Department of Climate Change, Energy, the Environment and Water

Guide to measurement and verification of energy efficiency projects in Australia

Module 2

August 2024

The measurement and verification (M&V) guide has 2 aims:

- Introduce M&V to the layperson who has an interest in the accurate and transparent determination of energy savings arising from energy efficiency measures (EEMs), and an interest in ensuring that the EEM continues to deliver savings, well after it was deployed.
- Provide a process and checklist for M&V practitioners to follow to deliver trustworthy M&V and to help ensure the persistence of savings.

As a result, this guide aims to contribute to better M&V practices and processes in Australia.

Acknowledgment of Country The Department of Climate Change, Energy, the Environment and Water acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

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Section 1: M&V technical analysis

This section is for audiences seeking more detailed guidance on M&V and issues to look out for.

1 Technical guidance for M&V practitioners

The proper implementation of each step highlighted in chapter 3 of module 1 requires M&V practitioners to have strong technical, organisational and communication skills. This section focuses on providing detailed guidance on the technical requirements to adequately implement M&V. To gain the required technical understanding of M&V processes, read this section and the International Performance Measurement and Verification Protocol (IPMVP®) guidelines and, where relevant, the local scheme requirements (ESS, VEU, and ERF).

This chapter will address 4 main areas of M&V:

- determining the measurement boundary (IPMVP option)
- data analysis
- energy savings calculations
- determining the uncertainty in the energy savings.

1.1 Determining the measurement boundary and IPMVP option

Deciding on the M&V approach and where to draw the measurement boundary in relation to the equipment is a key M&V decision. The 2 main considerations are selection of the M&V measurement boundary and of the IPMVP option.

1.1.1 IPMVP option selection

The IPMVP guidelines set out 4 options that can be used to determine saving. They are:

- Option A: retrofit isolation, key parameter measurement
- Option B: retrofit isolation, all parameter measurement
- Option C: whole-of-site measurement
- Option D: calibrated simulation.

The M&V practitioner decides where to draw the measurement boundary and which of the 4 IPMVP options to use.

IPMVP guidance recommends that if determining savings from the equipment affected by the EEM, the measurement boundary for M&V should be placed around that equipment – it should be a 'retrofit isolation' boundary – and one of options A and B should be used.

In practice, this often requires installing additional sub-metering. This means that M&V activities must start well before implementation of the EEM, so as to establish baseline energy performance for all operating conditions.

IPMVP guidance on selection of measurement boundary

If the reporting is to verify the **savings from equipment** affected by the energy efficiency project, draw a measurement boundary around that equipment so that measurement requirements for the equipment within the boundary can be determined. This is a retrofit isolation option (option A or B).

If the reporting is to verify and/or help manage **total facility energy performance** or verify the savings from multiple EEMs with interactive effects, use the meters measuring the supply of energy to the whole facility to assess performance and savings. The measurement boundary, in this case, encompasses the whole facility. The approach used is option C: whole facility.

The IPMVP recommendation is that options C and D should be used if multiple EEMs have been implemented or there might be complex 'interactive effects' between these EEMs.

If M&V is being undertaken to create VEECs, only IPMVP options B or C can be used. This guide focuses on options B and C, which are the options most used in Australia.

> Begin M&V planning when the EEM is first seriously considered

The selection of the measurement boundary and IPMVP option are key M&V decisions because they affect M&V costs, the time required to develop a baseline model, and the accuracy of savings estimates. To make the best possible decisions, M&V planning must begin when the EEM is first seriously considered.

Identify what will be required to develop a baseline model as early as possible. Consider:

- time required to develop a baseline
- metering requirements for energy and independent variables.

1.1.2 Option B or option C?

Tables 1 and 2 provide guidance on choosing between options B and C.

Option C generally costs less than option B. This is why much of the M&V undertaken under the ESS and VEU programs uses option C.

However, option C gives less reliable savings estimates and is more likely to be affected by non-routine events (NREs). Such NREs could include the implementation of other EEMs, the addition of onsite generation, and changes to how the site operates.

Some considerations when selecting option B or option C are given in Table 2.

Table 1 Options B and C compared

Consideration	Option B: retrofit isolation (all parameter measurement)	Option C: whole of site
Where is the measurement boundary?	Around the equipment subject to the EEM only	The whole site
What energy data are used?	Submeter data, measuring energy supplied to the equipment subject to the EEM	Utility meter data
What independent variable data are used?	Variable(s) that impact the energy use within the measurement boundary	Variable(s) that impact on energy use of the whole site
What are the main disadvantages?	Costs associated with submetering Ensuring reliable data collection from the meter Having enough time before implementation of the EEM to collect enough data to develop an acceptable baseline model	Having to adjust baseline data to account for non-routine events/changes to static factors at the site, which impact energy use but are unrelated to the EEM (this can be challenging) Savings estimates have larger uncertainties
What are the main advantages?	Reduced uncertainty in the estimates of savings	Data are provided by the utility, and are generally very reliable and inexpensive

Table 2 Considerations for choosing between options B and C

Consideration	Option B is better when ...	Option C is better when ...	Good practice notes
Variation in annual site energy use: use the baseline model test (part 1.2.7 of this module) to gauge the suitability of the energy model	... there is significant variation in energy use that is difficult to explain in whole-of-site regression models	... there is negligible or small difference between predicted and observed energy	Have at least 3 years of baseline energy use and whole-of-site independent variable data to test a model developed from part of the data
There are multiple EEMs and the total savings from all EEMs are to be determined	... all EEMs are related to one system (e.g. HVAC)	... the EEMs are unrelated	If using option C for one energy sources at a site that has more than one source (e.g. electricity and natural gas), any interactions with the other energy sources must be considered – e.g. a lighting upgrade may increase winter gas heating energy use
Expected saving as a percentage of whole-of-site energy use	... expected savings are less than 10% of site energy use (monthly regression model), or less than 5% of site energy use (daily regression model)	... expected savings are greater than 10% of energy use (monthly regression model), or greater than 5% of site energy use (daily regression model)	Estimates for the expected savings are often too optimistic. If savings are near the suggested thresholds, option B is recommended
Expected uncertainty of savings (tolerance of error)	... you want to minimise the uncertainty in the savings estimate	... the uncertainty is predicted to be a small percentage of savings, so savings can be determined accurately	Always remember that IPMVP requires that savings be at least twice the standard error
Available data in relation to the timing of EEM implementation	... submeter data (and independent variable data) are available for a full operating cycle (in some cases up to 12 months) before implementing the EEM	... the EEM is about to be implemented, implementation cannot be delayed, or option B cannot be considered because of a lack of submeter data	Start M&V planning when the EEM is first conceived, not just before implementation. This avoids being forced to use option C where option B is better

continues

Table 2 *continued*

Consideration	Option B is better when ...	Option C is better when ...	Good practice notes
Expected monetary value of savings	... high savings are expected to more than cover the extra metering costs, and the improved accuracy provided by option B is important	... the cost of the extra metering needed by option B is high compared to the expected savings	Where expected annual savings are more than $20,000 and less than 10% of site annual energy usage, option B is preferred[a]
Future changes to site (i.e. non-routine events) that may impact energy use	... changes are expected on site (outside the option B measurement boundary)	... non-routine events are not expected; the site has a history of stable energy use	Option B is strongly preferred if changes impacting on energy use are expected
Interactive effects	... interactive effects do not exist or are expected to have negligible impact on overall site savings	... there are significant interactive effects between EEMs	Carefully consider the likelihood of interactive effects
Reliability and stability of expected savings	... the EEM's performance is highly dependent on control settings (e.g. BMS upgrade) ... the EEM can easily be turned off (e.g. solar PV system) ... EEM is not well understood or is unproven	... the EEM is known and reliable measure whose performance is unrelated to control settings, and it cannot easily be turned off (e.g. LED lighting) and ongoing monitoring of savings is less important	Option B will more clearly show the failure of an unreliable EEM than will option C (data from option C may not be sensitive to the failure) Part 1.3 of this module discusses reliability of savings in more detail

a Author's estimate for an EEM that is reducing electricity consumption.

1.2 Data analysis

Effective data analysis requires a systematic approach, which is outlined in this section.

1.2.1 Identify potential independent variables

Independent variables must meet several criteria as outlined in the definition of an independent variable.

When considering independent variables also consider the availability of data, the cost of data collection, and the completeness, accuracy and credibility of the data.

Below are some examples that illustrate the appropriate selection of independent variables.

Example 1: Using IPMVP option C, for a site that has significant comfort heating and cooling energy usage, weather variables such as heating degree days and cooling degree days are likely to be suitable independent variables. Note that even if the EEMs are unrelated to HVAC energy use (e.g. a lighting upgrade), weather variables are valid independent variables in accordance with the IPMVP, because they influence energy use within the measurement boundary (which is the whole of site for IPMVP option C).

Note: In the ESS, an independent variable is defined as one that affects the energy consumption of the equipment that is subject to the EEM. This would mean that weather variables could not be used for a lighting EEM using option C. This characteristic of an independent variable is not stipulated in the IPMVP. However, the IPMVP states that, where the intent is to determine savings from an equipment upgrade, the boundary should be drawn around the equipment that is subject to the EEM. This is the basis of the definition of an independent variable in the ESS.

Example 2: Using IPMVP option B, a conference centre has a lighting upgrade. The measurement boundary is drawn around the power supply to the lights. The number of days on which conferences are run in a month would likely be an independent variable. However, as the weather has no impact on energy use within the measurement boundary, in this case weather variables would not be acceptable independent variables.

Example 3: Using IPMVP option B, a hot water boiler is replaced. The measurement boundary is put around the boiler. The demand for hot water, measured using a thermal meter, is likely to be an acceptable independent variable.

Example 4: Using IPMVP option B, a hot water boiler is replaced, and a hot water temperature reset strategy is used to vary the temperature of the hot water delivered to air handling units and fan coil units. The demand for hot water, measured using a thermal meter, is not an acceptable independent variable, as the demand for hot water will change with the reset strategy. Heating degree days, however, would likely be an acceptable independent variable.

Example 5: Using option C, a linear regression analysis using multiple independent variables tries to model energy consumption based on using the days of the week as binary independent variables. Table 3 shows the results of this analysis.

As can be seen in Table 3, Monday is an unacceptable independent variable because it failed the test of collinearity. In other words, the Monday variable's effect cannot be separated from the effects of other variables (Excel has returned a 0 value). Tuesday, Thursday and Friday are also unacceptable because the absolute value of their t-statistics are all less than 2.

Table 3 Example independent variable collinearity and t-statistics

Parameter	Mon	Tue	Wed	Thu	Fri	Sat	Sun	CDD
Coefficient	0	15	60	8	13	−373	−388	69
t-statistic	#DIV/0!	0.5	2.1	0.3	0.4	−12.9	−13.3	13.8
|t-statistic acceptable|? (>2)	#DIV/0!	No	Yes	No	No	Yes	Yes	Yes

CDD = cooling degree days

Example 6: The scatter plot in Figure 1 shows how the amount of energy used within the measurement boundary changes with the independent variable, which is CDD. Data points are scattered around a weak linear relationship between the dependent variable and the independent variable. Therefore, CDD as the sole independent variable cannot explain much of the variability in energy use (R^2 will be low, CV_{RMSE} will be high).

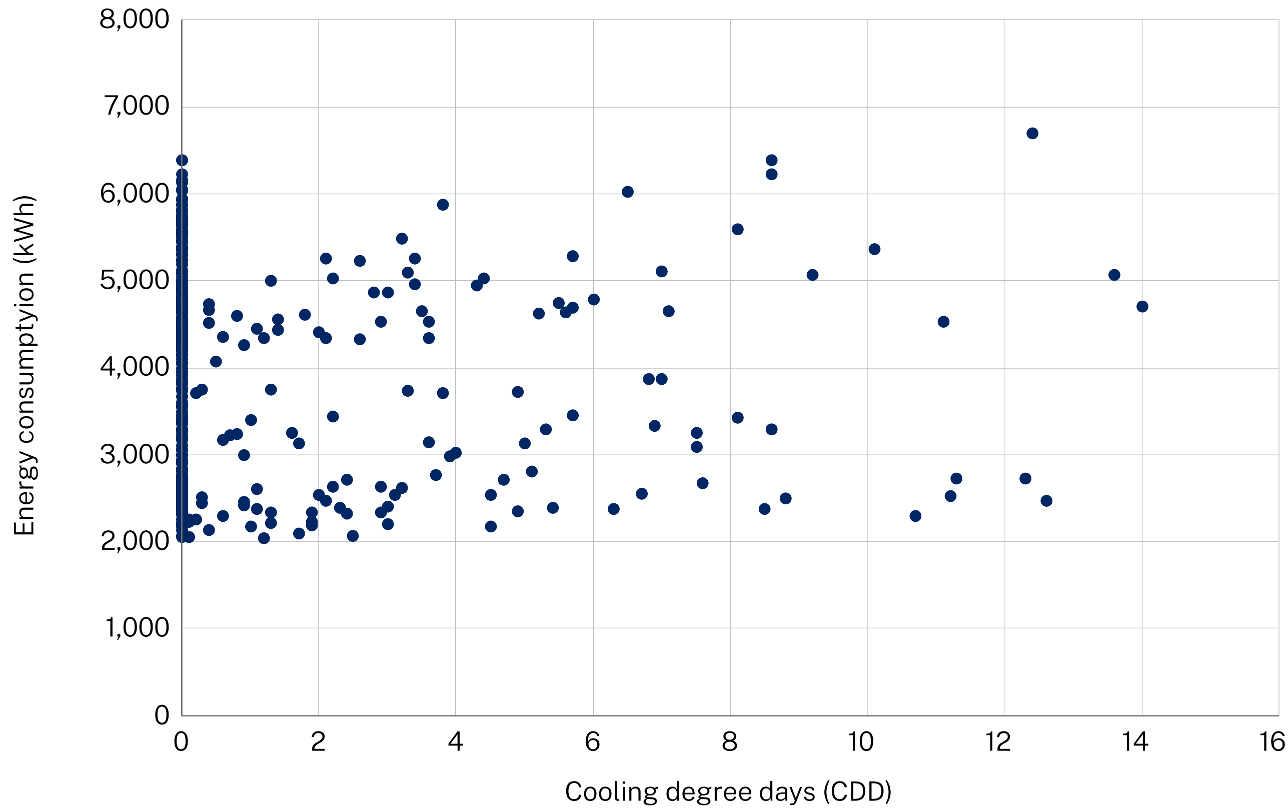

Figure 1 Scatter plot of the amount of energy used within the measurement boundary plotted against weekly CDD data

More independent variables, such as binary indicators for the day of the week and whether or not a day is a public holiday, may explain some of the scatter and allow a satisfactory multiple linear regression model to be obtained.

Example 7: In a daily regression model, it is observed that energy use on weekends is different from on weekdays. This is due to occupancy of the site being different on weekends. The decision is made to use an indicator variable that has a value of 1 on weekdays and 2 on weekends. However, this is not an acceptable independent variable, because there is no logical reason as to why an indicator coefficient should be multiplied by either 1 or 2. Any indicator coefficients must be binary – take values of 0 or 1. For example, 0 could be for weekdays, and 1 for weekend days. Binary variables cannot be used in isolation in a regression – at least one variable must be non-binary.

Example 8: In a daily regression model, it is observed that energy use in a supermarket is lower on 3 days in a year, corresponding to days when the store is closed (Christmas day, Good Friday and Easter Sunday) (Figure 2). The decision is made to use an indicator variable that is 1 on a day that the store is closed and 0 otherwise. Although the store is only closed 3 days a year, this is likely to be a good independent variable because there is a logical explanation as to why energy use would be lower on days the store is closed.

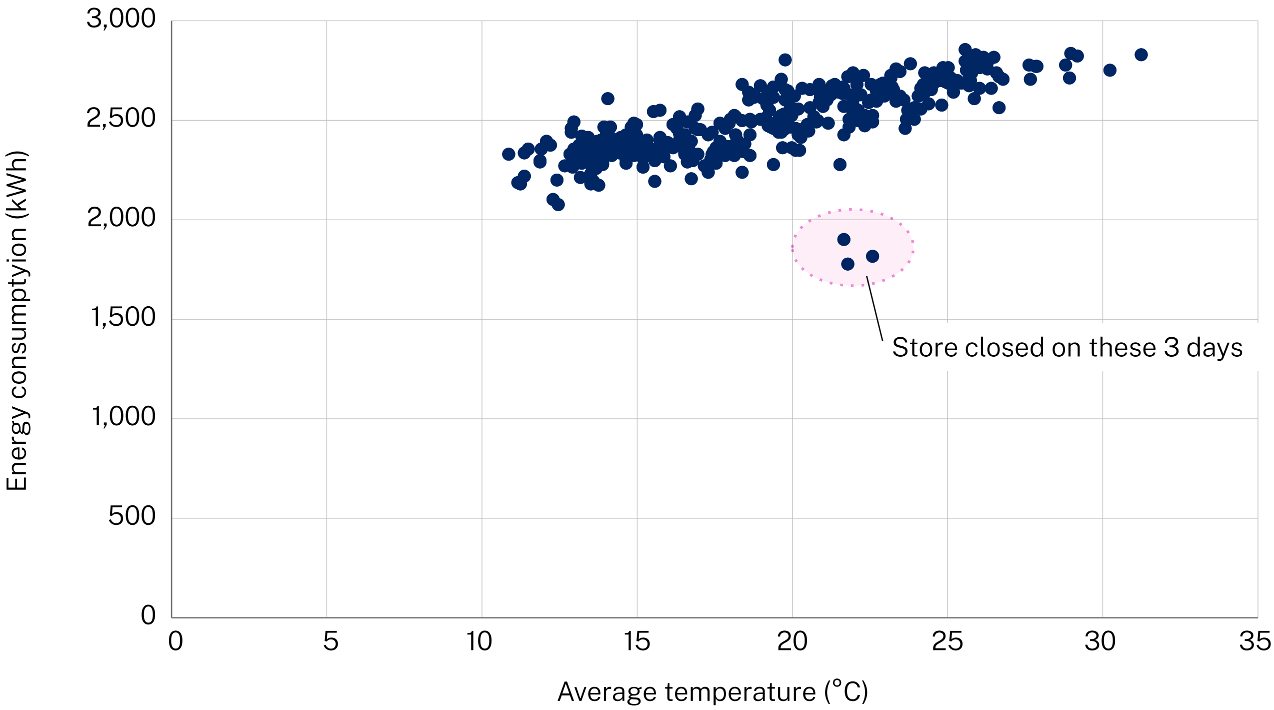

Figure 2 Energy usage in a supermarket plotted against average temperature, with 3 data points circled to indicate days the store was closed (Christmas day, Good Friday and Easter Sunday)

1.2.2 Interval alignment of measured data

Data from all variables should be aligned to have the same measurement interval.

For example, if daily weather data are available, but gas-use data are only available for the billing interval of 60 days, then the weather data must be transformed into average or total values, aligned exactly with the dates in each gas billing interval.

1.2.3 Addressing gaps in interval data

Gaps in the raw interval data must be identified (both for energy data and independent variable data). If data have been transformed into average or total values, examine all the data that were used to determine the average or total value, because data may be missing and some values may be estimates.

1.2.4 Dealing with missing data

If data are missing in the baseline measurement period, the IPMVP allows data substitution with data from similar periods.

If energy consumption data are missing from Monday 3 February 2020, they may be replaced by data from around a year earlier, for a Monday with similar weather (if weather variables are used as independent variables). Alternatively, the baseline period could be moved to avoid periods of missing data.

Another way to deal with missing data, suggested in the IPMVP, is to build an energy model that excludes the missing data intervals. In general, this will result in a model that has fewer observations and larger uncertainties.

Note: There are differences in the treatment of missing data between the IPMVP and the Australian local schemes (ESS & VEU programs; Table 4).

Table 4 Comparison of approaches to dealing with missing data in the IPMVP, ESS and VEU program

Approach	IPMVP guidance	ESS requirement	VEU requirement
Move baseline to a period with no missing data	Acceptable, noting it may be harder to identify changes in static factors	Acceptable	Acceptable; however, the baseline period cannot start more than 24 months before project works commence
Exclusion of missing data	Acceptable	Acceptable, but only up to 25% of observations under the NRE/A Requirements	Not advised; considered on a case-by-case basis[a]

a Refer to section 4.16 of the M&V method activity guide for details on how missing data should be dealt with under PBA.

1.2.5 Develop regression models

Regression models can be developed using a spreadsheet with statistical functions (such as Microsoft Excel), using a coding language (such as R[1] – which is designed for statistical analysis), or using dedicated statistical software.

Because Microsoft Excel is widely available, a suggested process is as follows:

1. Assemble the energy data and potential independent variables, aligned by time period, into a table. Note that there must some plausible scientific or engineering reason as to why changes in the value of an independent variable would cause energy usage to change.
2. Do a time series plot of the energy data to see if there are any periods of energy use that are particularly high or low and are difficult to explain. This could indicate that it may be quite challenging to build an acceptable regression model. If you were considering using option C, it may be better to switch to option B.
3. Do individual scatter plots of energy use vs each variable to see how energy use varies with changes in the independent variable. Exclude those independent variables for which there appears to be no relationship between energy use and the independent variable.
4. Build a multiple linear regression model:
    - First try to incorporate all independent variables into the model.
    - Eliminate those independent variables that show collinearity or have t-statistics less than 2 (see the definition of an independent variable for an example).
    - Verify that the model is acceptable (see part 1.2.6 of this module).
    - If the model is unacceptable, then
        - review the EEM and the factors likely to influence energy use of the equipment subject to the EEM, and which could be independent variables, but for which there is no data; see if it is possible to get data for those independent variables and add them to the regression
        - use data from a different period in the baseline – for example, from a year earlier
        - change the time interval; for example, go from a daily model to a weekly model, or from a weekly model to a monthly model
        - use a polynomial model; if an X–Y plot shows a nonlinear relationship, using a polynomial model may make building an acceptable regression model significantly easier.
    - If the model is acceptable, see if it is possible to reduce the number of independent variables and still build an acceptable model. The greater the number of independent variables, the more work needed to verify the accuracy, availability and credibility of each independent variable.

If it is still not possible to build an acceptable model using option C, then it may be possible to use option B to build an acceptable model.

1 https://www.r-project.org

1.2.6 Evaluating the acceptability of the model

A model is acceptable when it satisfies prescribed tests.

IPMVP makes several recommendations:

- The model t-statistics for each independent variable be 2 or higher.
- The model CV_{RMSE} be less than 0.2.
- The expected savings be more than twice the expected standard error. The error must include all uncertainty from modelling, metering, sampling and any assumptions made. When using option C, typically the only source of error is the modelling error. With option B, there is also metering error.
- The ranges of the independent variables cover the range of typical facility operation.

The IPMVP Uncertainty Assessment Guide (2018)[2] notes that some industry guides suggest 0.75 as a cut-off for R^2, but states that there is no universal standard for a minimum acceptable R^2 value.

There are additional recommended statistical requirements that can be considered best practice. They are based on an analysis of the residuals of a regression model, and account for autocorrelation. These are mandatory if seeking to create ACCUs under the Emissions Reduction Fund. The tests are outlined in the IPMVP Uncertainty Assessment Guide. Although these represent best practice, they are beyond the minimum acceptable requirements outlined above.

2 Uncertainty assessment for IPMVP, International Performance Measurement and Verification Protocol, July 2019, EVO10100 – 1:2019, page 15.

Table 5 compares the IPMVP statistical requirements for regression models with those of the PIAM&V and PBA M&V methods used under the ESS and VEU, respectively.

Table 5 Regression model statistical requirements for M&V

Parameter	IPMVP recommendation	PIAM&V requirement	PBA M&V requirement
Adjusted R^2	No clear recommendation	$CV_{RMSE} < 0.25$ for Adjusted $R^2 \geq 0.5$ $CV_{RMSE} < 0.1$ for Adjusted $R^2 < 0.5$	No clear recommendation[a]
CV_{RMSE}	Must be < 0.2	$CV_{RMSE} < 0.25$ for Adjusted $R^2 \geq 0.5$ $CV_{RMSE} < 0.1$ for Adjusted $R^2 < 0.5$	No clear recommendation[a]
t-statistics	Must be ≥ |2|	Must be ≥ |2|	No clear recommendation[a]
Savings vs standard error	Savings must be ≥ 2 × savings standard error	No requirements	No clear recommendation[a]
Range	When building a baseline model, select a period that contains the full independent variables' range	A 5% extension of the actual range is permitted with no impact on savings determination; outside this range, an adjustment factor is applied to savings	A 5% extension of the actual range is permitted
Number of observations	No specific requirements	Must be at least 6 times the number of independent variables	Must be at least 6 times the number of independent variables

a The VEU program in Victoria places the responsibility of creating a statistically relevant model on the modeller, which largely entails complying with the IPMVP standards.

If it is not possible to build an acceptable model as outlined part 1.2.6 of this module, then:

- the measurement boundary could be changed
- using an estimate of the mean value may be preferred to developing a model.

Savings twice the standard error

When determining 'normalised savings' to see if the savings are likely to be more than twice the standard error, multiply the baseline standard error by $\sqrt{2}$ to get a rough estimate of the standard error of savings.

1.2.7 Testing baseline models with other data from the baseline

It is good practice to test the suitability of a baseline model by first developing a regression based on one year of data, then testing this model on other periods in the baseline for which energy and independent variable data are available. A suitable model will closely predict energy consumption for adjacent unmodelled intervals in the baseline. Examples of this test are shown in Figures 3 and 4. If the model does not closely predict energy use in other periods of the baseline, this could indicate:

- a poor model that is 'over fitted' (this can happen if there are too many independent variables used)
- the omission of an independent variable (perhaps a supposedly static factor is actually an independent variable).
- changing static factors (if these cannot be easily accounted for, then changing the measurement boundary to exclude static factors is recommended).

Applying the model illustrated in Figure 3 to the 12 months immediately before the modelled baseline shows that the kWh predicted by the model has an error of 1% compared to the observed – this is a good option C model.

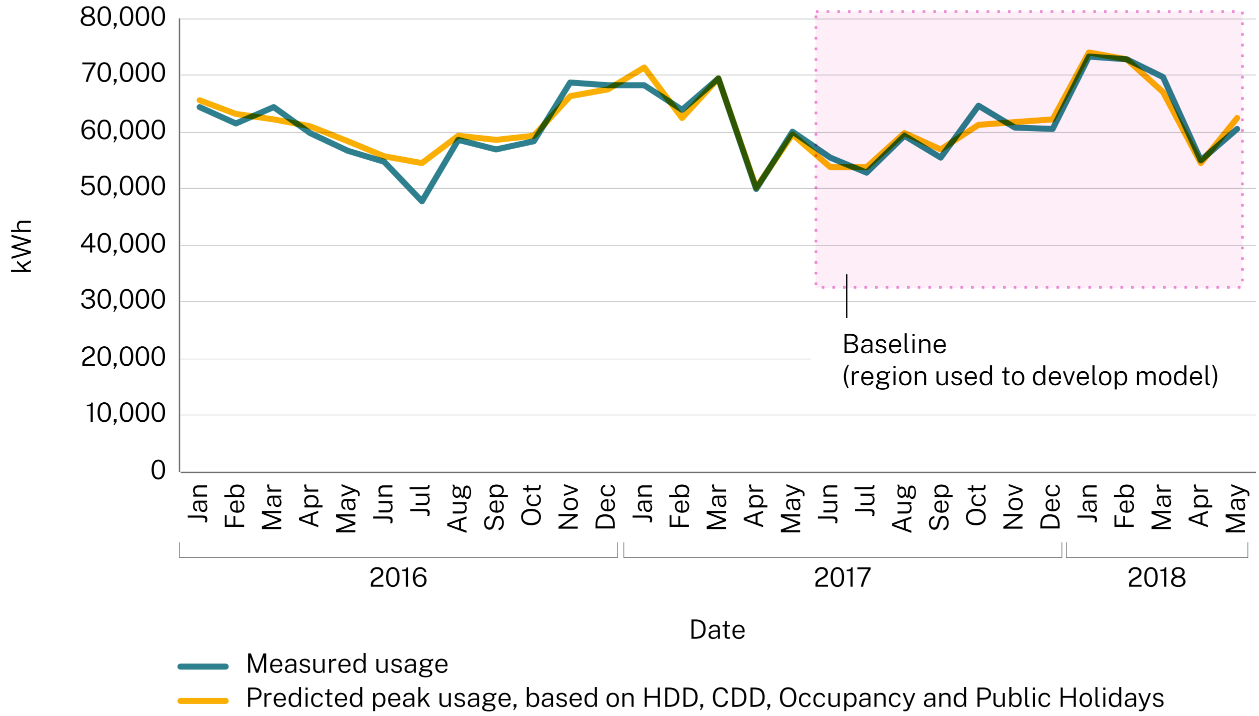

Figure 3 Predicted and measured energy usage plotted against date for a good option C model; the region in the dotted box was used to develop the model

Applying the model illustrated in Figure 4 to the 12 months of the baseline immediately after the modelled baseline shows that the gas consumption predicted by the model has an error of 20% compared with the observations. It is thus a poor model. In this case, changes in supposedly static factors that that explain the variation in baseline energy usage must be identified, or independent variables must be added to or removed from the model to improve it.

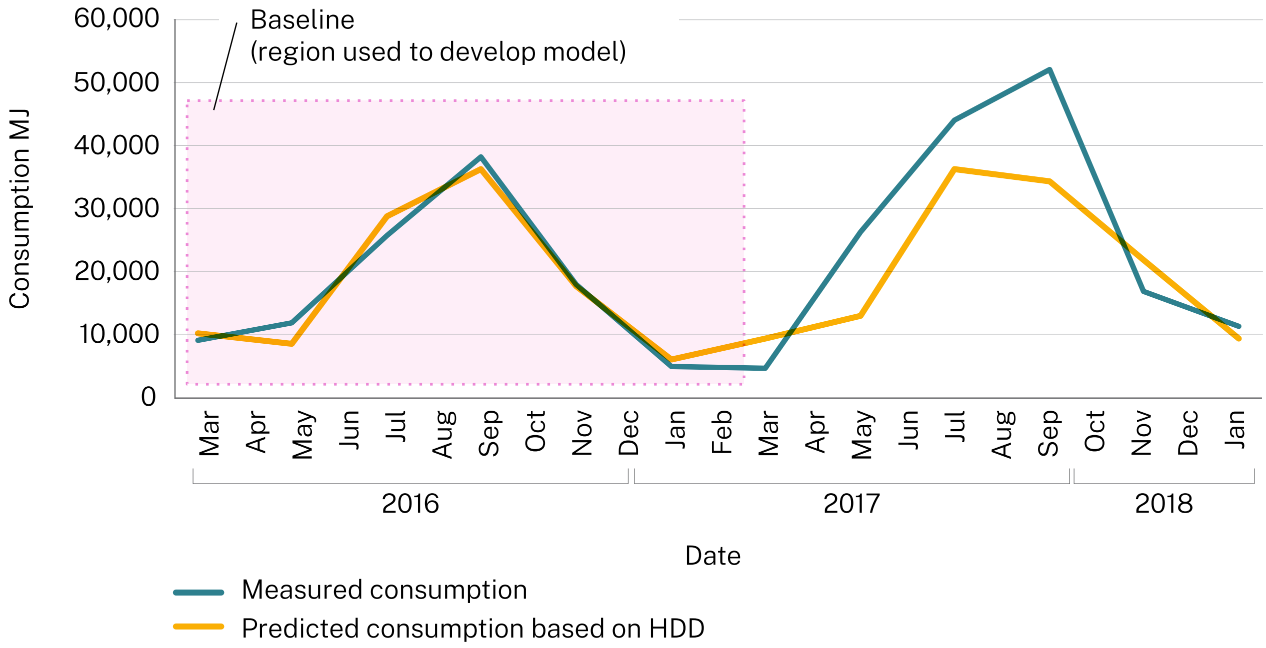

Figure 4 Predicted and measured energy usage plotted against date for a poor option C model; the region in the dotted box was used to develop the model

The baseline model must be trustworthy and a sound representation of energy use before implementation of the EEM. The tests just described provide a common sense way of testing a model.

1.2.8 Identifying the range of the model

Identify the minimum and maximum values of each independent variable. This is important to determine the conditions under which the model can be considered valid.

When determining energy models, there are distinct requirements for calculating the effective range in accordance with the ESS PIAM&V method, and for calculating the eligible range in accordance with the VEU PBA M&V method.

To best explain how the effective range and eligible range are calculated, examples are provided the boxes below for calculating overall effective range for NSW and eligible range for Victoria.

Generally, Victoria's VEU calculates eligible range as the range over which the operating model and baseline model overlap, while New South Wales's ESS calculates effective range for each model and then compares the overlap between models.

Calculating the overall effective range (New South Wales ESS PIAM&V)

1. **Calculate the baseline effective range**

   Example

   For the baseline period, the minimum was 50 and the maximum 150.

   range = maximum – minimum = 150 – 50 = 100

   The end points of the baseline effective range are calculated from these minimum and maximum values by subtracting or adding 5% of the range, respectively.

   effective baseline minimum = minimum – range × 0.05 = 50 – 100 × 0.05 = 45

   effective baseline maximum = maximum + range × 0.05 = 150 + 100 × 0.05 = 155

2. **Calculate the operating period effective range**

   Example

   For the operating period, the minimum was 40 and the maximum 140.

   range = maximum – minimum = 140 – 40 = 100

   effective operating minimum = minimum – range × 0.05 = 40 – 100 × 0.05 = 35

   effective operating maximum = maximum + range × 0.05 = 140 + 100 × 0.05 = 145

3. **Find the overall effective range**

   The overall effective range is the range that is common to both the baseline and the operating effective ranges.

   Example

   overall effective minimum = 45

   overall effective maximum = 145

   overall effective range = 45 to 145

Calculating the eligible range (Victoria VEU PBA M&V)

1. **Find the baseline range**

   Example

   For the baseline period, the minimum was 50 and the maximum 150.

   range = maximum – minimum = 150 – 50 = 100

2. **Find the operating period effective range**

   Example

   For the operating period, the minimum was 40 and the maximum 140.

   range = maximum – minimum = 140 – 40 = 100

3. **Find the effective range**

   The effective range is the range that is common to both the baseline and the operating effective ranges.

   Example

   effective minimum = 50

   effective maximum = 140

   effective range = 50 to 140; width of range = 140 – 50 = 90

4. **Calculate the eligible range**

   The end points of the eligible range are calculated from the effective minimum and maximum values by subtracting or adding 5% of the effective range, respectively.

   Example

   eligible minimum = 50 – 90 × 0.05 = 45.5

   overall eligible maximum = 140 + 90 × 0.05 = 144.5

   overall eligible range = 45.5 to 144.5

1.2.9 Identify the period over which the savings are to be reported

Savings are typically reported for periods of one year. However, if more frequent savings reports are required, this is permissible.

1.2.10 Undertake non-routine adjustments

Changes that impact energy use within the measurement boundary and are not accounted for by changes to the independent variables are called non-routine events (NREs). When NREs occur non-routine adjustments (NRAs) must be undertaken to determine the savings. An NRE is usually caused by a change in static factors.

An example of an NRE could be additional equipment being installed during the reporting period at a site where option C is being used to determine savings.

If details of NREs are not recorded (e.g. date the NRE occurred, whether permanent or temporary, nature of the NRE, etc.) it may not be possible to undertake effective NRAs, and thus be impossible to determine savings with any confidence.

NREs can occur at any time in the baseline, implementation or reporting periods. Therefore, it is vital to be engaged with the energy user during the whole M&V process, and for energy users to be monitoring and reporting on changes to the site that may impact energy use within the measurement boundary.

It is beyond the scope of this guide to explain how to undertake NRAs. Readers may consult the following guides:

- EVO's IPMVP application guide on non-routine events and adjustments
- the Victorian PBA M&V COVID provisions
- the New South Wales PIAM&V method application requirements for non-routine events and adjustments
- the demonstration projects included as part of this guide.

1.3 Energy savings calculation

1.3.1 Determine the basis on which savings will be calculated

The IPMVP specifies that savings can be determined following one of 3 available options. Each of these options is referred to as a 'basis for savings'. The options are explained below; the first and the third are the most common:

- **Avoided energy use.** Using the values of the independent variables in the reporting period, the baseline model is used to determine what the baseline energy would have been in the reporting period. The actual energy use is then subtracted from this, to determine the savings. This method is commonly used with EPCs, with annual M&V savings reports developed over the savings guarantee period (typically 5 to 10 years).
- **Back-cast energy use.** With this method, a model is developed for the reporting period. This reporting period model is used to determine what the reporting period energy would have been in the baseline period. This is subtracted from actual energy consumption in the baseline period to determine the savings. This cannot be used in the ESS and is only permissible in the VEU when accounting for the impacts of COVID.
- **Normalised energy savings.** With this method regression models are built for both the baseline and the reporting periods. Both models are then applied to independent variable data for a 'normal' year. The normalised savings are obtained by subtracting the energy consumption predicted by the reporting period energy model from the energy use predicted by the baseline energy model. The independent variables selected must be the same in both the baseline and reporting year.

The 'basis for savings' option should be decided upon during the baseline measurement period but confirmed after producing the first M&V savings report. In the ESS and VEU programs, the basis of adjustment must be in accordance with the rules of those schemes.

1.3.2 Identify intervals where savings cannot be determined

Regression models are based on data sets with a finite range, so it is not statistically acceptable to assume that a regression model is valid for predicting energy consumption when values of the independent variables are outside their range.

The IPMVP advises that regression models be developed across the full range of operating conditions, and that M&V plans should report the range of independent variables over which a model is valid.

When a regression model is used to predict energy use with an independent variable that is outside of its range, a strict interpretation of the IPMVP would be that in this case it is not possible to predict energy use, and therefore also not possible to determine savings.

In the PBA M&V method, when independent variables are outside the eligible range , it is not possible to assume that there are savings, and thus the savings are considered to be zero.

In the PIAM&V method, when independent variables are outside the effective range, savings are discounted, by applying an eligible range adjustment factor. Savings gradually decrease until no more can be claimed. This is when the independent variable is more than 33% outside its effective range.

1.3.3 Calculate the savings

Savings are calculated for each interval using 3 steps:

1. Use the selected basis for adjustment (avoided, back-cast, or normalised) to determine savings in the interval.
2. Apply any NRAs to the interval.
3. Screen the interval for its range and assume zero savings if the range is outside what is acceptable.

Over the entire reporting period the total saving is the sum of savings across all intervals.

1 .4 Determining the uncertainty in the energy savings

Because savings cannot be directly measured, there is always some uncertainty in any calculation of savings. The IPMVP lists various sources of uncertainty, including metering uncertainty and uncertainty associated with regression models.

With option C, the only source of uncertainty is that from the regression models, because utility meters are assumed to have zero error or uncertainty.

With option B, an additional source of uncertainty is the metering uncertainty.

Mathematical techniques, described in EVO'S uncertainty assessment for IPMVP[3], enable the determination of uncertainty.

3 Uncertainty assessment for IPMVP International Performance Measurement And Verification Protocol, July 2019, EVO 10100 – 1:2019; https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp.

In the ESS and VEU the term relative precision (of savings) is used instead of uncertainty. The relative precision is the uncertainty in the savings expressed as a percentage of the savings.

The following steps provide simplified analysis of the uncertainty calculations in accordance with IPMVP. For more detailed guidance on each of those steps, it is recommended to study EVO's uncertainty assessment for IPMVP.

1. Determine the percentage standard error of the energy meter used in the baseline. If the confidence level of the manufacturer's stated meter uncertainty is unknown, assume it is at the 95% confidence level. In this case the standard error of the meter is determined by dividing the meter uncertainty by 1.96. Note that utility meters are assumed to have zero error.[4]
   - For example, a gas submeter has a manufacturer-stated error of 3% of the reading. The confidence level is not stated, so is assumed to be 95%. The standard error is 3% / 1.96 = 1.53%.
2. Convert the percentage standard error of the energy meter to an error in energy units (SE_m), by multiplying the percentage standard error by the average measured value of energy.
   - For example, the average monthly gas consumption measured by a gas meter is 10,000 MJ. If the meter has a standard error of 1.53%, the SE_m is 10,000 MJ × 1.53% = 153 MJ.
3. Examine the baseline regression model to determine its standard error – that is, the standard error of *y* (SE_y).
   - For example, using the LINEST function in Microsoft Excel, the standard error of a regression model is found to be 4,192 MJ (Figure 5).

slope coefficient	68.65	1081.80	slope coefficient
standard error for slope	10.96	3184.98	standard error for intercept
coefficient of determination R^2	0.91	4192.37	standard error for *y* estimate
F statistic	39.25	10	degrees of freedom
regression sum of squares	689879865	70303909	residual sum of squares

Figure 5 Output of LINEST function

4 Note that in the VEU scheme a utility meter in an embedded network is considered to have an error.

4. Combine the baseline meter standard error (SE_m) with SE_y from the regression model to determine the overall baseline standard error (SE_b) using this formula:

$$SE_b = \sqrt{{SE_m}^2 + {SE_y}^2}$$

   - For example, if SE_m = 153 MJ and SE_y = 4,192 MJ then:

$$SE_b = \sqrt{153^2 + 4{,}192^2} = 4{,}195 \text{ MJ}$$

5. Repeat steps 1 to 4 for the reporting period, based on the standard error of the meter used in the reporting period and the regression model in the reporting period, to determine the standard error for the reporting period (SE_r). Note that if the basis of savings is avoided energy there is no regression model error in the reporting period.
   - For example, SE_r = 5,012 MJ
6. Combine SE_b with SE_r to determine the standard error of savings over one measurement (SE_{s1}) using this formula:

$$SE_{s1} = \sqrt{{SE_b}^2 + {SE_r}^2}$$

   - For example, if SE_b = 4,195 MJ and SE_r = 5,012 MJ then:

$$SE_{s1} = \sqrt{4{,}195^2 + 5{,}012^2} = 6{,}535 \text{ MJ}$$

7. Identify how many measurement intervals, N, there are in the year over which savings are to be determined.
   - For example, Measurements are made monthly, so there are 12 measurement intervals (N = 12).
8. Determine the standard error over the entire year of savings (SEs) using this formula:

$$SE_s = \sqrt{N}.SE_{s1}$$

   - For example, if N = 12 and SE_{s1} = 6,535 MJ then:

$$SE_s = \sqrt{12}.\,6{,}535 = 22{,}641 \text{ MJ}$$

9. Determine the degrees of freedom (*DF*) in the regression model with the fewest degrees of freedom using this formula:

$$DF = (N - 1) - the\ number\ of\ variables$$

- For example, the baseline model and reporting model both use 12 months of data with one independent variable, so *DF* = (*N* – 1) – 1 = 10, as provided by the LINEST function in Microsoft Excel (Figure 6).

slope coefficient	68.65	1081.80	slope coefficient
standard error for slope	10.96	3184.98	standard error for intercept
coefficient of determination R^2	0.91	4192.37	standard error for *y* estimate
F statistic	39.25	10	degrees of freedom
regression sum of squares	689879865	70303909	residual sum of squares

Figure 6 Output of LINEST function

10. Define the confidence level at which you wish to state the uncertainty of savings. In the ESS and VEU this is 90%.
    - For example, confidence = 0.90
11. Consult a t table, or use the T.INV function in Excel, to determine the t value. In Microsoft Excel the formula would be T.INV(probability, DF).

    Where: probability = 1 – confidence level

    - For example with 10 degrees of freedom and a confidence of 0.90, the t value = T.INV(1 − 0.9, 10) = 1.81
12. Determine the uncertainty in the savings at the desired confidence level by multiplying the standard error over the entire year of savings (SE_s) by the t value.
    - For example, With SE_s = 22,641 MJ and a t value of 1.81, the overall savings uncertainty at the 90% confidence level = 22,641 × 1.81 = 41,036 MJ.
13. Determine the uncertainty in savings at the desired confidence level as a percentage of savings. Note that the ESS and VEU have savings accuracy factors that are based on the percentage uncertainty in savings at the 90% confidence level.
    - For example, Savings are 100,000 MJ. The uncertainty in savings at the 90% confidence level is 41,036 MJ. The percentage uncertainty of savings, at the 90% confidence level, is 41,036 / 100,000 = 0.41 or 41%.

1.4.1 Check that the savings are at least twice their standard error

Determine if the savings are more than twice the standard error of savings, as required by the IPMVP.

- For example, Savings are 100,000 MJ. The SE_s is 22,641 MJ. 100,000 is greater than 2 × 22,641, so the IPMVP requirement is satisfied.

1.4.2 State the savings and the savings uncertainty at the desired confidence level

The savings should be expressed along with the relative uncertainty of savings, at the desired confidence level.

- For example, savings are 100,000 MJ plus or minus 41,000 MJ (41%) at a 90% confidence level.

1.5 Deficiencies arising from the M&V practitioner's actions or omissions, and how to avoid them

There are various deficiencies that may arise when undertaking M&V. Some are best prevented or resolved by M&V practitioners (Table 7).

Table 7 Deficiencies M&V practitioners are best positioned to resolve

Deficiency	Likely consequences of the deficiency	Why the deficiency may occur	How to avoid it
Lack of effective communication between the M&V practitioner and the energy user (and energy service provider)	Lack of awareness of available data that could be useful (energy or independent variable data) A short-term focus (e.g. a focus on creating certificates) that may result in loss of savings in the long term	Taking a narrow view of M&V – e.g. the sole purpose of M&V is to create certificates Feeling blocked by the energy service provider or energy user Focusing on only one outcome (e.g. creating certificates) because of limited budget	Effective communication is at the heart of effective M&V. As an M&V practitioner, you are largely responsible for ensuring effective communication. This includes taking time at the start of an engagement to present the 'big picture' of M&V, the benefits it can provide, and the need for all parties to contribute (including with appropriate M&V budgets).
Always selecting option C, and never option B	Greater uncertainty in savings determination Savings cannot be determined with confidence	A short-term focus on minimising the cost of M&V Concern that there is insufficient time to build a baseline using option B – e.g. because the energy user wants the EEM implemented straight away	Put effort into communicating the value of M&V to the energy service providers and energy users you engage with; outline the consequences of inadequate M&V budgets and or rushed projects (e.g. give them this guide and talk through it). Focus on the savings that might be missed if submeters are not installed, and the importance of sustained, reliable, energy savings informed by sub-meter measurements.

continues

Table 7 *continued*

Deficiency	Likely consequences of the deficiency	Why the deficiency may occur	How to avoid it
Selection of independent variables that are not logically or statistically acceptable Conversely, unwarranted exclusion of independent variables	M&V cannot be trusted Savings cannot be determined with confidence	Independent variable(s) chosen are not actually truly independent, and their values change due to the EEM It may be that: • weekly hours of light operation are chosen as the independent variable for an upgrade that puts occupancy sensors on lights • independent variable(s) that have t-statistics <2 are chosen • independent variable(s) are chosen that are unlikely to influence energy use within the measurement boundary	Have a clear understanding of what an independent variable is; refer to section 1.2.5 for examples. Favour option B, rather than option C, which will often make it easier to identify independent variables.
Poor selection of CDD or HDD balance point	Lower R^2 and higher CV_{RMSE} in the model, leading to less certainty of savings and lower t-statistics	Set point temperature (i.e. the comfort temperature that a HVAC system is set to achieve) is always chosen as the balance point	Choose the balance point based on the inflection point of a scattergram of energy versus average temperature. Refer to Figure 7 for an example.

continues

Table 7 *continued*

Deficiency	Likely consequences of the deficiency	Why the deficiency may occur	How to avoid it
Use of average temperature instead of HDD/CDD in daily models (a deficiency in statistical analysis)	Lower R^2 and higher CV_{RMSE} in the model, leading to less certainty of savings and lower t-statistics	Not understanding the relationship between energy and temperature – there may be a point at which lower temperature does not result in lower energy use (for cooling), or higher temperature does not result in lower energy use (for heating)	Use HDD and CDD in daily models, taking care with the selection of balance point. Only if there is no inflection point in a scattergram of energy use against average temperature can average temperature be used instead of HDD or CDD.
Over-fitting a model to maximise R^2 or minimise CV_{RMSE}, or to avoid using option B (a deficiency in statistical analysis)	Model is less trustworthy	Failure to test the model on another set of baseline data Focus on always using option C, which may result in using too many independent variables and over-fitting	Get 2, but preferably 3, years of baseline data, and test any model developed with one year of data on another dataset from the baseline (as shown in Figure 3 and Figure 4). If it can be established that there are no changes in static factors in the baseline, build a model that has the least error when applied to non-modelled baseline years. Use option B instead of option C.

continues

Table 7 *continued*

Deficiency	Likely consequences of the deficiency	Why the deficiency may occur	How to avoid it
Insufficient metering of energy and independent variables (a deficiency in planning)	The effective range of a model is limited, reducing ability to identify savings Models are poor Savings cannot be determined	A short-term focus on minimising the cost of M&V Concern that there is insufficient time to build a baseline and use option B	Put effort into communicating the value of M&V to the energy service providers and energy users you engage with, and outline the consequences of inadequate M&V budgets and or rushed projects. (e.g. supply them this guide and talk through it). When communicating the value of M&V to stakeholders, explain how energy savings can be missed if submeters are not installed, and the importance of sustained, reliable, energy savings informed by sub-meter measurements.
Wrong application of white certificate scheme requirements	Energy saving certificates cannot be created	Failure to understand the scheme rules	Undertake M&V in accordance with the scheme rules.

Figure 5 shows a scattergram of energy use against average temperature – for this particular site, an appropriate CDD balance point is around 15 degrees Celsius, found by locating the inflection point of the graph.

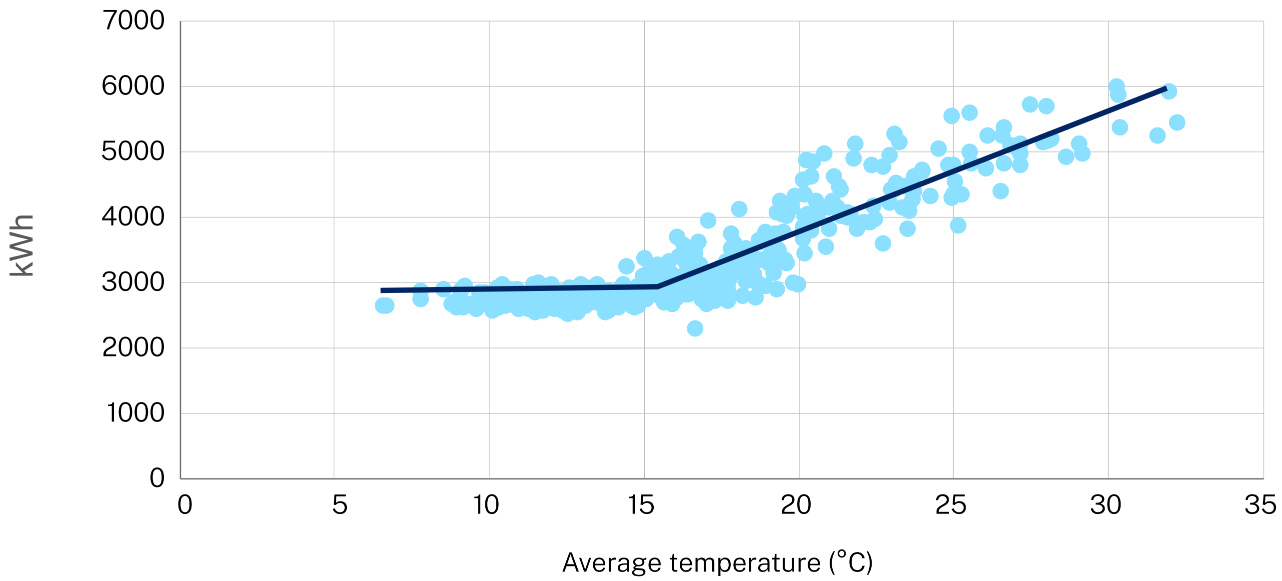

Figure 7 Example scatter plot of energy use against average temperature

Acronyms and definitions

ACCUs (Australian carbon credit units): a tradable product – similar to a white certificate – that can be created in the ERF.

ACP (accredited certificate provider): an entity accredited to create certificates in the New South Wales Energy Security Safeguard (including the Energy Savings Scheme and the Peak Demand Reduction Scheme).

Adjusted R^2 (adjusted coefficient of determination): a statistical measure of the extent to which variations in the energy consumption are explained by an energy model, allowing for the number of independent variables used in the model.

AP (accredited person): an entity accredited to create certificates in the VEU program.

Baseline: the period before the EEM is implemented that is used to determine energy usage before implementation of the EEM. The baseline period must be long enough to cover one complete operating cycle of the upgraded system, from maximum energy consumption and demand to minimum.

CDD (cooling degree day): used to assess how hot a climate is over a period – a day, week, month or year. A CDD references a 'balance point'. When the average daily temperature is above the balance point, the number of CDDs is the difference between the average temperature and the balance point.

With a balance point of 18 degrees Celsius:

- If today's average temperature is 20 C, then there are 2 CDDs (i.e. 20 – 18 C).
- If today's average temperature is 16 C, then there are zero CDDs, because it is not possible to have negative CDDs.

The number of CDDs in a month is the sum of the CDDs across all days in the month.

The number of CDDs is very commonly used as an independent variable in regression models for buildings in which HVAC energy use is a significant proportion of total energy use. This includes most commercial buildings. See also HDD.

Collinearity: occurs when the value of one of the independent variables can be highly accurately predicted by other independent variables in the regression model. It is strongly recommended that collinearity be avoided.

CV_{RMSE} (coefficient of variation of the root mean squared error): the standard error of an energy model expressed as a percentage of the average energy consumption.

Dependent variable: the value of y in a regression model. For M&V, this is usually the energy consumption.

ECM (energy conservation measure): a term used in earlier versions of the IPMVP guidelines. It has been replaced by energy efficiency measure (EEM).

EEM (energy efficiency measure): a project implemented to reduce energy usage.

Effective range: the range of independent variable values over which an energy model is deemed valid, in the context of the PIAM&V method.

- The PBA M&V method uses **eligible range** to describe this concept. The 2 distinct processes used to determine the PIAM&V method effective range and the PBA M&V method eligible range are detailed in the first section of module 2.
- The PBA M&V method defines the effective range as the range of the independent variable values over a measurement period.

The terms effective range and eligible range have specific meanings in PIAM&V and PBA M&V, which do not necessarily align with the IPMVP term range.

Energy service provider: the entity responsible for specifying and installing the EEM.

Energy user: the owner of the site where the EEM is being implemented. May also refer to the individual employed by the energy user who is responsible for energy efficiency improvements (e.g. a facility manager). Also known as the energy consumer under the VEU program.

EPC (energy performance contract): a contract in which an energy service provider guarantees the savings from EEMs, and agrees to cover the cost of any shortfall in savings.

ERF (Emissions Reduction Fund): a scheme administered by the federal Clean Energy Regulator, enabling the Australian Government to purchase emissions reductions.

ESC (Energy Savings Certificate): a tradable white certificate created in the Energy Savings Scheme.

ESCO (energy services company): a company that develops, designs, builds, and finances projects that save energy and reduce energy costs.

ESS (NSW Energy Savings Scheme): a white certificate scheme administered by the Independent Pricing and Regulatory Tribunal.

EVO® (Efficiency Valuation Organization): the publisher of the IPMVP.

HDD (heating degree day): a measure used to assess how cold a climate is over a period – a day, week, month or year. An HDD references a 'balance point'. When the average daily temperature is below this balance point, the number of HDDs is the difference between the balance point and the average temperature. For example, with a balance point of 18 C:

- If today's average temperature is 16 C, then there are 2 HDDs (i.e. 18 – 16 C).
- If today's average temperature is 20 C, then there are zero HDDs, because it is not possible to have negative HDDs.

The number of HDDs in a month is the sum of the HDDs across all days in the month.

Like CDDs, HDDs are very commonly used as an independent variable in regression models for buildings in which HVAC energy use is a significant proportion of total energy use. This includes most commercial buildings.

HVAC (heating, ventilation and air conditioning): a system that is used to provide comfortable temperatures inside a building by providing heating and/or cooling, in addition to ventilating the building.

ICER (industrial and commercial emissions reduction): a method in the ERF that uses M&V to create ACCUs.

Implementation: a term used in the ESS and VEU in place of the term energy efficiency measure (EEM).

Independent variable: a parameter that routinely varies (such as the weather), which must satisfy the following 5 conditions:

- It can be reasonably expected to influence energy use within the measurement boundary, because there is an engineering or scientific explanation as to why energy use will change when the independent variable changes.
- Using regression analysis, it can be shown that the amount of energy used within the measurement boundary is related to changes in the independent variable – this should be visible on a scatter plot.
- The strength of the statistical correlation with energy use is such that the absolute value of the variable's t-statistic in a regression is equal to 2 or more.
- The variable does not demonstrate collinearity with any other independent variable used in the regression model.
  - Microsoft Excel's® LINEST function tests for collinearity; the coefficient of the independent variable will be zero if there is collinearity. Variables that demonstrate collinearity with one or more variables must be excluded from regression models.
- The independent variable is independent of the EEM and does not change because of the EEM. For example, the flow rate in a compressed air system cannot be used as an independent variable to measure air leakage.

Interactive effects: occur when an EEM causes a change in energy use outside the EEM's measurement boundary.

Example: A lighting upgrade is undertaken, using IPMVP option B: retrofit isolation. The new lights consume less energy than the old lights. The decrease in lighting energy has the following interactive effects on the HVAC system:

- More energy is needed to heat the building because less heat is provided by the lighting.
- Less energy is needed to cool the building because less heat is provided by the lighting.

IPMVP® (International Performance Measurement and Verification Protocol): owned and maintained by EVO, the IPMVP is used globally for the determination of savings. At the time of writing, the latest version of the protocol is IPMVP Core Concepts, March 2022, EVO10000 – 1:2022.

M&V practitioner: the person undertaking the M&V process for an energy efficiency project.

Measurement boundary: the boundary of what is measured by meters and instruments that record energy use and the independent variables. The boundary is either drawn around the whole site, using utility energy meters, or around the equipment subject to the EEM, using sub-meters (Figure 8).

IPMVP offers 4 options for determining energy savings (options A, B, C, and D), depending on where the measurement boundary is drawn (Table 8).

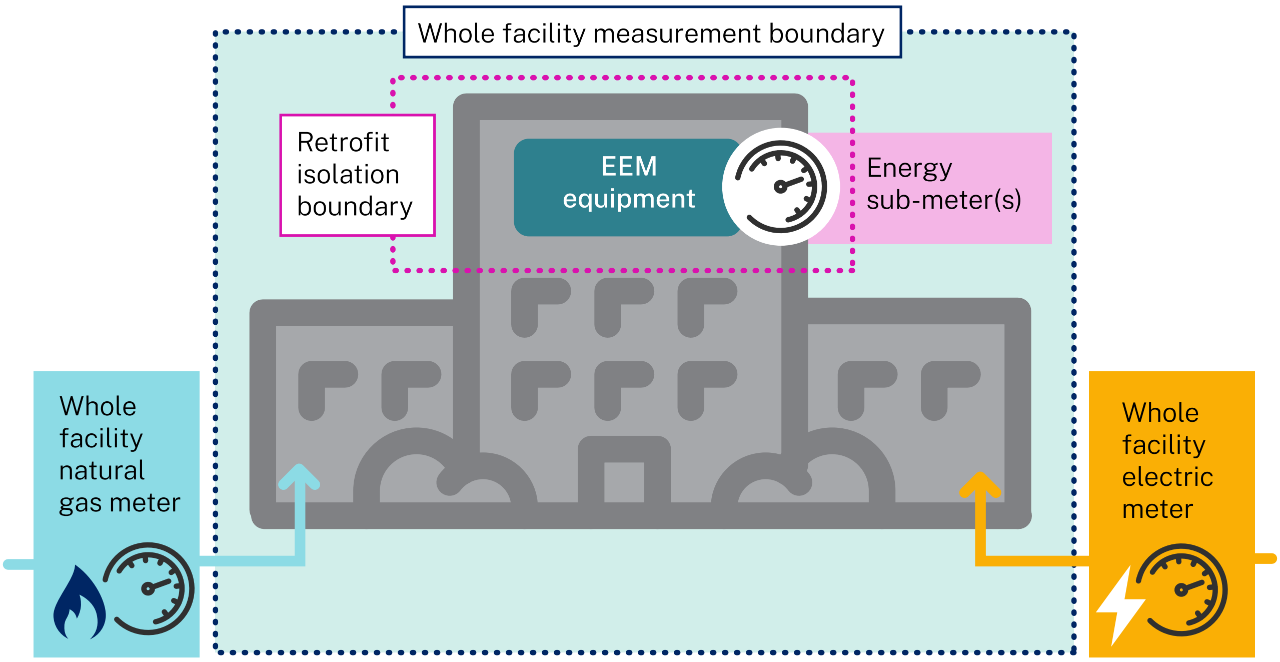

Figure 8 Examples of measurement boundaries (from IPMVP Core Concepts 2022)

Table 8 IPMVP Options

IPMVP option	How savings are calculated	Typical application
A. Retrofit isolation: Key parameter measurement	Engineering estimate of baseline and reporting period energy from short-term or continuous measurements of key parameter(s) and estimated values.	Replacing lights with more efficient lights – the power draw (kW) of the lights is the key parameter and operating hours are estimated.
B. Retrofit isolation: All parameters measurement	Short-term or continuous measurements of baseline and reporting period energy, or engineering estimates using measurements of proxies of energy consumption.	Application of a variable-speed drive and controls to a motor to adjust pump flow.
C. Whole facility	Analysis of the whole facility baseline and reporting period meter (utility) data.	Multifaceted energy management programs affecting many systems in a facility.
D. Calibrated simulation	Energy consumption simulation, calibrated with hourly or monthly utility billing data. Energy end-use metered performance data may be used in model refinement.	Multifaceted energy management programs affecting many systems in a facility, but with no metering existing during the baseline period.

NRA (non-routine adjustment): an adjustment made when determining energy savings to account for a non-routine event.

NRE (non-routine event): an unexpected change that causes energy use within the measurement boundary to change in a way that cannot be accounted for by the regression model.

Operating period: a term used in the ESS and VEU in place of the term reporting period.

PBA M&V (Project Based Activities – Measurement and Verification): the method in the VEU program through which an AP can undertake the M&V process to create VEECs.

PIAM&V (Project Impact Assessment with Measurement and Verification): the method in the ESS through which an ACP can undertake the M&V process to create ESCs.

Project sponsor: anyone responsible for getting capital expenditure for a project approved (e.g. executive management, finance department, financial institution).

Range (of independent variable): the range of values of an independent variable, from lowest to highest, as used in a regression model.

Regression model: more correctly called a (multiple) linear regression model, is a mathematical model of the form $Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 +\ldots + b_nX_n$ where Y is the dependent variable; X_1, X_2, X_3 ... X_n are independent variables; and b_0, b_1, b_2, b_3 ... b_n are constants.

Relative precision (of energy savings): a term used in the PIAM&V and PBA M&V methods in place of the term uncertainty; expressed as a percentage of the energy savings.

Reporting period: is the measurement period following the implementation of EEM. The reporting period needs to be long enough to cover one complete operating cycle, from maximum energy consumption and demand to minimum.

Site constant: a term used in the ESS and VEU in place of the term static factor.

Static factor: a factor that is likely to impact the energy use within the measurement boundary, but is not expected to vary. Should it change significantly in a way that is not expected, this change would need to be taken into consideration.

The square meters of occupied space of a school with a stable student population, which the principal says is unlikely to change, would be a static factor. If the school added extra portable classrooms, increasing the occupied space and energy use, a project using IPMVP option C would need to take this into consideration when determining energy savings using M&V.

t-statistic: a statistical test used to verify the accuracy and significance of the estimated relationship between an independent variable and energy consumption for an energy model.

Uncertainty: represents the range in which the true value is likely to lie, at a given confidence level – for example, savings ± uncertainty, at confidence level. Uncertainty may be expressed as a value or as a percentage. Uncertainty may also be referred to as ‘error’.

Example:

Energy savings = 100 MWh ± 5 MWh, at a 90% confidence level.

VEEC (Victorian Energy Efficiency Certificate): a tradable white certificate created in the VEU program.

VEU (Victorian Energy Upgrades) program: a white certificate program administered by the Victorian Essential Services Commission.

White certificate: a tradable commodity that either represents a certain amount of energy savings – typically 1 MWh – or a certain amount of greenhouse gas emission savings – typically 1 tonne CO2-e.

In a white certificate scheme, a government requires each energy retailer to surrender to the government each year a certain number of white certificates. The certificates are created through energy efficiency projects, with the number of certificates from any given project determined through a methodology defined by the government.

The ESCs and VEECs are examples of white certificates that are defined by the ESS and VEU respectively.

Comparison of IPMVP, PIAM&V and PBA M&V terminology

The terminology varies between IPMVP, ESS and VEU. An understanding of which terms are equivalent is useful (Table 9).

Table 9 Comparison of IPMVP, ESS and VEU terminology

IPMVP term	ESS: PIAM&V term	VEU: PBA M&V term
EEM (energy efficiency measure)	Implementation	Implementation
Interactive effects	Interactive effects	Interactive savings
Reporting period	Operating period	Operating period (forward creation) Reporting period (annual creation)
Static factor	Site constant	Site constant
Uncertainty of savings (as a percentage)	Relative precision (as a percentage)	Relative precision (as a percentage)
Range	Effective range[a]	Effective range, eligible range[a]

a The terms effective range and eligible range have specific meanings in PIAM&V and PBA M&V, which do not necessarily align with the IPMVP term range.

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