PROJECT DEVELOPMENT SPECIFICATION - INDUSTRY

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0.0 INVESTOR CONFIDENCE PROJECT

The Investor Confidence Project (ICP) provides a framework for energy efficiency project development, which standardises projects into verifiable project classes in order to reduce transaction costs associated with technical underwriting, and increase reliability and consistency of energy savings. The ICP Protocols and certification system provides a comprehensive framework of elements that is flexible enough to accommodate the wide range of methods and resources that are specific to individual projects.

0.1 PROJECT DEVELOPMENT SPECIFICATION

This ICP Project Development Specification (PDS) represents a comprehensive resource designed for project specialists, third-party Quality Assurance Assessors, and investors to ensure that projects are developed in full compliance with the ICP Protocols. This document provides essential information about the protocol's requirements, best practices, quality management tasks, and references to ensure that all stakeholders are operating from a common set of requirements and practices.

The ICP PDS verification process can be applied either through a central authority such as a public programme, by distributed third parties such as a qualified independent engineering firm, or by an individual investor. Projects that successfully complete the ICP System and comply with the PDS are eligible to be certified as an ICP Investor Ready Energy Efficiency (IREE) project, which assures investors that a project conforms to ICP Protocols, has standard documentation, and has been verified by a certified third party. Therefore investors can rest assured that the project has been engineered to consistent industry best practices.

ICP is contract agnostic, and it does not guarantee energy or cost savings or set any performance requirements for projects. ICP can help reduce risks for investors on projects following ICP, but it does not itself eliminate risk. Examples of risks which are outside the scope of ICP, but which should be considered and addressed in the delivery of any well-conceived energy efficiency project include:

- Contractual risks
- Budget risks
- Programme risks/time delays
- Risks associated with third parties e.g. equipment suppliers, installers
- Selection of poor quality equipment
- Loss of income generation e.g. renewable energy generation incentives

0.2 USING THIS SPECIFICATION

This PDS is intended to support the elements, procedures and documentation requirements presented in the ICP Protocols. This document's structure mirrors the protocols and utilises the same five categories that represent the lifecycle of a well-conceived and well-executed energy efficiency project. Within each category, this document presents an overview of the requirements, best practices, quality assurance tasks, and available resources.

Energy efficiency investors, which can include facility owners, energy service companies, finance firms, insurance providers, and utility programmes, are exposed to performance risk but often do not have the expertise necessary to evaluate the complex technical details associated with an energy efficiency project. Regardless of the expertise and skills of the investors, transaction costs can mount when multiple investors evaluate a project with each pursuing an expensive and time consuming technical due diligence process.

For this reason, it is important that the project investor select and engage a team with established experience and skills in energy efficiency project development, which is willing to engage with and adhere to the ICP protocols.

The Project Developer team is responsible for developing a project based on sound engineering principles and best practices as outlined in this document, utilising industry standard approaches for the development of each component of the project. This PDS describes the minimum requirements and the resources that each team member should utilise in order to adhere to these industry standards and protocols, as well as best practice approaches where relevant.

The Quality Assurance Assessor must be an independent party to the project developer, and is responsible for reviewing the outlined components and project documentation to ensure the specifications laid out in this PDS are met. Best practice is to involve the QA provider in the process early on during project development, so that issues can be identified and addressed as the project progresses, rather than at the end of a project when necessary information may be difficult to capture, or when changes may have far reaching (and serious financial) implications. The QA provider should refer to the requirements for each section of this specification, and to the QA tasks listed to help guide the process of evaluating and ultimately signing off a project as compliant with the Protocols.

In general, it is not feasible or necessary for the QA providers to recreate the entire project development process. The QA effort should involve application of available resources to review and address the areas of a project that represent the greatest level of potential uncertainty and risk. The QA provider should take a collaborative approach, working with the project development team to resolve issues in order to develop a financially sound investment built on strong engineering and conservative assumptions.

0.3 PROJECT DEVELOPMENT PROCESS

The ICP framework is divided into five categories that represent the entire lifecycle of a well-conceived and well-executed energy efficiency project:

1. **Baselining**
2. **Savings Calculations**
3. **Design, Construction, and Verification**
4. **Operations, Maintenance, and Monitoring**
5. **Measurement and Verification (M&V)**

It is important that project development activities are performed at specific points in the development of an energy efficiency project since the development of preceding components of a project will affect subsequent project components and results. For example, the baseline and energy end-use consumption estimates are used in the calibration of an energy model or bounding of energy savings predictions, as well as in the M&V efforts. Inaccuracies in the development of these key baseline components can affect the subsequent accuracy of the energy model, possibly resulting in over-prediction of energy savings estimates, and/or an inaccurate assessment of verified energy savings.

The following table provides a general overview of the specific project development and quality assurance activities by that should be performed by the third-party QA provider, the periods within a project's development that these tasks should be performed, and under which protocols.

Key	
(grey)	All protocols
(green)	Targeted protocol has adapted / less stringent requirements as detailed in the protocol document
(purple)	Complex protocol only
(orange)	Applicable for targeted protocol. Only applcaible for complex protocol if IPMVP Option B is selected.

STAGE	Develop Baseline	Savings Calculations / Investment Package	Design, Construction & Verification	Operations, Maintenance & Monitoring	Measurement & Verification
PROJECT TASKS	Work with the M&V specialist to define the measurement boundary	Develop a set of recommended ECMs	Appoint an Operational Performance Verification Resource	Select and document ongoing management regime e.g. SCADA / aM&T	All Options: Develop M&V plan
	Establish the baseline period	Perform model / spreadsheet calculations	Develop OPV plan	Develop OM&M plan	Option A/B: Collect post-retrofit energy / performance data
	Collect energy source data, production, weather and other significant variable data, and utility rate schedules	Develop costs / constructability	Develop systems manual (if one does not exist)	Develop operator's manual (if one does not exist)	Option A/B: Performance data analysis
	Develop energy balances	Develop investment package	Update systems manual (if one already exists)	Update operator's manual (if one already exists)	Option A/B: Verified savings calculations
	Calendarise the independent variable data	Develop ECM report	Perform facility operators training	Develop and perform facility operators training	Option C: Post-utility data
	Establish the energy-use characteristics of the equipment or system which are within the measurement boundary				Option C: Identify / quantify non-routine adjustments
	Develop the baseline energy consumption model and test accuracy				Option C: Regression based analysis
	Establish peak demand and pricing				
	Chart average daily demand				

STAGE	Develop Baseline	Savings Calculations / Investment Package	Design, Construction & Verification	Operations, Maintenance & Monitoring	Measurement & Verification
QUALITY ASSURANCE TASKS	Review and approve selected baseline period	Review and approve ECM report including baseline, facility/systems and ECM descriptions, savings calculations, performance and cost analysis	Review and approve credentials of individual responsible for OPV	Review and approve OM&M plan, setting out procedures	Review and approve credentials of individual responsible for M&V
	Review and approve utility data and rates, signficant variable data and energy baseline	Review and approve credentials of individual responsible for energy model/savings calculations	Review and approve OPV plan	Review and approve selected ongoing management regime	Review and approve M&V plan
	Review and approve energy consumption model	Review and approve savings spreadsheet calculations, including supporting data	Review and approve systems manual (if one exists)	Review and approve operator's manual (if one exists)	Option C: Review and approve performance-period utility data (12 months), regression based model, and adjustment calculations
	Review and approve energy balances	Review and approve supporting costs / constructability information	Review and approve training (interview facility operators)	Review and approve training (interview facility operators)	Option A/B: Review and approve monitored data files, data analysis results, and revisions to savings calculations
	Review and approve load profiles and interval data	Review and approve investment package	Option A/B: Ensure pre-retrofit energy / performance data collected		Review and approve adjustments and proper application

0.4 PROTOCOL SELECTION

There are currently two protocols available that describe a standardised approach to the development of Complex and Targeted energy efficiency projects in industrial facilities. Selecting the most applicable protocol for use with development of an industrial energy efficiency project represents a key first step in the process. Selection of the appropriate protocol to use must involve assessment of the nature of the proposed ECMs.

The Complex Industrial protocol is intended for projects that include:

- **Installation of new technology types or capacities, including new utility generation technologies** - for example, major changes to plant configuration requiring controls modifications
- **Installation of ECMs with variable and/or unpredictable loads** - for example, refrigeration plant

The Targeted Industrial protocol is intended for:

- **Installation of simple, commonly used technologies** - such technologies will usually have consistent and predictable load profiles; for example, lighting retrofits or motor upgrades; projects could include a number of these types of ECMs
- **Installation of ECMs which are like-for-like replacements** - for example, direct utility plant replacements for a similar technology type and capacity

Each project will have its own set of characteristics, as well as limitations on resources and time. Selection of the right protocol depends on many factors, and the project specialist should work with the investors and Quality Assurance Assessor to determine the most suitable protocol to apply to any given project.

0.5 DETERMINING PROJECT APPROACHES

A comprehensive project development approach should be established early in the process. In particular, the Measurement and Verification approach(es) needs to be determined and planned for as early on in the process as is feasible. An *International Performance Measurement and Verification (IPMVP) Option C,* Whole Facility approach, which analyses pre- and post-retrofit utility bills to verify performance, represents a comprehensive method for savings verification, but it may not be appropriate for all projects. This approach requires that energy savings are significant enough to have a discernible impact on the facility's overall energy consumption (typically representing greater than 10% of total energy consumption). Additionally, this approach can become complicated by non-routine adjustments that need to be quantified and incorporated into the analysis, such as changes in facility occupancy, loads, etc.

IPMVP Option A and/or B approaches, which deal with key or all parameter measurement of a *Retrofit Isolation*, can isolate the performance of individual measures and may be more appropriate for some projects. However, these approaches require parameter measurements, which will require trending through the facility's automation system or through the use of remote data logging equipment, tools that may not be available to a project. These approaches also require access to, and understanding of, the live savings calculations so that assumptions can be revised to reflect new observations and develop verified energy savings.

These approaches, among others, should be evaluated and incorporated into an overall plan that takes into account the scope of the measures, their potential interactive effects, and the available resources. These factors will also guide the project development team to the most appropriate protocol to utilise in the development of a project.

1.0 BASELINING

1.1 OVERVIEW

A technically sound energy consumption baseline provides a critical starting point for accurate projection of potential energy savings, and is also critical for measurement and verification upon completion of a retrofit and/or retro-commissioning.

A facility baseline is required for Complex projects using IPMVP Option C. In all other cases, a baseline is required which relates to all systems and equipment within the measurement boundary. The baseline must establish how much energy a facility, system or piece of equipment can be expected to use over a representative energy use cycle. For projects using IPMVP Option C, this will usually - but not always - be a period of 12 months.

The baseline needs to cover all energy sources and account for:

- Total electricity purchased
- Purchased or delivered steam, hot water, or chilled water
- Natural gas
- Fuel oil
- Coal
- Propane
- Biomass
- Any other resources consumed as fuel and any electricity generated on site from alternative energy systems
- Any renewable energy generated and used on site

It must also factor in the impact of independent variables such as production, material throughput, weather, occupancy, and operating hours which relates to the baseline energy consumption.

The process of data collection, compilation, analysis, and reporting should be consistent, transparent, and practical. While in-house tools for performing these tasks represent a reasonable approach, there are also a myriad of available proprietary tools that automate many of these tasks that should be considered as part of the project development process. These tools can download data automatically from the energy provider, perform regressions, provide visualisation of the data, and typically include reporting and exporting features. Many of these applications can be used to perform IPMVP Option C M&V analysis, or to bound energy savings estimates.

The table below indicates which elements described in this document apply to each protocol.

Element	Section	Protocol	
		Complex	Targeted
Requirements for energy audits	1.2		
Documenting facility activities and energy uses	1.3		
Energy analysis techniques	1.4		
Regression analysis	1.5		
Uncertainty analysis	1.6		

1.2 REQUIREMENTS FOR ENERGY AUDITS

There are a number of requirements to consider when preparing for, conducting and assessing the quality of an energy audit. The two principal concerns should be:

1. The experience competency of the auditor
2. The process undertaken for the energy audit

The auditor

These requirements will vary by audit type and industrial sector:

- Education - a base level of appropriate technical education is expected
- Experience - familiarity with industrial sector and end-uses being assessed - e.g. lighting, small power, heating, ventilation, comfort cooling

The protocols require that, where national requirements exist for individuals or organisations conducting energy audits, then these requirements must be met. A list of mandatory and non-mandatory certification schemes for countries in Europe can be found in the *National Certification Schemes List*.

The audit

In order to cover off all of the necessary elements, the format of the audit should follow the principles set out in the following seven steps:

1. ***Planning*** - work with the organisation to agree the scope, boundaries and objectives of the audit, the constraints around organisation resource, time and level of detail required, criteria for evaluating and ranking opportunities and expected deliverables.
2. ***Opening meeting*** - the auditor should spell out specific requirements for data, facility access and personnel resource and present the indicative timeline for implementation and reporting.
3. ***Data collection and measurement plan*** - the auditor will collect data on energy supply and demand, other key variables such as production volumes or degree days, O&M manuals, and future energy plans. If datasets are needed to develop reasonable energy and cost saving estimates, it is necessary to document the method and hardware/software used to collect this.
4. ***Conducting the site visit*** - conduct a physical survey of facility areas within the agreed scope, noting the quantity and type of assets. Conduct interviews with operational staff to understand impact of operating routines and user behaviour on energy performance. Draw up a preliminary list of ECMs.
5. ***Analysis*** - calculation methods should be transparent and technically appropriate, clearly highlighting any assumptions that are made. Ensure that variables which affect measurement uncertainty and their contribution to results have been taken into account, and factor in regulatory constraints/incentives. Current energy use should be presented and broken down by end-use and utility. ECMs should be presented and evaluated considering best available technology/practice, the operating lifetime of the equipment and systems being audited, and any anticipated future changes to energy use.
6. ***Reporting*** - the energy audit report should be set out in such a way that the methods used - with regards to data collection, site survey approach, inclusion/exclusion of ECMs, savings calculations - are clearly set out and justified. The report should be clearly written, and contain an executive summary which ideally contains technical and non-technical sections, background and context for the audit, facility energy use summary, ranked ECM list, conclusions and recommendations.
7. ***Closing meeting*** - the report should be made available in advance and presented to the organisation, explaining the results and responding to questions.

For more detailed guidance on applying this methodology please refer to *Reference Document on Best Available Techniques for Energy Efficiency (section 2.11)*, *ISO 50002:2014 Energy management systems — Energy audits— Requirements with guidance for use*, *EN 16247-1:2012 Energy audits: General requirements* and *EN 16247-3:2014 Energy audits: Processes.*

1.3 DOCUMENTING FACILITY ACTIVITIES AND ENERGY USES

Part of the documentation required in the protocols is to provide a summary of the facility's activities and energy uses, including a description of the processes undertaken within the facility. The table below can be used as a generic pro-forma with which to provide such a summary. Comments can be provided against each of the rows as appropriate.

Category	*Sub-category*	*Detail*
Contextual data	Geography	Location of facility (city/region, country)
	Facility type	Sector
	Production	Product(s)
	Process description / flow	Brief description of processing stages, from raw materials 'in' to finished product(s) 'out'
Process energy use	Process energy	Describe the energy use within process elements i.e. direct fuel or electricity for heating
Utility energy use	Process heating	Brief description including how utility is generated, number approximate size and type of generator, any other key criteria you can mention
	Process cooling	
	Compressed air	
	Distributed electricity generation	Brief description, if applicable
	Other utility energy use	Brief description of other noteworthy systems, if applicable
Building services energy use	Space heating	Brief description including how utility is generated, number approximate size and type of generator, any other key criteria you can mention
	Space cooling	
	Ventilation	

1.4 ENERGY ANALYSIS TECHNIQUES

This section provides guidance on typical methods for assessing and analysing baseline data. These methods are often employed to help identify opportunities, as well as to gain a full understanding of net energy consumption within the measurement boundary.

Energy balances

The purpose of an energy balance is to understand the energy flows entering and exiting a defined system. This facilitates:

1. Identification of ECMs, by highlighting those areas with the highest consumption which merit a more detailed review through a survey or an audit
2. Quantification of energy savings for the proposed ECMs, whether these are operational (utilising

existing plant more effectively) or technological (upgrades to existing plant or replacement).

The input data which feeds into an energy balance can come from a number of sources:

- Directly measured energy supplies i.e. facility metering
- Modelled energy flows using spot-measurements from the facility e.g. temperature of a stream combined with a measured or assumed flow rate and heat capacity
- Modelled energy flows based upon empirical estimates from similar facilities

It is important to take account of the energy content of *all* flows which pass across the defined system boundary. This should include those streams that are considered to have little-to-no energy content e.g. ambient water lines.

One of the most effective means of constructing an energy balance is within a spreadsheet, or a similar open-source data manipulation tool. The tabular format makes it easy to set out the various streams in a logical and concise manner, and facilitates review of the calculation stages by a third party since any assumptions can be seen and methods interrogated.

Specialist energy analysis techniques

Certain projects may warrant the use of specialist energy analysis techniques, depending on their complexity and specific client requirements. Examples of such techniques are pinch analysis, which is a methodology for minimising energy consumption in processes by calculating thermodynamically feasible energy targets and achieving them by optimising heat recovery systems, energy supply methods and process operating conditions. Another example is bin analysis, which is a statistical technique that is often deployed in the context of an energy project to calculate or verify the optimum size/capacity of utility generation plant. Examples of such projects are installation of a new refrigeration system, like for like replacement of an existing plant, or installation of a decentralised energy generation solution e.g. combined heat and power plant.

For more detailed guidance on applying pinch analysis methodology please refer to Reference Document on Best Available Techniques for Energy Efficiency (section 2.12).

Adjustment models for different operating modes

If a facility has multiple modes of operation, separate adjustment models may need to be created for each mode which may result in fewer data points being available to create each model. In some cases, a single adjustment model may be created by incorporating additional relevant variables that account for the different energy consumption patterns for the different operational modes, rather than opting for multiple models, such as 1-shift and 2 shift operations.

For more guidance on how to assess the requirements for multi-mode adjustment modelling please refer to *Superior Energy Performance® (SEP) Measurement & Verification Protocol, 2017 (section 6.5)*

Net energy consumption and energy accounting

It is important that the net consumption is calculated separately for all energy streams, accounting for pass-through energy sources and feedstocks and on-site energy consumption.

The following equation can be used to calculate the net energy consumption of a given energy source:

> *Net energy consumption of energy source A = (Energy content of incoming energy source A) - (Energy content of the amount of energy source A used as a feedstock) - (Energy content of energy source A sold or transferred to outside the boundary) + (Energy content of energy source A stored on the facility at the start of the period) - (Energy content of energy source A stored on site at the end of the period)*

Calendarisation of partial month data

Data for energy consumption and relevant variables will frequently not be available for exact calendar months, nor for exactly aligning time intervals. For example, monthly production data may be reported on the first of the month, while utility data may be provided mid-month. Alignment of time intervals is preferred and may facilitate development of more representative adjustment models.

In order to convert partial to whole calendar months, determine average daily consumption during each partial month, and multiply the daily average consumption by the total number of days in the calendar month. For raw fuel delivered to the facility (e.g. fuel oil, propane), estimate monthly energy consumption based on actual consumption between fuel deliveries, or by pro-rating actual consumption between deliveries by an appropriate metric such as heating degree days.

1.5 REGRESSION ANALYSIS

Normalisation is used to analyse, predict and compare energy performance under equivalent conditions. Regression-based energy modelling is a specific type of normalisation, and involves the development of an energy consumption equation, which relates the dependent variable (total facility/system/equipment energy consumption, including electricity and on-site fuel) to independent variables known to significantly impact the facility, system or equipment's energy consumption. Independent variables typically include production, weather (heating and cooling degree days), and may include other variables such as raw material input characteristics, shift patterns or operating hours.

Under an IPMVP Option C approach, a regression model is usually required to develop the baseline energy consumption model. Under an IPMVP Option A or B approach, this is the Retrofit Isolation Baseline, which may also require regression analysis depending on the relationship between the energy consumption data and the independent variables.

The energy consumption equation can be determined using a regression analysis – the process of identifying the straight line of 'best fit' between the building's energy consumption and one or more independent variables. An example of linear regression is shown below:

Energy consumption (kWh) = $m_1X_1 + m_2X_2 + C$

Where

C = energy baseload in kWh (determined from regression analysis)

$m_{1,2,etc}$ = energy consumption in kWh per unit e.g. energy consumption per tonne of product kWh/tonne, or energy consumption per degree day kWh/°C (determined from regression analysis)

$X_{1,2,etc}$ = number of units e.g. tonnes of product produced, or number of degree days in °C

Further variables can also be included – this is known as multiple-linear regression. More complex regression techniques may also be employed – where these are required, the reasoning and calculation details must be provided.

For projects following IPMVP Option C, in rare cases it may be deemed that variation in baseline energy use is not correlated with the independent variables, and therefore that normalisation and development of the energy consumption equation is not required. In such cases, clear justification for the omission of an energy consumption equation should be provided.

As part of an initial evaluation of the regression-based energy model and the energy consumption equation, an assessment should be made of the coefficient of correlation (R^2). Regression models should be evaluated on the basis of the predicted savings, which must be greater than twice the standard error of the baseline value, as set out in IPMVP - see *IPMVP: Statistics and Uncertainty for IPMVP, 2014 (section 1).* Guidance for developing and evaluating regression models can be found in *IPMVP: Statistics and Uncertainty for IPMVP, 2014 (section 2)* and *Superior Energy Performance - Measurement and Verification Protocol for Industry, 2017 (section 6.3.2 and 6.4)*. IPMVP sets outs alternative approaches that should be considered where the baseline model criterion is not met:

- More precise measurement equipment

- more independent variables in the energy consumption model
- Larger sample sizes
- An alternative IPMVP Option that is less affected by unknown variables

Generally, a value of 0.75 or more, and a CV[RMSE] of less than 0.2 would usually indicate a good relationship.

1.6 UNCERTAINTY ANALYSIS

Baseline development should also include an assessment of uncertainty quantified in the form of a lower and upper bound. This can be accomplished by comparing the baseline energy consumption predicted by the developed energy consumption equation to the actual utility bills or metered data for the baseline period, using the difference in energy consumption to form the error associated with the baseline. This error, combined with the standard deviation and the required confidence/precision levels, can subsequently be used to create a range around the baseline (minimum and maximum). EVO 10100 – 1:2014, *Statistics and Uncertainty for IPMVP, Section 6* provides an example of how ranges of predictions can be calculated.

The baseline data collection process should include an assessment of any periods of non-typical operating conditions, such as periods of unusually high or low production. Technical information regarding these changes to the operation should be collected during the energy audit. In such cases, these periods should either be excluded from the baseline or the baseline should be adjusted to normalise energy consumption to typical conditions.

Where a facility or a process has different modes of operation, either regular or irregular, and an energy consumption model which meets the required statistical criteria cannot be developed, then separate models for each mode of operation may be developed. These models are then combined into a multi-mode model. An example of this type of operation may include when production is temporarily shut down. Refer to *Superior Energy Performance - Measurement and Verification Protocol for Industry, 2017 (section 6.5)* for further guidance on this.

2.0 SAVINGS CALCULATIONS

2.1 OVERVIEW

Savings calculations are usually performed using spreadsheet calculations, but the use of proprietary tools may be required to carry out supporting calculations. Regardless of the method employed, the procedure should be transparent and well documented. Calculation methods must be based on sound engineering methods, and assumptions must be based on observations, field measurements, monitored data, or documented resources. In all cases, these assumptions should be conservative, transparent, and documented.

ECM descriptions submitted for Quality Assurance review should be thorough, documenting existing conditions, the proposed retrofit, and potential interactive effects. The descriptions should provide enough detail to demonstrate to the Quality Assurance Assessor that the design has been developed to a sufficient level of detail so as to develop accurate scopes of work and informed costings.

The results of the savings calculations must be calibrated to energy balance consumption estimates or measurements.

The table below indicates which elements described in this document apply to each protocol.

Element	Section	Protocol	
		Complex	Targeted
Developing the recommended set of ECMs	2.2		
ECM Savings Calculations	2.3		
Interactive Effects	2.4		
Investment Package	2.5		

2.2 DEVELOPING THE RECOMMENDED SET OF ECMS

The results of the energy audit provide a list of ECMs that can include low-cost and no-cost measures, operations and maintenance (O&M) improvements, and capital cost items. Estimates of annual energy savings and implementation costs are key components of the financial evaluation of an EE project (see section 2.5). Detailed descriptions of the measures must be developed so as to aid in the development of these estimates.

As a minimum, documentation for each recommended measure should include the following information:

- The present condition of the system or equipment
- Recommended action or improvement

A best practice approach would also include:

- Risk of equipment failure
- Schedule for implementation
- Summary of specific maintenance requirements or considerations associated with the ECMs, particularly any impacts on maintenance costs
- Interaction with other end uses and ECMs (see section 2.4)
- Potential issues which may prevent successful completion
- Organisations and individuals involved in implementing this action or improvement, and their responsibilities
- Staff effort required

2.3 ECM SAVINGS CALCULATIONS

When preparing savings estimates for a list of proposed ECMs, the adopted calculation methods should be based on sound engineering principles and methodologies. Inputs should be derived from production and weather data, system design information, manufacturer specifications, and operational data from on-site monitoring. For each ECM, the calculation methodology, formulas, inputs, assumptions and their sources need to be clearly documented.

References such as the IPMVP Core Concepts Guide and the US' Uniform Methods Project (UMP) provide detailed guidelines for calculation methods such as regression analysis. Vetted resources for calculation tools, particularly those that are nationally recognized, can be used or referred to as models for calculation methods.

When developing spreadsheet-based savings calculations, assumptions and values should never be "embedded" in formulas. The formulas should use cell references for constants, assumptions and other inputs. These inputs should be clearly defined, calculations explained, and associated units noted elsewhere in the spreadsheet. This clear, consistent, "open book" approach is critical to the quality assurance process.

Each ECM calculation should contain sufficient explanation such that (with the necessary input information) a reviewer can reconstruct the calculations. This explanation should include documentation of the formulas used, as well as any assumptions and their sources.

Inputs for the savings calculations are derived from the outputs of the energy audit. Each of these inputs is critical to the accurate estimation of energy savings and should always be conservative, especially if they are less well defined or unknown. Operational and performance data also provide key inputs to inform and bound the savings calculations. These data can be obtained from functional performance tests or short-term monitored data, supplemented by driving variables (such as production or weather), and can help define or demonstrate opportunities or deficiencies in operation or performance.

Interactions are also an important part of the energy savings calculation process. Savings calculations should always take into account the potential effects of other proposed ECMs. For example, a measure that involves replacement of a piece of equipment with a higher efficiency unit may need to account for a reduced operating schedule associated with another ECM. A general best-practice approach is to calculate savings for ECMs affecting facility-level loads first (i.e. utility generation plant), then departmental/process-level equipment, and finally end-use equipment. This method allows for effectively “carrying through” the characteristics of the earlier measures through to the later measures.

If independent-party proprietary calculation tools are used, sufficient documentation must be included to validate unbiased assessment of energy savings estimates. This documentation should include sources such as calculation methodology, white papers, independent testing results of the application. Caution should be applied when using any tools provided by a retailer or manufacturer to estimate the energy savings associated with their product.

Estimated energy savings should always be compared to estimated or measured energy end-use consumption to ensure that the estimated energy savings are reasonable. They should also be compared to simple estimation efforts or previous energy savings estimates. This ensures figures are credible and provides an elementary level of quality assurance.

2.4 INTERACTIVE EFFECTS

Interactive effects are secondary energy effects occurring as a result of ECMs, usually associated with heating and cooling, and must be considered for all types of projects. Interactive effects must be included where their magnitude is significant in relation to the predicted energy savings for the measure, unless clear written justification is provided as to why they have been not been included, and an estimate of each interactive effect.

For example, for a lighting retrofit project, the reduced heat gains from the lighting system may affect the energy savings by increasing the heating demand but also decreasing the cooling demand. If the overall interactive effect is expected to have a significant impact on the savings, conventional heating and cooling calculations would be used to determine the appropriate fraction(s) for each season. However, if the measurement boundary can be expanded to encompass interactive effects during the baseline period, there is no need to estimate them.

IPMVP (EVO), Core Concepts, 2016 - section 5 describes interactive effects and how they may be addressed under an IPMVP compliant approach.

2.5 INVESTMENT PACKAGE

Accurate cost estimation for the proposed ECMs represents a critical component that is used to financially evaluate a proposed EE project. Sound cost estimates are the basis for developing return on investment criteria and to prepare a clear, realistic financial package.

At the feasibility stage, initial quotes may be obtained from the contractor, provided a minimum of three are used. Alternatively, cost estimates may be based upon the engineer's experience with previous projects of similar nature and scope. Either of these approaches can be used to rank improvements and determine which measures will be included in a final bid package.

Ultimately, however, the final investment package should have pricing based upon bids that represent the price for which a contractor has committed to make the improvements. Cost estimates during the calculation phase must include as applicable:

- A construction feasibility review indicating which measures will be included, description of construction methods, allowable working hours, impacts on the facility, access points for bringing in any large equipment, major removals (demolition), permits required, and possible environmental issues (i.e. asbestos, hazardous materials, or other issues that impact indoor air quality).
- Categories and multiple line items for all necessary trades, i.e. civil (structural and site work, demolition, rigging), mechanical, plumbing, electrical, architectural (finishes), environmental (hazardous material mitigation), provision of temporary services as necessary. Underlying lists or spreadsheets which include cost information must be submitted.
- All lines by trade must include labour and materials. "Labour" can be specified by budgetary allowance rather than by hours and hourly rates.
- Operation and maintenance costs throughout the life of the project.
- Line items for professional fees, engineering, commissioning, construction management, permitting, measurement & verification, contractor overhead and profit (O&P), and contingency. These are typically estimated as percentages of the total implementation costs.
- Cost estimates may need to be split into total cost and incremental cost, depending on the audience and the investment contemplated. The incremental cost is the additional cost of installing the energy efficient system or piece of equipment compared to the baseline cost, or non-energy-related investment. For example, utility incentives are often based on incremental cost.
- Lifecycle Cost Analysis (LCCA) is not required, but may be included where there are benefits of the proposed retrofit other than energy-cost savings. Refer to *ISO 15686-5:2017 Buildings &*

constructed assets – Service life planning – Part 5: Life cycle costing, and in the US: *National Institute of Standards and Technology (NIST) Life Cycle Costing Handbook 135*
- Estimated equipment useful life expectancy and equipment degradation are not required (although some projects may require this when assessing the investment term), but may be included to assess the overall economic performance of proposed retrofits. These estimates should be conservative and based on accepted values.

3.0 DESIGN, CONSTRUCTION AND VERIFICATION

3.1 OVERVIEW

This part of the process focuses on the engineering, implementation and operational performance verification phase of the project. The key objectives here are to ensure that the project is designed and implemented as intended by providing oversight to the design as well as general oversight during implementation. The submission of designs, equipment, performance specifications and installation plans should all be carefully reviewed to ensure compliance with the proposed project and the stakeholder's requirements.

The term "operational performance verification" (OPV) is used specifically for retrofit or energy efficiency upgrade projects to distinguish the activity from "comprehensive" commissioning. OPV focuses on the commissioning activities specific to the ECMs, rather than involving the commissioning of all facility systems and components.

An important part of the OPV process is ensuring that roles, responsibilities, expectations, timelines, communication, health and safety and site access requirements have been established. Furthermore, it should be confirmed that arrangements have been made regarding inspections, operational performance verification activities, testing, balancing, training, acceptance criteria, operations, maintenance and monitoring requirements, and that M&V guidelines are being met.

A qualified OPV Specialist should be appointed to manage the process, either under an in-house role or using a third party. Although there are advantages to appointing an in-house representative, the use of a third party is recommended to avoid conflicts of interest and to take advantage of specialised skills.

The quality assurance (QA) process should provide unbiased recommendations for fast and fair resolution of any project related issues that might arise during design and/or construction. The QA provider should work closely with the OPV Specialist, stakeholders and project development/construction teams to ensure that the project is completed on time and within budget.

The table below indicates which elements described in this document apply to each protocol.

Element	Section	Protocol	
		Complex	Targeted
Operational Performance Verification Plan	3.2		

Systems Manual	3.3		
Training	3.4		
Designing Complex Projects	3.5		

3.2 THE OPV PLAN

The OPV effort begins with the development of an OPV plan. The plan should be developed pre-construction, and should describe the verification activities, target energy budgets and key performance indicators associated with the project and the individual ECMs. Performance indicators should be used to identify underperformance, although these are optional under the Targeted protocol.

The plan should also describe the data logging, control system trending (analysis of historical data and using it to predict future performance, usually using the BMS), functional performance tests, spot measurements, or observations that will be used to establish both baseline operation as well as post-construction operation, to demonstrate that operations and performance have improved and have the ability to perform over time.

The OPV process itself, led by the OPV Specialist, should include consultation with the energy audit team, monitoring of designs, submittals and project changes, and inspections of the implemented changes. It also includes the responsibility for and means of reporting deviations from design and projected energy savings to the project owner in an issue log. If the collected post-installation data, testing results, or other observations indicate underperformance or a lack of potential continued performance, the OPV Specialist needs to:

- Help the customer / project development team fully install the measure properly and then re-verify its performance; or
- Work with the project development team to revise the ECM savings estimates using the actual post-installation data and associated inputs.

Successful OPV is achieved by applying traditional commissioning methods to the measures and affected systems involved in the project, and supplementing these methods with more data-driven activities, such as data logging, trending, and functional performance testing, as appropriate.

The level of effort required to verify proposed ECMs will vary. Measures that are well-known or have relatively low expected savings, and measures whose savings are considerably certain may only warrant installation verification. That is, visual inspection to ensure that the measures have been implemented properly – for example, pipework and valve insulation. Measures with greater savings at risk or greater uncertainty will require a greater depth of OPV, such as sample spot measurements (for example, lighting fixtures and lamps, pumps), short term performance testing (for example, fans fitted with variable speed drives), and the collection and analysis of post-installation performance data (for example, more complex projects with multiple ECMs).

The M&V method being employed may also affect the OPV approach taken. That is to say, if an Option B M&V approach is being employed, where all key parameters associated with the ECM are to be measured, then a more simple visual inspection may suffice for OPV. However, if an Option A or Option C approach is being employed, then a more thorough OPV approach should be utilised to verify ECM functionality.

Typical OPV approaches include:

- Visual inspection - verify the physical installation of the ECM; applied when ECM operation is well understood and uncertainty or anticipated relative savings are low.
- Spot measurements - measure key energy consumption parameters for ECMs or a sample of ECMs; applied when ECM performance may vary from published data based on installation details or load, or anticipated relative savings are low.
- Functional performance testing - test functionality and proper control; applied when ECM performance may vary depending on load, controls, or interoperability of other systems or components, and savings or uncertainty are high.
- Trending and data logging – set up BMS trending or install data logging equipment and analyse data, and/or review control logic; applied when ECM performance may vary depending on controls or loads, and savings or uncertainty are high.

Concise documentation should be provided that details activities completed as part of the OPV process and significant findings from those activities – this is the OPV report, and is required for all projects. This documentation should be continuously updated during the course of a project.

3.3 SYSTEMS MANUAL

In general, a Systems Manual contains information and documentation regarding facility design and construction, commissioning, operational requirements, maintenance requirements and procedures, training, and testing. The document is intended to support building operations and maintenance, and to optimise the facility systems over their useful lives. Specifically, it includes technical instructions to ensure systems, plant and equipment reach their optimum performance according to their technical specifications, and to ensure that they are preserved in, or restored to, a state where they can function in their optimum state.

The Systems Manual should document the modified systems and equipment involved with the energy efficiency project as well as be comprehensive yet concise so that it is usable to the facility personnel. It should also include the following information as appropriate (defined in more detail in EN 13460:2009 Maintenance – Documents for maintenance, and in the US, in the ASHRAE Guideline 1.4-2014, Procedures for Preparing Facility Systems Manuals):

- Facility design and construction: owner's project requirements (OPR) / current facility requirements (CFR); basis of design (BOD); and construction / project record documents
- Facility, systems and assemblies information: specifications; approved submittals; coordination drawings e.g. system schematics, circuit diagrams, plantroom drawings; assets register; manufacturer's operation and maintenance data; warranties; as well as contractor / supplier listing (including components lists and spare parts lists) and contact information
- Facility operations: operating plan; organisational structure, including roles and responsibilities; facility and equipment operating schedules; set points and ranges; sequences of operation; limitations and emergency procedures actions; maintenance procedures, checklists and records; maintenance schedules; record of maintenance costs; instrument/meter calibration procedures and logs; ongoing commissioning procedures; cleaning plans and procedures; utility measurement and reporting
- Training: plans and materials; training records; training for ongoing system manual updating
- Commissioning process report: commissioning (or OPV) plan; design and submittal review reports; testing reports, permits and inspections, and certificates; commissioning (or OPV) progress reports; issues and resolution logs; item resolution and open items

The development of the manual should be coordinated with operations and maintenance personnel so that it best serves their needs. In addition to containing facility operating procedures associated with the equipment, the manual should also provide details regarding ongoing optimisation of the systems, and a clear process and responsibility matrix for addressing issues.

Note that for Targeted projects, any existing Systems Manual should be updated; if one does not exist, then a new manual is not required.[BP2]

3.4 TRAINING

Training of the facility staff and building operators may be one of the most important factors in determining the operational performance and persistence of energy savings. Without proper understanding of the new systems, the skills to operate the systems correctly, and a plan regarding how to resolve or report issues, it will be impossible for an energy efficiency project to succeed and perform optimally over time.

The facility operating staff should be involved with all OPV activities, from planning through to implementation. Assisting with the OPV process provides critical on-the-job training, and ensures familiarity with the new systems and installed ECMs.

A well-developed training plan should be created , supported by comprehensive and useful facility documentation. As a best practice approach, and where appropriate, video recorded training sessions should also be provided. The training sessions should cover the changes arising from the energy efficiency project and the implemented ECMs. They should be developed and delivered by the consultants, vendors, and contractors.

The training associated with the OPV activities should be combined with the training performed as part of the OM&M efforts. Taken as a whole, they will provide a thorough understanding of the proper operation of the systems and how to diagnose and respond to issues that may arise over time. Key points to be covered by the OPV and OM&M training may include:

- Thorough descriptions of the ECMs implemented, and descriptions of improved performance generated by these ECMs
- Review of the OPV plan (where required)
- Objectives for the investor and building users with respect to the ECMs
- Energy performance targets
- Key performance indicators
- Operating schedules and owner's operating requirements
- Ongoing data analysis, and investigation process and methods used to identify issues and deficiencies in performance – this should include the use of diagnostic methods and instruments for maintenance associated with the ECMs, and the means for collecting, analysing and storing data
- O&M requirements needed to ensure persistence of performance and savings (service, corrective maintenance and preventative maintenance tasks, and associated schedule of these tasks)
- Staff roles and responsibilities to maintain persistence of performance and savings, and methods for responding to or reporting issues
- Relevant health and safety issues and concerns

- Special issues to maintain warranties

3.5 DESIGNING COMPLEX PROJECTS

Complex projects may consist of:

- Integration of energy use, such as the use of recovered heat from one process for use in another, or site-wide optimisation of energy
- A step change in either process design, energy supply, or both - for example, the installation of new process technology, or combined heat and power plants.

Whilst the second type of project tends to generate greater savings, it also tends to be more expensive and there may be greater risks associated with it. It may also require input from multiple departments within an organisation. Such projects therefore require specialist knowledge and skill (see *Best practices and Case Studies for Industrial Energy Efficiency Improvement - An Introduction for Policy Makers, Copenhagen Centre on Energy Efficiency, 2016, section 4).* They may also require more extensive due diligence by the investor to assess non-technical aspects such as financial, liabilities, environmental compliance, and health and safety risks. All projects will require an assessment of technical risks, including any potential impact on production output (for example, due to equipment failure), and a review of constructability commensurate with the level of complexity of the project. As mentioned earlier in this document, it is important to note that ICP does not and cannot eliminate risk.

Although the ICP process also does not directly set out requirements relating to design, detailed design work is required in order to develop the investment package. Detailed design associated with any energy project in an industrial setting should follow standard construction processes. This may include, depending on the complexity and nature of the project, the development of coordination drawings and detailed plantroom layouts to ensure the proposed equipment can be accommodated within the existing facility, as well as on-site assessments by manufacturers or specialist equipment suppliers. Specific energy efficient detailed design activities are listed in the *Reference Document on Best Available Techniques for Energy Efficiency, European Commission, Table 2.2*:

- Design of optimal process plants and utility systems
- Assessment of needs for control and instrumentation
- Process integration/heat recovery systems (pinch methodology)
- Minimisation of pressure losses, temperature losses, etc.
- Selection of efficient motors, drives, pumps, etc.

• Supplementary specifications to tendering material regarding energy efficiency

4.0 OPERATIONS, MAINTENANCE AND MONITORING

4.1 OVERVIEW

The primary objective of the Operations, Maintenance and Monitoring stage is to ensure the savings associated with the ECM persist over the lifetime of the project. The QA process must ensure that an appropriate and reasonable practice has been selected and developed to monitor energy system performance, and that corrective action plans have been developed to ensure "in specification" energy performance. This OM&M practice can vary in scope, and may involve ongoing commissioning, monitoring-based commissioning, performance-based monitoring (fault detection and diagnostics), periodic recommissioning, system or equipment re-tuning, or periodic inspections.

General guidance on Operations and Maintenance can be found in *Operations & Maintenance Best Practices: A Guide to Achieving Operational Efficiency, Federal Energy Management Program, 2010*. This document sets out five key principles associated with integrated, successful O&M: operations, maintenance, engineering, training and administration. The document also provides guidance on best practice O&M for specific technologies, including how to ensure persistence of energy savings for them.

General guidance on monitoring and reporting on energy performance, including types of monitoring methods and reports, and types of energy performance indicator targets, can be found in *ISO 50006:2014 Energy Management Systems – Measuring Energy Performance Using Energy Baselines and Energy Performance Indicators.*

4.2 OPERATIONS, MAINTENANCE & MONITORING PROCEDURES

Operations, Maintenance & Monitoring (OM&M) and facility performance tracking is a process of continuous improvement, and involves tracking, analysing, diagnosing and resolving issues involving process energy systems, utility plant , lighting or other energy-consuming systems. While the focus from an energy efficiency project perspective is on system energy performance, it is very important to consider any impact the project may have on the facility's adherence to its planned production schedule and minimise and mitigate the likelihood accordingly.

Good OM&M processes involve a proactive strategy for maintaining production plan adherence while optimising energy performance. A problem that can arise in industrial facilities is due to the fact that facility operators' principal focus is to meet the planned production schedule. This directive can be counter-productive to facility energy efficiency performance - for example, optimising the cooling load on chilled food products increases the risk of spoiled product, which operators are keen to avoid wherever possible. Development of specific OM&M procedures can provide more clear direction to the facility's operations and maintenance staff, empowering them and providing specific methods for identifying, analysing, and resolving issues over time.

The overall OM&M process should involve the following key components:

1. *Data collection and performance tracking* - process energy system, utility plant, lighting or other energy-consuming system performance data is tracked along with energy consumption data. Various tools are available to support this process, and typically multiple tools are employed as part of the overall management strategy.
2. *Detection of performance issues* - use of automated tools to perform real-time analysis and identification of issues (fault detection and diagnostics), or the use of tools to present information in a way that facilitates identification of problems manually.
3. *Diagnosing issues and identifying solutions* - while automated tools can help facilitate issue diagnostics and the development of solutions, the skill, knowledge and training of operational personnel, supplemented by the assistance of service contractors or consultants, are critical components in diagnosing issues successfully and identifying appropriate solutions.
4. *Resolve issues and verify results* - issues should be resolved in a manner that addresses risks to production continuity, and also considers and optimises energy performance.

A strong OM&M management framework needs to clearly set out how automated or manual tools or processes are to be used, and provide the guidance, training and support necessary to extract, interpret and act on the data and analysis results. This management framework should dedicate resources to the OM&M effort by establishing roles and responsibilities and assigning them to the appropriate team member. The framework must set quantifiable performance goals, determine accountability, and define the performance tracking methods and metrics (the performance indicators).

Identifying energy performance indicators will depend on the ECMs proposed, and the associated energy consumption characteristics, and the factors affecting this. They can be applied at an equipment, system or whole facility level, and are usually directly measured (e.g. kWh), calculated using a ratio of measured values (e.g. efficiency), or a calculated or modelled relationship between energy consumption and relevant variables (e.g. linear regression modelling to determine kWh/tonne of product). A performance indicator for a process refrigeration system could be energy consumption kWh/cooling demand kWh.

Automated energy management systems (EMS) can be incorporated into the OM&M management regime, and provide a method for tracking, analysing, and assessing energy performance against savings projections and benchmarks. These tools can be used at the project development and implementation stages to support the Baselining and M&V activities.

Data collection systems are used to collect energy data and transmit this data to the EMS. This data is typically collected in intervals of between one minute and one hour, and can track either whole-facility energy consumption, or the energy consumption of specific systems or end-uses. The EMS aggregates this data, identifies errors, analyses the data, and provides graphical representations of the data or reports used to assess the energy performance of the facility in real time.

While EMS tools provide the ability to identify underperformance or problems, they cannot diagnose the cause of these problems. Trending and analysis through the use of Supervisory Control and Data

Acquisition (SCADA) and/or automatic Monitoring and Targeting (aM&T) reporting, or the use of automated fault detection and diagnostic (FDD) tools, provide system tracking methods that can pinpoint problems with system operation and performance in real time.

Use of SCADA/aM&T to track key performance metrics can present a cost-effective method for tracking and identifying facility performance improvements. Trended metrics can be plotted and reviewed on a regular basis to identify abnormal changes in values that might indicate problems. Long term patterns, averages, and minimum or maximum values can also be used to identify issues and track energy efficiency and system performance. Performance metrics typically include zone temperatures, equipment efficiencies, system efficiencies, and ventilation rates.

While use of the SCADA/aM&T to track performance metrics provides a useful, manual method to track system performance, FDD tools provide functionality beyond these manual judgment methods. FDD tools utilize system-level performance data to automatically detect, and in some cases, quantify issues and report problems in real time.

FDD tools utilize existing SCADA points, and in some cases additional dedicated sensors external to the SCADA, and analyse the data using fault detection algorithms. These algorithms are typically proprietary, but some tools allow for customisation or programming of additional fault detection routines. FDD tools are typically installed by a third-party, and their features, diagnostic levels and associated costs can vary significantly.

Retro-commissioning or recommissioning (RCx) can provide an additional or alternative method for providing OM&M on a periodic basis. RCx is a cost-effective means to improve the performance of existing facilities with the goals of reducing energy consumption and peak demand consumption, improving system performance, meeting planned production volumes, and reducing maintenance issues and costs. RCx involves a review of the facility's systems and their operation that identifies problems due to system operation deficiencies or design flaws that occurred during the original construction. RCx also identifies problems that may have developed during the facility's existence. Typical energy efficiency measures identified during the RCx process focus on improving control of existing equipment or correcting hardware and sensor malfunctions.

4.3 OPERATOR'S MANUAL

In many cases, the Operator's Manual and Systems Manual can be combined into one document to be used by the operations and maintenance personnel. In this case, the requirements described in Section 3.3 of this Specification should be adhered to for development of this document. Otherwise, these two Manuals can be developed as two separate documents.

The Operations and Maintenance sections of the Systems Manual, or the separate Operator's Manual, should contain the following information as appropriate:

- Photographs

- Reduced-size as-built drawings and schematics
- List of major equipment
- Invoices for major equipment purchases and repairs
- Balance reports
- Equipment locations
- Control system logic
- O&M instructions; training materials

Note that for Targeted projects, any existing Operators Manual should be updated; if one does not exist, then a new manual is not required.

4.4 TRAINING

The OM&M specific training practices described here should be combined with the training efforts and best practices described in Section 3.4.

Proper operation, maintenance practices, and monitoring are tasks critical to the ongoing energy-efficient performance of the building's systems. Overriding of system setpoints or controls due to lack of understanding, or diminished performance due to improper maintenance, are common issues that can affect system energy performance over time, and jeopardise the financial performance of an energy efficiency project. Training of the building operators represents a critical component of the OM&M process, and helps avoid these issues.

In conjunction with the training associated with the OPV efforts, a well-developed training plan should be created specific to the OM&M tasks. The OM&M training sessions should be video recorded and supported by comprehensive and useful building documentation. The training should, at a minimum, cover the following OM&M components (under the Targeted protocols, some components may not be relevant, such as automated management, and, therefore, need not be provided):

- *Management structure* - Development and structure of the management, responsibility and reporting structure and its components, including operations, maintenance, engineering, training, and administration.

- *Performance metrics* - Development and analysis methods to evaluate maintenance, operational and energy performance of the facility's systems. This should also include review of the M&V plan.

- *ECM maintenance* - Responsibility for the operation, maintenance, repair and replacement of each ECM.

- *Reporting* - Reporting requirements for O&M activities and their frequency, including submission of ECM-specific O&M checklists.
- *Manuals* - Review of the Operator's/Systems Manual(s).
- *Automated management* - Integration of the ECMs into a computerised maintenance management system.
- *Issue resolution* - Discussion of potential issues that can adversely affect operation or savings persistence, and a review of the process to address or report identified issues.

A properly designed O&M programme, and associated training, must include predictive maintenance best practices. Predictive maintenance attempts to detect the onset of a degradation mechanism with the goal of correcting that degradation prior to significant deterioration in the component or equipment. Training as it is applied to predictive maintenance is particularly important, as it is continuously becoming more sophisticated and technology-driven.

Predictive maintenance can incorporate many different approaches, and all of the following should be considered for inclusion in the O&M management structure, with associated training: vibration monitoring/analysis, lubricant and fuel analysis, wear particle analysis, bearing and temperature analysis, performance monitoring, ultrasonic noise detection, ultrasonic flow, infrared thermography, non-destructive testing (thickness), visual inspection, insulation resistance, motor current signature analysis, motor circuit analysis, polarization index, and electrical monitoring.

The OM&M activities will include a method to monitor and assess the ongoing performance of the installed ECMs. This may include ongoing commissioning, monitoring-based commissioning, performance-based monitoring (fault detection and diagnostics), periodic recommissioning, facility re-tuning, or periodic inspections. As part of the training curriculum, the process operators must be trained on how to utilize and interpret systems in place to monitor the ECMs and associated facility systems, and how to respond to issues identified as a part of this process. The facility/process operators represent the "first line of defence" against performance degradation, and their proper understanding of the monitoring systems and analysis tools represent key contributors to an energy efficiency project's success.

Where available, nationally recognized competency-based training and certification programmes should be used to formally educate process operators on the proper operation and maintenance of facility systems. Facility staff should be encouraged to pursue and obtain relevant education and certifications, which will enhance their ability to provide comfortable, energy efficient and environmentally friendly workplaces.

5.0 MEASUREMENT AND VERIFICATION

5.1 OVERVIEW

All Measurement & Verification (M&V) efforts involve reliably quantifying the savings from energy conservation projects (or individual ECMs) by comparing the established baseline with the post-installation energy performance and use, normalised to reflect the same set of conditions. The ICP complex industrial protocol supports the use of Option B (*Retrofit Isolation: All Parameter Measurement*), and Option C (*Whole Facility*), as defined by the IPMVP. Option A (*Retrofit Isolation: Key Parameter Measurement*) may be used when appropriate under the targeted industrial protocol. The use of IPMVP Option D, *Calibrated Simulation*, is not considered practical for industrial facilities and is not permitted by ICP.

For most M&V efforts, non-routine adjustments need to be made to the baseline to reflect unanticipated changes in the facility's energy use after the retrofits have been completed, such as changes in plant and equipment, shift patterns or process configuration. These items affect process and ancillary energy use, and need to be calculated and subtracted from or added to the baseline, so that it can be accurately compared to the post-retrofit energy use in an Option C approach. Calculation of the effects of these adjustments on the facility's energy use can be challenging, especially those that have potentially complex interactive effects with process elements or building services.

In general, the QA process involves review of the M&V Plan, verification inspections, baseline development review, review of proper application of adjustments (routine and non-routine), review of monitoring equipment, collected data review, and review of the calculations performed to quantify verified savings. Review of M&V reports and baseline adjustments will also be necessary throughout the duration of the performance period.

The table below indicates which elements described in this document apply to each protocol.

Element	Section	Protocol	
		Complex	Targeted
M&V Plan and Implementation	5.2		
Estimated Parameters: IPMVP Option A	5.2.1		
Revised Calculations: IPMVP Options A and B	5.2.2		

5.2 M&V PLAN AND IMPLEMENTATION

The M&V process can be simply broken down into the following fundamental activities:

1. Document baseline energy
2. Plan and coordinate M&V activities (M&V Plan)
3. Verify operations
4. Gather data
5. Verify savings
6. Report results

The first step in the M&V process, the development and documentation of the baseline, is covered in earlier in this specification. The level of uncertainty should be quantified as part of this process. This can be performed by using the energy consumption equation and actual data on explanatory independent variables (such as production volume) to determine the monthly baseline energy consumption, and comparing the results to the actual historical energy consumption associated with the baseline period. The difference, or error, in the calculated baseline can then be combined with the standard deviation and the confidence/precision levels to develop the uncertainty in the energy consumption equation.

The second step in the process involves planning and coordinating the M&V activities, the foundation of which is formed by the development of the M&V Plan.

M&V Plan

The M&V Plan should be developed shortly after the energy efficiency project has been defined. Early development of the plan will ensure that all data needed for the savings calculations during the baseline period will be collected and available. This is particularly important in an Option A or B approach, in which pre-retrofit data is needed to establish the baseline operation of systems affected by the proposed ECMs. Early development of the M&V Plan will also allow for coordination with Operational Performance Verification activities.

The M&V Plan itself should be adherent to the IPMVP, which defines in detail the components the Plan needs to contain and consider (defined in *IPMVP Core Concepts-2016, section 7*). In summary, the M&V Plan should address the following topics:

- Descriptions of the ECMs and operational performance verification procedures
- Definition of the measurement boundary, and discussion of potential interactive effects
- Documentation of the baseline period, energy use, and conditions; include descriptions of independent variable data coinciding with the energy data, and static factors coinciding with the energy data (the routine and non-routine adjustments)
- Definition of the reporting period (typically the length of time required to recover the investment costs associated with the energy efficiency project)
- Descriptions of the basis for adjustments (routine and non-routine – see later in this section)
- Description of the analysis procedures, including algorithms and assumptions to be used for savings verification
- Definition of energy prices used to value the energy-cost savings, and future adjustments to energy prices
- Description of the proposed metering plan and meter specifications, including methods for handling the data, and responsibilities for reporting and recording the data
- Qualitative (and, if feasible, quantitative) descriptions of expected accuracy
- Definition of the budget and resources required for the M&V process (initial and ongoing)
- Description of the M&V reporting format and schedule
- Description of quality assurance procedures applicable to the M&V process

The third step in the M&V process involves operational performance verification, which provides a means for realising savings potential, and is covered in Section 7 of this specification. The fourth step involves data collection, which must be performed both before and after the planned retrofit.

The fifth step involves determination of verified energy savings. Savings may be determined for the entire facility (Option C) or for portions of it (Options A and B). In all cases, the determination of verified savings involves consideration of the measurement boundaries, interactive effects, selection of appropriate measurement periods, and basis for adjustments.

Verified Energy Savings - Option C

Requirements

For Option C approaches, the measurement boundary will include the entire building. The measurement periods should adhere to the guidance set out in *IPMVP Core Concepts-2016*, and must include at a minimum a representative 12 month period for both pre- and post-retrofit utility data.

Adjustments to the baseline must be well defined and applied conservatively. The “adjustments” term is commonly used to restate the baseline energy consumption in terms of the reporting-period conditions. The verified savings equation expressed in the IPMVP is defined as:

Savings = (*Baseline Energy* +/- *Routine Adjustments* to reporting-period conditions +/- *Non-Routine Adjustments* to reporting-period conditions) - *Reporting-Period Energy*

Routine adjustments which are expected to change routinely can be accounted for through regressions or other techniques to adjust both the baseline and reporting periods to the same set of conditions. This allows for accurate comparison between the two measurement periods.

Non-routine adjustments include factors which affect energy consumption that were not expected to change such as facility size, operation of installed equipment, conditioning of previously unconditioned spaces, number of occupants, or load changes. The first step is to identify these changes in the reporting period, but specifically, to pinpoint those adjustments that present a reasonable effect on energy consumption. This can be accomplished through interviews with the facility owner and facility personnel, periodic site visits, observation of unexpected energy consumption patterns, or other methods.

Accurate and conservative calculation of the effects these non-routine adjustments have on energy consumption is critical. Sometimes these effects can be estimated as part of the energy savings calculations for the project. In other cases, side calculation methods need to be employed, in which case applying the appropriate level of rigour and sound engineering principles is key. This includes accurately determining any assumptions used in these calculations.

In all cases, the application of adjustments needs to be handled with care. Only adjustments that are expected to have a relatively significant impact on energy consumption should be considered. And assumptions used within the adjustments need to be conservative and based on actual measurements, field observations, or well vetted and documented sources.

Verified Energy Savings - Options A and B

Requirements

For Option A or B approaches, the measurement boundary must be considered and defined. The measurement boundary should be drawn around the equipment or systems affected by the ECMs, and all significant energy requirements of the equipment within the boundary should be determined. Determination of the energy performance of the equipment can be accomplished by direct measurement of the energy flow, or through direct measurement of proxies of energy consumption that provide an indication of energy consumption.

All energy effects of the ECMs should be considered and measured if possible. In particular, interactive effects of the measures beyond the measurement boundary should be evaluated to determine if their effects warrant quantification, or if these effects can be reasonably ignored. The M&V Plan should still include a discussion of each effect, and its likely magnitude.

Both the baseline period and the post-retrofit (reporting) period need to be determined early on in the project development so that appropriate and adequate baseline data can be captured. The measurement periods need to collect data that reflect equipment operation through its full operating cycle (maximum energy consumption to minimum). The data should represent all operating conditions, and the baseline period should ideally coincide with the period immediately before commitment to undertake the retrofit.

5.2.1 Estimated Parameters: IPMVP Option A

Requirements

Option A is can only be used for projects using the Targeted protocol. It can be applied to a single measure or at the system level for M&V assessment. The approach is intended for retrofits where key performance factors such as end-use capacity, demand, power, or operational factors such as lighting operational hours or pumping power can be spot-measured or short-term-measured during the baseline and post-retrofit periods. Under Option A, any factor not measured is estimated based on assumptions, analysis of historical data, or manufacturer’s data.

While Option A can provide a more economical approach to M&V than Option B, it should only be applied to “simpler” measures. This would include measures in which at least one of the parameters is expected to be fairly constant or consistent, and can therefore be estimated.

When considering an Option A approach, and what variables to estimate, consideration should be given to the amount of variation in baseline energy consumption or the energy impact that variables have on the ECMs before establishing which variables to estimate. Estimates should be based on reliable, documentable sources, with a high degree of confidence. These estimates should never be based on "rules-of-thumb," proprietary sources ("black box"), or "engineering estimates."

Key parameters that are not consistent (and should therefore not be estimated), must be measured. This typically includes parameters such as capacity, efficiency, or operation - essentially, any parameters that represent a significant portion of the savings uncertainty.

As described earlier in this section, the amount that the key parameter is expected to vary will determine the frequency of measurement - i.e. continuously or periodically.

5.2.2 Revised Calculations: IPMVP Options A and B

Following the installation of the ECMs, application of an Option A or B approach will require revisions to the original savings calculations to determine verified energy savings for the associated ECMs. Spot or short-term measurements and observations of post-retrofit operation should provide the inputs to the assumptions originally used in the savings calculations, so that accurate (verified) savings associated with the actual operation of the measures can be calculated. The measurement plan and process to apply the results to the verified savings calculations should be documented in the M&V Plan and adhered to for these efforts.

As with the original savings calculations, all inputs and assumptions should be transparent and well documented through data analysis, pictures, BMS screenshots, or other resources used to inform the verified savings calculations.