Establishing a platform to harmonize ISO 50001 energy performance improvement measurement and verification protocols

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Abstract

ISO 50001:2011 requires that organizations demonstrate verifiable improvements in energy performance. To encourage organizations of all levels of complexity and resources to take up the standard, ISO 50001 is flexible and does not specify the method by which an organization must conduct the measurement and verification (M&V) of energy performance improvement and if energy performance improvement must be demonstrated for the facility boundaries or for part of the organization within. This flexibility allows for the valid use of any number of M&V methods. As guidance, ISO 50015 and ISO 50047 together outline a process of measuring and verifying energy performance improvement in the form of normalized energy savings based on a "top down" facility-wide approach. However, these standards are not intended to be used for certification as they do not include specific requirements.

While flexibility in how energy performance improvement is measured and verified is advantageous for individual organizations, the ability to define energy performance improvement in any number of ways is problematic for the purposes of comparing energy savings between organizations, particularly as part of national ISO 50001 based programs. To ensure credibility in reported energy performance improvement, harmonization between M&V protocols used to determine facility wide energy savings for the purpose of demonstrating ISO 50001 energy performance improvement should be based upon ISO 50015 and ISO 50047.

To encourage a dialogue for harmonization of M&V practices, this paper identifies eight key elements for the M&V of energy performance improvement based upon ISO 50015 and ISO 50047 and presents an "ISO 50001 M&V Harmonization Matrix." This matrix expands the eight key elements allowing M&V protocols to specify how to calculate facility-wide energy savings as a metric of energy performance improvement in a harmonized way. The US Department of Energy's Superior Energy Performance Protocol is applied to the matrix as a test case and invitation is made for inclusion of other M&V protocols. By doing so, the process of harmonizing M&V protocols used to determine energy savings as a metric of energy performance improvement resulting from ISO 50001 will move forward, ultimately establishing confidence in reported values.

Introduction

Published in June 2011, ISO 50001 – Energy management systems – Requirements with guidance for use, is an international standard that provides a flexible framework for the implementation of an energy management system (EnMS) for the purpose of continuously improving energy performance (ISO 2011). ISO 50001 provides guidance to organizations of all types to integrate energy efficiency into their daily management practices. For industrial facilities, this includes fine-tuning production processes and improving the energy efficiency of industrial systems (McKane et al. 2009). The standard gives organizations management strategies that can be applied for a number of objectives including reducing energy consumption, carbon emissions, and costs, and to improve environmental performance.

Globally, more than 20,000 facilities have implemented ISO 50001 by organizations seeking to cut operating costs while furthering competitiveness and resilience (ISO 2017). Uptake of ISO 50001 is anticipated to quicken as businesses incorporate energy management into supplier requirements and corporate sustainability strategies. National and regional governments are incorporating ISO 50001 into policies and regulations to encourage economic development, conserve energy, and reduce greenhouse gas emissions (McKane et al. 2017).

A central concept of ISO 50001 is the improvement of energy performance. Energy performance is a broad term that ISO 50001 defines as, "measurable results related to energy efficiency, energy use, and energy consumption." By using the term energy performance rather than more traditional terms such as energy efficiency or energy savings, ISO 50001 makes space for organizations to manage energy through improvements to the way in which energy is used, not just the reduction of how much energy is used. This openness enables organizations to holistically evaluate and improve their management of energy rather than simply focus on reduced consumption without consideration of why and how energy is being used in the first place. Additionally, ISO 50001 does not specify that energy performance improvement need be demonstrated at the facility boundary level. Energy performance improvement can be demonstrated within a subset of the EnMS scope and boundaries for the purpose of ISO 50001 certification.

Energy performance improvement is demonstrated with metrics known as energy performance indicators (EnPIs). ISO 50001 directs organizations to select EnPIs that are appropriate to itself, it does not specify what EnPIs are acceptable or not for certification nor prescribe a process that should be used to calculate and demonstrate improvement. One process of demonstrating energy performance improvement, regardless of the selected metric of improvement, is commonly referred to as measurement and verification (M&V). The standard leaves it to the organization implementing ISO 50001 to conduct M&V and for the third-party auditing the implementation of ISO 50001 to accept the EnPI(s) selected by the organization and results of the M&V process.

In part to support ISO 50001, but also other energy efficiency and conservation efforts more broadly, ISO has published two relevant standards focused on conducting M&V and determining energy savings at the organizational level; ISO 50015:2014 – Energy management systems – Measurement and verification of energy performance of organizations – general principles and guidance and ISO 50047:2016 – Determination of energy savings in organizations. Energy savings are one common metric used to demonstrate energy performance improvement. Both of these standards provide guidance but not requirements regarding how to conduct M&V and are optional for use when reporting energy performance improvement as part of ISO 50001 certification.

The lack of specification of acceptable EnPIs, scope and boundaries on which energy performance improvement must be demonstrated, or M&V process to determine energy performance improvement for ISO 50001 certification makes the standard flexible to fit the business needs to various organizations, but also makes aggregation and comparison of energy performance improvements across multiple organizations or regions challenging, if not impossible. This challenge is of particular interest to national and international organization that offer ISO 50001 based energy savings programs and wish to understand the impact ISO 50001 has made on their region. If, energy performance improvement is reported to a national program with a variety of EnPIs and not consistently matched scope and boundaries of each participating organization ISO 50001 based programs will be at a loss to understand the aggregate impact of their efforts.

While it might be enticing to create a single international requirements-based ISO 50001 M&V standard to enable such aggregations and comparisons, many national and regional governments have regulations and existing legislation that such a standard may conflict with rendering the standard not globally relevant. To ensure reported energy performance improvements are comparable while respecting national and regional interests, a common framework based on ISO 50015 and ISO 50047 for the harmonization of multiple M&V protocols for ISO 50001 energy performance improvement determination that defines acceptable energy savings EnPIs and approach to M&V is needed.

This paper outlines the justification and a proposed approach to creating a harmonized foundation for the measurement and verification (M&V) of facility-wide calculated energy savings for the purposes of establishing comparable energy performance improvements values resulting from implementation of ISO 50001. The harmonization of M&V for energy savings as a metric of energy performance improvement resulting from implementation of ISO 50001 will establish confidence when comparing and aggregating reported energy savings values. This framework is not meant to be required for ISO 50001 certification, the flexibility of the standard to be approachable by any organization should be maintained but could be used for that purpose when reporting comparable facility-wide energy savings results is desired.

Background

In the context of energy savings activities, measurement and verification (M&V) is the process by which energy savings, energy efficiency, or another metric of performance is determined. M&V is typically conducted as part of the implementation of one or a set of energy efficiency actions.

Many existing M&V protocols have been developed and are used in various regions and for specific purposes. M&V protocols may focus on specific types of energy efficiency actions or contain specifications, so they meet national or regional regulatory or legislative requirements. M&V protocols commonly will specify metrics or units in which to report results along with the way in which energy and other data are collected and handled, used to calculate those results. M&V protocols may contain quantifiable and qualitative requirements regarding data, calculations, reporting results, and workforce accreditations or the protocol may frame the M&V process with guidance, leaving varying levels of flexibility for whomever performs the M&V and interprets the results.

Typically, M&V protocols will have specific metrics of energy consumption or efficiency that define the improvement or status being determined. One of the most widely used M&V protocols is the, "International Performance Measurement and Verification Protocol," (IPMVP). IPMVP includes multiple "options" that cover M&V approaches including options A and B which focus on project or action level savings and option C which focuses on facility wide savings.

ISO has also published multiple M&V protocols that span various levels, from the project level in ISO 17741:2016 – General technical rules for measurement, calculation and verification of energy savings of projects, to the regional level in ISO 17742:2015 – Energy efficiency and savings calculation for countries, regions and cities. ISO has published two standards focused on the facility-wide level, ISO 50015:2014 – Energy management systems – Measurement and verification of energy performance of organizations – general principles and guidance and ISO 50047:2016 – Determination of energy savings in organizations. These ISO standards provide guidance, not requirements regarding how to conduct and report results of an M&V process.

Section 4.1 of ISO 50001:2011 states that organizations shall determine how they will meet the requirements of the standard in order to achieve continual improvement of their energy performance. The use of the general term energy performance creates space for organizations to manage energy through improvements to the way in which energy is used, not just reducing how much energy is consumed. ISO 50001 also states that organization wide improvements in energy performance are to be consistent with the organization's energy policy and that the energy policy must include a commitment to continual improvement in energy performance. The organization is responsible for developing a statement of the method by which an improvement in energy performance shall be verified. While flexibility in how energy performance improvement is measured and verified is advantageous for individual organizations, it is problematic when trying to aggregate or compare energy performance improvement between organizations, particularly as part of national or regional ISO 50001 based programs.

ISO 50015 and ISO 50047 are founded on the "top-down" or "organization-based" approach to M&V. This approach focuses on accounting for energy consumption and calculating energy savings (as a proxy for energy performance improvement) at the facility-wide level. A "bottoms up" or "energy performance improvement action-based approach" is presented as a way to confirm that the "top-down" facility-wide energy savings value is reasonable. Both ISO 50015 and ISO 50047 include guidance for the normalization of energy consumption prior to calculation of energy performance improvement, a process not required by ISO 50001 and goes beyond the minimum intention of the standard. The normalization process aids in facility-wide M&V as it provides context by creating estimates of actual and expected energy consumption, making comparison between two-time periods more representative.

It could be proposed that an ISO requirements standard for ISO 50001 M&V be developed, but as an international standard this protocol would need to be globally relevant and might be incorrectly assumed as the only valid approach for demonstrating energy performance improvement as part of an ISO 50001 audit. The wide variety of various national and regional regulations and legislation regarding reporting energy performance improvement and the process by which such a determination must follow casts doubt on the idea that any one M&V standard could truly be globally relevant.

Instead, we propose that national and regional ISO 50001 programs be allowed to create their own facility-wide energy savings-based ISO 50001 M&V protocols that are built upon the key elements of ISO 50015 and ISO 50047. In this way, any number of national M&V protocols will be harmonized and reported energy savings (energy performance improvement) results will be comparable, even if they were not determined with the exact same M&V protocol.

This paper identifies the key elements of facility wide energy savings M&V as defined by ISO 50015 and ISO 50047. These key elements create the framework for a harmonization matrix that can be used to ensure requirements of existing or developing ISO 50001 M&V protocols are consistent with one another.

Approach

ISO 50015 and ISO 50047 provide an internationally accepted basis for the development of a harmonized approach to the process of conducting measurement and verification (M&V) in order to determine normalized facility-wide energy savings estimates as a means of demonstrating energy performance improvement at facilities that have implemented ISO 50001.

To develop the ISO 50001 M&V Harmonization Matrix, ISO 50015 and ISO 50047 were analysed and the key elements needed to conduct facility-wide energy savings M&V for ISO 50001 were identified. These key elements were then expanded upon to create a harmonization approach that includes requirement concepts necessary to create an actionable M&V protocol that could be used by internal staff or external assessors.

Lastly, details from the United States Department of Energy's Superior Energy Performance M&V Protocol were extracted and inserted to the harmonization matrix. In this way, the requirements of the SEP M&V Protocol can be examined against the key elements of ISO 50015 and ISO 50047 along with specific details of other national or regional M&V protocols that are developed and analysed in the harmonization matrix.

Results

ANALYSIS OF ISO 50015 AND ISO 50047

ISO 50015 – Energy Management Systems – Measurement and Verification of Energy Performance of Organizations – General Principles and Guidance, and ISO 50047 – Determination of Energy Savings in Organizations, are based upon common components of facility-wide M&V. ISO 50015 details how the process of M&V could be conducted for determining energy performance improvement as part of ISO 50001. ISO 50047 details the process to determine organization wide energy savings.

ISO 50015 identifies the following key elements for conducting M&V for ISO 50001. Section numbers from ISO 50015 are in parentheses:

- Terminology (3)
- Establish M&V plan (5)
  - Scope and purpose (5.2)
  - Energy performance improvement actions (EPIAs) (5.3)
  - Boundaries (5.4)
  - Sources of data (5.5)

  - Energy performance indicators (5.6)
  - Characterization and selection of relevant variables and static factors (5.7)
  - Method for quantifying energy performance improvement (5.8)
  - Data gathering plan (5.9)
  - Adjustments (non-routine) (5.10)
- Implementation of the M&V plan (6)
  - Data gathering (6.1)
  - Verify the implementation of any EPIAs (if any) (6.2)
  - Conduct M&V analysis (6.4)
  - Report M&V results (6.5)
  - Review the need to repeat the process, as necessary (6.6)
- Uncertainty (7)

ISO 50047 builds upon ISO 50015, paralleling the process of conducting M&V while supplying guidance on the method of calculating energy savings using an "organization-based" approach for ISO 50001.

ISO 50047 identifies the following key elements for determining energy savings. Section numbers from ISO 50047 are in parentheses:

- Terminology (3)
- Facility boundaries (4.3)
- Energy accounting (5)
  - General principles of energy accounting (5.1)
  - Measurement of energy consumption (5.2)
  - Energy with relatively insignificant consumption (5.3)
  - Expressing energy consumption in common units (5.4)
  - Primary and delivered energy (5.5)
- Data preparation for determination of energy savings (6)
  - Time periods (6.1)
  - Establishing the energy baseline (6.2)
  - Non-routine adjustments (6.3)
  - Normalization for relevant variables (6.4)
    - Methods of normalization (6.4.2)
    - Determination of normalized energy consumption (6.4.4)
- Calculation of energy savings (7)
  - EPIA-based approach to determining energy savings (7.2)
  - Ensuring consistency between organizational-based and EPIA-based approaches (7.3)
- Improving the accuracy of energy savings results (8)
  - Data quality (8.1)
  - Communicating energy savings results (8.2)

KEY ELEMENTS OF FACILITY WIDE ENERGY SAVINGS MEASUREMENT AND VERIFICATION FOR ISO 50001

Together, eight key elements for the facility-wide energy savings M&V as a metric of energy performance improvement resulting from the implementation of ISO 50001 are identified:

1. Terminology
2. Facility boundaries
3. Time periods
4. Energy accounting
   a. Energy consumption data
      i. Primary and delivered energy
      ii. Measurement of energy consumption
      iii. Special case considerations
   b. Expressing energy consumption data in common units
   c. Energy consumption for the time periods of interest
      i. Establishing the baseline and reporting period energy consumption
      ii. Non-routine adjustments
   d. Relevant variables
   e. Data sources and quality
5. Normalization for relevant variables – adjustment modeling
   a. Methods of normalization
   b. Development of energy consumption adjustment models
   c. Adjustment model validity requirements
      i. Quantitative requirements
      ii. Qualitative requirements
   d. Special case considerations
6. Calculation of energy savings
   a. Common energy performance indicators
      i. Reporting period energy consumption / baseline period energy consumption
   b. Calculating the energy performance indicator
7. Bottom-up comparison
   a. Register of implemented energy performance improvement actions
   b. Conducting the bottom-up comparison
      i. Top-down energy savings
      ii. Bottom-up energy savings
      iii. Reconciliation

8. Reporting energy performance improvement

These key elements can be used to frame specific requirements in a host of M&V protocols that reflect national or regional situations. In this way confidence in the approach and resulting estimation of energy savings as a representation of energy performance improvement can be established when conducted.

ISO 50001 Measurement and Verification Harmonize Matrix

To enable widespread use of these key elements as a foundation for determining facility-wide energy savings as a metric of energy performance improvement for ISO 50001 M&V harmonization, an "ISO 50001 Measurement and Verification Harmonization Matrix" based upon the identified eight key elements of ISO 50015 and ISO 50047 has been created (see Table 1). This matrix includes the eight key elements, the supporting sections of ISO 50015 and ISO 50047, and a harmonization approach which expands the key elements into functional elements.

The intent of the harmonization matrix is for national and regional policymakers who are looking to harmonize their existing or create a new M&V protocol for determining facility-wide estimated energy savings resulting from ISO 50001 implementation to consult with or add their own requirement specifications to the matrix for consideration.

To encourage a dialogue, the United States Department of Energy has incorporated the details of the 2018 Superior Energy Performance (SEP) M&V Protocol into the harmonization matrix. The SEP M&V Protocol is not required for certification to ISO 50001 but is required to be used by an accredited third-party to conduct M&V and report results if an organization is seeking ANSI-ASQ National Accreditation Board (ANAB) accredited certification to the SEP program. The SEP M&V Protocol has been used to certify over 60 industrial and commercial facilities to the SEP program (U.S. DOE 2018). The SEP M&V Protocol was originally published in 2012, was revised in 2016, and again in 2018. The 2018 revision of the SEP M&V Protocol is based upon feedback from industrial participants in the SEP program as well as to ensure consistency with the key elements of ISO 50015 and ISO 50047.

Invitation is made for other M&V protocols that could be used for reporting facility-wide energy performance improvement as part of ISO 50001 to be applied to the ISO 50001 M&V Harmonization Matrix. By doing so, the process of harmonizing M&V protocols for determining energy performance improvement resulting from ISO 50001 will move forward, ultimately establishing confidence in reported values. It is proposed that fora such as the Clean Energy Ministerial Energy Management Working Group could serve as a natural forum to facilitate conversations for continued and deeper harmonization of M&V.

Conclusion

With the intent of creating a dialog around the harmonization of national and regional M&V protocols, a "ISO 50001 M&V Harmonization Matrix" has been created. This harmonization matrix is based upon eight key elements for facility-wide determination of energy performance based upon ISO 50015 and ISO 50047. Requirements from the United States Department of Energy Superior Energy Performance M&V Protocol have been applied to the harmonization matrix. Potentially through the Clean Energy Ministerial Energy Management Working Group, a discussion of how additional M&V protocols align with the ISO 50001 Harmonization Matrix is proposed.

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Table 1. ISO 50001 M&V Harmonization Matrix.

Key Element of facility-wide energy savings M&V for ISO 50001 – based upon ISO 50015 and ISO 50047	**ISO 50015 (section number)**	**ISO 50047 (section number)**	**Harmonization Approach (expansion of key element)**	**SEP M&V Protocol requirement (February 2018)**
General Materials	Scope and purpose (5.2) Energy Performance Indicators (5.6)		Overall Approach	1. Determine top down energy performance improvement with adjustment 2. Conduct bottom up reconciliation of energy performance improvement
	Competency (4.5)		Who approves the energy savings determination and to what level?	Individual accredited with a SEP Performance Verifier certificate who is not associated with the organization
Terminology	Terminology (3)	Terminology (3)	Terminology	Based upon ISO 50001 with additions from ISO 50015 and ISO 50047
			Reference notation	Consistently used
Facility Boundaries	Boundaries (5.4)	Facility boundaries (4.3)	General	Physical or site boundaries that may be the same as the boundaries of the ISO 50001 EnMS.
			Physical consideration	Considered three dimensional, includes energy that enters the facility from the sky or ground (e.g. solar, on-site natural gas extraction)
			Allowance to modify	Facility boundaries must remain constant between baseline and reporting periods
Time Periods	Establish M&V plan (5)	Time periods (6.1)	Span of baseline period	12 months
			Span of achievement period	12–120 months
			Span of reporting period	12 months
			Allowance to modify	If model significance cannot be established, then longer baseline and reporting periods may be used. If longer, the baseline and reporting periods must start on the same date. The midpoint of the two periods is used to measure the length of time between them
			Starting point of the baseline period	12 months prior to start of the achievement period
			Starting point of the achievement period	At the end of the baseline period

Key Element of facility-wide energy savings M&V for ISO 50001 – based upon ISO 50015 and ISO 50047	ISO 50015 (section number)	ISO 50047 (section number)	Harmonization Approach (expansion of key element)	SEP M&V Protocol requirement (February 2018)
			Starting point of the reporting period	12 months prior to the end of the achievement period
Energy Accounting	Relevant variables and static factors (5.7) Adjustments (non-routine) (5.10) Energy Accounting (data gathering) (6.1) Data gathering plan (5.9) Data gathering (6.1) Sources of data (5.5)	Energy accounting (5) General principles of energy accounting (5.1) Energy with relatively insignificant consumption (5.3) Expressing energy consumption in common units (5.4) Primary and delivered energy (5.5) Establishing the energy baseline (6.2) Non-routine adjustments (6.3) Improving the accuracy of energy savings results (8) Data quality (8.1)	Energy types included	All types of energy
			Measurement point of the energy consumption	Facility boundaries. Considerations for on-site generation from natural resources (wind, solar, on-site extraction)
			Accounting when one type of energy is converted to another type of energy	Energy is accounted for when it crosses the facility boundaries (to and away from), not when it is converted (e.g. electricity generated on-site from delivered natural gas is accounted for as natural gas). Special considerations for generation of energy from natural resources (wind, solar)
			Other on-site generation of energy	Accounted for when it crosses the facility boundaries, allowances for on-site generation from biomass (waste water plants called out specifically)
			Data collected as part of the energy accounting	Energy consumption and relevant variable data

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Table 1. ISO 50001 M&V Harmonization Matrix (continuation).

Key Element of facility-wide energy savings M&V for ISO 50001 – based upon ISO 50015 and ISO 50047	**ISO 50015 (section number)**	**ISO 50047 (section number)**	**Harmonization Approach (expansion of key element)**	**SEP M&V Protocol requirement (February 2018)**
			Energy data sources	Utility meters may be sufficient for energy consumption, submeters may be needed. Other meter sources for relevant variables.
			Potential relevant variables	Production and weather required
			Data collection frequency	Monthly at a minimum, may need to be more frequent
			Data collection duration	Baseline and achievement period (this includes the reporting period)
			Delivered or primary	All energy data is to be converted to primary energy consumption data
			Primary energy multiplier – grid purchased electric	National value (3)
			Primary energy multiplier – electricity exported to grid	National value (-3)
			Primary energy multiplier – onsite generated renewable electricity	1
			Primary energy multiplier – fossil fuels combusted onsite	1
			Primary energy multiplier for other types of energy	Specified in M&V Protocol Annex
			Measurement of energy consumption	Equation to calculate energy consumption based upon energy delivered to the facility, away from the facility as export and product, energy put into and taken out of storage, energy used as a feedstock, and energy generated onsite from a natural resource
			Conversion to common units	All energy types must be converted to a common unit, none specifically required
			Energy baseline	Energy baseline for each type of energy is created as well as an energy baseline for all types of energy in aggregate

Key Element of facility-wide energy savings M&V for ISO 50001 – based upon ISO 50015 and ISO 50047	ISO 50015 (section number)	ISO 50047 (section number)	Harmonization Approach (expansion of key element)	SEP M&V Protocol requirement (February 2018)
			Reasons for a non-routine adjustment	Made to energy consumption data in the baseline and/or reporting periods if 1) a static factor changed during the achievement period, or 2) relevant variables have been subject to unusual changes in at least one of the two periods.
			Conducting a non-routine adjustment	Based upon engineering analysis,
			Documenting a non-routine adjustment	Rationale for making a non-routine adjustment and the method for making the adjustment shall be recorded and maintained, including the general reasonableness of the methodology and the calculations, the adequacy of the metering and monitoring methodologies, and conformance of the calculation applied.
			Identification of relevant variables	Care shall be taken to both (1) avoid omitting relevant variables that affect energy consumption and (2) include variables that are relevant to energy consumption. Variables are excluded from the model if there is no logical mechanism by which the variable would affect the consumption of the energy type(s) being modelled.
			Allowable types of relevant variables	Physical quantities, characteristics, or conditions. Financial metrics or metrics that include a financial component, such as product price or energy costs are not allowed EXAMPLES: production quantities, equivalent products, number of batches, heating degree-days, humidity, occupancy, hours worked, raw material characteristics, and guests served. Relevant variables that shall be included in the energy accounting and considered when developing adjustment models: 1) Activity level (e.g., occupancy, operating hours, production level, and equivalent products) 2) Weather (e.g., heating degree-day, cooling degree-day, and humidity)
			Calibration of meters	Calibration of meters shall follow manufacture recommendations and records kept. Utility meters are not the responsibility of the organization

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Table 1. ISO 50001 M&V Harmonization Matrix (continuation).

Key Element of facility-wide energy savings M&V for ISO 50001 – based upon ISO 50015 and ISO 50047	ISO 50015 (section number)	ISO 50047 (section number)	Harmonization Approach (expansion of key element)	SEP M&V Protocol requirement (February 2018)
			Data outliers	If high variability is characteristic of the operation, outliers do not necessarily need to be removed. However, the effect of outliers on the reliability of the model estimates and the reason for removing them is maintained as a record. If an anomalous value is found, reasons for the anomaly shall be identified if possible. If the anomaly is determined to be a data error, the error shall be corrected if possible; otherwise deleted from the model.
Normalization for Relevant Variables	Method for quantifying energy performance improvement (5.8) Uncertainty (7)	Normalization for relevant variables (6.4) Methods of normalization (6.4.2) Determination of normalized energy consumption (6.4.4) Improving the accuracy of energy savings results (8) Data quality (8.1)	Normalization approaches	linear regression forecast, linear regression backcast, linear regression chaining, linear regression standard conditions
			Creating adjustment models	An adjustment model is made for each type of energy. Allowance with specific rationale for aggregating energy consumption prior to modelling (e.g. add up natural gas and electricity prior to modelling) 1. All energy consumption units are converted to a common energy unit (e.g., BTU, Joules, kWh) using document multipliers and are converted to primary energy. 2. The period during which the data to be summed was collected is the same for all energy types. 3. The model for the combined energy types satisfies validity requirements
			Model time period	The start and end date of all models is to be the same, selected based upon the normalization approach being employed.
			Adjusted energy consumption	Adjusted energy consumption values from each model are summed to create a facility-wide adjusted energy consumption value.
			Minimum data to create model	12 data points, taken at any regular frequency. Data collected at high rates of frequency can be summer to slower frequencies

Key Element of facility-wide energy savings M&V for ISO 50001 – based upon ISO 50015 and ISO 50047	**ISO 50015 (section number)**	**ISO 50047 (section number)**	**Harmonization Approach (expansion of key element)**	**SEP M&V Protocol requirement (February 2018)**
			Model forms	Model form 1 – ratio of energy consumption to a significant relevant variable Model form 2 – linear regression Model form 3 – complex regression
			Minimum model R^2	>0.5
			Max F-test	p-value <0.1
			Maximum allowable p-value for relevant variables included in each adjustment model	<0.2
			Maximum allowable p-value for at least one relevant variable included in each adjustment model	<0.1
			Numeric model validity requirements when applying model	Mean of the relevant variables used in the model shall fall within: 1) the range of observed relevant variable data 2) three standard deviations from the mean of the relevant variable data
			Qualitative validity factors	No substantial difference between the two periods in product type Meters were functional, calibrated, and operating as appropriate
			Allowance to modify modelling approach	1) create models for multiple operating modes 2) create models for multiple facility subsets
Calculation of Energy Savings	Energy Performance Indicators (5.6) Conduct M&V analysis (6.4)	Calculation of energy savings (7)	EnPI(s) of interest	Superior Energy Performance Indicator (SEnPI) and % Improvement

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Table 1. ISO 50001 M&V Harmonization Matrix (continuation).

Key Element of facility-wide energy savings M&V for ISO 50001 – based upon ISO 50015 and ISO 50047	**ISO 50015 (section number)**	**ISO 50047 (section number)**	**Harmonization Approach (expansion of key element)**	**SEP M&V Protocol requirement (February 2018)**
Bottom-Up Comparison	Energy Performance Improvement Actions (5.3) Verify the implementation of energy performance improvement actions (6.2) Uncertainty (7)	EPIA-based approach to determining energy savings (7.2) Ensuring consistency between organizational-based and EPIA-based approaches (7.3)	Bottom up reconciliation method	Use top-down calculated energy savings and compare to bottom-up value determined with an accounting of individual EPIAs
			Accounting for individual EPIAs	Register of implemented EPIAs
			Register of implemented EPIA contents	Description of energy performance improvement action Anticipated annual delivered energy savings for each energy type (natural gas, electricity…) Describe operating conditions for which energy savings are calculated Describe the starting point or baseline situation that was improved upon (e.g., equipment, systems, practices, or procedures) Anticipated annual primary energy savings for each energy type Link or location of action plan documentation, as appropriate Date action implementation was completed Actual annual delivered energy savings for each energy type for the reporting period, determined after the implementation of the energy performance improvement action is complete Actual annual primary energy savings for each type of energy for the reporting period, determined after the implementation of the energy performance improvement action is complete Method(s) used to determine actual annual energy savings
			Bottom up reconciliation factor	0.8
Reporting Energy Performance Improvement	Energy Performance Indicators (5.6) Report M&V results (6.5)	Communicating energy savings results (8.2)	Unit savings reported in	SEnPI and % Improvement