use by the Scheme Administrator. ▼ If using the built-in persistence model with the PIAM&V Tool, some inputs are fixed. To use other inputs, you will need to submit evidence that is acceptable to the Scheme Administrator.

Step	Description and PIAM&V Tool reference	Details
11	Determine counted energy savings ▼ Step 11 of the Counted Energy Savings sheet	▼ It is possible that energy savings may have already been claimed in relation to the EUE within the measurement boundary, in which case they must be identified and accounted for. ▼ As this calculation is for the initial forward creation of certificates, ESCs must not have previously been created for the implementation under this RESA (or a corresponding scheme). ▼ For counted energy savings that are from energy savings under a different RESA, determine the counted energy savings for the implementation in each year.
12	Calculate energy savings ▼ Step 12 on the Energy Savings Summary sheet	▼ The energy savings to be forward created over the maximum time period for forward creation are then calculated according to Equation 7A.1.

[a] The lower limit is calculated as the minimum of the measured values, minus 5% of difference between the minimum and maximum of the measured values.
The upper limit is calculated as the maximum of the measured values, plus 5% of difference between the minimum and maximum of the measured values.

[b] The equation for calculating relative precision at 90% confidence level is (t-statistic x sample standard error)/estimate, where the estimate is any empirically derived value of a parameter of interest (p. 91 – IPMVP vol.1 2012).

[c] Input measurement uncertainty arises from independent variables (eg, weather conditions), while output measurement uncertainty is estimated from the accuracy of an instrument used to measure energy use.

Table A.2 Detailed calculation steps for topping-up after forward creation at an individual site

Step	Description and PIAM&V Tool reference	Details
1	Measure operating energy consumption	▼ Measure the operating period energy consumption, along with all independent variables and site constants that were defined for the RESA for the forward creation sub-method. ▼ Measurement period must be for a full year that commences on the anniversary of the implementation date as previously determined for the RESA for the forward creation sub-method, and must end within the maximum time period for forward creation.
2	Calculate interactive energy savings	▼ Calculate the interactive energy savings as defined for the RESA for the forward creation sub-method as per step 7 of Table A.1 of this guide. ▼ The interactive energy savings must be adjusted to be representative of operating period conditions.
3	Calculate measured annual energy savings	▼ Calculate measured annual energy savings, in MWh, using Equation 7A.4 of the ESS Rule. – The predicted baseline energy consumption is determined by substituting values of independent variables from a measurement period into the baseline energy model. – The operating energy consumption is as measured during a measurement period. – The interactive energy savings are calculated as per step 2. ▼ Exclude any time periods for which any values for the independent variables fall outside the effective range of the baseline energy model, for the purpose of calculating energy savings. ▼ Additionally, any time periods where the site constants are not their standard value must be excluded from the savings calculation.
4	Apply accuracy factor	▼ The accuracy factor is either the value in Table A23 of the ESS Rule that corresponds to the relative precision of the energy savings estimate at a 90% confidence level, or the value determined by another process published by the Scheme Administrator. ▼ The energy savings estimate is the measured annual energy savings as defined in Equation 7A.3 of the ESS Rule. ▼ The relative precision of the energy savings estimate must account for model and measurement uncertainty.[a] ▼ For the measured operating period energy consumption, only output measurement uncertainty is considered. ▼ Depending on the measurement frequency, the relative precision may also need to be adjusted for autocorrelation effects.

Step	Description and PIAM&V Tool reference	Details
5	Determine counted energy savings	▼ It is possible that energy savings may have already been claimed in relation to the EUE within the measurement boundary, in which case they must be identified and accounted for. ▼ Account for energy savings for the RESA determined using the forward creation sub-method for each measurement period. ▼ Counted energy savings that are from energy savings under a different RESA (or a corresponding scheme), not included in the counted energy savings during the forward creation sub-method, must also be included for each measurement period.
6	Calculate energy savings	▼ The energy savings for a measurement period are then calculated according to Equation 7A.3 of the ESS Rule.

[a] Input measurement uncertainty arises from independent variables (eg, weather conditions), while output measurement uncertainty is estimated from the accuracy of an instrument used to measure energy use

Table A.3 Calculation steps for annual creation at an individual site

Step	Description and PIAM&V Tool reference	Details
1	Define implementation, site and measurement boundary	Describe the equipment or process that will comprise the RESA, including: ▼ performance characteristics of the EUE, including that used to modify the system, and ▼ consideration of Australian certification, performance and safety standards applicable to the equipment. The measurement boundary must include all EUE whose energy consumption will be affected by the RESA, where feasible: ▼ consider setting the measurement boundary to minimise the proportion of measured energy consumption that is unrelated to the project. Define the measurement boundary with reference to: ▼ the business / operating cycle ▼ independent variables impacting energy use within the boundary, and ▼ site constants impacting energy use at the boundary.
2	Define energy model data frequency and variables	For the baseline energy model, define the data frequency for measurements of: ▼ energy consumption ▼ independent variables, and ▼ site constants. The frequency of these measurements must be consistent to allow them to be used in the baseline energy model. For each variable, site constant and energy consumption, include: ▼ name, description and units ▼ measurement procedure, including responsibility for recording and reporting measurement equipment ▼ how any measurements were converted to a different frequency for use in the baseline energy model ▼ any calculations performed on measurements to derive each input, and ▼ the value of a site constant or independent variable during normal operating conditions, and ▼ measurement accuracy (relative error or absolute error). To further support the baseline energy model development process, identify and define variables that are neither independent variables nor site constants (ie, will not be used in the baseline energy model), including details of: ▼ assigned name, description and units, and ▼ measurement procedure. This may include any number of variables that were considered as inputs to the energy model, but were not included in the final energy model, for example due to finding that the variable had very little influence in describing variations in energy use.

Step	Description and PIAM&V Tool reference	Details
3	Establish baseline energy model	Establish the baseline energy model to estimate the energy consumption in the absence of the implementation, as a function of independent variables and site constants. The baseline energy model may be established by: ▼ an estimate of the mean that is based on measurements of energy consumption, independent variables and site constants, where relevant, specifies a measurement period, and where the coefficient of variation of the energy consumption over the measurement period is less than 15%, or ▼ regression analysis that is based on measurements of energy consumption, independent variables and site constants, specifies a measurement period, and where the number of independent observations for each site when calculated in accordance with clause 7A.6 of the ESS Rule is at least six times the number of model parameters in the energy model (refer section B.2 of this guide), or ▼ computer simulation using a commercially available software package determined to be acceptable by the Scheme Administrator (refer section B.3 of this guide). For new-end user equipment, the baseline energy model may be established by one of the above methods, by using average energy performance of the same type of EUE, to transform the measurements of energy consumption, independent variables and site constants into inputs, used to measure the annual energy savings.
4	Implement and commission activity	Define and record the implementation date.
5	Measure operating energy consumption	Measure the operating period energy consumption, along with all independent variables and site constants that were defined for the RESA. ▼ The measurement period must be for a full year, and commences after the implementation date.
6	Calculate interactive energy savings	Identify and define interactive effects, which lead to interactive energy savings, by including all EUE outside of the measurement boundary that will have its energy consumption affected by the RESA. ▼ Include written explanation as to why the measurement boundary has not been modified to include this equipment. ▼ An example of an interactive effect is a decrease in the energy requirements for a cooling system, located outside of the measurement boundary, which occurs as a result of a project that installs high efficiency lights that emit less heat. ▼ When estimating interactive energy savings, they cannot represent more than 10% of total energy savings respectively, unless they are estimated in accordance with a guidance document published by the Scheme Administrator.

Step	Description and PIAM&V Tool reference	Details
7	Calculate measured annual energy savings	Calculate measured annual energy savings, in MWh, using Equation 7A.4 of the ESS Rule. ▼ The predicted baseline energy consumption is determined by substituting values of independent variables from a measurement period into the baseline energy model. ▼ The operating energy consumption is as measured during a measurement period. ▼ The interactive energy savings are calculated as per step 6. ▼ Exclude any time periods for which any values for the independent variables fall outside the effective range of the baseline energy model, for the purpose of calculating energy savings. ▼ Additionally, any time periods where the site constants are not their standard value must be excluded from the savings calculation.
8	Apply accuracy factor	The accuracy factor is the value in Table A23 of the ESS Rule, or as otherwise determined by another process published by the Scheme Administrator, that corresponds to the relative precision of the energy savings estimate at a 90% confidence level. ▼ The energy savings estimate is the measured annual energy savings as defined in Equation 7A.3 of the ESS Rule. ▼ The relative precision of the energy savings estimate must account for model and measurement uncertainty. ▼ For the measured operating period energy consumption, only output measurement uncertainty is considered. ▼ Depending on the measurement frequency, the relative precision may also need to be adjusted for autocorrelation effects.
9	Determine counted energy savings	It is possible that energy savings may have already been claimed in relation to the EUE within the measurement boundary, in which case they must be identified and accounted for. ▼ Energy savings for the RESA determined using the forward creation sub-method for each measurement period. ▼ Counted energy savings that are from energy savings under a different RESA (or corresponding scheme), not included in the counted energy savings during the forward creation sub-method, must also be included for each measurement period.
10	Calculate energy savings	▼ The energy savings for a measurement period are then calculated according to Equation 7A.3 of the ESS Rule.

Table A.4 Detailed calculation steps when using forward creation at multiple sites using sampling

Step	Description and PIAM&V Tool reference	Details
1	Define the population eligibility requirements	▼ Define the eligibility requirements for the Population, including: – existing EUE – end-use services being provided – RESA to be undertaken – site constants, and – any additional requirements published by the Scheme Administrator. ▼ Have a process to ensure that only sites that meet the population eligibility requirements are included in the population.
2	Define implementation, site and measurement boundary	▼ Describe the equipment or process that will comprise the RESA, including: – performance characteristics of the EUE, including that used to modify the system, and – consideration of Australian certification, performance and safety standards applicable to the equipment. ▼ The measurement boundary for each sample site must include all EUE whose energy consumption will be affected by the RESA, where feasible: – consider setting the measurement boundary to minimise the proportion of measured energy consumption that is unrelated to the project. ▼ Define each measurement boundary with reference to: – the business / operating cycle – independent variables impacting energy use within the boundary, and – site constants impacting energy use at the boundary.
3	Define the representativeness test and select sample sites	▼ Determine the distribution of site constants in the population. ▼ Define the representativeness test. ▼ Select sample sites and ensure that: – sample sites meet the representativeness test, and – the number of sample sites is at least six times the number of site constants in each energy model.

Step	Description and PIAM&V Tool reference	Details
4	Define energy model data frequency and variables	▼ For each energy model, define the data frequency for measurements of: – energy consumption – independent variables – site constants, and – any other relevant parameters. ▼ The frequency of these measurements must be consistent to allow them to be used in the energy models. ▼ For each variable, site constant and energy consumption, include: – name, description and units – measurement procedure, including responsibility for recording and reporting measurement equipment – how many measurements were converted to a different frequency for use in the energy model – any calculations performed on measurements to derive each input – the value of a site constant or independent variable during normal operating conditions, and – measurement accuracy (relative error or absolute error). ▼ To further support the energy model development process, identify and define variables that are neither independent variables nor site constants (ie, will not be used in an energy model), including details of: – assigned name, description and units – measurement procedure – typical value or range of values, and – reason they have been excluded from the model. ▼ This may include any number of variables that were considered as inputs to the energy model, but were not included in the final energy model, for example due to finding that the variable had very little influence in describing variations in energy use.

Step	Description and PIAM&V Tool reference	Details
5	Establish normal year of operating conditions for each site	▼ Define the procedure to establish the values for independent variables and site constants over a normal year of operation, representing a typical year of operation for the end-user equipment over the maximum time period for forward creation. ▼ This procedure should be included in the M&V Plan and be able to be applied to all sites in the population. ▼ When defining a normal year, ACPs must: – consider future ‘typical’ operating conditions of the site, which may differ from the baseline period. Operating conditions may include typical weather conditions, operating days per year, maintenance periods, changes in site activities (ie, production levels), etc, – use actual data rather than estimates, where practical (typically, data should not be older than 3 years to be indicative of current/predicted performance), – describe how the normal year is constructed, noting any adjustments, calculations or manipulations, and – where the operating cycle of the system is less than one year, the normal year may be constructed by combining values from multiple operating cycles to make up one year.
6	Take baseline measurements at sample sites	▼ Measurements are taken from the selected sample sites.
7	Establish baseline energy model	▼ Establish the baseline energy model to estimate the energy consumption at samples site for the population in the absence of the implementation, as a function of independent variables and site constants measured under normal operating conditions and based on a normal year. See Appendix B for more details.
8	Implement and commission activity on sample sites	▼ Define and record the implementation date (note that the implementation date is the date that the implementation at each site commenced normal operations).
9	Take operating energy measurement at sample sites	▼ Measurements are taken from sample sites selected by the ACP in accordance with step 3. Appendix B for more details.
10	Establish operating energy model	▼ Establish the operating energy model to estimate the energy consumption following implementation, as a function of independent variables and site constants measured under normal operating conditions and based on a normal year.
11	Implement and commission activity on non-sample sites	▼ This step can be undertaken at an earlier stage. However, ESCs for any site may only be created in accordance with the ESS Rule. See section 5 for more information.

Step	Description and PIAM&V Tool reference	Details
12	Calculate interactive energy savings for each site	▼ Identify and define interactive effects, which lead to interactive energy savings, by including all EUE outside of the measurement boundary that will have its energy consumption affected by the RESA. ▼ Include written explanation as to why the measurement boundary has not been modified to include this equipment. Refer to section 3.6 for more information. ▼ An example of an interactive effect is a decrease in the energy requirements for a cooling system, located outside of the measurement boundary, which occurs as a result of a project that installs high efficiency lights that emit less heat. ▼ When estimating interactive energy savings, they cannot represent more than 10% of total energy savings, unless they are estimated in accordance with a guidance document published by the Scheme Administrator.
13	Calculate normal year energy savings for each site	▼ Calculate normal year energy savings, using Equation 7A.5 by substituting the value of independent variables and site constants from the normal year into the baseline energy model and operating energy model, and using the interactive energy savings calculated in step 12. ▼ Any time periods for which any of the normal year values for the independent variables that outside of the effective range for either the baseline energy model or operating energy model must be excluded from the energy savings calculation. ▼ Additionally, any time periods where the site constants are not their standard value must be excluded from the savings calculation.
14	Apply accuracy factor	▼ Apply an accuracy factor (as specified in Table A23 of the ESS Rule or as otherwise determined by another process published by the Scheme Administrator) that corresponds to the relative precision of the energy savings estimate at a 90% confidence level. ▼ The relative precision of the energy savings estimate must take into account model uncertainty, input and output measurement uncertainty, and where relevant, sampling uncertainty. ▼ Depending on the measurement frequency, the relative precision may also need to be adjusted for autocorrelation effects.

Step	Description and PIAM&V Tool reference	Details
15	Determine lifetime and decay factors for each site	▼ The expected lifetime of the end-user equipment determines the maximum time period for forward creation, to a maximum of ten years after the implementation date). In addition, a decay factor is used to estimate the decay of the energy savings due to equipment degradation over its lifetime. ▼ **Decay factors** ▼ A decay factor can be estimated by either using a persistence model or specified default values from Table A16 of the ESS Rule. ▼ **Persistence model** ▼ If a persistence model is being applied, it must take into account: – the business classification of the site (from Table A18 of the ESS Rule), if known and relevant – the EUE type, – the operating hours (as determined by measurements) for the EUE, and – typical ambient conditions for that site, including temperature, humidity and salinity. ▼ It also needs to: – estimate the expected lifetime of the EUE in whole years – estimate the decay factor for each future year within the maximum time period for forward creation, and – be publicly accessible and satisfy any requirements published by the Scheme Administrator. ▼ ACPs may use the PIAM&V Tool – "Persistence Model Only" function to establish the persistence model for each site.
16	Determine counted energy savings for each site	▼ It is possible that energy savings may have already been claimed in relation to the EUE within the measurement boundary, in which case they must be identified and accounted for. ▼ As this calculation is for the initial forward creation of certificates, ESCs must not have previously been created for the implementation under this RESA (or a corresponding scheme). ▼ For counted energy savings that are from energy savings under a different RESA, determine the counted energy savings for the implementation in each year.
17	Calculate energy savings	▼ The energy savings to be forward created over the maximum time period for forward creation are then calculated according to Equation 7A.1.

B Guidance for development of energy models

B.1 Establishing energy models by estimate of the mean

ACPs can use estimate of the mean to establish an energy model to estimate the energy consumption of a system, where energy is not driven by any factors (ie, there is no correlation between energy consumption and any independent variables).

Requirements

To use the estimate of the mean, ACPs must ensure that:

- the energy model is based on measurements of energy consumption or, if based on estimates, ACPs must ensure the estimates are determined in accordance with IPMVP standards, and
- the coefficient of variation of the energy consumption over the measurement period is less than 15%.

B.2 Establishing energy models by regression analysis

ACPs can use regression analysis to establish an energy model to estimate the energy consumption of a system subject to a number of independent variables and site constants that vary over time.

The energy model will be established for:

- baseline conditions, before implementation (forward creation and top-up sub-methods), and
- operating conditions, after implementation (for forward creation sub-method).

The energy model expresses the energy consumption as a mathematical function of the independent variables and is used to perform "routine adjustments", as defined under the IPMVP.

The form of the model is defined based on the independent variables and site constants, and a regression analysis is performed to optimise the values of the coefficients of each of the variables in the energy model.

Table B.1 provides a suggested approach to regression analysis when it is being used in an energy model (like that being developed in Table A.1). Regression analysis can be used to establish the baseline and operating energy model for an Implementation, to meet the requirements of the ESS Rule.

Requirements

To use regression analysis, ACPs must ensure that:

- the energy model is based on measurements of energy consumption or, if based on estimates, ACPs must ensure the estimates are determined in accordance with IPMVP standards
- the number of independent observations for each site is at least six times the number of model parameters,[63] and
- the minimum statistical requirements of the regression analysis model are in accordance with industry standards. Guidance on statistical thresholds of statistical good-fit is provided in Table D.2.

B.3 Establishing energy models by computer simulation

Computer simulation can be used to establish an energy model for an implementation that estimates the energy consumption using a number of independent variables and site constants that vary over time.

The energy model will be established for:

- baseline conditions, before implementation (forward creation and top-up sub-methods), and
- operating conditions, after implementation (for forward creation sub-method).

The energy model expresses the energy consumption as a mathematical function of the independent variables and is used to perform "routine adjustments" as defined under the IPMVP.

Requirements

To use computer simulation, the ESS Rule requires the use of software that:

- is commercially available
- is approved by the Scheme Administrator for use in modelling the relevant type of EUE
- is calibrated against measurements taken from the actual EUE being simulated to meet requirements as published by the Scheme Administrator, and
- can be tested against requirements published by the Scheme Administrator.

ACPs will also have to meet the following additional Scheme Administrator requirements:

- the computer simulation software must calculate energy consumption for specified time intervals and be based on engineering equations and user-defined parameters relevant to the EUE that is modelled (for example, a tool that performs regression analysis or similar type of statistical simulations is not considered computer simulation software), and

63 The number of model parameters equals the number of independent variables in the case of single site models, or the number of independent variables plus site constants in the case of multi-site models.

- ACPs must determine and justify the accuracy requirements of the calibrated computer simulation model in accordance with industry standards.

Applicants proposing to use computer simulation to calculate energy savings should contact IPART prior to submitting an application for accreditation. Applicants can propose the software package to be used to develop the energy models, however the Scheme Administrator will need to consider the validity of its use on a case-by-case basis. The process for assessing and approving computer simulation software is conducted as part of an application for accreditation assessment process.

When assessing the use of a chosen software package, the Scheme Administrator may assess it using the guidelines described in Table B.2.

Table B.1 Suggested approach for establishing energy models by regression analysis

Step	Description	Details
1	Measure energy consumption and site variables over the measurement period	Define the start date and end date of the measurement period. ▼ Measurement periods are required before implementation (baseline conditions) and after implementation (operating conditions). ▼ Ideally the measurement period should define a full operating cycle of the EUE. ▼ If a measurement period is shorter than a full operating cycle, there is a risk that the data collected over the measurement period will not be representative of the full operating range of the equipment and the independent variables and site constants – this has implications in determining the effective range. ▼ Measure energy consumption and all independent variables and site constants for the set measurement period.
2	Remove measurements taken under non-normal site conditions	▼ Non-routine adjustments account for those characteristics of a facility which affect energy use, within the chosen measurement period, that are not used as the basis for any independent variables or site constants. ▼ Record any non-routine adjustments of measured data, where time periods that cover non-routine events (eg, unscheduled maintenance) are excluded from all measurements. ▼ Calculate the non-routine adjustment ratio as the percentage of measurements removed from total number of measurements taken within the measurement period.
3	Test for correlation between independent variables	▼ It is important that the variables used in the energy model are independent of one another, since co-dependence will result in poor regression parameters and introduce unnecessary complexity to the energy model. ▼ Test for correlation between the measured values for the variables, for example by calculating the Pearson's correlation coefficient. ▼ Review any variables that are strongly correlated and consider refining your regression model. ▼ If using the OEH PIAM&V Tool, this function is performed in the tool using the CORREL function. ▼ The effective range is to include any normal year values for each independent variable under which the implementation could reasonably be expected to increase energy consumption.
4	Determine effective range	▼ The effective range is the range of values over which the energy models are valid. ▼ Each independent variable used in an energy model must have an accompanying effective range. ▼ The effective range needs to be consistent with the range of measured values for independent variables. ▼ Techniques for determining the effective range are provided below in Steps 4a, 4b. ▼ Other methods for determining the effective range may be considered.

Step	Description	Details
4a	Method to determine effective range – Bounding Box	▼ The OEH PIAM&V Tool uses a bounding box of all of the measured values of each independent variable to determine its maximum and minimum values, the values being: – $x_{j.max}$ = max(x_j(t)), and – $x_{j.min}$ = min(xj(t)), ▼ where xj(t) is the value of the independent variable x_j measured during the relevant time period.
4b	Method to determine effective range – Convex Hull	▼ A convex hull method can be used to incorporate all of the measured values of an independent variable to define the effective range. ▼ The convex hull method determines an equation, or range, that describes a single or multi variable region within which all the measured values exist.
5	Using regression analysis to estimate energy model	▼ Regression analysis may include linear and non-linear multivariate regression techniques. ▼ ACPs can use the OEH PIAM&V Tool to record the data and calculate energy savings, however: – the regression analysis must be calculated outside of the tool – it can only accept linear regression equations, and – non-linear regression analysis must be conducted outside of the tool using appropriate software or tools. ▼ ACPs can also use their own calculation spreadsheets to calculate the energy savings. ▼ When submitting the energy model and evidence to support the calculation of ESCs, ACPs should provide at least the following, describing their use and any assumptions in the M&V Plan (or similar): – the software/tool used to conduct the regression analysis – the value of the regression coefficient for each variable and associated t-statistic – the coefficient of determination (R2) and adjusted R2, and – the standard error (SE) of the regression equation.

Table B.2 Guidelines for the use of computer simulation (using a commercially available software package determined to be acceptable by the Scheme Administrator)

Requirement	Information provided by applicant	Guidelines that may be used by Scheme Administrator to assess requirement
Commercially available & models relevant type of EUE	▼ Name and version of the software ▼ Description of the model, including process or equipment diagram, key inputs/outputs and other simulation parameters	▼ List of programmes on US Dept. of Energy at: http://apps1.eere.energy.gov/buildings/tools_directory/ ▼ Validated using IEA-BESTest protocol.
Calibrated against measurements taken from the actual EUE being simulated	▼ Calibration data ▼ Inputs, outputs, parameters and assumptions ▼ M&V Professional ability to calibrate outputs from computer simulation	▼ Calibration using ASHRAE 14 Guideline – 2002. ▼ Other applicable standards. ▼ Relevant skills, experience or qualifications of M&V Professional.

C Fuel switching activities

Under clause 5.3 of the ESS Rule, fuel switching (from electricity to gas or from gas to electricity) that increases the efficiency of energy consumption may constitute a RESA, provided the activity meets certain criteria.

Figure C.1 may assist potential applicants for accreditation to determine if a proposed fuel switching project is eligible to be treated as a RESA under the ESS.

Some project examples are included in Table C.1 and Table C.2 for further reference.

Table C.1 Examples of fuel switching activities eligible under the ESS

Eligible Activity	Example
Gas to Electricity	▼ Replacing gas-fired heating equipment with electric heating equipment.[64]
Electricity to Gas	▼ Installing a gas engine, cogeneration or trigeneration unit with a power generation capacity of less than 5MW, where all generated electricity is used onsite for the production of goods and/or services (ie, no power exports). ▼ Replacing electric heating equipment with gas-fired equipment.[65] ▼ Replacing an electrical drive or electrically driven equipment[66] with gas-powered equipment.

64 Such as a furnace, water heater or steam producer using eg, a resistance, induction or microwave heater.
65 Heating equipment such as a furnace, kiln, dryer, water heater or steam generator.
66 Such as air-conditioning systems, refrigeration compressors or pumps.

Figure C.1 Flowchart of eligible fuel-switching activities

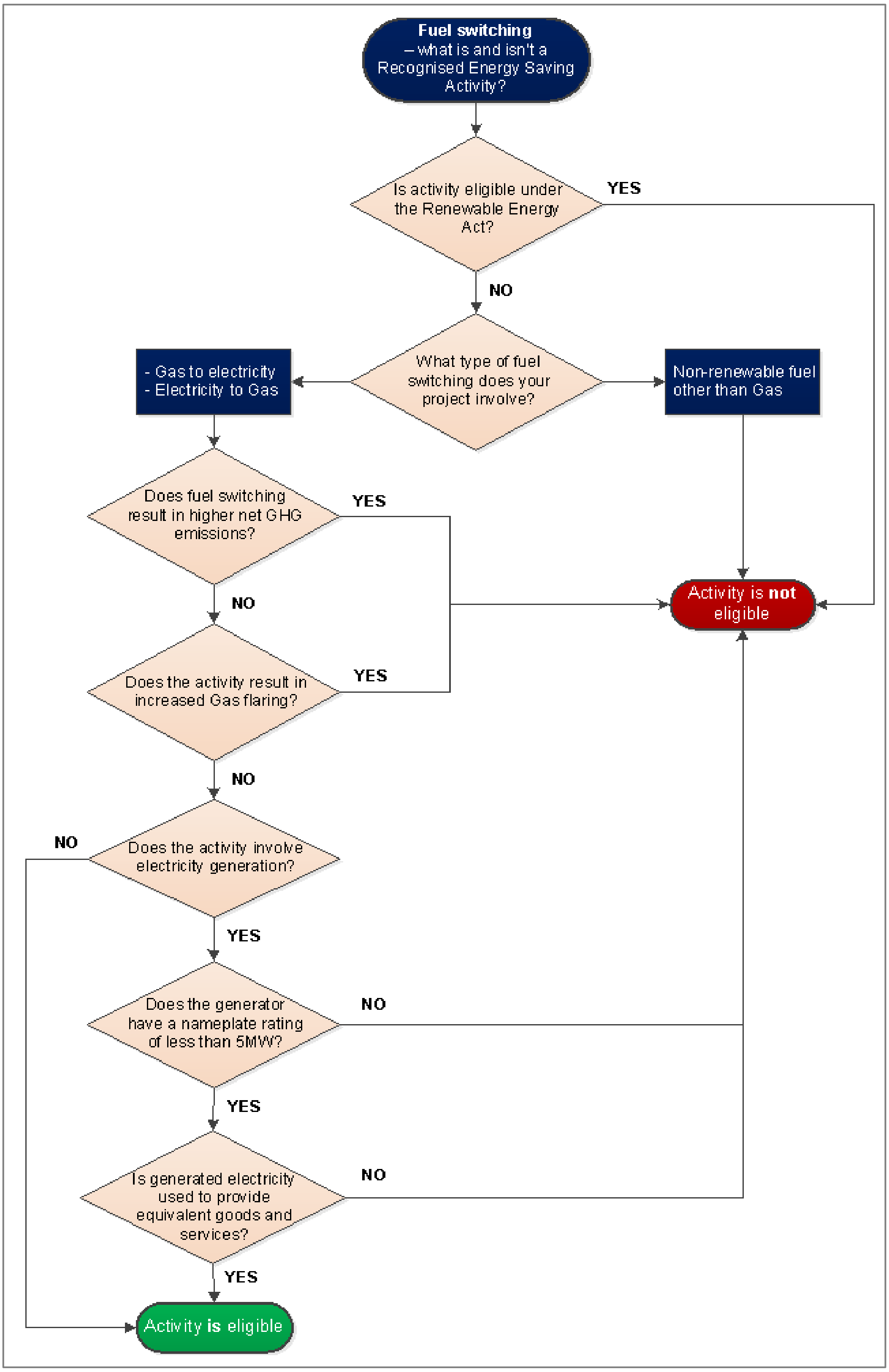

Table C.2 Examples of fuel switching activities not eligible under the ESS

Ineligible Activity	Examples
Gas or electricity to other fuels (renewable and non-renewable)	▼ Replacing a gas-fired boiler with a: – coal-fired boiler – biogas-fired boiler – biomass boiler ▼ Retrofitting a dual gas burner on an existing boiler to replace natural gas with biogas.
Fuel switching that results in an increase in flaring	▼ Replacing a biogas-fired heater with an electric heater resulting in increased biogas flaring as less biogas is used (where biogas is generated onsite).
Fuel switching that results in an increase in net Greenhouse Gas (GHG) emissions	▼ Removing a gas cogeneration system to reduce gas consumption resulting in higher purchased electricity use and increased net GHG emissions. ▼ Retrofit a dual gas burner on an existing cogeneration system to co-fire coal seam gas and reduce natural gas consumption. The switch to coal seam gas will result in higher GHG emissions due to the higher emission factor of coal seam gas compared to natural gas.
Fuel switching activity that is eligible to create tradeable certificates under the *Renewable Energy (Electricity) Act 2000*	▼ A 1MW biogas electric generator, which is eligible to create Large-scale Generation Certificates (LGCs) under the Renewable Energy Target (RET) scheme. Biogas is an eligible renewable energy source under the RET scheme to create renewable energy certificates.
Electricity generation where any generated power is not used to provide equivalent goods or services	▼ A 4MW cogeneration system that supplies more than 100% of a site's electrical consumption with the excess power exported to the grid.
Electricity generation from a generating system that has a nameplate rating greater than 5MW	▼ A 6MW cogeneration system running at 80% capacity. Though the power output is less than 5MW the nameplate rating is greater than 5MW.

D Technical guidance

D.1 Introduction

Clause 7A.16 of the ESS Rule provides that the Scheme Administrator may publish guides that detail acceptable and unacceptable approaches for ACPs and M&V Professionals to meet the requirements of the PIAM&V method.

This technical guidance provides ACPs with information on acceptable approaches for the development of M&V plans, which is a key requirement under the PIAM&V method.

An example of a completed M&V Plan can also be found in Appendix E.

D.2 Overview of the PIAM&V process

The PIAM&V method allows for energy savings to be calculated using one of three approaches:[67]

- forward creation of ESCs from a single site calculated from a baseline energy model and operating energy model (modelling energy performance before and after project implementation)
- annual creation or top-up of ESCs based on actual performance of a project following implementation, and compared to a baseline energy model, or
- multiple site ESC creation based on a baseline energy model and operating energy model, and using a sampling method approach.

Figure D.1 below outlines the general PIAM&V process, detailing the stages required for forward and annual ESC creation.

The PIAM&V process requires ACPs to define a number of parameters at each of these stages. These parameters are described in more detail in the following sections.

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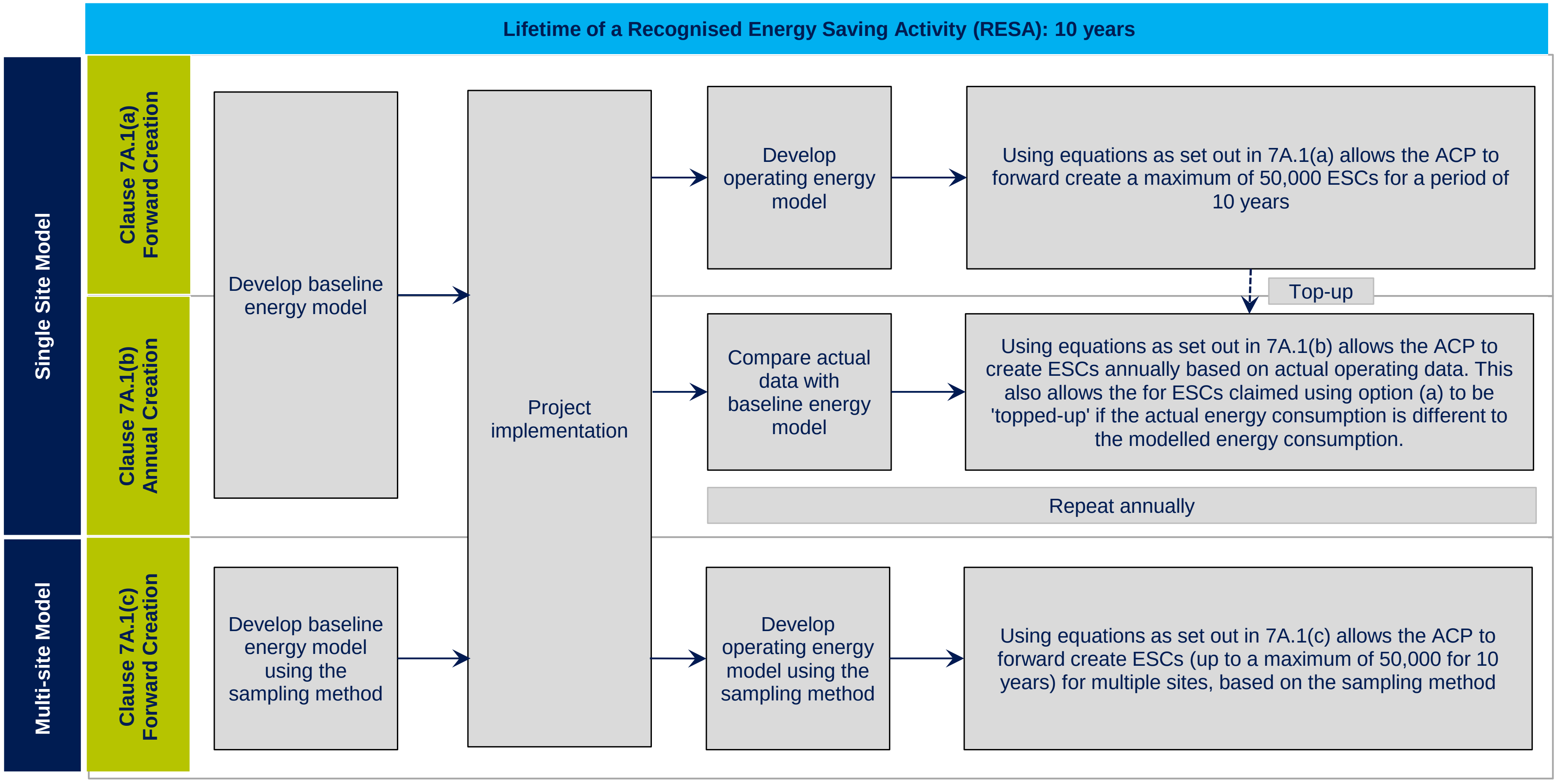
67 *ESS Rule*, cl 7A.1

Figure D.8.4 Multi-site versus single site model development



D.3 Developing energy models

Method Guide – section 2.1

There are three acceptable types of energy models that may be used to model energy use and calculate energy savings: estimate of the mean, regression analysis and computer simulation.

The ESS Rule requires that the following parameters are considered and established to support the development of the baseline and operating energy models:

- measurement boundary
- choice of independent variables and site constants
- effective range, and
- project implementation date.

D.3.1 Establish the measurement boundary

Method Guide – section 3.6

When establishing energy models, the measurement boundary needs to be established. This determines what equipment and parameters will be included and excluded from the energy savings calculations. It effectively sets a boundary for the energy models.

ACPs will need to demonstrate an understanding of the EUE and proposed activities that will result in energy savings, as well as the site specific operating environment, in order to select an optimal measurement boundary. The boundary determines the physical scope of an implementation and its associated energy model(s). The effects of a RESA are therefore determined at this boundary. The choice of measurement boundary is a key consideration influencing the complexity and accuracy of measuring energy savings associated with a RESA. Some scenarios are illustrated in Figure D.2 and Figure D.3 below.

Figure D.8.5 Example measurement boundary around entire building

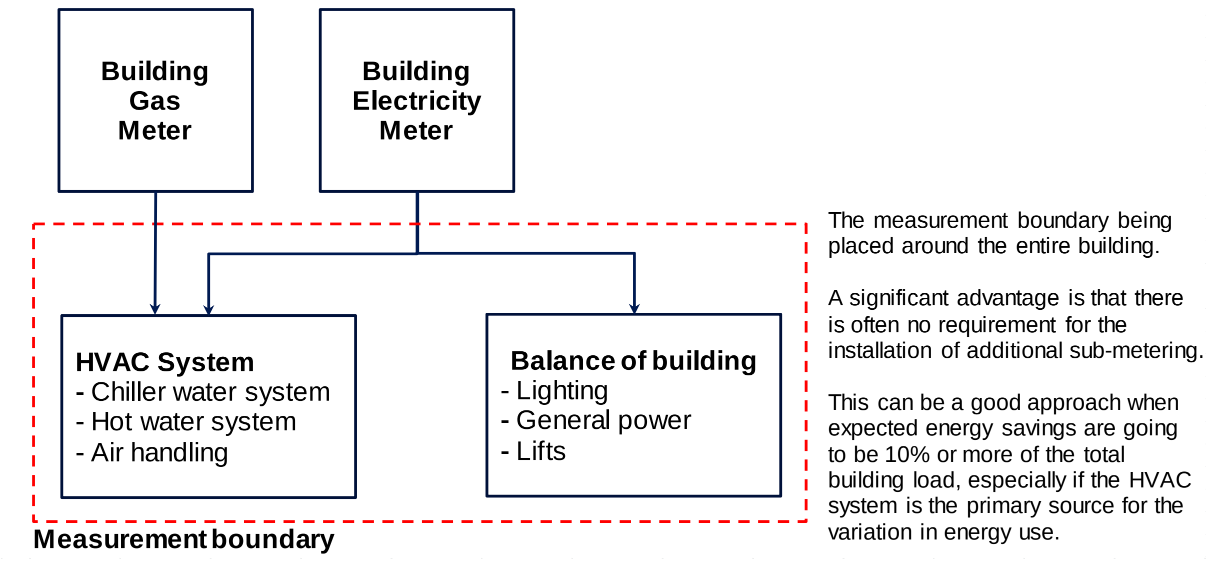
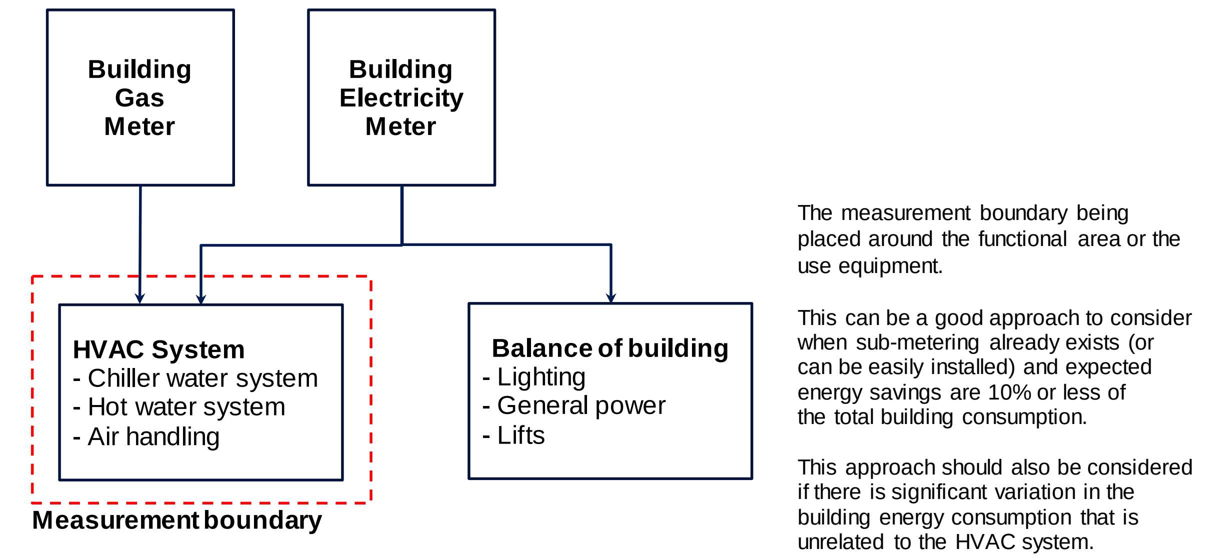


Figure D.8.6 Example measurement boundary around functional area



For each implementation, ACPs must justify the appropriateness of their choice of measurement boundary for the RESA, with specific reference to:

- the effective range of the energy models (refer section D.3.4)
- the size of the estimated savings relative to the energy consumption within the defined boundary, and
- how the energy consumption outside the measurement boundary changes as a result of the RESA (refer section D.4.2).

The choice of measurement boundary will also determine what the independent variables and site constants are for the energy model. In the examples in Figure D.2 and Figure D.3 independent variables are likely to be temperature and occupancy related. With the whole of site measurement boundary in Figure D.2, the temperature related independent variables could be cooling degree days and heating degree days. However, for the functional equipment measurement boundary in Figure D.3, the temperature related independent variables could be flows of chilled water and hot water.

As a guide only, ACPs should be aiming to set the boundary so that the expected energy savings are greater than or equal to 10% of the predicted energy performance within the measurement boundary.[68] For values less than this it can be difficult to differentiate between actual savings and the unexplained variance using the energy models.

Both effective range and interactive effects will influence the total energy savings that may be calculated from an implementation. If interactive effects are likely to be substantial, a larger boundary is recommended. Under certain circumstances it may even be justifiable to extend the boundary further to represent the total facility. Alternatively, ACPs could develop the relationship between energy consumption, energy savings and interactive effects.

Further guidance on establishing the measurement boundary can be found in section 4.1.2 of the OEH *Measurement and Verification Operational Guide – Best practice M&V processes*.[69]

D.3.2 Define variables

Method Guide – section 2.3

The calculation of energy savings under this method (…) requires independent variables and site constants to be determined and included in the energy models.

A key component of developing an appropriate energy model involves the identification and use of relevant project variables.

ACPs should ensure that their methodologies take account of these site specific variances. This is particularly important if the method is, or will be, used for multi-site sampling approaches. Therefore, in addition to the general performance characteristics of the EUE and equipment used to modify systems, ACPs should consider the effectiveness of a RESA with reference to the interplay between the EUE and site specific characteristics.

Typically this would include the calculation of the standard load requirement of the site, and identification of factors that will impact on the site's final load requirements, including:

- independent variables, such as operating hours, production levels, service levels, and external factors (eg, climate), and
- site constants, including:
  - static factors, such as one-off changes (eg, maintenance shut down) or permanent changes (eg, building expansion), or
  - design features (eg, HVAC temperature set points and dead bands).

68 Refer to the *International Performance Measurement and Verification Protocol, Concepts and Options for Determining Energy and Water Savings, Volume I, 2012*

69 Available at www.environment.nsw.gov.au/energyefficiencyindustry/confirm-energy-savings.htm

ACPs and M&V Professionals need to consider these site specific variables when developing or evaluating baseline and operating energy models, as performance efficiency of EUE may vary significantly across sites, based on site-specific independent variables and site constants.

Further information on potential independent variables and site constants for common technologies and RESAs is included in section D.5.

Independent variables

Independent variables are parameters that explain how energy consumption changes over time under normal operating conditions. They are used in baseline and operating energy models to estimate energy consumption. As they are inputs to the energy models, it is essential that they can be measured and monitored for data collection purposes.

The location of the variables may be external to a site or within the site, though not necessarily within the measurement boundary. Typical independent variables that applicants should consider when using the PIAM&V method include:

- nature based (eg, ambient temperature, humidity, rainfall, wind speed/direction)
- site specific (eg, occupancy, operating hours, visitors/customers), and
- system specific (eg, production line output, raw materials, purity, moisture content).

Independent variables must be measured during the same period of time as the energy consumption measured. However, the nature of the independent variables and site constants influence the duration of a typical 'business cycle' for which baseline and operating energy data should be collected. Ideally, data to inform the development of baseline and operating energy models should be collected over the full range of normal operating conditions. If independent variables are not measured over the full range of normal operating conditions, this can limit the effective range and the energy savings for the implementation (see section D.3.4)

Included below is additional guidance on approaches for identifying independent variables.

Identification of independent variables

While the choice and applicability of independent variables in the development of a good energy model can be a simple process, this is not always the case.

ACPs should ensure they have a good understanding of how energy is used on site, or in relation to a particular piece of equipment, prior to identifying variables. This will ensure that the most appropriate independent variables are selected for a project.

Some approaches for understanding site energy consumption include:

- energy audits
- analysis of collected data, and
- graphical representation of data.

It will normally be necessary to use a combination of the above methods and it is often an iterative process. An overview of these methods is included in Table D.1 below.

Table D.1 Methods for understanding site energy consumption

Method type	Site energy consumption approaches
Energy audit	Site energy consumption can be determined through an energy audit[70] which seeks to identify: 1. All incoming energy flows (eg, gas, electricity) 2. All energy using equipment (eg, motors, lights, air compressors) 3. Data associated with how the equipment is operated and its influence on energy consumption (eg, operating hours, production, on demand, occupancy) The results of the last step may reveal certain parameters or operating conditions that have a major influence on the energy consumption and should be considered as independent variables.
Analysis of the collected data	There are a number of steps that should be conducted on any collected data before attempting to establish if there is a sufficient relationship to develop an energy model. These include: ▼ For each measured parameter, does each data point represent the same time period? For example, some Supervisory Control and Data Acquisition (SCADA) systems will record values only on change by a certain percentage amount rather than at set time periods. Alternatively there may have been errors in the recording of data, resulting in missing or mismatched values (eg, SCADA daily totaliser failed to write to disk at midnight, resulting in the subsequent day's total value representing two days of data). ▼ Does each measured parameter use the same time interval (eg, SCADA value every 5 minutes compared to energy consumption data of every 30 minutes)? If not, data aggregation is required to ensure that the frequency of the energy consumption values is the same in the measurement period. ▼ Examine the data for outliers, or non-routine events, and investigate possible reasons. These may be the result of abnormal operating conditions, not modelled by independent variables or site constants, or the result of bad data which may warrant either the exclusion of the value or a manual adjustment of the value. This ensures a like for like comparison of energy savings before and after the implementation. The percentage of time excluded must be less than 20%[71] of the measurement period. **Document any data that is removed or modified from the measured data set** ▼ Where some data is at too large a time interval compared with other measured data onsite (eg, monthly electricity consumption based on utility invoicing versus production data that can be highly variable on a daily basis), an ACP may want to consider installing additional metering to gain data at a higher frequency interval for all data points. There are no minimum requirements for the frequency of the data, however the granularity of data will impact on the regression values, and the development of the baseline and operating energy models, as the largest time interval of any of the measured parameters determines the frequency for the final energy model. Once data is all of the same time interval, consider aggregating into different time periods (eg, if you currently have data for every 30 minute interval, consider aggregating into daily, weekly or monthly time intervals). This can be a useful step when data is highly irregular or seemingly random at too fine a time period (eg, refrigeration motors or compressors cycling on and off). In these instances a greater sense of uniformity in the data can be gained when the data is examined over a longer time period.

70 The AS/NZS 3598 Energy Audits Standard sets out the requirements for commissioning and conducting energy audits, and identifying opportunities for cost effective investments, to improve efficiency and effectiveness in the use of energy.

71 *ESS Rule,* cl 7A.5(g)

Method type	Site energy consumption approaches
Graphical representation of data	Once the data has been assessed and processed, charts should be used to graphically represent the data in the form of XY scatter plots against energy consumption. This is not a requirement, but can assist with the visualisation of data and establishment of regression values (where a regression model is used). This should be conducted with each measured variable and for different time periods to confirm where possible relationships may exist to inform the selection of an independent variable. Importantly, observe the scatter in the data and look for multiple groupings of data, which may suggest the inclusion of additional variables relating to the selected data. This should be investigated further by categorising the data into the two or more groups and investigating possible reasons for differences in values. Some examples of common additional categories that could be encountered include: ▼ energy related to the operating hours of electric motors, with additional categorisation based on two different production modes, or ▼ building energy consumption being strongly correlated to ambient temperature with additional categorisation based on certain days of the week (eg, working versus non-working days, or certain events being held every Tuesday). The desired output is a shortlist of possible measured parameters that appear to show some relationship with energy that should be considered when developing the energy model.

Site constants

Site constants are parameters that may vary between sites and influence energy consumption within the measurement boundary, but are expected to remain constant under normal operating conditions. Some common examples include operating hours and net lettable area in commercial buildings, or control set-points in production based facilities.

For a single site model, the site constants must not change during the measurement periods that are used to establish the baseline and operating energy models.

The site constants must also be measured over the life of the project, and any time periods where the site constants are not their standard value must not be included in the energy saving calculation.

If the site constants are expected to change, then they should be included as independent variables, or the measurement boundary of the project adjusted so that the change does not affect the energy consumption being measured. For example, if a new building was built on the site in the example in Figure D.2 and connected to the same site utility meter, the whole of site approach would include this new building energy consumption and the site constant of 'building area' would change. However, if the measurement boundary was around the HVAC system of the existing building only, as per Figure D.3, then the new building would not affect the site constants or energy consumption.

Suggested independent variables and site constants for common technologies and RESAs, which should be considered under the PIAM&V method, are included in Appendix D.5. ACPs should demonstrate that they have considered these variables as inputs for the energy model. If they are found to have little impact on variances in energy consumption, ACPs should provide justification for not incorporating them in the model (eg, an independent variable may be excluded if is shown to not significantly affect energy consumption by returning a low t-statistic in the regression modelling).

D.3.3 Energy models

Method Guide – section 2.3

The calculation of energy savings under this method is based on comparing the results of a baseline energy model with those from an operating energy model.

To determine the energy savings associated with an implementation, the first step when conducting M&V is to develop a baseline energy model. This establishes an understanding of what the energy consumption would have been if the RESA had not been implemented. Savings are then determined by one of the following:

- the difference between the energy consumption estimated by the baseline energy model and the operating energy model, for forward creation of ESCs, or
- the difference between the energy consumption estimated by the baseline energy model and actual measurements taken after the implementation under the same conditions, for annual creation or top-up.[72]

Developing an energy model is generally done using linear regression with one or more independent variables, but can also be done using non-linear regression, an estimate of the mean or computer simulation methods.

It may be necessary to develop multiple energy models to determine the best combination of independent variables and different time intervals that results in the optimal energy model.

Depending on the project, the baseline and operating energy models may be based on the same or different independent variables and site constants. Likewise, the method used to develop the energy models may be the same or different for the baseline and operating energy models. Note that if the baseline and operating energy models have different independent variables and site constants, normal year values for all of the independent variables and site constants must be specified to calculate normal year energy savings.

Section 2.1 outlines the three acceptable energy model types under the PIAM&V method. The two types of method most commonly used, regression analysis and estimate of the mean, are described in the sections below.

Regression analysis

Regression analysis is a statistical process for estimating the relationship between a dependent variable, in this case the energy consumption, and one or more independent variables. For models that have only one independent variable, this is called simple linear regression. For models that have more than one independent variable, the process is called multiple linear regression.

Table D.2 presents some guidance on thresholds of statistical good-fit that could be used by ACPs in developing an energy model using linear regression.

72 To determine energy savings, the normal year, interactive savings, accuracy factor, decay factor, persistence model and counted energy savings will need to be defined too. These parameters are described in section D.4.

Table D.2 Guidance for determining the statistical validity of energy models developed using linear regression

Modelling criteria	Definition	Threshold
t-statistic of independent variable	The t-statistic is a measure of the statistical significance of each independent variable.	Absolute value > 2
Adjusted R^2 (coefficient of determination)	The R^2 is a measure of the suitability of a set of data to a fitted regression model.	> 0.75
Relative precision calculated at 90% confidence level	The relative precision is a measure of how much the predicted value from the baseline or operating energy model is predicted to vary from the true value. The relative precision of the baseline and operating energy model both influence the relative precision of the savings estimate, which then is used to calculate the accuracy factor (section D.4.3 of this guide).	Within ±200%

The relative precision of the baseline and operating energy model both influence the relative precision of the energy savings estimate.

The relative precision of the energy savings estimate is used to calculate the accuracy factor used to discount savings, as discussed in section D.4.3 of this guide, and must be within ±200%. Values exceeding this threshold will result in an accuracy factor of zero and will not result in any energy savings.

There can be a range of reasons that result in an adjusted R^2 below 0.75 or cause the relative precision to be too large, including:

- too much random variation occurring within the site or system
- inclusion of abnormal events / operations within the period from which data has been collected that need to be removed or accounted for
- time interval is too fine or too coarse
- not all independent variables have yet been identified, or
- the inclusion of variables that do not provide a strong relationship with the energy consumption (generally where the t-statistic for the variable is less than 2).

ACPs should document the steps taken in developing the energy models to support the final form of the model and to allow for review by the M&V Professional.

An example of a regression model for an HVAC system is provided in Box D.1.

Box D.1 Regression model example

An energy model for a HVAC system will typically be established using linear regression analysis which relates energy consumption to independent variable(s) such as the number of Cooling and/or Heating Degree Days (CDDs and/or HDDs), as well as occupancy levels. A basic HVAC simple linear regression model based on one independent variable may be presented as follows:

$$Y = a + b_1 X$$

Where:

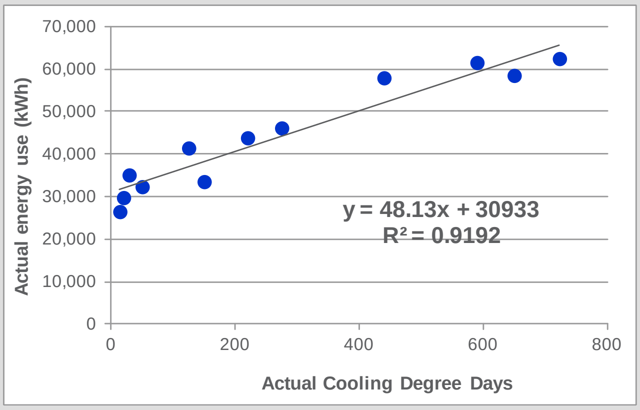
Y = Estimated electricity consumption (kWh)

X = CDD, the variable used to predict Y

a = y-intercept coefficient = baseline electricity consumption

b_1 = the slope coefficient of the CDD

A typical representation of the strength of the relationship is provided below. This example shows a good correlation between electricity consumption and CDD, with R^2 = 0.9192. This indicates that the methodology is adequate and that the cooling system is working well (the 'control' of the system is good, with a reasonable CDD base temperature).



Estimate of the mean

It is not always possible to develop a satisfactory energy model where there are no independent variables that significantly affect energy consumption. In this case, a graph of energy consumption over time will show that there is little variation in energy consumption, and using a regression analysis with any combination of independent variables will give an R^2 value close to zero. In these circumstances, it may be necessary to use the estimate of the mean approach where the energy model uses a single value for an estimate of the energy consumption that is calculated from the mean energy consumption over the measurement period.

A key requirement when developing an energy model via this approach is that the coefficient of variation of the energy consumption over the measurement period is less than

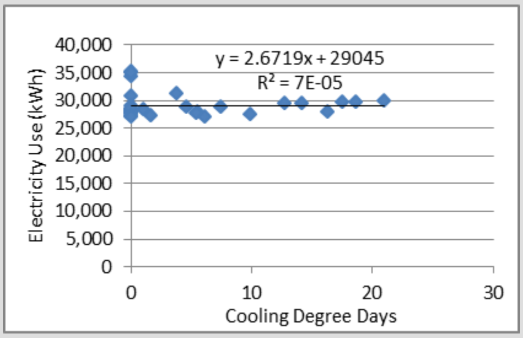
15%.[73] The coefficient of variation is defined as the sample standard deviation expressed as a percentage of the sample mean.

An example of an estimate of the mean for an HVAC system is provided in Box D.2.

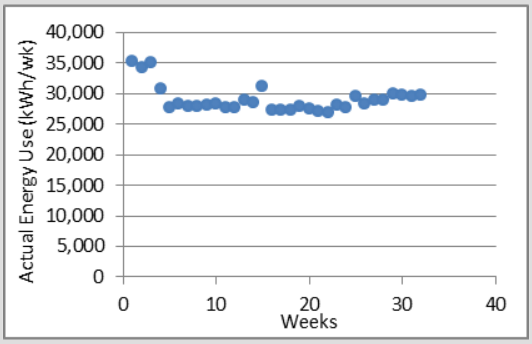
73 *ESS Rule*, cl 7A.2(a)(i)

Box D.2 Estimate of the mean energy model example

In this case, the graph of electricity consumption against cooling degree days shows that there is little variation in electricity consumption that is explained by this independent variable, and the R2 value is close to zero. Before determining if the use of an estimate of the mean energy model is appropriate, it is necessary to analyse the system to determine if there are other independent variables that significantly affect electricity consumption. Note that it may be necessary to measure likely independent variables to determine that they do not have a significant effect on the energy consumption. This should be considered in the M&V design.



In this case, the electricity consumption over the time period measured is relatively constant, indicating that it may be appropriate to use an estimate of the mean energy model.



The mean weekly energy consumption is 29,057 kWh, with an accompanying standard deviation of 2,177. This results in a coefficient of variation of 7.5%, meaning that it still qualifies for use under the estimate of the mean approach.

This is a typical example of a system running at full capacity (eg, a ventilation fan), where the energy consumption does not vary significantly with any independent variables, meaning the estimate of the mean method may be used to develop the baseline energy model.

After the project is implemented (eg, installation of a control system upgrade), the energy consumption of the equipment may be influenced by an independent variable (eg, temperature or production). As such, linear regression may be used to develop the operating energy model. This shows that independent variables do not have to be the same for both baseline and operating periods. Likewise, the energy models for both periods may be developed using different methods.

D.3.4 Effective range

The effective range defines the range over which the energy model has been developed and is therefore valid in terms of predicting future performance. The PIAM&V method does not allow for the extrapolation of the model beyond the range of data, extended by ±5%,[74], from which it was created.

It is advisable to select a measurement period that covers a wide range of possible operating conditions, hence values of independent variables, so that the energy model can be used with greater confidence in predicting future performance. ACPs should consider the effective range of the independent variables for both baseline and operating energy models in conjunction with the range of the independent variables in the normal year established for the site. This is because energy savings are not able to be calculated for any normal year values that fall outside the effective range of either the baseline or operating energy models.

For commercial buildings or other sites that have energy models that use ambient temperature, or related variables such as cooling degree days, as an independent variable, between 6 - 12 months of data may be needed to maximise the effective range of the energy model.

For independent variables that are within the control of the project developer, for example production, project developers may wish to consider running the energy using process at values of these independent variables towards their limits during the measurement period, to maximise the effective range. Care must be taken to ensure values chosen are still within the normal operating conditions for the site.

Under the forward creation for a single site model approach, if a limited range of data is used to establish the effective range, ACPs will forego possible energy savings when the normal year value for any independent variable lies outside the effective range of either the baseline energy model or operating energy model.[75] ACPs will need to balance the cost of collecting additional data versus the possible additional savings to be claimed.

It is important to note that energy models developed using the estimate of the mean method do not have an effective range applied, as they do not have any independent variables. As such, baseline or operating models developed using this method (that meet all ESS Rule requirements, including the test on coefficient of variation) will not have energy savings limited by the effective range. Site constants are still relevant however, and energy savings are zero for any times that the site constants are not their standard value.

An example of how the effective range is determined for an industrial application is provided in Box D.3.

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74 *ESS Rule*, clause 7A.8

75 Note that ESCs foregone due to a limited effective range of the operating energy model may still be claimed by ACPs using top-up applying equations 7A.3 and 7A.4. This will require the ongoing measurement of electricity and gas consumption following implementation.

Box D.3 Effective range example

In this example an upgrade of an industrial process results in both a reduction of electricity consumption (due to implementation of energy efficient equipment) and an increase in production levels (due to increased capacity of the new equipment installed).

The independent variable (monthly production) is measured over 12 months before implementation and then for 12 months post-implementation.

The recorded production values are shown below:

Baseline Period			Operating Period		
Month	**Production (tonnes/month)**	**Electricity consumption (MWh/month)**	**Month**	**Production (tonnes/month)**	**Electricity consumption (MWh/month)**
Jan-14	1,892	2,661	Jan-16	5,558	7,211
Feb-14	1,779	2,667	Feb-16	1,155	1,583
Mar-14	2,917	4,196	Mar-16	1,917	2,398
Apr-14	2,270	3,563	Apr-16	5,674	7,351
May-14	1,190	1,727	May-16	1,292	1,623
Jun-14	1,271	1,715	Jun-16	4,882	6,293
Jul-14	2,407	3,533	Jul-16	4,609	6,187
Aug-14	1,568	2,177	Aug-16	3,817	5,045
Sep-14	2,891	4,536	Sep-16	3,176	4,062
Oct-14	2,474	3,873	Oct-16	3,643	4,703
Nov-14	2,036	3,145	Nov-16	1,566	1,928
Dec-14	2,274	3,348	Dec-16	5,973	7,725
Min	**1,190**		**Min**	**1,155**	
Max	**2,917**		**Max**	**5,973**	

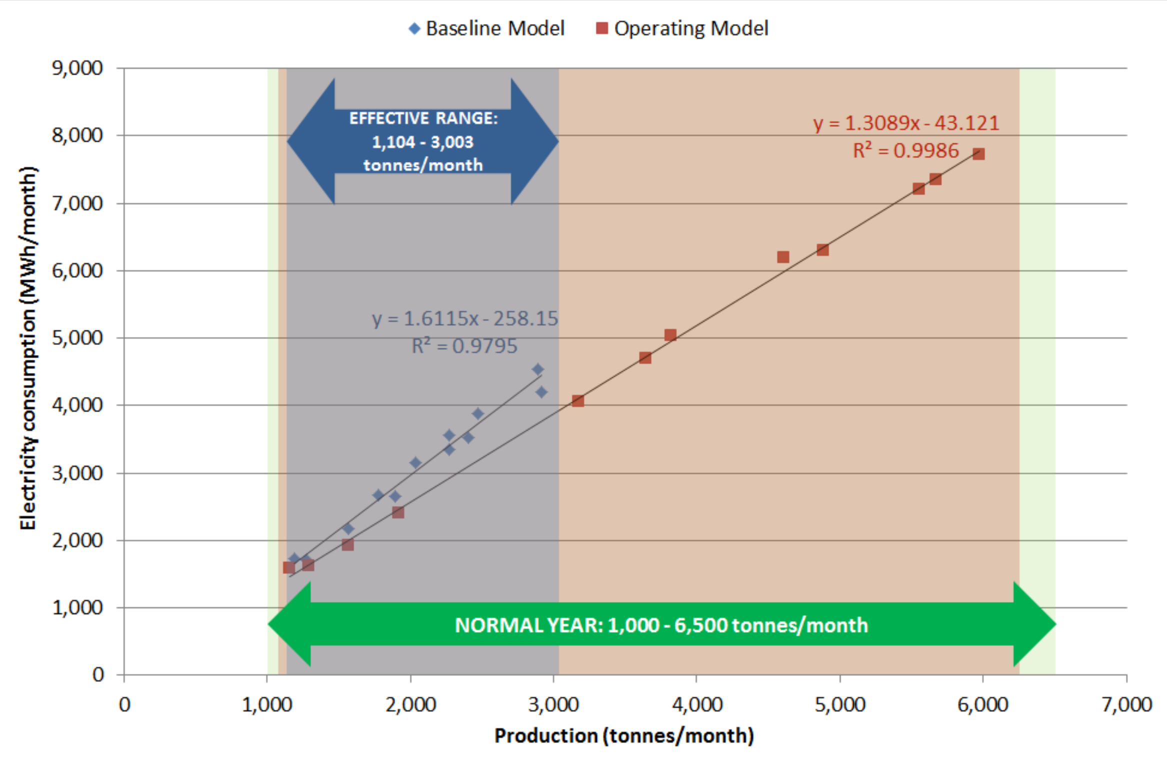
In this case, the normal year has been determined based on historical production as well as forecasted production levels post-implementation. Monthly production values in the normal year (12 months) range between 1,000 and 6,500 tonnes.

The range for which normal year energy savings can be calculated is determined by intersecting the effective ranges of the baseline and operating energy models and the range of the normal year.[76] In this case, it is limited by the baseline energy model effective range:

Period	**Production (tonnes/month)**	
	Min	**Max**
Baseline effective range	1,190 – 0.05 *x* (2,917 – 1,190) = 1,104	2,917 + 0.05 *x* (2,917 – 1,190) = 3,003
Operating effective range	1,155 – 0.05 *x* (5,973 – 1,155) = 914	5,973 + 0.05 *x* (5,973 – 1,155) = 6,214
Normal year values	1,000	6,500
Range over which normal year energy savings can be calculated	**1,104**	**3,003**

The determination of the effective range is graphically represented in the chart below:

76 The OEH PIAM&V Tool provides an acceptable approach for determining the effective range.



In this case, although the normal year considers increased production levels occurring as a result of increased capacity of the upgraded process, the effective range is limited by the baseline period range.

If it is known that the range of values for independent variables in the normal year is likely to increase, savings can be maximised by focusing on extending the effective range of the energy models where possible. An example could be a manufacturing line that is originally only forecast to run at a maximum of 70% capacity during the chosen baseline measurement period. The project developer, with approval of the site owner, could then schedule a production run at 100% capacity during a measurement period in order to record values of the energy consumption and independent variables at this limit, and extend the baseline effective range.

D.3.5 Project implementation

Method Guide – section 3.6

To establish a working energy model, the time period over which measurements are taken must also be established, including the start date and end date of the measurement periods.

The baseline energy model must use a baseline measurement period with an end-date before the implementation date. Similarly, both the operating energy model and measured annual electricity or gas savings require a measurement period with a start date occurring after the implementation date.[77] The implementation date is the date that the implementation commences normal operations.[78]

It is advised that projects where commissioning or other post implementation issues may occur are allowed time to become 'embedded' into normal operations before any post implementation data is collected for the operating energy model or measured annual electricity or gas savings, so as to allow for any issues to be resolved.

D.4 Determining energy savings

The calculated 'lifetime' energy savings are based on the expected life of the end user equipment (to a maximum of 10 years) and the following additional factors:

- a normal year, which is defined as a typical year of operation of the EUE at a site, after the implementation date
- any interactive energy savings, which are changes to a site's energy consumption that are due to the implementation, but that occur outside of the measurement boundary
- an accuracy factor, with a value between 0 and 1, is used to discount the energy savings according to the relative precision of the calculation of the energy savings
- a decay factor, either from a persistence model or from default values, is used to discount the normal year energy savings to calculate the lifetime energy savings, and
- any counted energy savings from previous ESC creation for the RESA or at the same site from another RESA (or corresponding scheme), which must also be deducted.

D.4.1 Normal year

Method Guide – section 3.6

The energy savings from an implementation are calculated for savings over a normal year (normal year energy savings). A normal year is defined as a typical year of operation of the EUE at a site, after the implementation date.[79]

This step requires ACPs to define the data that forms a 'normal year of operating conditions' for the purposes of predicting the energy savings due to the implementation over the lifetime of the project. Note that a normal year is not required for annual creation of ESCs.

This is achieved by specifying 12 months of data for each independent variable at the same measurement frequency as data used to develop the baseline and operating energy models.

This data is then used as inputs into the baseline and operating energy models for the purpose of estimating business as usual (baseline) and post-implementation (operating) energy consumption on a like-for-like basis, so that energy savings can be estimated. The

77 The only exception is for top-up creation (clause 7A.14), for which measurements are done annually and the start date must fall on an anniversary of the implementation date. This means that the start of the top-up measurement period for year one is the implementation date.

78 *ESS Rule*, cl 7A.17

79 Clause 7A.12 of the ESS Rule defines the maximum time period for forward creation.

normal year values must represent a typical year of operation for the EUE over the life of the project (maximum time period for forward creation).

Where the operating cycle of the system is less than one year, the normal year may be constructed by combining values from multiple operating cycles to make up one year of data representative of a typical year of operation.

When defining a normal year, ACPs must:

- consider future 'typical' operating conditions, which may differ from the baseline period; operating conditions may include typical weather conditions, operating days per year, maintenance periods, or changes in site activities (eg, production levels)
- use actual data, rather than estimates, where practical (eg, manufacturing records); typically, data should not be older than three years to be representative of future operating conditions, and
- describe how the normal year is constructed, noting any adjustments, calculations or manipulations.

D.4.2 Interactive energy savings

Method Guide – section 3.6

The interactive energy savings must be estimated and added when determining the normal year energy savings. Setting the correct measurement boundary is important as the energy models also need to account for interactive energy savings. These are changes to a site's energy consumption that are due to the implementation, but that occur outside of the measurement boundary.

Based on the identification of any interactive effects, this step involves establishing an energy model that describes how energy consumption outside the measurement boundary changes as a result of the RESA.

Some interactive effects are well known and understood and it may be possible to draw on external sources of documentation in defining the interactive energy model. A common example of an interactive effect is a lighting upgrade and the resultant change in HVAC requirements. In this case, the HVAC system is considered to be outside the measurement boundary. A change to more efficient lighting will decrease the heat load on the HVAC system, and reduce the energy required for cooling, but increase the energy required for heating. The overall size of the interactive effect is dependent on the proportion of time the HVAC system is cooling and heating.

Another example involves the utilisation of waste heat from a boiler or compressed air system. This could reduce the plant room air temperature which may reduce the operating hours of temperature dependent plant room exhaust fans.

The ESS Rule requires that the interactive electricity savings and interactive gas savings account for no more than 10% of total electricity savings and gas savings respectively, unless estimated in accordance with a guide published by the Scheme Administrator.[80] The OEH

80 *ESS Rule*, cl 7A.9(c)

PIAM&V Tool provides an acceptable approach for estimating interactive effects on HVAC systems if the EUE is within an air conditioned space.

In some circumstances, it may be necessary to conduct a number of trials with data logging on a variety of EUE that is outside the measurement boundary to generate enough data for an interactive energy model to be developed (possibly using the same regression analysis techniques already used to develop the baseline and operating energy models). However, this approach creates significant complexity for the RESA and ACPs and is generally not recommended.

In all circumstances, it is desirable that interactive effects are kept to a minimum. Furthermore, rather than develop a separate interactive energy model, it is instead recommended that ACPs widen the measurement boundary so that the interactive effects can be incorporated within the baseline and operating energy models. This, however, needs to be balanced against the size of the energy savings compared to the energy consumption within the measurement boundary.

An alternative to simply widening the measurement boundary may be to install additional sub-metering on relevant equipment, which may enable ACPs to isolate and eliminate the interactive effects from the measured data when determining energy savings.

Further information on how to address interactive effects can be found in Section 4.1.4 of the OEH *Measurement and Verification Operational Guide – Best practice M&V processes*.[81]

D.4.3 Accuracy factor

The purpose of the accuracy factor is to discount the energy savings, and therefore ESC creation, based on the accuracy of the energy models that are used.

The accuracy factor is based on calculating the relative precision associated with the energy savings estimate at 90% confidence level, with Table A23 of the ESS Rule stating the thresholds used to assign an accuracy factor. Once the accuracy factor has been determined, it is used to adjust the normal year or measured annual energy savings.[82]

The PIAM&V Tool developed by OEH can be used to assist development of an accuracy factor.[83]

Note that the relative precision should be calculated using the combined standard error that takes into account all uncertainties from individual components such as metering accuracy, data capturing systems, data adjustments, sampling and modelling.[84] The relative precision in the OEH PIAM&V Tool is calculated using only the standard error of the energy models (ie, standard error of the estimate).

81 Available at www.environment.nsw.gov.au/energyefficiencyindustry/confirm-energy-savings.htm
82 *ESS Rule*, equations 7A.1 and 7A.3
83 The tool is available at www.environment.nsw.gov.au/business/piamv-tool.htm
84 Refer to Appendix B of the IPMVP's *Concepts and Options for Determining Energy and Water Savings, Volume I, January 2012* for more details.

D.4.4 Decay factor and persistence model

Method Guide – section 3.6

The calculation of energy savings also requires the use of a decay factor, which accounts for the degradation in equipment operation over time.

The decay factor (…) may be influenced by the measurement boundary, the type of EUE that is the subject of the implementation, as well as the site conditions where the implementation occurs.

The application of a decay factor is intended to account for a gradual deterioration of any new equipment and estimate the decrease in energy savings in future years when forward creating ESCs. This can either be applied through the default decay factors (as outlined in Table A16 of the ESS Rule), or calculated using a persistence model that has been determined to be acceptable for use by the Scheme Administrator.

The OEH PIAM&V Tool provides a persistence model that may be used to calculate decay factors and estimate the lifetime of the upgrade based on a number of project variables and implementation conditions. The application of a persistence model must be deemed appropriate by an M&V Professional.

D.4.5 Calculated energy savings

To calculate the expected energy savings for a project, ACPs must apply the results of the various energy models (or measurements) to the relevant equations as specified in the ESS Rule. Where applicable, it is important that the ACP recognises any previously counted ESCs arising from this or other projects.[85] An example of how counted energy savings should be applied in the calculation of energy savings is provided in Box D.4.

As described previously in section D.1, there are three options to calculate energy savings using the PIAM&V method:

- option (a) allows forward creation up to 10 years (after the implementation date) for a single site model with no requirement for future ESC creation
- option (b) allows annual creation, or if option (a) was previously used, it allows the ACP to top-up on an annual basis, and
- option (c) allows forward creation up to 10 years (after the implementation date) for a multiple site model with no provision for future ESC creation.

The specific equations relevant to each option can be found under clause 7A of the ESS Rule.

85 *ESS Rule*, equations 7A.1 and 7A.3

Box D.4 Counted energy savings example

In this example, a refrigeration upgrade project is implemented at an industrial site. A whole of site measurement boundary has been selected and energy models (for baseline and operating periods) have been developed using total site electricity consumption (using utility meter data)

In this case, ESCs have already been created using a different method (Project Impact Assessment Method) for another project previously implemented at the same site (compressed air upgrade). The baseline measurement period for the refrigeration upgrade ended before the implementation of the compressed air upgrade project. The operating measurement period started after the implementation date of both projects. Therefore, energy savings achieved under the compressed air upgrade project (calculated using the PIAM calculation method) must be subtracted from the energy savings calculation using PIAM&V to avoid double counting.

According to the definition provided in Equations 7A.1 and 7A.3, counted energy savings is the total electricity (or gas) savings for which ESCs have previously been created for the implementation.

No interaction between counted energy savings and effective range:

As shown previously in Box D.3, the effective range can limit the normal year energy savings calculated using Equations 7A.2 or 7A.5, ie, the calculation excludes periods for which values fall outside the effective range. This is the only calculation that is affected by the effective range. All other inputs to Equations 7A.1 and 7A.4, including counted energy savings, are not affected by the effective range. For example, counted energy savings must not be adjusted based on effective range, even if there is a discrepancy in the time periods considered for both.

D.5 Suggested independent variables and site constants

Note that for all technology types, some of the parameters that are suggested as independent variables could also be classed as site constants. This is especially true where the parameter may significantly influence energy consumption, but does not change significantly over the course of a measured period.

One example of this is operating hours. In a commercial building, operating hours is likely to be considered as a site constant (eg, 8am to 6pm, Monday to Friday), but may vary more on a daily basis in other circumstances such as conference facilities or an industrial production site. Parameters such as operating hours can be included as an independent variable by introducing them as a discrete variable, for example with the value of 1 if operating, and 0 if not operating.

The suggested parameters set out below should not be treated as an exhaustive list. There may be additional parameters that require consideration in the context of a particular RESA.[86]

[86] Section 6 of the *M&V Guidelines: Measurement and Verification for Performance-Based Contracts*, developed for the US Department of Energy, provides further guidance on how to develop M&V plans for various types of technologies.
Available at energy.gov/sites/prod/files/2016/01/f28/mv_guide_4_0.pdf.

D.5.1 Boilers, steam and compressed air applications

The following parameters provide an overview of the most common parameters that should be used by ACPs to measure and verify energy savings from boiler, steam and compressed air upgrade or replacement projects.

Table D.3 Suggested parameters for boiler, steam and compressed air applications

Energy consumption measurement	Energy consumption before and after implementation will need to be measured to establish both the baseline and operating energy models. The following elements should be measured: ▼ electricity consumption, measured using either utility or sub-meters ▼ gas consumption using either utility or sub-meters ▼ energy content and conversion factors where fuel is metered via volumetric and mass flow measurement (eg, m^3/hr or tonnes/hr)
Common independent variables	Some of the common independent variables that should be considered when developing an energy model for boiler, steam and compressed air applications are: ▼ production, at either a total site level or individual product line. For example, tonnes or number of units. ▼ operating hours – total boiler or compressor operating hours, though this may be impacted by the measurement boundary ▼ compressor delivered air, which can be measured in L/s or m^3/min
Common site constants	Some of the common site constants that should be considered are: ▼ system design, which could include factors such as system type, design and the number of boilers/compressors ▼ efficiency, which would relate to the efficiency of individual pieces of equipment or the system in its entirety ▼ control set points for pressure and temperature of air or steam ▼ steam blowdown rates
Possible interactive effects	There are no common interactive effects from projects for boiler, steam and compressed air applications. Projects will need to be assessed on a case-by-case basis to determine whether interactive effects exist.
Common measurement boundary considerations when developing energy model	The measurement boundary will generally include the boiler or compressor and any supplying pipe network, as well as the EUE. This would need to also include aspects such as air and water inputs to boilers. If interactive effects with other thermal systems are determined on a project specific basis, the measurement boundary should be broadened to take these into account.

D.5.2 Commercial and industrial refrigeration applications

The following parameters provide an overview of the most common parameters that should be used by ACPs to measure and verify energy savings from refrigeration upgrade or replacement projects.

Table D.4 Suggested parameters for commercial and industrial refrigeration applications

Energy consumption measurement	Energy consumption before and after implementation will need to be measured to establish both the baseline and operating energy models. Electricity consumption should be measured using either utility or sub-meters.

Common independent variables	Some of the common independent variables that should be considered when developing an energy model for commercial and industrial refrigeration applications are: ▼ HDDs and CDDs ▼ ambient temperature ▼ relative humidity ▼ production, which could be measured in terms of the throughput of refrigerated content, measured in tonnes ▼ operating hours
Common site constants	Some of the common site constants that should be considered are: ▼ space temperature set points, as applicable to both ambient temperature and relative humidity ▼ system design, including the type, design and number of cabinets ▼ size of the system, which could be measured in terms of total display/floor area (m^2) or volume of refrigerated space (m^3) ▼ seasonality of usage if related to certain production cycles (eg, agricultural produce) ▼ Efficiency, related to the efficiency[87] of individual pieces of equipment and would be measured through either: – Coefficient of Performance (COP) – Energy Efficiency Ratio (EER), or – Integrated Part Load Value (IPLV).
Possible interactive effects	The possibility of any interactive effects in commercial and industrial refrigeration is largely dependent on the type of refrigeration installed. For example, in some commercial retail spaces, refrigerated display cabinets can often have spill over of chilled air providing additional cooling to the internal space which can lead to either additional heating or reduced cooling requirements from the HVAC system.
Common measurement boundary considerations when developing the energy model	Measurement boundaries for refrigeration upgrades are generally drawn around an individual piece of equipment, but can also be expanded to include larger segments of a facility such as the full refrigerated space and all associated equipment, through to placing the boundary at the site level where refrigeration represents a significant amount of site energy consumption (eg, cold storage facilities). The applicable measurement boundary will generally be linked to the available metering.

D.5.3 Commercial heating, ventilation and cooling applications

The following parameters provide an overview of the most common parameters that should be used by ACPs to measure and verify energy savings from HVAC upgrade or replacement projects.

Table D.5 Suggested parameters for commercial heating, ventilation and cooling applications

Energy consumption measurement	Energy consumption before and after implementation will need to be measured to establish both the baseline and operating energy models. Electricity consumption should be measured using either utility or sub-meters.

87 Note that for new end-user equipment baseline efficiencies may be published by the Scheme Administrator in accordance with clause 5.3B of the ESS Rule.

Common independent variables	Some of the common independent variables that should be considered when developing an energy model for commercial heating, ventilation and cooling applications are: ▼ HDDs and CDDs ▼ ambient temperature ▼ relative humidity ▼ operating hours, including times of reduced usage such as weekends, public holidays and seasonality ▼ site occupancy including standard number of people occupying the space included within the project boundary
Common site constants	Some of the common site constants that should also be considered are: ▼ temperature set points, as they apply to both temperature and relative humidity ▼ total floor area (m^2) serviced ▼ IT and lighting loads ▼ control configuration (eg, use of economy cycle) ▼ thermal load, which could be used as both an independent variable and a site constant as it is directly affected by ambient temperature, humidity and occupancy ▼ efficiency[88] of individual pieces of equipment, which can be measured through either: – COP – EER – IPLV
Possible interactive effects	Interactive effects from HVAC projects are not common. There may be minor interactive effects where absorption chillers replace standard chiller systems – resulting in reduced electricity consumption but increased gas consumption.
Common measurement boundary considerations when developing the energy model	Measurement boundaries for HVAC projects are generally drawn around the entirety of the HVAC system and conditioned space (ie, the entire building where the HVAC upgrade has occurred) to ensure that changes to site energy consumption (eg, from lighting upgrades or substantial IT upgrades) are taken into account. An alternative approach would be to draw the measurement boundary around the cooling component of the HVAC system only – with cooling outputs established as the relevant independent variable. Smaller measurement boundaries can have the benefit of creating a larger effective range for the project.

D.5.4 Lighting applications

The following parameters provide an overview of the most common parameters that should be used by ACPs to measure and verify energy savings from commercial lighting upgrade projects.

Table D.6 Suggested parameters for lighting applications

Energy consumption measurement	Energy consumption before and after implementation will need to be measured to establish both the baseline and operating energy models. Electricity consumption should be measured using either utility or sub-meters.

88 Note that for new end-user equipment baseline efficiencies may be published by the Scheme Administrator in accordance with clause 5.3B of the ESS Rule.

Common independent variables	Some of the common independent variables which should be considered when developing an energy model for lighting applications are: operating hours including times of reduced usage such as weekends and public holidays daylight hours, in the event that daylight sensors are installed
Common site constants	Some of the common site constants which should also be considered are: ▼ type of lamps ▼ number of lamps ▼ lighting control system ▼ driver type[89] ▼ air-conditioned or non-air-conditioned space
Possible interactive effects	There is a possibility of interactive effects when developing lighting savings projects. Changes to lighting within the measurement boundary may have positive or negative impacts on the total energy consumption of a building's HVAC system.
Common measurement boundary considerations when developing the energy model	All circuits with affected lamps should be captured within the measurement boundary. Measurement boundaries are typically drawn around a lighting circuit, but can be drawn around a larger space, in which case it should capture all affected lighting circuits. Consider including an assessment of the HVAC system or expanding the measurement boundary to the whole of building to ensure all interactive effects can be addressed.

D.5.5 Motor, pump and fan applications

The following parameters provide an overview of the most common parameters that should be used by ACPs to measure and verify energy savings from motor, pump and fan upgrade projects.

Table D.7 Suggested parameters for motor, pumps and fan applications

Energy consumption measurement	Energy consumption before and after implementation will need to be measured to establish both the baseline and operating energy models. Electricity consumption should be measured using either utility or sub-meters**.**
Common independent variables	Some of the common independent variables that should be considered when developing an energy model for motor, pump and fan applications are: ▼ production, at either a total site level or individual product line, eg, tonnes or number of units. ▼ process flow rate and demand ▼ operating temperature ▼ operating pressure ▼ operating hours, including periods of reduced usage and the impacts of seasonality ▼ emissions levels, related to situations where system set-points are based on the air composition, eg, carbon monoxide levels in carparks and tunnels ▼ motor utilisation, applicable systems with variable flow and load processes

89 Refer to the OEH Energy Efficiency Lighting Technology Report for an overview of the different driver types. Available at www.environment.nsw.gov.au/resources/business/140017-energy-efficient-lighting-tech-rpt.pdf

Common site constants	Some of the common site constants that should also be considered are: ▼ medium that is pumped ▼ impeller size ▼ pipeline and pumping system design / configuration ▼ load factor based on the efficiency and utilisation of the motor and/or fan and pumping system
Possible interactive effects	There is a possibility of interactive effects if the pump or fan motor is part of a larger system which is being changed.
Common measurement boundary considerations when developing the energy model	Measurement boundaries for pumps, motors and fan systems will generally be drawn around the individual pump, motor or fan system. Where the system upgrade affects part of a larger system, resulting in interactive effects, the measurement boundary should be drawn around the broader system to capture these effects.

D.5.6 Fuel switching applications

Following is an overview of the most common parameters that should be used by ACPs to measure and verify energy savings from fuel switching projects such as cogeneration or trigeneration.

Fuel switching projects are not a RESA where the project is eligible to create tradeable certificates under the *Renewable Energy (Electricity) Act 2000* (Cth) or leads to a net increase in greenhouse gas emissions.[90] Cogeneration projects are not RESAs where the generated electricity is exported to the electricity network or the cogeneration system has nameplate rating of 5MW or higher.[91]

Cogeneration parameters have been included to provide ACPs with guidance on how to calculate appropriate electricity and gas consumption, to net out amounts for applicable projects.

Table D.8 Suggested parameters for cogeneration applications

Energy consumption measurement	Energy consumption before and after implementation will need to be measured to establish both the baseline and operating energy models. The following elements should be measured: ▼ input energy – broken down into electricity and gas where applicable ▼ total electricity generation – electricity consumed on-site and electricity exported ▼ thermal heat recovered
Common independent variables	Some of the common independent variables that should be considered when developing an energy model for cogeneration applications are: ▼ power produced from the system, generally measured in megawatts (MW) ▼ heat, in terms of the quantity of heat recovered from the system, generally measured in gigajoules (GJ) ▼ type of fuel used to power the system (eg, natural gas) ▼ operating hours, including times of reduced usage such as weekends and public holidays, as well as seasonality ▼ system loads/activity levels ▼ input raw materials ▼ production types and amounts

90 *ESS Rule*, cl 5.4(g) and 5.4(j)
91 *ESS Rule*, cl 5.4(i)

Common site constants	Some of the common site constants that should also be considered are: ▼ total installed capacity of the system ▼ conversion efficiency ▼ system downtime, which would refer to average shutdown hours based on both planned and unplanned maintenance as well as system availability ▼ system design, related to the system type, sizing and utilisation factor for any cogeneration system. As well as the design of any inherent pumping system
Possible interactive effects	Any interactive effects would be largely dependent on the type of technology installed, and whether the cogeneration/ trigeneration system interacts with any other thermal systems on site.
Common measurement boundary considerations when developing the energy model	Measurement boundaries will generally be drawn around an individual piece of installed equipment. Boundaries can be expanded to include larger segments of the facility where there is an interactive effect between the cogeneration system and other thermal systems (such as heat recovery).

D.5.7 Whole building application

The following parameters provide an overview of the most common parameters that should be used by ACPs to measure and verify energy savings where upgrade projects cover a range of activities and impact on the total energy consumption of a particular site.

Table D.9 Suggested parameters for whole of building applications

Energy measurement consideration	Energy consumption before and after implementation will need to be measured to establish both the baseline and operating energy models. The total site energy consumption should be measured (both gas and electricity).
Common independent variables	Some of the common independent variables that should be considered when developing an energy model for whole building applications are: ▼ ambient temperature ▼ relative humidity ▼ operating hours, including times of reduced usage such as weekends and public holidays, as well as seasonality where applicable. ▼ occupancy, using units relevant to the applicable service area (for instance a hospital might use hospital bed days or number of hospital beds, event centres might use special event occupancy, and commercial building occupancy might be based on Full Time Employees (FTEs))
Common site constants	Some of the common site constants that should also be considered are: ▼ temperature system set points and how they react to both temperature and relative humidity set points ▼ total serviced floor area (m^2) ▼ changes to system control logic
Possible interactive effects	The inherently broad measurement boundary will include interactive effects, so these will not have to be accounted for.
Common measurement boundary considerations when developing the energy model	The measurement boundary would be drawn around the entire building in this instance so that all energy flows can be measured from the primary utility meter(s).

E Worked example – Measurement & Verification Plan

Contact details

ACP contact details

Name	John Smith
Corporation name	Major Sydney Hospital
ABN	11111111111
Postal address	100 George Street, Sydney, 2000
Phone number	(02) 1111 1111

Individual site details

Corporation name	ABN	Site address	Contact name	Phone number
Major Sydney Hospital	12121212121	100 George Street, Sydney, 2000	Jane Smith	(02) 8888 8888

M&V Professional details

Name	Paul Jones
Corporation name	M&V Professionals Pty Ltd
ABN	99999999999
Postal address	100 Miller Street, North Sydney, 2060
Phone number	(02) 9999 9999

Measurement & Verification Design

This is a sample M&V planning format only. ACPs are not restricted to using this format and may develop their M&V plans using different templates.

Site details

Example Project Input

Site details

The site is a hospital in Sydney. The building is 38 years old and has a capacity of 2,000 beds. The hospital is in operation 24 hours per day with a range of adminsitrative staff that work Monday to Friday 7am to 5pm.

Total energy summary

Provide a summary of energy consumption for the site(s).

Site	Energy Source	Consumption	Unit	Period
Major Sydney Hospital	Electricity	2,705,278	kWh	1/01/2012 – 31/12/2012
	Natural Gas	3,637	GJ	1/01/2012 – 31/12/2012
	Diesel	20,000	Litres	1/01/2012 – 31/12/2012

Meter Details

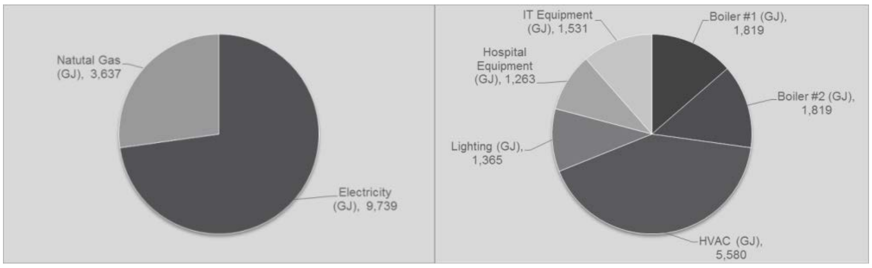
Provide a summary of existing available meters, and sub-meters on site.

Site	Meter Identifier	Description
Major Sydney Hospital	NMI: NCCC123456	Electricity Utility Meter
	EM_S2_CH1 (kWh)	Chiller 1
	EM_S2_CH2 (kWh)	Chiller 2
	EM_S2_CH3 (kWh	Chiller 3
	EM_S2_CH4 (kWh)	Chiller 4
	EM_S2_CH5 (kWh	Chiller 5
	EM_S2_CH6 (kWh)	Chiller 6
	EM_S2_CH7 (kWh)	Chiller 7
	EM_S2_CH8 (kWh	Chiller 8
	EM_S2_CTE (kWh)	Lighting
	EM_S2_CTN (kWh)	Ancillary equipment including cooling tower, chilled water pumps, condenser water pumps and control systems
	DPI: 12345678901	Natural gas utility meter

Fuel source breakup

Provide a chart indicating the breakup of both fuel source and functional area consumption for each site. The purpose of this is to enable a broader understanding of how total energy is consumed on site, and can be used as supporting evidence to justify the selection of the project boundary or help estimating the impact of interactive effects.

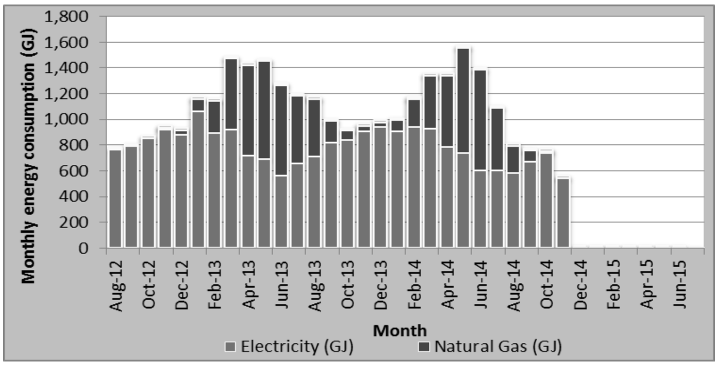
Major Sydney Hospital – Energy breakup



Energy consumption trends

Provide a chart indicating the monthly trend of fuel source consumption for each site. The purpose of this is to identify any cyclical patterns in consumption that may need to be understood for M&V inputs.

Major Sydney Hospital – Monthly energy consumption



Project details

Example Project Input

Project description

The hospital is planning to upgrade its air conditioning plant. Equipment that will be replaced includes:

- upgrade of 2 x existing chillers (installed in 1978 and 1983) to 2 x 4000kWr variable speed drive centrifugal chillers
- additional 2 x cooling towers to meet increased capacity and provide improved condenser water temperature control
- new condenser water and chilled water pumps with variable speed drives, and
- new integrated control system with automatic system optimisation.

This upgrade will build on other recent upgrades including fitting variable speed drives to chilled water and condenser water pumps.

As the intention is to measure all variables relating to energy consumption by the chillers pre and post retrofit, this M&V activity aligns itself with an Option B (IPMVP) methodology to determine energy savings.

Available metering

Existing metering linked with the current Building Management System (BMS) is able to provide consumption data for individual chillers. This level of coverage is sufficient to meet M&V requirements.

Independent variables and site constants

Example Project Input

Measurement boundary

The measurement boundary is defined as being the electricity input supply to the air conditioning system measured by the data points within the BMS system and defined in the energy consumption section below.

Energy consumption

Identify and define how energy consumption will be calculated based on meter data.

Meter identifier/name	Description	How measured	Precision
EM_S2_CH2 (kWh)	Chiller 2	Through BMS	1%
EM_S2_CH4 (kWh)	Chiller 4	Through BMS	1%
EM_S2_CH6 (kWh)	Chiller 6	Through BMS	1%
EM_S2_CH7 (kWh)	Chiller 7	Through BMS	1%
EM_S2_CTN (kWh)	Ancillary equipment including cooling tower, chilled water pumps, condenser water pumps and control systems	Through BMS	1%

Independent variables

Independent variables refer to regularly changing parameters affecting a site's energy consumption.

Independent variable name	Units	Description
Daily air temperature	°C	Average air temperature, calculated from daily minimum and maximum temperature data. Average air temperature is used to calculate CDD and HDD
Working days	TRUE / FALSE, or 1 / 0	Binary value to describe if a day is a working day (Monday to Friday) or non- working day (Saturday, Sunday and public holidays)

Site Constants

Site constants refer to less regular changes or events that may affect a site's energy consumption.

Site constant name	Units	Description
Chiller #1 operational	on/off	Chiller is operational and not offline as part of commissioning / maintenance
Chiller #2 operational	on/off	Chiller is operational and not offline as part of commissioning / maintenance
Hospital operating hours	Hours	Standard operating hours for day patients and administrative staff

Example Project Input

Excluded variables

Excluded variables refer to independent variables or site constants for which data is available, but are either dependent on the other variables or don't have a strong influence on energy consumption.

Excluded variable name	How measured/calculated	Reason excluded from model
Floor area	Site plans/drawings	Floor area has remained constant during the baseline period and there are no plans for future expansions or reduction of hospital areas for the life of the project. As such, this site constant has been excluded from the model.
Patient beds	Can be retrieved from hospital records	Regression analysis shows a poor correlation between the number of patient beds and the energy consumption. The t-statistic value obtained is lower than 2. The number of patient beds is not expected to vary significantly in the future and it is therefore excluded from the model.
Relative humidity	Measured from local weather station	Regression analysis shows a poor correlation between relative humidity and the energy consumption. The t-statistic value obtained is lower than 2. High humidity levels can increase HVAC energy consumption, but in this case, the effect of humidity did not increase the predictive power of the model. Temperature was generally found to be correlated with humidity, so the inclusion of temperature in the model already indirectly included the effect of humidity.

Data sources

Variable name	How measured/ calculated	Accuracy Type	Margin of error
Daily air temperature	Measured from local weather station (BOM[92] station no. 66124). Average of Daily minimum and maximum recorded values	Absolute error	±0.05°C
Working days	Set to TRUE (1) for all days Monday to Friday, except public holidays	Absolute error	± 0
Chiller #1 operational	Maintenance records	Absolute error	± 0
Chiller #2 operational	Maintenance records	Absolute error	± 0
Hospital operating hours	Hospital records	Absolute error	± 0

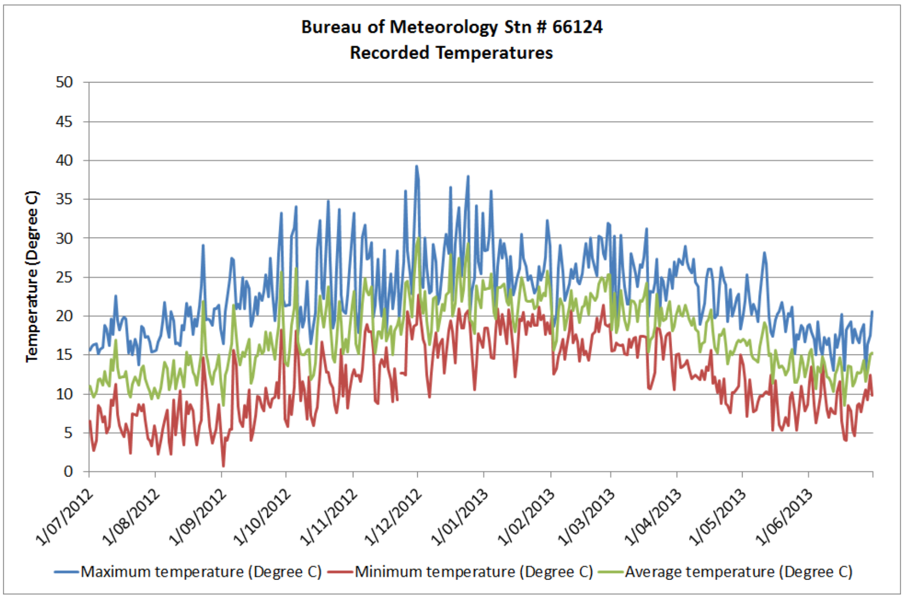
92 BOM: Bureau of Meteorology

Normal year

Example Project Input		
	Definition	The 12 months of collected data used to inform the development of the baseline energy model has been selected as the definition of the normal year.
	Justification	Defining the normal year to be an actual period of 12 months of performance data ensures that a full operating cycle is captured for the independent variables. In this case, it includes the full seasonality associated with daily ambient air temperature across the year and the full amount of normal working days in a year associated with the hospital.

Effective range

<table>
<tr><td rowspan="1">Example Project Input</td><td>How has this been defined?</td><td>
For daily air temperature (variable #1), minimum and maximum values from BOM station number 66124 are obtained. Daily air temperature is then defined as being the average of the minimum and maximum. Data is reproduced in the figure below.



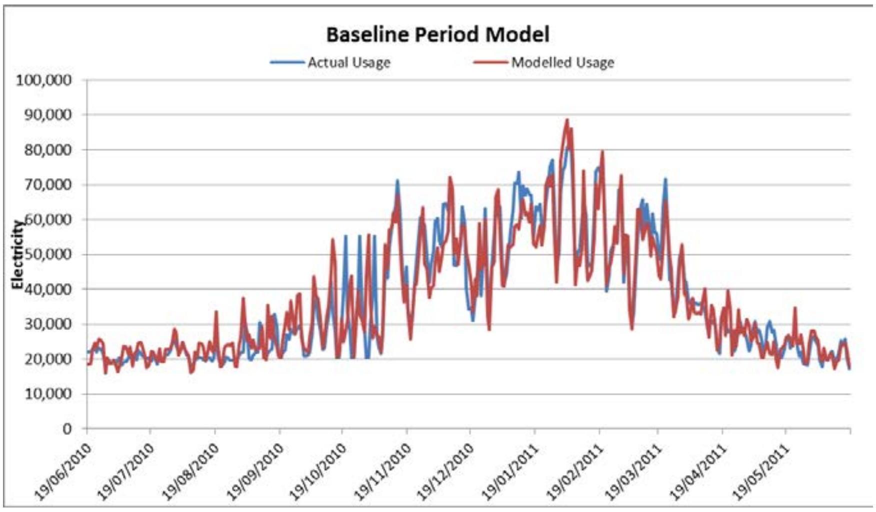
The daily average temperature is used to calculate CDD and HDD, which are the independent variables used to develop the energy models.

CDD/HDD minimum and maximum values are then extended by ±5% to determine the lower and upper limits of the effective range.

For working day (variable #2), this is determined as a Boolean either TRUE or FALSE based on hospital operation as follows:

- TRUE: Monday to Friday where the hospital is in full operation
- FALSE: Saturday, Sunday and Public Holidays where the hospital is partly operating
</td></tr>
</table>

Baseline energy model

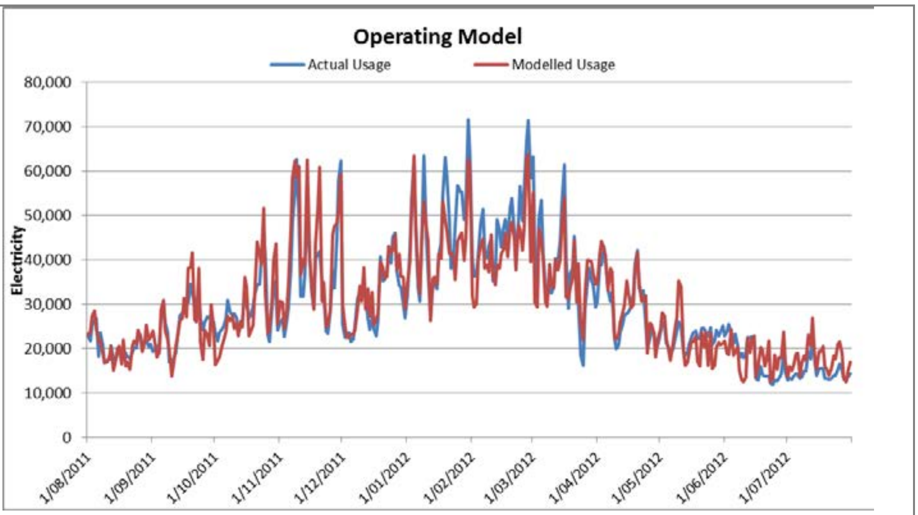
Example Project Input		
	Regression equation	A regression analysis was completed using a relevant software package.
	Baseline energy model	Present a chart of the baseline energy model showing the predicted consumption against actuals. This could be in the form of an XY plot where only one variable exists, or as energy consumption over time for one or more variables. 
	Statistical validity	Is the model statistically a good fit? Note that meeting the following criteria is not a requirement under the ESS Rule, however doing so should provide the ACP with confidence that they have developed an adequate energy model.
	Justification	The energy model is representative of a standard commercial building within the Sydney built environment with a strong relationship with weather, together with a higher energy usage occurring on standard working days compared to weekends.

Modelling criteria	Recommended values	Baseline energy model value
t-statistic of independent variables	>2	CDD t-stat = 39.7 HDD t-stat = 10.0 Working day t-stat = 6.4
Lesser R^2 or adjusted R^2	> 0.75	0.87682
Non-routine events removed	<20% of the measurement period	0%

Operating energy model[93]

Example Project Input		
	Regression equation	A regression analysis was completed using a relevant software package.
	Operating energy model	Present a chart of the operating energy model showing the predicted consumption against actuals. This could be in the form of an XY plot where only one variable exists, or as energy consumption over time for one or more variables.

93 Note: this is only required for the forward creation of ESCs. If creating annually or topping-up ESCs, please skip this section and continue straight to 'Interactive energy savings'.



Statistical validity

Is the model statistically a good fit? Note that meeting the following criteria is not a requirement under the ESS Rule, however doing so should provide the ACP with confidence that they have developed an adequate energy model.

Modelling criteria	Recommended values	Operating energy model value
t-statistic of independent variables	>2	CDD t-stat = 29.9 HDD t-stat = 9.1 Working day t-stat = 7.2
Lesser R^2 or adjusted R^2	> 0.75	0.86322
Non-routine events removed	<20% of the measurement period	0%

Justification

The energy model is representative of a standard commercial building within the Sydney built environment with a strong relationship with weather, together with a higher energy consumption occurring on standard working days compared to weekends.

Interactive energy savings

Example Project Input		
	Have any interactive energy savings been considered within the measurement boundary?	None were identified for this example
	Justification	N/A

Accuracy factor

Example Project Input		
	Has an accuracy factor been applied to any estimated savings?	The relative precision of the estimated energy savings is calculated at 90% confidence level and using the combined standard errors (SE) from both the baseline and operating energy models: $SE_{savings} = \sqrt{(SE_{baseline})^2 + (SE_{operating})^2}$ The standard errors for both baseline and operating energy models are in turn calculated using the combined uncertainties of the regression model and the measurements (ie, accuracy of

		electricity meters): $SE_{baseline} = \sqrt{(SE_{\hat{Y}})^2 + (SE_{EM\_S2\_CH2})^2 + (SE_{EM\_S2\_CH4})^2 + \cdots + (SE_{EM\_S2\_CTN})^2}$ Refer to equations B-11 and B-18 in Appendix B of the IPMVP's ***Concepts and Options for Determining Energy and Water Savings, Volume I, January 2012*** for more details. The relative precision of the estimated energy savings is between 25-50%, which according to Table A23 of the ESS Rule gives an accuracy factor of 0.9.
	Justification	Use of accuracy factor drawn from Table A23 of the ESS Rule.

Persistence model / Decay factor

Example Project Input	**How has a decay factor been applied to any estimated savings?**	(see table below)
	Justification	This has been drawn from the default values in Table A16 of the ESS Rule.

Expected lifetime/year	Decay Factor
1	1
2	0.8
3	0.64
4	0.51
5	0.41
6	0.33
7	0.26
8	0.21
9	0.17
10	0.13

Calculated energy savings

Example Project Input	**Please provide details of any previous energy savings**	Nil – This is a new project and will be forward creating ESCs for anticipated energy savings for up to 10 years after the implementation date.
	Which equations will be used to calculate energy savings?	This project involves the forward creation of ESCs using the normal year approach. As such, Equations 7A.1 and 7A.2 of the ESS Rule will be used to determine the energy savings over the 10 year period. Additional energy savings may be claimed in the future using the annual top-up approach (starting in Year 1).