TOPIC 1-2

Evaluation, Measurement & Verification (EM&V)

by

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AGENDA PRESENTATION

- Evaluation, Measurement and Verification (EM&V)
  - *Definition and goals*
  - *Principles and approaches*
  - *Methodologies*

- MS ISO 50001: 2011 EnMS
  - *EnMS : Clauses 4.6 definition*
  - *M&V communication*
  - *M&V continual improvement process*

- M&V constraints and solutions
  - *Energy data extraction and analysis*
  - *Personnel competency*
  - *M&V IoT solutions energy architectural*

EM&V Definitions

EM&V is the process of estimating energy, peak demand and emissions impacts from the energy efficiency (EE) policies, programmes, or projects
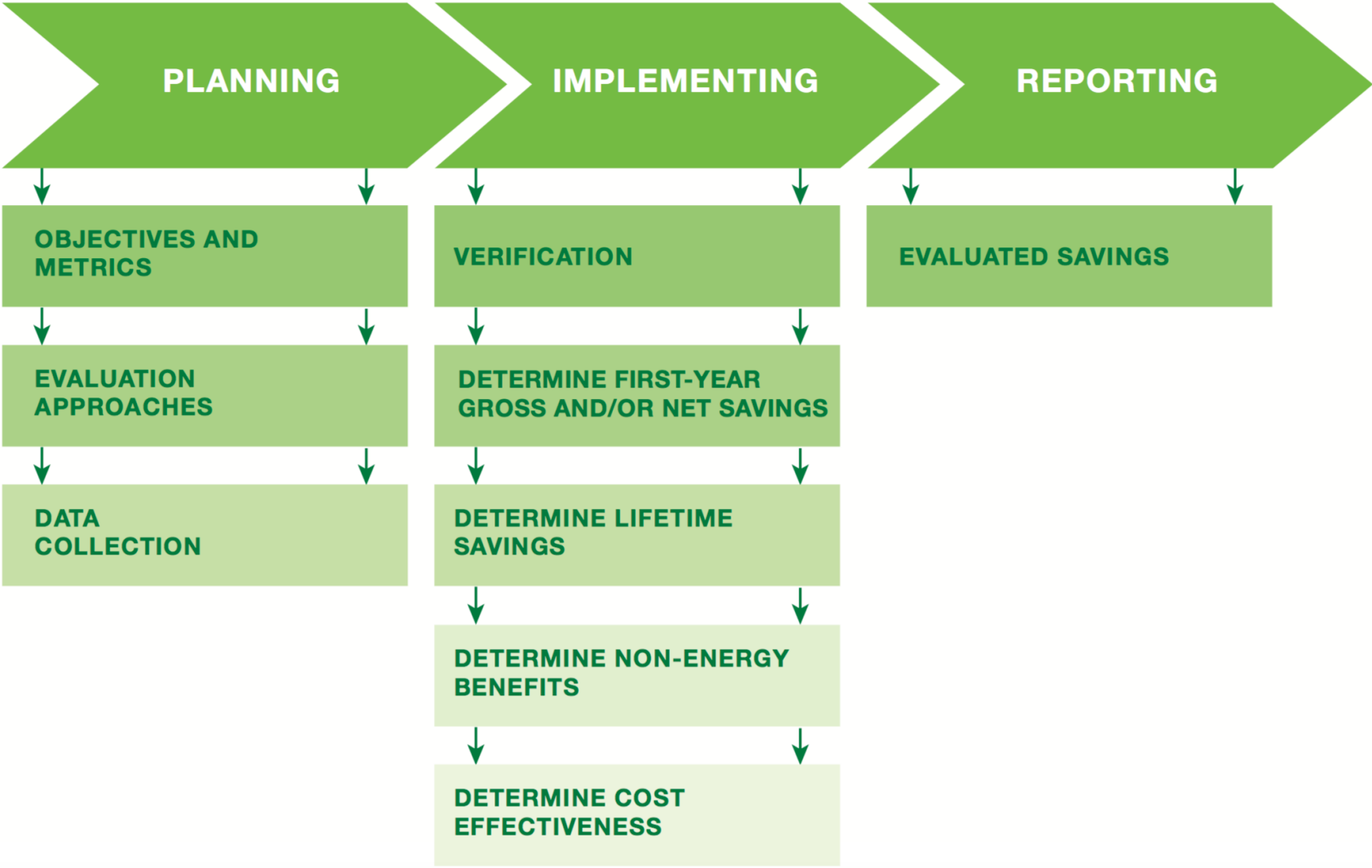
- **Evaluation** refers to a review of the entire program including the implementation process, program cost effectiveness and the stated objective and savings;

- **Measurement** activities include the data collection, monitoring and analysis necessary to document the energy and demand savings and expected costs of the energy efficiency project;

- **Verification** activities occur after a program has been in place for a period of time, typically a year, and seek to validate the savings expected using the data collected from the measurement activities documented for the program.
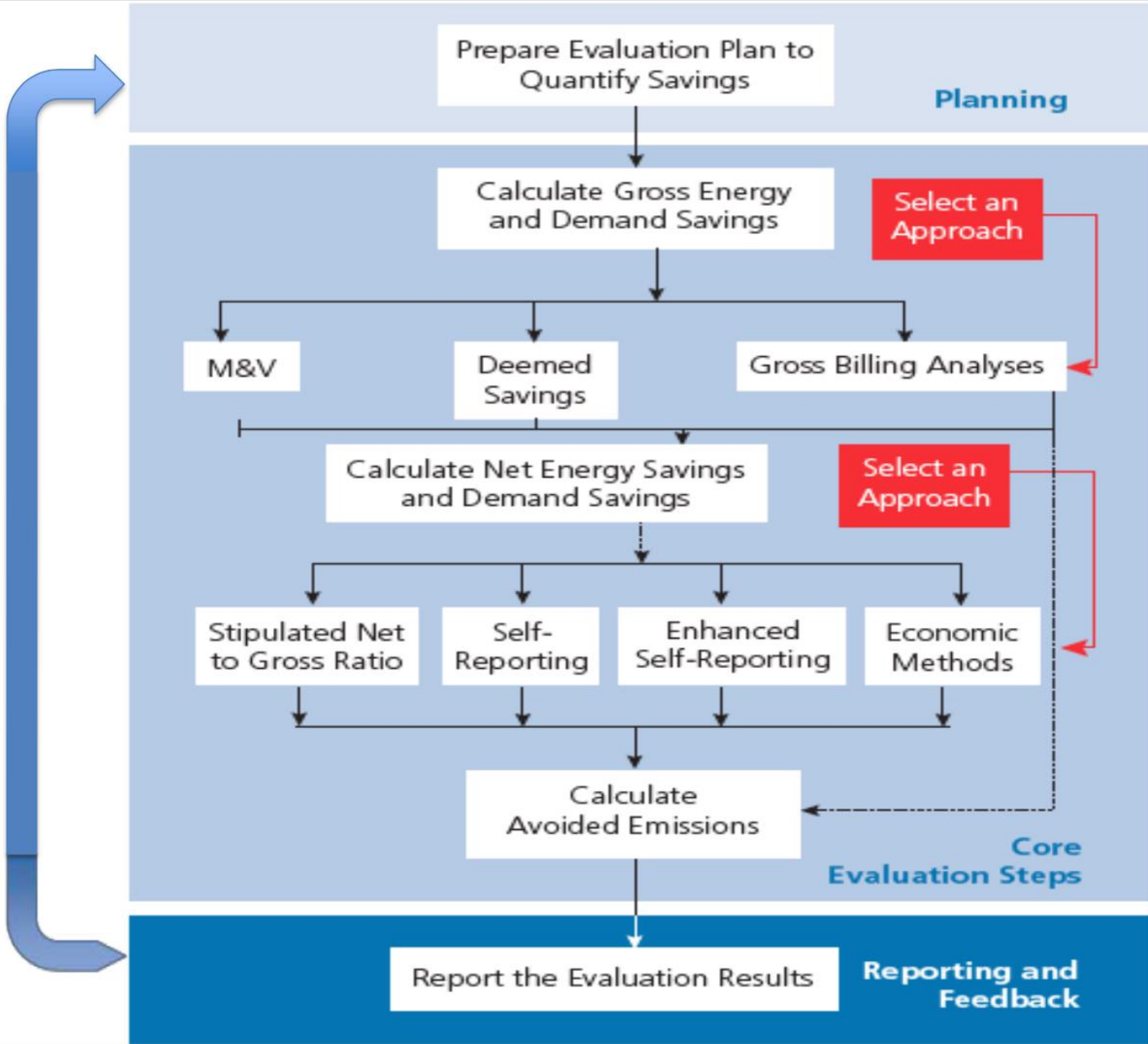
Goals of EM&V

- Determining whether overall objectives are being achieved;
- Identifying any necessary program improvements;
- Assessing program cost-effectiveness;
- Estimating impacts and their persistence over time;
- Capturing energy (kWh) and demand (kW) impacts in energy planning

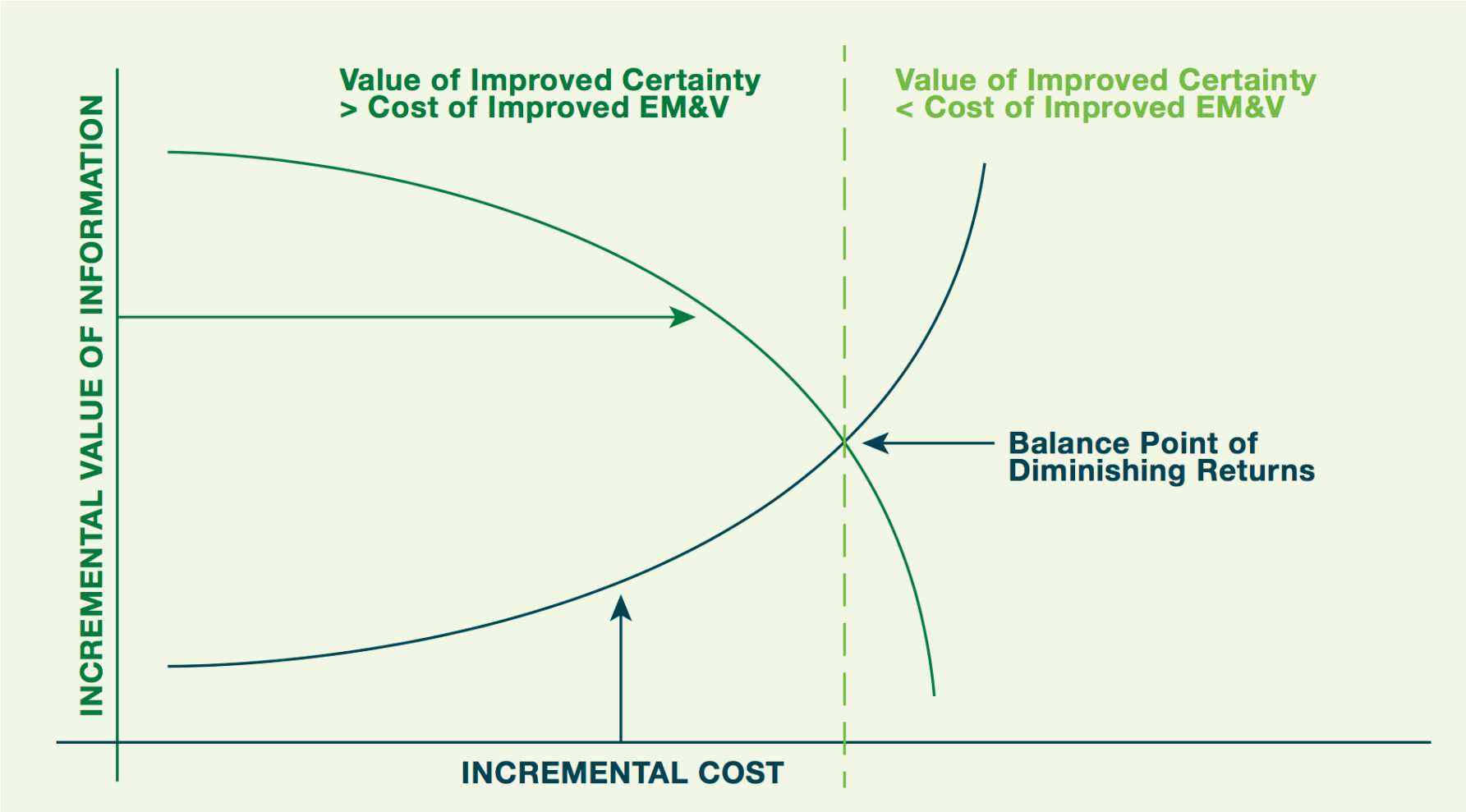| Evaluation Types	Purpose	Information Derived
Impact Evaluation	Quantifies the direct and indirect benefits of a program or project using measured or deemed savings methods.	Determines the quantity of energy and/or demand saved, the monetary value of these savings; can include the amount of emissions reductions and other non-energy benefits.
Process Evaluation	Indicates how to improve the structure and delivery of a program or project. These evaluations typically survey program stakeholders, analyze their feedback, and use this information to identify opportunities for program improvement.	Determines how well program or project processes are performing and provides recommendations for how these systems they can be improved.
Market Effects Evaluation	Indicates how a program affects the structure or functioning of a market – or the behavior of participants in a market – that result from one or more program efforts.	Determines changes that have occurred in state operations and/or private markets, and evaluates how the marketplace is different as a result of the program.

EM&V Functions and Approaches

EM&V Process Flow

EM&V Cost vs Energy Available Information

INCREMENTAL VALUE OF INFORMATION

Value of Improved Certainty > Cost of Improved EM&V

Value of Improved Certainty < Cost of Improved EM&V

Balance Point of Diminishing Returns

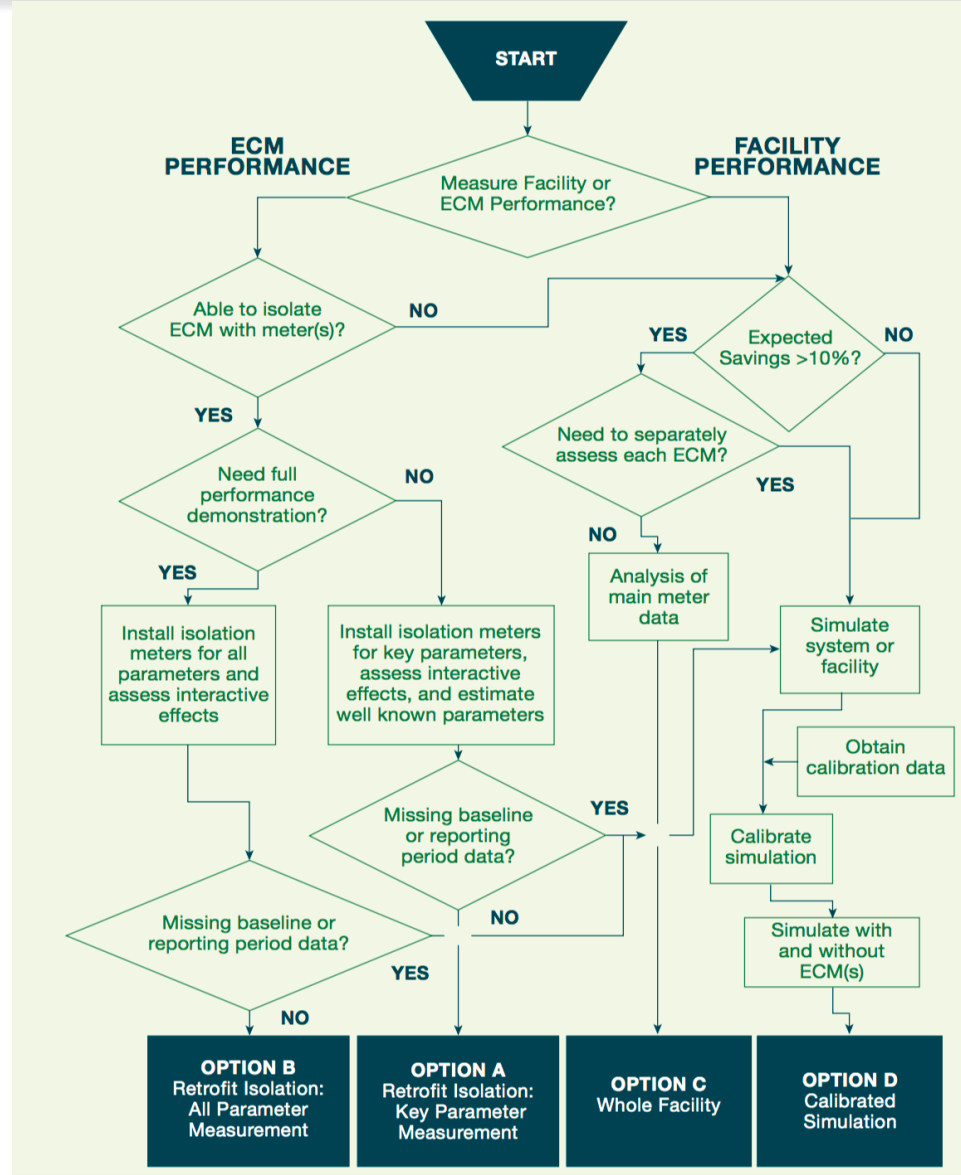**INCREMENTAL COST**

EM&V - Measure Methodologies

Measured Savings Approaches to Impact Evaluation	
Engineering Methods	Standard formulas and assumptions are used to calculate the energy use of the baseline and post-installation energy systems.
Statistical Analyses	Statistical models are used to estimate "before" and "after" scenarios, while taking into consideration changes in weather, facility occupancy, factory operating hours, and other factors that affect energy use.
Computer Simulation of System Performance	Computer models are used to predict the change in energy use after complex, system-wide improvements in energy efficiency are implemented. These models are typically calibrated with actual performance data.
Metering and Monitoring	Baseline and post-installation energy use is directly metered and monitored, while accounting for the non-energy factors that affect energy consumption.
Integrative Methods	Integrative methods combine some or all of the preceding approaches. For example, metering and engineering methods can calibrate computer simulations of baseline and post-installation buildings that receive efficiency retrofits.

IPMVP Protocol
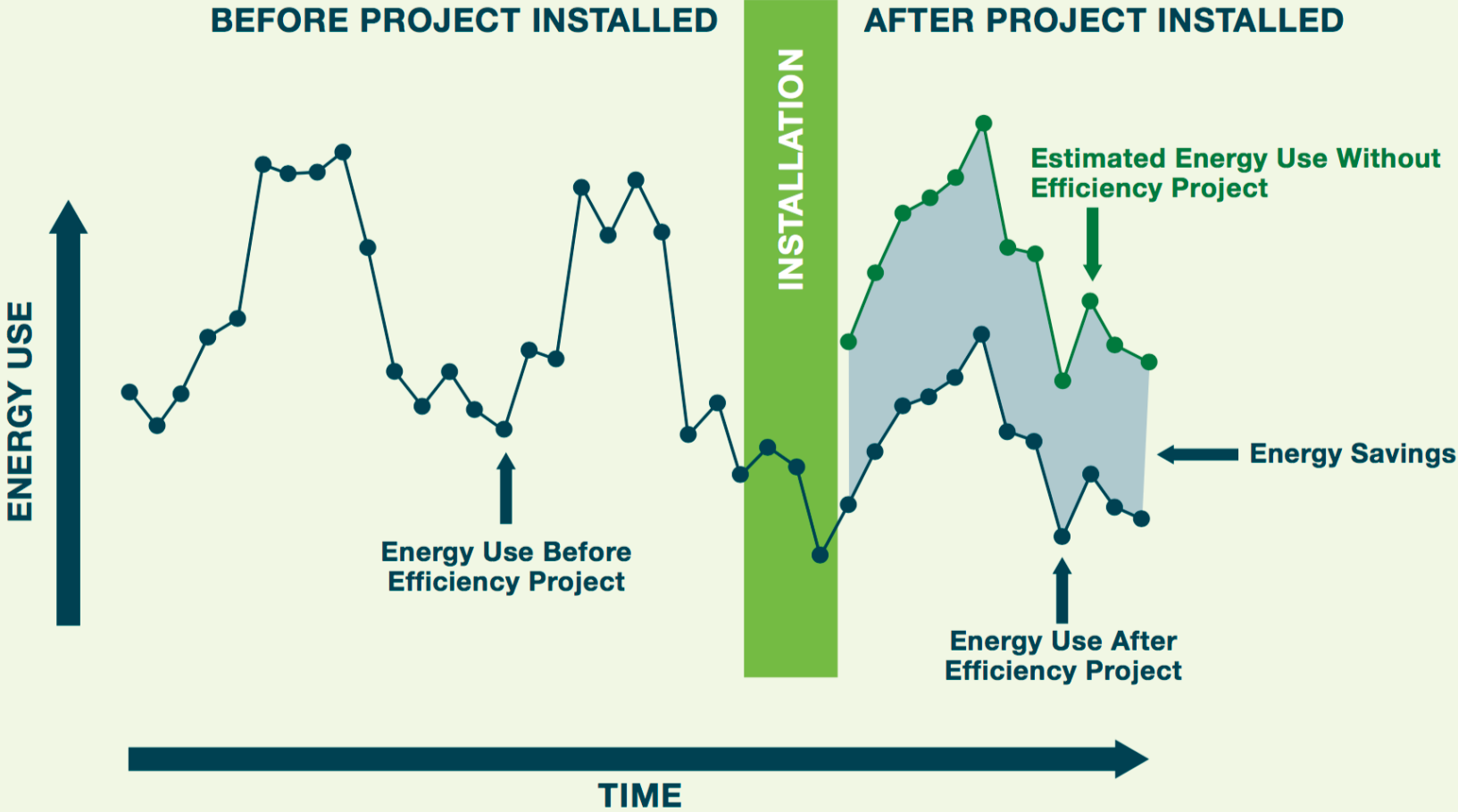
OPTION A Retrofit Isolation – Key Parameter Measurement is best applied where:	OPTION B Retrofit Isolation – All Parameters Measurement is best applied where:	OPTION C Whole Facility is best applied where:	OPTION D Calibrated Simulation is best applied where:
• The magnitude of savings is low for the entire project or for the portion of the project to which Option A is applied • The project is simple with limited independent variables and unknowns • The risk of not achieving savings is low • Interactive effects are to be ignored or are stipulated using estimating methods	• The project involves simple equipment replacements • Energy savings values per individual measure are desired • Interactive effects are to be ignored or are stipulated using estimating methods • Independent variables are not complex	• The project is complex • Predicted savings are large (typically greater than 10%) compared to the recorded energy use • Energy savings values per individual measure are not needed • Interactive effects are to be included • Independent variables that affect energy use are not complex or excessively difficult to monitor	• New construction projects are involved • Energy savings values per measure are desired • Option C tools cannot cost-effectively evaluate particular measures • Complex baseline adjustments are anticipated • Baseline measurement data do not exist or are prohibitively expensive to collect

Source: Efficiency Valuation Organisation (EVO). (2010). International Performance Measurement and Verification Protocol. IPMVP, EVO 10000—1:2010

M&V Options Selection Flowchart

Source: Efficiency Valuation Organisation (EVO). (2010). International Performance Measurement and Verification Protocol. IPMVP, EVO 10000—1:2010

Before and After EM&V Implementation

BEFORE PROJECT INSTALLED

AFTER PROJECT INSTALLED

INSTALLATION

ENERGY USE

Estimated Energy Use Without Efficiency Project

Energy Savings

Energy Use Before Efficiency Project

Energy Use After Efficiency Project

TIME

MS ISO 50001: 2011 EnMS

- *EnMS : Clauses 4.6 definition*
- *M&V communication*
- *M&V continual improvement process*

MS ISO 50001: 2011 EnMS

MALAYSIAN STANDARD

MS ISO 50001:2011

Energy management systems - Requirements
with guidance for use
(ISO 50001:2011, IDT)

ICS: 27.010

Descriptors: energy management systems, requirements, guidance for use

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DEPARTMENT OF STANDARDS MALAYSIA

EnMS - Clauses 4.6

4.6 Checking

4.6.1 Monitoring, measurement and analysis

The organization shall ensure that the key characteristics of its operations that determine energy performance are monitored, measured and analysed at planned intervals. Key characteristics shall include at a minimum:

a) significant energy uses and other outputs of the energy review;

b) the relevant variables related to significant energy uses;

c) EnPIs;

d) the effectiveness of the action plans in achieving objectives and targets;

e) evaluation of actual versus expected energy consumption.

The results from monitoring and measurement of the key characteristics shall be recorded.

An energy measurement plan, appropriate to the size and complexity of the organization and its monitoring and measurement equipment, shall be defined and implemented.

NOTE   Measurement can range from only utility meters for small organizations up to complete monitoring and measurement systems connected to a software application capable of consolidating data and delivering automatic analysis. It is up to the organization to determine the means and methods of measurement.
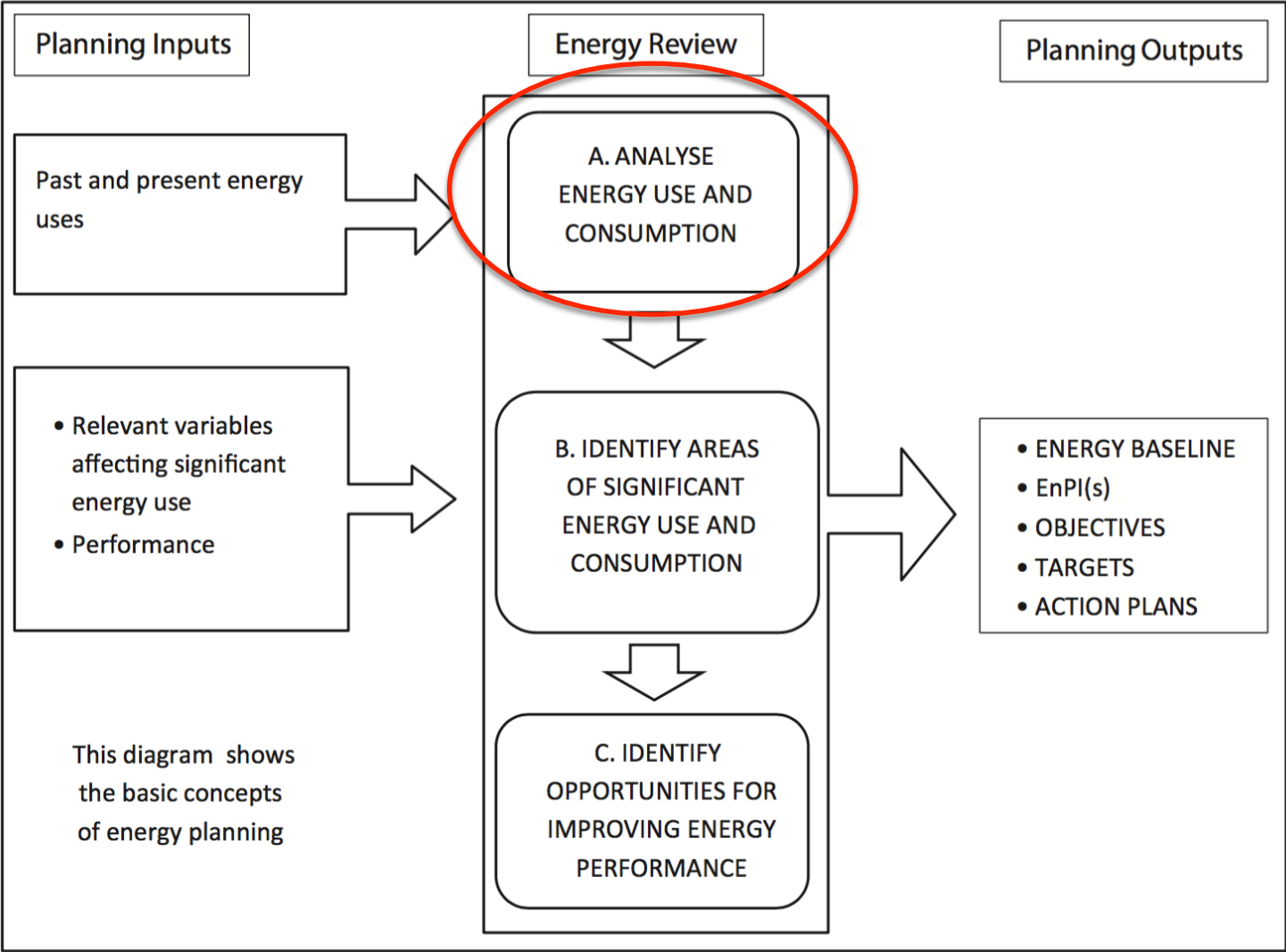
The organization shall define and periodically review its measurement needs. The organization shall ensure that the equipment used in monitoring and measurement of key characteristics provides data which are accurate and repeatable. Records of calibration and other means of establishing accuracy and repeatability shall be maintained.

The organization shall investigate and respond to significant deviations in energy performance.

Results of these activities shall be maintained.

M&V Focus Area

Energy Planning Process

| Planning Inputs | Energy Review | Planning Outputs |

Past and present energy uses

A. ANALYSE ENERGY USE AND CONSUMPTION

- Relevant variables affecting significant energy use
- Performance

B. IDENTIFY AREAS OF SIGNIFICANT ENERGY USE AND CONSUMPTION

- ENERGY BASELINE
- EnPI(s)
- OBJECTIVES
- TARGETS
- ACTION PLANS

This diagram shows the basic concepts of energy planning

C. IDENTIFY OPPORTUNITIES FOR IMPROVING ENERGY PERFORMANCE

EnMS Communication - Clauses 4.5.3

The organization shall communicate internally with regard to its **energy performance and EnMS**, as appropriate to the size of the organization.

The organization shall establish and implement a process by which any person working for, or on behalf of, the organization can make comments or suggest improvements to the EnMS.

The organization shall decide whether to communicate externally about its energy policy, **EnMS and energy performance**, and shall document its decision. If the decision is to communicate externally, the organization shall establish and implement a method for this external communication.

EnMS continual improvement
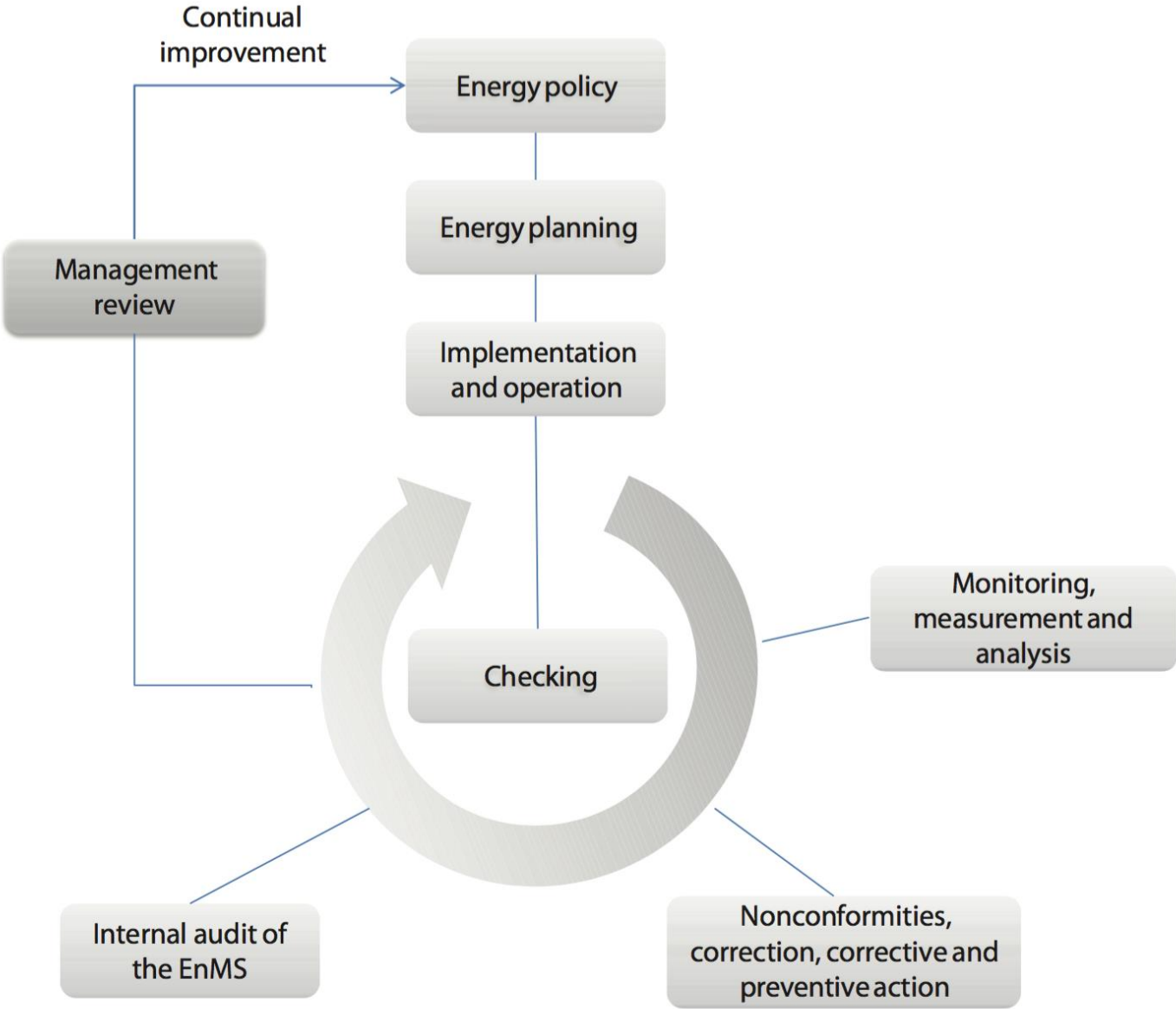
EnMS - Clauses 4.7 : Management Review

Inputs to the management review shall include:

. a) follow-up actions from previous management reviews;

. b) review of the energy policy;

. **c) review of energy performance and related EnPIs;**

. d) results of the evaluation of compliance with legal requirements and changes in legal requirements and other requirements to which the organization subscribes;

. e) the extent to which the energy objectives and targets have been met;

. f) EnMS audit results;

. g) the status of corrective actions and preventive actions;

. h) projected energy performance for the following period;

. i) recommendations for improvement.

EnMS - Clauses 4.7 : Management Review

Outputs from the management review shall include any decisions or actions related to:

. a) changes in the energy performance of the organization;

. b) changes to the energy policy;

. c) changes to the EnPIs;

. d) changes to objectives, targets or other elements of the EnMS, consistent with the organization's commitment to continual improvement;

. e) changes to allocation of resources.

M&V constraints and solutions

- *Energy data extraction and analysis*
- *Personnel competency*
- *M&V IoT solutions energy architectural*

M&V Constraints - Energy data collection for analysis

- No sub energy meter for SEU and only bulk meter from the purchased energy meter;

- Too many sub metering in the facilities;

- Difficulty in understanding the collected energy data;

- Manual energy recording and inaccuracy analysis;

- Energy information ended up in the finance department;

- No one know how to analyse collected energy data;

M&V Constraints - Common Problems in Energy Audit

Reference ASHRAE Journal February 2011

10. Inadequate review (30% of Audits)

9. Overestimated savings (53% of Audits)

8. In adequate billing analysis (57% of Audits)

7. Poor Building description (60% of Audits)

6. Low (or missing) installed costs (60% of Audits)

M&V Constraints - Common Problems in Energy Audit

Reference ASHRAE Journal February 2011

5. Poor improvement selection (63% of Audits)

4. No Life-cycle costing (73% of Audits)

3. Improvement life too long or not provided (73% of Audits)

2. Weak improvement scope (77% of Audits)

1. Missed improvements (80% of Audits)

M&V Constraints - Personnel competency

- No trained energy personnel in organisation;

- Additional task to the primary functions of the personnel;

- No or partial department / ownership in energy monitoring;

- No requirement to carry out the energy reporting beside to Regulator.

M&V Solutions : IoT Solutions Energy Architectural

click view measurements to display all channels (selected among the available ones) on a single page. Also view your data in charts and graphs and save the configurations to use them afterwards.
Control the predisposed instruments' outputs such as X Meter and X R W U with Energy Sentinel Web.

End of Topic 1-2