IPART
New South Wales

Independent Pricing and Regulatory Tribunal

Consultation Draft: Technical requirements - Project Impact Assessment with Measurement and Verification Method

Energy Savings Scheme
May 2016

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Invitation for submissions

IPART invites written comment on this document and encourages all interested parties to provide submissions addressing the matters discussed.

Submissions are due by 10 June 2016.

We would prefer to receive them electronically via email. Please email your response to ESS@ipart.nsw.gov.au. All feedback received will be considered as confidential.

You can also send comments by mail to:

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Late submissions may not be accepted, at the discretion of the Scheme Administrator.

If you would like further information on making a submission, IPART's submission policy is available on the IPART website.

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1 Introduction

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]

Clause 7A.16 of the *Energy Savings Scheme Rule of 2009* (**ESS Rule**) provides that the Scheme Administrator may publish guides that detail acceptable and unacceptable approaches for ACPs and Measurement and Verification (**M&V**) Professionals to meet the requirements of the Project Impact Assessment with Measurement and Verification (**PIAM&V**) method.

IPART has developed this draft *Technical requirements – Project Impact Assessment with Measurement and Verification* document to provide ACPs with additional guidance for the development of M&V plans, which is a key requirement under the PIAM&V method. This consultation paper provides a draft of our proposed guidance and seeks feedback from all interested parties.

We would like to get feedback on how this guidance material addresses the technical requirements of the PIAM&V method, especially the most complex aspects. We particularly seek comment on the following issues:

1 Should section 4.3 provide a description and an example on computer simulation methods too? 16

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[1] *Electricity Supply Act 1995*, section 98(2)

[2] *Electricity Supply Act 1995,* sections 153(2) and 151(2)

2 Does section 4.4 provide enough guidance on how to determine the effective range? Should a short example be included to better illustrate the impact of the effective range on the calculation of energy savings? 17

3 Should section 5 also provide a description and an example on counted energy savings? 22

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Following review of the feedback received, the information in this document will be used to make amendments to the PIAM&V Method Guide.[3] This document should, therefore, be read in conjunction with the Method Guide.

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[3] The *PIAM&V Method Guide* provides guidance on the application process and is available here: www.ess.nsw.gov.au/Methods_for_calculating_energy_savings/Project_Impact_Assessment_with_MV.

2 About this document

This document is designed to provide technical guidance for ACPs in establishing appropriate M&V plans, and determining the M&V parameters that are required at different stages of the process. An M&V plan template has been developed in conjunction with this document,[4] which can be used by ACPs when applying for accreditation or when preparing records to support any ESCs created using the PIAM&V method.

This guidance document does not cover the requirements for:

- applications for accreditation using the PIAM&V method, or
- applications to become an approved M&V Professional under the ESS.[5]

As noted above, this document should be read in conjunction with the PIAM&V Method Guide. Throughout this document, excerpts of the Method Guide are included in blue boxes to assist.

In addition to this document, the following references are recommended reading when considering the PIAM&V 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, Concepts and Options for Determining Energy and Water Savings, Volume I, 2012* (**IPMVP**), published by the Efficiency Valuation Organization.[7]

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[4] To be made available when the final version of this document is published.

[5] The *Guide for M&V Professionals* is available here: www.ess.nsw.gov.au/Methods_for_calculating_energy_savings/Project_Impact_Assessment_with_MV.

[6] Available at www.environment.nsw.gov.au/energyefficiencyindustry/confirm-energy-savings.htm

[7] Available at www.evo-world.org

3 Overview of the PIAM&V process

The PIAM&V method allows for energy savings to be calculated using one of three approaches:[8]

- 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.

There are four acceptable types of energy models that may be used to model energy use and calculate energy savings:[9]

- 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%
- regression analysis based on measurements of energy consumption, independent variables and site constants during a specified measurement period where the number of independent observations for the independent variables must be at least six times the number of model parameters in the energy model
- computer simulation using commercially available software approved by IPART for use in modelling the relevant type of end-user equipment and calibrated against actual measurements, or
- a sampling method that is based on measurement and estimate of the mean, regression analysis or computer simulation of similar end-user equipment at similar sites.

Figure 3.1 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 on each of these stages. These parameters are described in more detail in the following sections.

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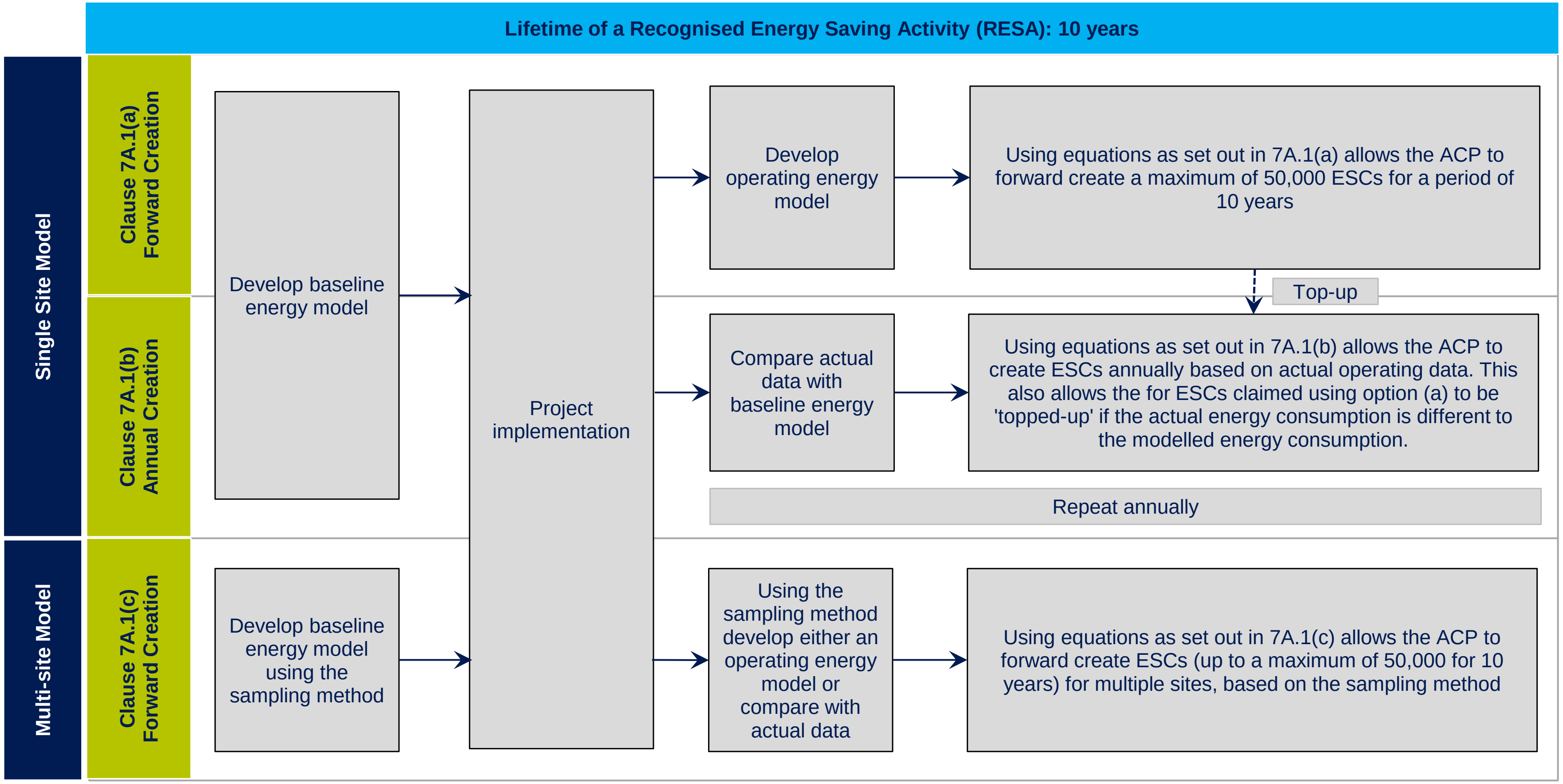
[8] Refer clause 7A.1 of the ESS Rule.

[9] Refer clause 7A.2 of the ESS Rule.

Figure 3.1 A typical PIAM&V timeline



4 Developing energy models

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
- independent variables and site constants
- effective range, and
- project implementation date.

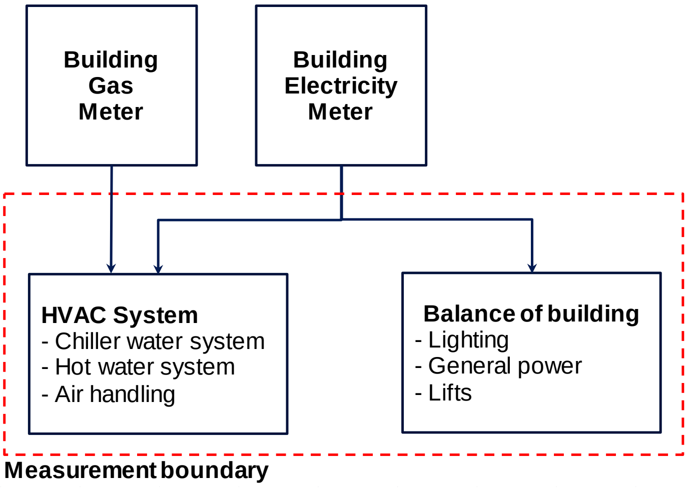
4.1 Establish the measurement boundary

Method Guide – section 3.7

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 end-user equipment (**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 Recognised Energy Saving Activity (**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 4.1 and Figure 4.2 below.

Figure 4.1 Example measurement boundary around entire building

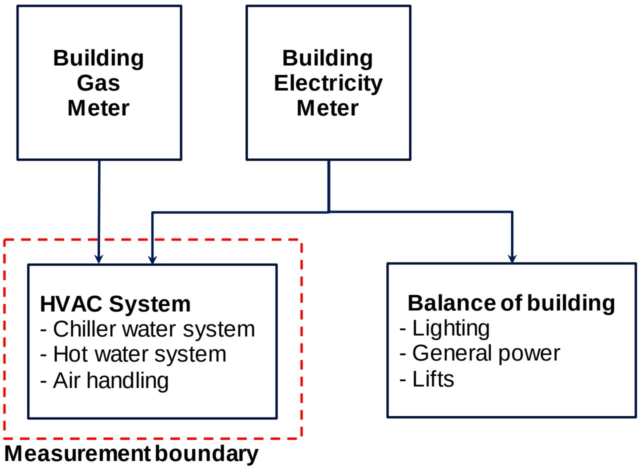


The measurement boundary being placed around the entire building.

A significant advantage is that there is often no requirement for the installation of additional sub-metering.

This can be a good approach when expected energy savings are going to be 10% or more of the total building load, especially if the HVAC system is the primary source for the variation in energy use.

Figure 4.2 Example measurement boundary around functional area



The measurement boundary being placed around the functional area or the use equipment.

This can be a good approach to consider when sub-metering already exists (or can be easily installed) and expected energy savings are 10% or less of the total building consumption.

This approach should also be considered if there is significant variation in the building energy consumption that is unrelated to the HVAC system.

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 4.4 of this guide)
- 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 5.2 of this guide on interactive effects).

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.[10] 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.

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

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*.[11]

4.2 Define variables

Method Guide – section 2.2

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, such as 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, heating, ventilation and air conditioning (**HVAC**) temperature set points and dead bands).

ACPs and M&V Professionals need to consider these site specific variables when developing 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 recommended independent variables and site constants for common technologies and RESAs is included in Appendix A.

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[11] Available at: http://www.environment.nsw.gov.au/energyefficiencyindustry/confirm-energy-savings.htm

4.2.1 Independent variables

Independent variables are parameters that explain how energy consumption changes over time under normal operating conditions and are used in baseline and operating energy models to estimate energy consumption. As they are inputs to the energy model, 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. It is essential that data collected to inform the development of baseline and operating energy models is done so over the full range of normal operating conditions.

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

How can independent variables be identified?

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 4.1 below.

Table 4.1 Methods for understanding site energy consumption

Method type	Site energy consumption approaches
Energy audit	Site energy consumption can be determined through an energy audit[12] 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 may influence 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 an independent variable.
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 operation 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%[13] of the measurement period. **Ensure that you 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

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[12] 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.

[13] Refer clause 7A.5(g) of the ESS Rule.

Method type	Site energy consumption approaches
	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 or 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 examining over a longer time period.
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.

4.2.2 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 4.1 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 4.2, 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 A. 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).

4.3 Energy models

> **Method Guide – section 2.2**
>
> 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.

In order 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.[14]

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 independent variables and site constants, 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.

Section 3 outlined the four 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.

4.3.1 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 4.2 presents some guidance on thresholds of statistical good-fit that could be used by ACPs in developing an energy model using linear regression.

Table 4.2 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.	> 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

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[14] 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 5.

Modelling criteria	Definition	Threshold
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 5.3 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 5.3 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 4.1.

Box 4.1 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:

$$\boldsymbol{Y = a + b_1 X}$$

Where:

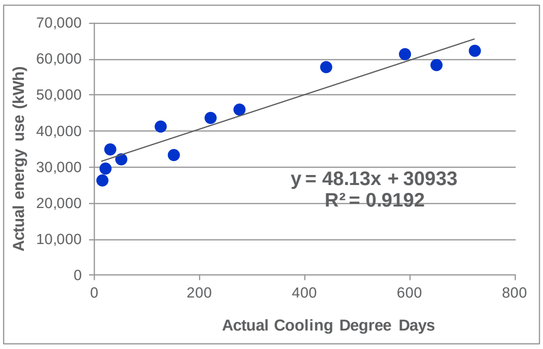
Y = Estimated electricity consumption (kWh)

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 sound (the pitfalls in degree-day analysis have been avoided or corrected for), and that the cooling system is working well (the ‘control’ of the system is good, with a reasonable CDD base temperature).



4.3.2 Estimate of the mean

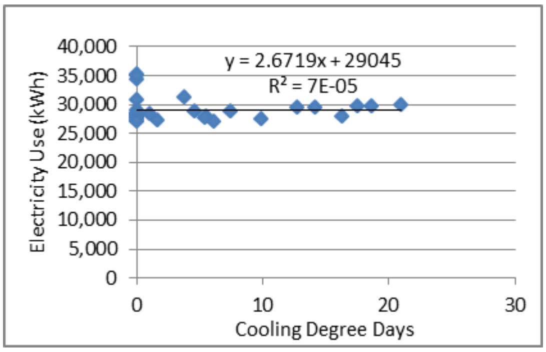
It is not always possible to develop a satisfactory energy model where there are no independent variables that significantly affect energy consumption. In this case, a graph of energy consumption over time will show that there is little variation in energy consumption, and using a regression analysis 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%[15]. The coefficient of variation is defined as the sample standard deviation expressed as a percentage of the sample mean.

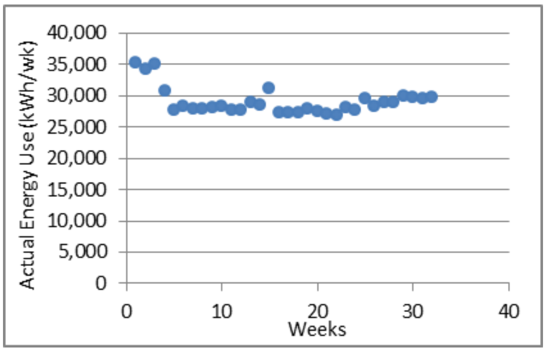
An example of an estimate of the mean for an HVAC system is provided in Box 4.2.

Box 4.2 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 R^2 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.



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.

We seek comment on the following:

1 Should section 4.3 provide a description and an example on computer simulation methods too?

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[15] Refer clause 7A.2(a)(i) of the ESS Rule.

4.4 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%[16], 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 (extended by ±5%) of either the baseline or operating energy models.

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

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 (extended by ±5%) of either the baseline energy model or operating energy model.[17] ACPs will need to balance the cost of collecting additional data versus the possible additional savings to be claimed.

We seek comment on the following:

2 Does section 4.4 provide enough guidance on how to determine the effective range? Should a short example be included to better illustrate the impact of the effective range on the calculation of energy savings?

4.5 Project implementation

Method Guide – section 3.7

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.

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[16] Refer Equation 7A.2 of the ESS Rule.

[17] 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.

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. The implementation date is the date that the implementation commences normal operations.[18]

It is advised that projects 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 commissioning issues to be resolved.

5 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 end-user equipment 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.

5.1 Normal year

Method Guide – section 3.7

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 end-user equipment at a site, after the implementation date.[19]

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[18] Refer clause 7A.17 of the ESS Rule.

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

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.

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 normal year values must represent a typical year of operation for the end-user equipment 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.

5.2 Interactive energy savings

Method Guide – section 3.7

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. For example, the OEH PIAM&V tool provides an acceptable approach for estimating interactive effects on HVAC systems if the EUE is within an air conditioned space. Other examples of interactive effects are in lighting upgrades and the resultant change in HVAC requirements. There are a number of appropriate references[20] extrapolating the fact that changes to more efficient lighting can increase the heating load for the space affected by the lighting project.

Another example involving the utilisation of waste heat from a boiler or compressed air system may 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.[21]

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 result in 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*.[22]

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[20] Refer https://ump.pnnl.gov/showthread.php/4840-4.13-Interactive-Effects-with-Heating-Ventilation-and-Cooling and http://www.nrel.gov/docs/fy13osti/53827.pdf for instance

[21] Refer clause 7A.9(c) of the ESS Rule.

[22] Available at: http://www.environment.nsw.gov.au/energyefficiencyindustry/confirm-energy-savings.htm

5.3 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.[23]

The PIAM&V tool developed by OEH can also be used to assist development of an accuracy factor.[24]

5.4 Decay factor and persistence model

> **Method Guide – section 3.7**
>
> 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 end-user equipment 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.

5.5 Calculated energy savings

In order 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,[25] it is important that the ACP recognises any previously counted ESCs arising from this or other

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[23] Refer Equations 7A.1 and 7A.3 of the ESS Rule.

[24] The tool is available at: http://www.environment.nsw.gov.au/business/piamv-tool.htm

[25] Equations 7A.1 and 7A.3 of the ESS Rule.

projects. As described previously in section 3, there are three options to calculate energy savings using the PIAM&V method:

- option (a) allows you to forward create up to 10 years for a single site model with no requirement for future ESC creation
- option (b) allows you to create annually, or if you have previously used option (a), it allows the ACP to top-up on an annual basis, and
- option (c) allows you to forward create up to 10 years 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.

We seek comment on the following:

3 Should section 5 also provide a description and an example on counted energy savings?

Appendices

A 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.

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.

A.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 A.1 Suggested parameters for boilers, 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 imposed ▼ compressor delivered air, which can be measured in L/s

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 be clearly defined to 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 have been determined on a project specific basis, the measurement boundary should be broadened to take these into account.

A.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 A.2 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, agriculture produce) ▼ Efficiency, related to the efficiency[26] 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.

A.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 A.3 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.

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[26] 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 temp, humidity and occupancy ▼ efficiency[27] 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.

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[27] 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.

A.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 A.4 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.
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[28] ▼ 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.

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

A.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 A.5 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. For example, 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
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.

A.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. [29] 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.[30]

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 A.6 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
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

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[29] Refer to clauses 5.4(g) and 5.4(j) of the ESS Rule.

[30] Refer to clause 5.4(i) of the ESS Rule.

	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).

A.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 A.7 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).

We seek comment on the following:

4 Do the proposed examples in Appendix A cover enough technology types? Are there other technology types that should be covered here?

5 Are the suggested parameters clear and adequate? Are there any other parameters that should be included?

B Worked example – Measurement & Verification Plan

B.1 Contact details

Table B.1 ACP contact details

Name	John Smith
Corporation name	Major Sydney Hospital
ABN	1111111111111
Postal address	100 George Street, Sydney, 2000
Phone number	(02) 1111 1111

Table B.2 Individual site details

Corporation name	ABN	Site address	Contact name	Phone number
Major Sydney Hospital	121212121212	100 George Street, Sydney, 2000	Jane Smith	(02) 8888 8888

Table B.3 M&V Professional details

Name	Paul Jones
Corporation name	M&V Professionals Pty Ltd
ABN	999999999999
Postal address	100 Miller Street, North Sydney, 2060
Phone number	(02) 9999 9999

B.2 Measurement & Verification Design

Table B.4 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

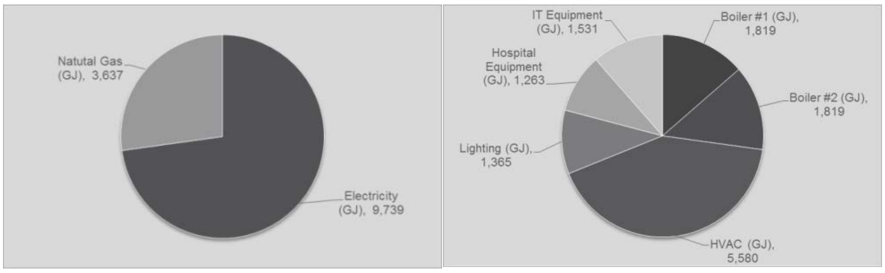
Provide a summary of existing available meters, and sub-meters on site.

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)	House Lighting
	EM_S2_CTE (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.

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

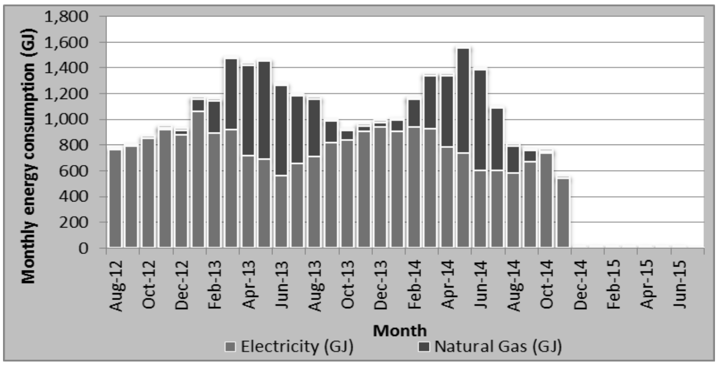


Table B.5 Project details

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 4000kW 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.

Table B.6 Independent variables and site constants

Guidance

Part 1: Energy consumption

Provide details of the meters for which the recorded ‘actual’ energy consumption will be based.

Part 2: Define / identify independent variables

Independent variables are parameters that explain how energy consumption changes over time under normal operating conditions and are used in baseline and operating energy models to estimate energy consumption.

Part 3: Define 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. 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.

Part 4: Optionally define variables not to be used

These include independent variables and site constants that were considered by the ACP as inputs to the energy model but were not included. 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).

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 area below.

Energy consumption

Identify and define how energy consumption will be calculated based on meter data. This data can be copied from the OEH PIAM&V tool.

Meter identifier/name	Description	How measured/calculated
EM_S2_CH2 (kWh)	Chiller 2	Through BMS
EM_S2_CH4 (kWh)	Chiller 4	Through BMS
EM_S2_CH6 (kWh)	Chiller 6	Through BMS
EM_S2_CH7 (kWh)	Chiller 7	Through BMS
EM_S2_CTE (kWh)	Ancillary equipment including cooling tower, chilled water pumps, condenser water pumps and control systems	Through BMS

Independent variables

Independent variables refer to regularly changing parameters affecting a site’s energy consumption. This data can be copied from the OEH PIAM&V tool.

Independent variable name	Units	Description
Daily air temperature	°C	Average air temperature. 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)

Example Project Input (cont)

Site Constants

Site constants refer to less regular changes or events that may affect a site's energy consumption. This data can be copied from the OEH PIAM&V Tool.

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

Excluded variables

Excluded variables refer to variables 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	No additional benefit to model
Patient beds	Can be retrieved from hospital records	No additional benefit to model

Data sources

Variable name	How measured/calculated	Accuracy Type	Margin of error
Daily air temperature	Measured from local weather station (BOM[31] 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

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[31] BOM: Bureau of Meteorology

B.3 Measurement & Verification Report

Table B.7 Normal year

Guidance	*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. 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.* *These data are 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 normal year values must represent a typical year of operation for the end-user equipment 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.*	
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.

Table B.8 Effective range

Guidance

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%, 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 (extended by ***±5%)*** *of either the baseline or operating energy models.*

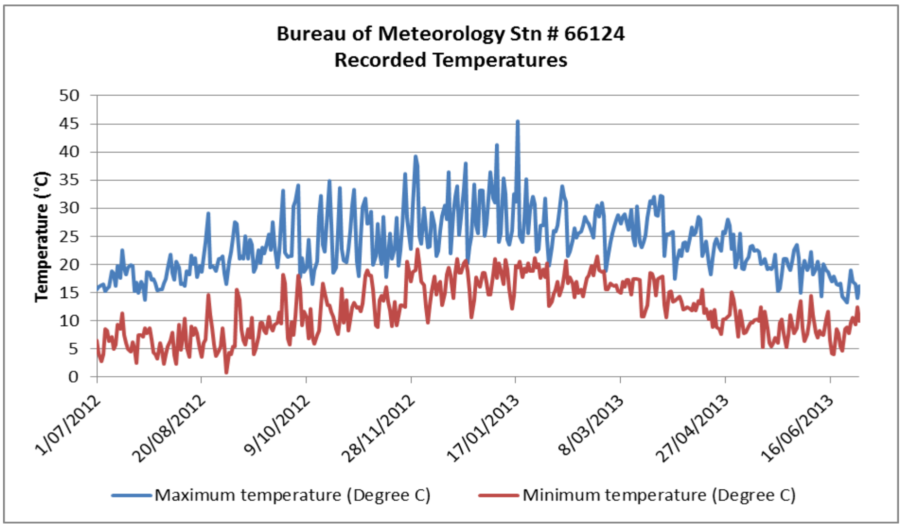
For commercial buildings that have energy models that use ambient temperature, or related variables such as cooling degree days, as the primary independent variable, between 6 - 12 months of data may be needed in order to maximise the effective range of the energy model.

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 (extended by ***±5%)*** *of either the baseline energy model or operating energy model. ACPs will need to balance the cost of collecting additional data versus the possible additional savings to be claimed.*

Example Project Input

How has this been defined?

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.



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

Have different ranges been applied to the baseline and operating energy models?

No

Table B.9 Baseline energy model

Guidance

In order 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.*

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.

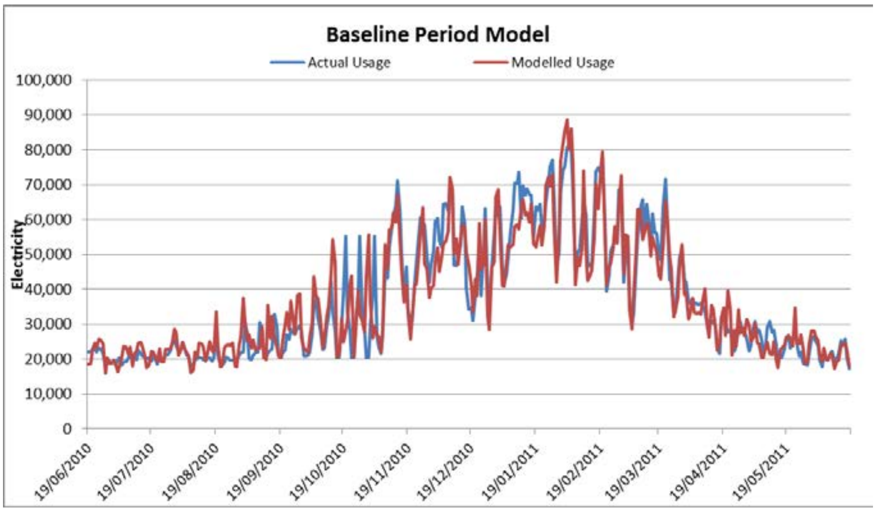
Example Project Input

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.

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
Relative precision calculated at 90% confidence level	Within ±200% (refer table A23 of ESS Rule)	29.1%
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 usage occurring on standard working days compared to weekends.

Table B.10 Operating energy model[32]

Guidance

The operating energy model is only applicable if an ACP is forward creating ESCs, and is not required for annual creation or top-up of ESCs.

The process of developing the operating energy model is very similar to that used when developing the baseline energy model, but uses data from the post implementation period.

Depending on the project, the baseline and operating energy models may be based on the same independent variables and site constants, 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.

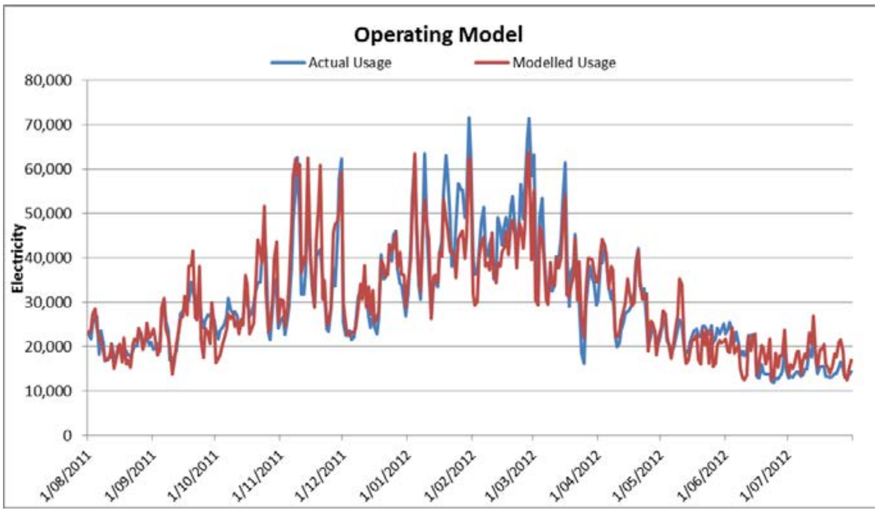
Example Project Input

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.



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
Relative precision calculated at 90% confidence level	Within ±200% (refer table A23 of ESS Rule)	27.2%
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.

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[32] 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'.

Table B.11 Interactive energy savings

Guidance	*Based on the identification of any interactive effects, this step involves establishing an energy model which 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. For example, the OEH PIAM&V Tool provides an acceptable approach for estimating interactive effects on HVAC systems if the EUE is within an air conditioned space. Other examples of interactive effects are in lighting technology and the resultant change in HVAC requirements.* *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.* *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 result in enough data that an interactive energy model may 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.*	
Example Project Input	**Have any interactive energy savings been considered within the measurement boundary?**	None were identified for this example
	Justification	N/A

Table B.12 Accuracy factor

Guidance	*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.* *This factor should be able to be reasonably determined by the ACP, rather than by the Scheme Administrator.* *The PIAM&V tool developed by OEH can also be used to assist development of an accuracy factor.*	
Example Project Input	**Has an accuracy factor been applied to any estimated savings?**	Based on the relative precision for both the baseline and operating energy models being between 25-50%, the accuracy factor should be 0.9.
	Justification	Use of accuracy factor drawn from Table A23 of the ESS Rule. Plan will be to use the OEH PIAM&V Tool so that the accuracy factor is automatically selected.

Table B.13 Persistence model / Decay factor

Guidance

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.

Example Project Input

How has as a decay factor been applied to any estimated savings?

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

Justification	This has been drawn from the default values in Table A16 of the ESS Rule.

Table B.14 Calculated energy savings

Guidance

In order 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. As described previously in section 3, there are three options to calculate energy savings using the PIAM&V method:

- *option (a) allows you to forward create up to 10 years for a single site model with no requirement for future ESC creation*
- *option (b) allows you to create annually, or if you have previously used option (a), it allows the ACP to top-up on an annual basis, and*
- *option (c) allows you to forward create up to 10 years for a multiple site model with no requirement for future ESC creation.*

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

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.
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).

We seek comment on the following:

6 Does the worked example provided in Appendix B cover all M&V parameters adequately? Are there other M&V elements that should be covered?

7 Should Appendix B include another example focused on a different technology type?

8 Does the worked example provide clear step-by-step guidance on how to develop an M&V plan and determine each parameter?