STREET LIGHTING PROTOCOL

VERSION 1.0 – MAY 2018

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TABLE OF CONTENTS

THE INVESTOR CONFIDENCE PROJECT

The Investor Confidence Project (ICP) is a global initiative that focuses on increasing energy efficiency deal flow by ensuring that projects are engineered robustly, financial returns are predictable, and project underwriting can be streamlined. The ICP system is comprised of the ICP Protocols and the Investor Ready Energy Efficiency™ Certification which offer a standardised roadmap for project developers, a market tested methodology for programme administrators, and a certification system for investors and street lighting system owners to accurately and efficiently manage project risk.

ICP is administered by Green Business Certification Inc. (GBCI) and was conceived, incubated and developed by the Environmental Defense Fund (www.edf.org).

For more information, please visit:
ICP North America (www.eeperformance.org) or ICP Europe (europe.eeperformance.org)

INVESTOR READY ENERGY EFFICIENCY™

Investor Ready Energy Efficiency™ (IREE) is a certification awarded to retrofit projects that conform to the requirements of the ICP Protocols, were originated under the direction of ICP developers, and certified through independent review by an ICP Quality Assurance Assessor. IREE projects provide investors, street lighting system owners, and other stakeholders with a new level of confidence in project quality.

Investor Ready Energy Efficiency™ Certification occurs after completion of project design and engineering, but prior to construction.

Development of an ICP compliant project includes the following two periods:

- **Certification Period** (pre-IREE Certification). The Certification Period includes all procedures and documentation associated with project development that occur prior to construction. This includes the development of plans (such as the OPV, OM&M, and M&V plans) that describe the tasks and documentation that will be performed during the Performance Period.
- **Performance Period** (post-IREE Certification). The Performance Period refers to the construction and post-construction (post-retrofit) period after IREE Certification is achieved. The ICP Protocols require certain procedures and documentation that occur during the Performance Period which are specified in various plans that are developed during the Certification Period. These plans, and the requirements identified in them, should be explicitly required by the investor or street lighting system owner to be included in the project developer's scope of work and contract. If necessary, the services of the Quality Assurance Assessor or other third parties may be retained during the Performance Period to

oversee implementation.

ICP Street Lighting Protocol

To conform to the ICP Protocols, projects must meet the specified procedural and documentation requirements detailed in this document. In order to ensure the protocol requirements optimally fit the project, it is crucial that the project developer selects the correct ICP Protocol. This protocol covers the energy associated with both controlling, powering and lighting the luminaire, and with energy associated with providing additional functionality such as WiFi connectivity.

Where Energy Service Companies (ESCOs) are involved in developing projects, they must meet any national requirements or certifications for ESCOs.

Additional resources to this protocol include:

- **Project Development Specification** is the reference guide for all ICP Protocols and includes detailed explanations of the requirements as well as supporting references and tools.
- **ICP Protocol Glossary** defines industry terminology found in the ICP Protocols.
- **ICP Acronym Dictionary** defines the various industry acronyms.
- This document also makes use of tool-tips to provide context and information associated with various terms and requirements.

Global Standards And References

Throughout this document, reference is made to European and international standards, guidance and resources when relevant to protocol requirements. Resource references are shown in *italics*. Where a relevant national standard, guidance or resource is available, this may be used as an optional alternative resource to the European or international standard, provided it can be demonstrated that it meets ICP requirements.

ICP Project Framework

The ICP Protocols are structured based on five project lifecycle phases that represent the entire lifecycle of a well-conceived and well-executed energy efficiency project. For each phase, the protocol establishes minimum requirements for:

- **Procedures** - specific tasks to be performed during the certification period.
- **Documentation** - required documentation supporting procedures, calculations, as well as plans that specify procedures to be executed in the performance period.

1.0 BASELINING

The baselining efforts involve the development of a baseline and collection of all the information needed to perform the tasks associated with the savings calculations, economic analysis, and development of plans for the performance period. Under a best practice approach, the starting point for any energy efficiency project is an energy audit (which may or may not include a physical site survey depending on the asset information available), following the requirements set out in *EN 16247-1 Energy audits - General requirements and ISO 50002 Energy audits - Requirements with guidance for use*.

The baseline must establish how much energy the street lighting system being upgraded can be expected to use over a representative time period. This should cover all energy consumed within the measurement boundary.

The baseline model may need to be normalised by factoring in the impact of independent variables such as hours of operation and changes to illuminance levels. Where demand charges or time-of-use pricing are in effect, load profiles must be provided to show the pattern of daily demand and incorporated annual adjustments.

Two approaches to baselining and M&V are permitted under this protocol.

1. IPMVP compliant measurement-based approach - Options A, B or C may be appropriate
2. Deemed savings - where reliable asset information is used to develop energy consumption estimates

Under an IPMVP compliant approach, in selecting an appropriate measurement boundary, the practicalities of collecting explanatory variable data to give a sufficiently accurate baseline model should be considered. For example, supporting data may be collected by a Central Management System (CMS) installed as part of the project.

Guidance on developing baselines can be found both in *EVO 10000 – 1:2016, IPMVP Core Concepts* and *ISO 50006:2014 Energy Management Systems – Measuring Energy Performance Using Energy Baselines and Energy Performance Indicators.*

1.1 PROCEDURES

Selection of baselining approach

A measurement-based approach is the most robust approach to evaluating the performance of energy efficiency street lighting projects. However, where a deemed savings approach is to be used - for example, where there is no energy monitoring system installed, or billing is based on deemed energy consumption - written justification must be provided.

Measurement-based approach

1. **Collect asset information.** Determine the extent of the street lighting system which relates to the physical scope of the proposed project, and use plans and drawings, utility asset registers and physical inspection as necessary. This information will be referenced in any future

adjustments to the street lighting system or assets that may be made.

2. **Work with the M&V specialist to define the measurement boundary** which will vary depending on the nature of the of the ECM(s) and the presence of other energy-consuming equipment in the street lighting system. The boundary should be set to be wide enough to capture the full extent of the energy changes caused by the ECMs, including any changes in ancillary energy consumption. In practice, for systems containing these ancillary components, meeting the statistical validity requirement described later in this section is likely to require the collection of data on independent variables that explain variations in energy use. Selecting a measurement boundary that is too broad - within which too many independent variables have a significant effect on variation in energy use - may make it impractical to achieve the statistical validity requirement. However, the ability to narrow the measurement boundary may be limited by the practicality of integrating metering into the street lighting system (for example, to isolate energy consumption by lamps from the consumption of ancillary equipment mounted on the same pole.) The M&V specialist must advise on the optimum measurement boundary based on the principles outlined in the IPMVP.
3. **Establish the baseline period** such that at least one full energy-use cycle is represented. For most street lighting systems that use a timer or daylight sensing regime to control hours of operation, a complete energy use cycle will be one year, but it is likely that energy readings at greater resolution (e.g. monthly) will be needed in order to meet the requirements of IPMVP. The baseline period should occur immediately prior to the deployment of the ECM(s).
4. **Collect electricity consumption data, independent data, and utility rate schedules** for all electricity consumption entering or leaving the defined measurement boundary to inform baseline and savings calculations. Data to gather should include:
   a. **Historical energy use**: Collect energy use data for all electricity inputs to the measurement boundary with a goal of accounting for 100% of electricity consumption. If electricity bills are based on estimated meter consumption, meter readings should be taken directly (manually or automatically).
      i. These data should be used as the basis for an analysis that is adherent with the requirements of IPMVP.
      ii. Frequency of data collected should be sufficient to meet the modelling criteria set out below.
      iii. Either exclude or adjust the baseline accordingly to account for any data which is not representative of typical operating conditions (for example, due to burn-outs).
   b. **Independent variable data**: For the defined baseline period and where relevant to explaining variation in energy use within the measurement boundary, acquire relevant independent variable data (such as number of burn-outs) for the defined baseline period chosen, where required, for an accurate regression model.
5. **Collect baseline operational/performance data:** Acquire system performance data used to inform the solution design and energy savings calculations (e.g. lux levels, timing and dimming regimes). These data may be collected through inspections/surveys, reviews of system documentation (up-to-date equipment inventories, technical specifications for equipment, site drawings, condition surveys, power distribution diagrams, control or

operation descriptions, etc.), observations, and short-term field monitoring or measurements. The collection procedure should follow the requirements set out in *EN 16247-1 Energy audits - General requirements* and *ISO 50002 Energy audits - Requirements with guidance for use*. This information will be referenced in any future adjustments to the assets that may be made.

6. **Calendarise the independent variable data** to the same time interval that aligns with the defined baseline period. Refer to PDS for guidance on partial month billing data calendarisation.
7. **Use energy end-use breakdowns** to create boundaries and reality checks associated with energy savings estimates and total energy consumption of the baseline case. Where available, sub-metering can be used to assess the energy consumption associated with each end-use (e.g. lighting, WiFi functionality) and the anticipated ECMs, or calculations can be performed to estimate energy end-use. As a minimum, energy consumption must be broken down into street lighting related energy consumption and ancillary energy consumption.
8. **Establish the energy-use characteristics of the equipment which is within the measurement boundary**, broken down into load and hours-of-use components, and whether these components may be considered constant or variable. Sources of information should include equipment inventories and operating performance, and should be consistent with calculated energy end-use consumption.
9. **Develop the baseline energy consumption model** which describes the relationship between the actual baseline energy consumption data and the appropriate independent variables. Where regression modelling is required, use the methodology described in *ISO 50006:2014 Energy Management Systems – Measuring Energy Performance Using Energy Baselines and Energy Performance Indicators (Annex D)*.
10. **For regression models, perform model sufficiency test** to an accuracy of achieving an appropriate goodness of fit of energy data variability to independent variables according to *IPMVP's Statistics and Uncertainty for IPMVP 2014*. Assessment of R^2 values should only be used an initial check. Any candidate model 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).* In the event that this criteria is not met, consider alternative approaches including more precise measurement equipment, more independent variables in the mathematical mode, larger sample sizes, or an IPMVP Option that is less affected by unknown variables.

Deemed savings approach

1. **Collect asset information**. Determine the extent of the street lighting system which relates to the physical scope of the proposed project, and use plans and drawings, utility asset registers and physical inspection as necessary. This information will be referenced in any future adjustments to the street lighting system or assets that may be made.
2. **Define the project boundary** for which savings will be calculated.
3. **Develop a project inventory for the fixtures and associated technology undergoing replacement.** Assess the number of each type of equipment, including any fixtures which are

not operational, and establish the associated power consumption for each piece of equipment. Conduct on-site measurements using a sampling approach (refer to *IPMVP's Statistics and Uncertainty for IPMVP 2014).* Where this is not possible, power consumption should be obtained from manufacturer's data. In the absence of either of these sources of data, nationally recognised reference documents may be used - refer to the PDS for guidance.

4. **Calculate estimated total annual operational hours** under baseline operation for each type of equipment. These should be based on a nationally recognised approach and must account for any effects which impact on the hours of operation, such as local sunrise and sunset times and burn-outs. If a nationally recognised approach, does not exist, either use on-site measurement of operating hours for a representative period to establish hours of operation, or refer to the PDS for guidance.
5. **Calculate the estimated power consumption** under baseline operation according to the appropriate power consumption and hours of operation for each piece of equipment within the project boundary.
6. **Calculate the estimated annual baseline energy consumption** by multiplying the annual operating hours by the power consumption for each type of equipment within the project boundary.
7. **Cross-check the baseline energy consumption** with measurements by taking spot measurements using a sampling approach (refer to *IPMVP's Statistics and Uncertainty for IPMVP 2014)*, and/or comparing results with existing nationally recognised information databases, such as inventories and charge codes used for billing purposes. Where the deviation between the final calculated energy consumption baseline and the comparison data is greater than 10%, justification for this difference must be provided.
8. **Clearly document** all sources of information, calculations carried out, and the results of the cross-checking exercise.

All approaches

1. **Establish peak demand and pricing** (where peak demand pricing is in effect), based upon hourly data as a minimum. Where hourly data are not available, explain why, and describe any potential impacts this may have on the baseline and savings calculations as well as how these issues will be addressed.
2. **Chart average daily demand** (where demand charges or time-of-use pricing is in effect) in 15-minute intervals (maximum available frequency if 15-minute is not available) with time on the x axis and kW on the y axis for typical weekday and weekend days in the spring, autumn, winter, and summer.

1.2 Documentation

Selection of baselining approach

- Statement of basis for the baselining approach selected.

Measurement-based approach

- Full energy data as a computer-readable file, including:
    - Raw meter readings should include from-date and to-date, energy-unit value, energy use charges, demand quantities and demand charges. The duration of the energy data should match the defined baseline period. Local currency should be used.
    - Provide a brief description of how periods are consolidated to the integer years/months periods applied. Dates of meter reading periods will vary from one energy source to another.
- The start and end dates of the baseline period and why that period was chosen. Provide a brief description on how the baseline period has been selected, and how the independent variable(s) relate to the energy-use cycle.
- All data used in the regression analysis, such as hours of darkness or traffic data, corresponding to the baseline period.
- All analysis carried out on the baseline data including outcomes of the model sufficiency and statistical validity tests

Deemed savings approach

- Inventory list for all equipment contained in the project boundary.
- Details of power consumptions related to all equipment contained in the project boundary, including sources of information.
- Details of all calculations relating to annual operational hours and total annual baseline energy consumption, including the results of the cross-checking exercise described in section 1.1.

All approaches

- A summary of the street lighting system equipment, including any energy uses which are not associated with lighting the luminaire, where relevant to the proposed ECMs.
- As appropriate for recommended upgrades, include system or equipment drawings, equipment inventories, system and material specifications, field survey results, observations, short-term monitored data, spot measurements, and functional performance test results.
- Utility rate structure as published by the utility including a breakdown of distribution costs, demand charges, taxes, and time-of-day variability for each of these elements.
- Copies of at least one bill, or equivalent data, preferably in a machine-readable format, including the description of the tariff structure and any fixed charges.
- List of project-specific routine adjustment factors to be included in the M&V Plan.

2.0 SAVINGS CALCULATIONS

Calculations of estimated savings for projects using this protocol must be based on transparent calculation methods or tools. All savings calculations must be based on sound engineering methods, and be consistent with the following core principles, whether a deemed savings approach or a measurement-based approach is being undertaken: best practice, accuracy, completeness, conservativeness and transparency.

The starting point for a street lighting project is the design of a lighting solution suitable for the street scene. The design of a street lighting upgrade project - particularly with regard to illuminance levels and the specification of suitable lamps without over-lighting - has a major bearing on energy consumption. Steps should be taken to ensure that the opportunity for achieving energy savings is maximised through the design of the solution. As a minimum, the proposed street lighting solution should be designed by a qualified professional (see section 2.1). The designer should reference the *EU Green Public Procurement Criteria for Street Lighting and Traffic Signals* and *EN 13201: Road lighting* as comprehensive resources for the best practice design and specification of street lighting projects.

Table 1 below illustrates the energy using components that may comprise a typical ECM, and gives examples of ancillary components that may also be found in an upgraded street lighting system. Such additional functionality is permitted where the load is predictable and does not form a significant part of the total energy consumption.

Table 1 - Illustration of typical street lighting ECMs and ancillary equipment

Energy use	Equipment
Typical street lighting equipment	Controls including timing and dimming
	Sensors including presence detection and light level detection
	Central management system (CMS) and associated communications modules
	Ballasts or drivers
	Lighting fixtures
	Power supply including cable losses
Typical ancillary equipment	WiFi hotspots
	Mobile phone cell sites
	Low power wireless networks
	Public information systems

	Sensors (e.g. pollution monitoring, traffic management)
	Other non-lighting-related ancillary load

The results of the savings calculation process should also be calibrated to estimated or known energy end-use consumption. Energy savings calculations must be developed using open source tools. However, supporting calculations may require the use of proprietary tools. Where these are used, the documentation must include history of previous use, detailed description of the calculation methodologies and assumptions used by the tool, as well as papers, studies or documentation demonstrating the technical rigour of the tool and methodologies employed.

In addition to the development of ECM savings calculations, other elements necessary to prepare an investment package must be documented here. This will necessitate detailed design work and coordination to allow fixed prices to be generated.

Under a measurement-based approach, once the savings calculation process is complete, if there has been a substantial change to the magnitude of the expected energy saving compared to initial estimates, it may be necessary to revisit the measurement boundary during the certification period (section 1.0). For example, if the expected saving is smaller than originally anticipated, the proposed baseline may no longer adhere to the statistical validity principle explained in section 1.1 (and EVO 10100 – 1:2014, *Statistics and Uncertainty for IPMVP*, section 1.2). This may necessitate the selection of a different measurement boundary, collection of more data on independent variables, or selection of an alternative IPMVP Option.

2.1 PROCEDURES

1. **Develop initial savings estimates** by comparing the current system to the specifications of the proposed ECMs. If this information is not yet available, compare to industry best practice, or use benchmarking data, input from system operators or empirical observations from existing projects. Ensure any ancillary equipment or functionality proposed as part of the investment package to be certified has a predictable load profile, and/or does not form a significant part of the total predicted energy consumption.
2. **Establish preliminary cost estimates** for each ECM under consideration. Initial quotes may be obtained from the contractor(s). Alternatively, cost estimates may be based on the engineer's experience with previous projects, detailed conceptual estimates, nationally recognised sources of cost estimating data, general contractor quotes or other sources.
3. **Ascertain the preferred financial analysis metrics** and criteria of the investor (or owner) in order to evaluate ECMs. Metrics may include simple payback period (SPB), return on investment (ROI), internal rate of return (IRR), net present value (NPV), cash-flow analysis, and/or savings-to-investment ratio (SIR). While energy savings (avoided utility costs) may be the primary source of financial returns from the project, ensure that other non-energy sources of cost savings or losses are integrated into the investment package, where these can

be feasibly and unequivocally translated into monthly cash flows, and documented accordingly. This must include avoided equipment maintenance costs. Where required by the investor, carry out sensitivity analysis to assess the impact of variations in critical variables (e.g. hours of operation) on the predicted savings.

4. **Develop a set of recommended ECMs** and select ECMs that are likely to achieve the investment criteria and the required design output. Under a best practice approach, this will be based on the results of the energy audit, as well as on the experience of the engineers involved, lighting design specialist, system owner preferences, observed condition and operation of existing systems, preliminary calculations, and contractor recommendations. Where an energy audit is being carried out, and if national requirements exist for individuals or organisations conducting energy audits, then these requirements must be met.
5. **Develop detailed energy savings calculations:**
   a. **Choose an individual to perform energy savings calculations with one of the following:**
      i. Nationally/Internationally recognised energy savings calculation certification, **or**
      ii. At least three years' experience in developing energy savings calculations, documented in the form of a CV outlining relevant project experience.
   b. **Use open-book methods** such as spreadsheets, or commercially available or in-house methods.
   c. **Under a deemed savings approach**:
      i. **Develop a project inventory** for the proposed ECMs which includes the number of items and the estimated power consumption under proposed operation, following the requirements set out in section 1.1.
      ii. **Estimate the total annual operational hours** under the proposed operation for each piece of equipment within the measurement boundary, following the requirements set out in section 1.1.
      iii. **Calculate and document the estimated annual performance period energy consumption.**
   d. **Under a measurement-based approach, prepare input values** using on-site observations, measured data, and input from equipment suppliers, engineering or maintenance teams and any other relevant specialists.
      - Prepare calculations in a readily readable and usable form based on system documentation including plans, equipment inventories, field confirmations, observations and tests.
      - Hourly energy consumption data should be used as the basis for calculations, unless it can be demonstrated that this is not relevant to the development of energy savings calculations. Where hourly data is not available, the maximum frequency of data that is available should be used, in conjunction with a suitable calculation approach which compensates for this lower resolution of data.
   e. **For all approaches:**
      - Document calculation processes, formulas, as well as assumptions used and their sources.
      - Where inputs must assign efficiencies, rates, and other values that are not readily

measurable, the basis of such assignments must be clearly stated.

- Identify equipment part-load profiles, operating conditions and associated efficiencies.
- Confirm operating schedules for hours of operation, seasonal variations, and zone variations.
- Disclose and describe inputs/outputs (identify and document defaults versus assumptions) including those from any companion tools (e.g. load calculators, field testing) used to create inputs for the savings calculations.
- Refer to IPMVP guidance and EN 16212:2012 Energy Efficiency and Savings Calculation, Top-down and Bottom-up Methods (section 6) for detailed guidelines for calculation methods and best practices.
- Where third-party proprietary calculation tools are used for supporting calculations, sufficient documentation must be included to validate unbiased assessment of energy savings estimates. The documentation should allow a Quality Assurance Assessor of reasonable skill and relevant experience to trace the projected saving back to the physics of the underlying system.
- Screening tools are an acceptable method for preliminary consideration of measure applicability, but must not be used as a substitute for detailed calculation methods.

f. **For each ECM, calculate the individual energy savings performance and cost effectiveness.** Clearly document the calculation methodology, formulas, inputs, assumptions and their sources.

6. **Provide a statement of the energy prices** used to establish the monetary value of the savings. This conversion from energy savings to cost savings must be based on the appropriate local utility rate schedule in effect at the time.
7. **Evaluate economics of each ECM** and package of ECMs included in the bid package.
8. **Obtain a fixed price for implementing each ECM which is based on the necessary detailed design work.** The final documentation package must have pricing based on bids that represent the price for which a contractor has committed to make the improvements.

a. **Where design work is required for the proposed lighting systems, the design must be carried out by an individual with one of the following:**

   i. Nationally/Internationally recognised professional qualification in lighting engineering, or membership of a professional body in the field of lighting design, **or**

   ii. At least three years' experience in designing street lighting systems, documented in the form of a CV outlining relevant project experience.

9. **Develop final investment package for ECMs** selected to be included in the project scope including operation and maintenance costs. Finalise model-based analysis and recommendations based upon pricing from bids received. Any long-term financial analysis metrics should incorporate available data or reasonable assumptions about the through-life performance of the proposed ECMs, taking account of any potential degradation in performance over time.

10. **Prepare a final report summarising ECMs** and compiling all required supporting data. The report must include a summary table with final energy cost savings and pricing for each measure and package of measures.

2.2 Documentation

All approaches

- Qualifications of the person(s) performing the savings calculations.
- Qualifications of the person(s) designing the lighting system, where required.
- ECM savings results, including:
    - The submission of workbooks, spreadsheets and other open-source calculation tools used to develop savings estimates is preferred. However, if this is not feasible, then full details of all outputs should be provided, in addition to the items below.
    - Disclosure and description of inputs (identify and document defaults versus assumptions), including those from any supporting tools (e.g. load calculators, field testing) used to create inputs for the spreadsheet calculations.
    - Calculation process description that, with the necessary input information, would allow a reviewer to reconstruct the calculation including documentation of the formulas used, and assumptions used and their sources.
    - Demonstration that the energy savings results have been calibrated to energy end use breakdown estimates or measurements.
- Where proprietary or third-party software modelling packages are used to support savings calculations:
    - Description of inputs/outputs (identify and document defaults versus assumptions).
    - Proprietary / third party model calculation description that with the necessary input files would allow a reviewer to reconstruct the calculations.
    - Proprietary / third party model input and output files together with information about the software that has been used (including version number).
- Report: Use of an industry-accepted format for reporting of results and for compilation of methods and underlying data is recommended. Refer to *EN 16247-1 Energy audits – Part 1: General Requirements (section 5.6)*
    - Annual predicted energy savings shall be documented in terms of energy units, and as cost savings using the correct marginal rate for that energy type.
- Detailed cost breakdown with line-items for each of the major project elements including all plant, pipework and other ancillaries, civil and other preparatory works, operation and maintenance costs.

Deemed savings approach

- Project inventory related to all proposed equipment contained in the project boundary.

- Details of all calculations relating to annual operational hours and total annual post-retrofit energy consumption.

3.0 DESIGN, CONSTRUCTION AND VERIFICATION

It is important that the teams involved in implementing energy efficiency projects commit to realising the intent of the recommended ECMs accepted by the project owner, as detailed in the investment package. The ICP verification methodology utilises an Operational Performance Verification (OPV) approach to ensure that the individual implemented ECMs were installed correctly and are capable of achieving the predicted energy savings. OPV is a targeted process that focuses specifically on the ECMs involved in the project and differs from traditional Commissioning (Cx) which typically refers to whole system optimisation.

The OPV process involves various methods based on measure type, complexity, and other factors. OPV processes may include visual inspection, targeted functional performance testing, spot measurements or short term monitoring of the installed systems and control sequences.

The OPV effort may be performed by an independent party or by the project developer as long as a Quality Assurance Assessor is providing oversight to these efforts. Procedures performed during the performance period should be specified in the OPV Plan and addressed in the proposal and contract.

3.1 PROCEDURES

1. **Appoint an Operational Performance Verification Resource**: A specified OPV resource shall be named, or provision should be made to appoint a resource, in the OPV Plan who has one of the following qualifications:
    a. Nationally/Internationally recognised commissioning certification, **or**
    b. Three years or more of commissioning experience in street lighting projects, documented in the form of a CV outlining relevant project experience.
2. **Develop a Operational Performance Verification Plan** (pre-construction) that includes:
    a. Procedures to consult with the project developer.
    b. Procedures to verify that the ECMs have been implemented as designed and can be expected to perform as conceived and projected by the energy audit. For simple ECMs, such as luminaire replacement, this usually involves simple methods such as visual inspection or spot checking system operation.
    c. Where appropriate to the nature of the proposed ECMs (e.g. provision of new Central Management Systems), provisions for the development and implementation of a training plan for operators to be conducted at the conclusion of the OPV effort that will train them in the correct operation of all new systems and equipment including how to meet energy performance targets.
    d. Provisions to update an existing Systems Manual (if one exists) at the conclusion of the OPV effort to document the modified systems and equipment and the process and responsibilities for addressing any future operational issues, to be prepared following guidance set out in *EN 13460:2009 Maintenance – Documents for maintenance*. If no

Systems Manual exists, then provisions must be made to provide a full inventory of the installed equipment, as a minimum.

e. Where appropriate to the scale and nature of the proposed project, description of a simple OPV report to be developed at the conclusion of the OPV effort that will detail activities completed as part of the OPV process and include significant findings from those activities.

3.2 Documentation

- Qualifications of the Operational Performance Verification Resource.
- Operational Performance Verification Plan.

4.0 OPERATIONS, MAINTENANCE, AND MONITORING

Operations, Maintenance, and Monitoring (OM&M) is the practice of systematic monitoring of energy system performance and implementing corrective actions to ensure "in specification" energy performance of ECMs over time. Good OM&M processes involve a proactive strategy for maintaining required lighting levels while optimising energy performance. Procedures to be performed during the performance period should be specified in the OM&M Plan and addressed in the proposal and contract.

4.1 PROCEDURES

1. **Select and document ongoing management regime** such as either periodic inspection, or remote management and monitoring systems.
2. **Develop an Operations, Maintenance and Monitoring Plan** (pre-construction) that includes:
    a. A description of the OM&M management regime to be selected. If a monitoring-based approach to OM&M is to be utilised, identify and document the number of points, interval and duration to be monitored by the selected monitoring system. The monitoring regime should involve such measurements as necessary to verify the ongoing performance of the system according to its design.
    b. Defined roles and responsibilities of the OM&M staff and plans for issue resolution and preventative (or predictive) maintenance.
        - Develop an organisational chart establishing contact information for all personnel involved in ongoing commissioning process and clear internal responsibility for the monitoring and response activities.
    c. Provisions for the appointment of suitable installers of the proposed equipment, with either a relevant professional qualification or membership, or at least three years' experience in the installation of street lighting systems.
    d. Where appropriate to the nature of the proposed ECMs (e.g. provision of new Central Management Systems), provisions for the development and implementation of a training plan that will be conducted for operations and maintenance staff and service providers on new/modified equipment, management and monitoring software, and reporting regime. This training is to be conducted at the conclusion of the OPV effort and can be combined with the training described in the OPV section. Refer to *CIE Technical Report 154:2003: The maintenance of outdoor lighting systems* for guidance.
    e. Description of the process to develop performance verification criteria based on the OM&M regime(s) selected.
    f. Provisions for the development of an Operator's Manual (related to, for example, any new Central Management System) if one exists. This will target the new systems and their operation, including assignment of responsibilities for communication of performance issues and implementation of corrective action.
    g. Provisions for the development and execution of instructions to notify affected stakeholders of the project's implemented energy reduction improvements and

descriptions of any associated best practices or recommended behaviour modifications.

4.2 Documentation

- Operations, Maintenance and Monitoring Plan.

5.0 MEASUREMENT AND VERIFICATION

Measurement and Verification (M&V) activities evaluate the energy savings achieved in practice and are crucial to understanding the efficacy of energy efficiency measures and projects. Prior to investment decision-making (e.g. as part of contract development and investment due diligence), an IPMVP-adherent M&V Plan or a compliant deemed savings methodology for the street lighting improvement project must be developed and specified to ensure that reliable accounting methods for energy savings are in place.

Measurement-based approach

The M&V procedures for this approach are consistent with the methods outlined in *EVO 10000 – 1:2016, IPMVP Core Concepts-2016* Option A (Retrofit Isolation: Key Parameter Measurement), Option B (Retrofit Isolation: All Parameter Measurement) and/or Option C (Whole Facility). Alternatively, projects may also follow an M&V approach which is compliant with *ISO 17741: 2016 General technical rules for measurement, calculation and verification of energy savings of projects.*

The pre-retrofit baseline of the energy using system(s) within the measurement boundary defined in the Baselining section of this protocol is used as the starting point for M&V calculations. The approach requires the following adjustments to baseline energy use:

1. **Routine adjustments**: Account for expected changes in energy use.
2. **Non-routine adjustments**: Account for unexpected changes in energy use due to factors other than the installed ECMs.

This adjusted baseline represents what the baseline energy use would have been if the project ECMs had never been installed, under the same set of post-retrofit conditions. Realised savings are then determined by comparing this adjusted pre-retrofit baseline energy use model with the actual post-installation energy use of the system(s) within the measurement boundary. In the case of Option A, some of these parameters are estimated rather than measured. The energy savings are verified through comparison of the pre- and post-retrofit energy performance of the system(s).

Selection of an IPMVP Option should take place as part of the Baselining stage and further details can be found in section 1.0 of this protocol. Option selection will depend on the magnitude of the expected energy savings relative to the variability of the baseline energy data, and the practicalities associated with collecting data on independent variables that explain variation in energy use within the measurement boundary. Refer to IPMVP documentation for guidance on selecting the most appropriate Option for an ECM.

The M&V effort may be performed by an independent party or by the project developer as long as a Quality Assurance assessor is providing oversight to these efforts.

Deemed savings approach

The pre-retrofit baseline for a deemed savings project is the **estimated annual baseline energy**

consumption (see section 1.0)**,** calculated by multiplying the annual operating hours by the power consumption for each type of equipment within the project boundary.

Post-upgrade energy consumption is estimated via an equivalent calculation for the system once the energy efficiency project has been implemented, replacing the power consumption for each piece of equipment and estimated annual operational hours with their new post-upgrade values.

The realised energy savings are given by the following calculation:

Energy savings (kWh) = Estimated annual baseline energy consumption MINUS Estimated post-upgrade energy consumption

The underlying data used in this calculation must be collected, recorded and retained according to the procedures described in 5.1, below. However the deemed savings approach does not need to be carried out by a qualified M&V professional.

5.1 Procedures

Measurement-based approach

The M&V efforts must fully comply with applicable sections of IPMVP Core Concepts-2016 Option A,B or C.

1. **Appoint an M&V Professional** during the certification period who meets one of the following sets of requirements:
    - Association of Energy Engineers (AEE) Certified Measurement & Verification Professional (CMVP) certification, **or**
    - At least three years of demonstrated M&V experience documented in the form of a CV outlining relevant project experience
2. **Develop an IPMVP based M&V plan** as early in the project development process as possible that adheres to the *IPMVP Core Concepts-2016, Section 7.1*.
3. **Provide the M&V Plan, input data sets, assumptions and calculations** to all parties in an efficiency project and any commissioned or independent reviewers.

Deemed savings approach

Develop a deemed savings plan, documenting the planned process for establishing the deemed energy savings after installation of the ECMs, following the process set out below:

1. **Verify asset information**. Ensure that as-installed data and material specifications/inventories for the physical parts of the system are accurate.
2. **Check the project boundary** for which savings will be calculated.
3. **Review estimated total annual operational hours** under baseline operation. These should be based on a nationally recognised approach and must account for any effects which impact on

the hours of operation, such as local sunrise and sunset times.

4. **Ensure that charge codes have been properly developed,** such that the requirements of the in-force charging regime are met, and in line with the requirements set out in section 1.1.
5. **Check the estimated baseline power consumption** as described in section 1.1.
6. **Verify the estimated post-upgrade energy consumption** by multiplying the annual operating hours by the power consumption for each type of equipment within the project boundary.
7. **Cross-check the post-upgrade energy consumption** with measurements by taking spot measurements using a sampling approach (refer to *IPMVP's Statistics and Uncertainty for IPMVP 2014)*, and/or comparing results with existing nationally recognised information databases, such as inventories and charge codes used for billing purposes.
8. **Calculate** the energy savings according to the equation in 5.0, above.

5.2 Documentation

Measurement-based approach

- M&V Plan adhering to the *IPMVP Core Concepts-2016, Section 7.1*. This M&V Plan should:
  - Contain all elements required by section 7.1 of the IPMVP;
  - Provide all adjustment parameters and formulae for routine and known or expected non-routine adjustments;
  - Define the principles upon which any unknown non-routine adjustments will be based;
  - Contain a full description of the calculation basis of any baseline models used, including whether the resulting model adheres to the IPMVP statistical validity requirement (EVO 10100 – 1:2014, *Statistics and Uncertainty for IPMVP*, section 1.2);
  - Provide a full evaluation of any baseline regression model based on the guidance in EVO 10100 – 1:2014, *Statistics and Uncertainty for IPMVP*, section 2.2;
  - Contextualise the expected savings in terms of statistical confidence and precision, as described in EVO 10100 – 1:2014, *Statistics and Uncertainty for IPMVP*, section 1.1.

Deemed savings approach

- Deemed savings plan, documenting the planned process for establishing the deemed energy savings after installation of the ECMs, following the process set out in section 5.1. This should include all calculations and supporting documents, as described in sections 1 and 2.