American National Standards Institute

PROGRESS REPORT

Standardization Roadmap
Energy Efficiency in the Built Environment

APRIL 2016

Prepared by the
Energy Efficiency Standardization Coordination Collaborative of the
American National Standards Institute

BUILDING ENERGY AND WATER ASSESSMENT AND PERFORMANCE STANDARDS

SYSTEM INTEGRATION AND SYSTEMS COMMUNICATIONS

BUILDING ENERGY RATING, LABELING, AND SIMULATION

EVALUATION, MEASUREMENT, AND VERIFICATION

TABLE OF CONTENTS

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The roadmap and progress report were developed based on the collective input of EESCC members, and does not necessarily reflect the views of the organizations listed. The employment status and affiliations of individual participants are subject to change.

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    - Chapter 1: Building energy and water assessment and performance standards
        - Stephanie Reiniche, ASHRAE
        - Billy Smith, ASPE
    - Chapter 2: System integration and systems communications
        - Henry Green, National Institute of Building Sciences
        - Dan Manole, Rockwell Automation
    - Chapter 3: Building energy rating, labeling, and simulation
        - Lilas Pratt, ASHRAE
        - Michael Rosenberg, PNNL
    - Chapter 4: Evaluation, measurement, and verification (EM&V)
        - Kevin Cooney, Navigant Consulting
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INTRODUCTION

Advancements in energy efficiency can help power the U.S. economy and job creation, increase competitiveness, and boost U.S. energy security, but realizing the promise of energy efficiency demands a comprehensive national approach and close coordination between the public and private sectors.

In June 2014, the ANSI Energy Efficiency Standardization Coordination Collaborative (EESCC) published the ***Standardization Roadmap: Energy Efficiency in the Built Environment***,[1] paving a strategic path forward for a more energy- and water-efficient built environment. Developed by over 160 public- and private-sector experts from more than 50 member organizations and 4 federal agencies, the roadmap established a national framework to which U.S. industry, government, standards developing organizations (SDOs), and others can look to enable greater energy and water efficiency capabilities for the nation's buildings. Since its publication, the roadmap has been downloaded 2,600 times, reaching a wide-ranging audience from companies, energy efficiency-focused organizations, SDOs, educational institutions, and international audiences.

Following the roadmap's publication, the collaborative reconvened in August 2014 to begin its next phase of activity to bolster energy and water efficiency standardization. In this second phase, the EESCC turned its attention to conducting broad outreach to the standardization community to pursue action on the roadmap's recommendations and to facilitating the coordination and development of related standardization activities. This report highlights the standardization community's known progress to date in addressing the standards-based gaps identified in the roadmap.

ABOUT THE EESCC STANDARDIZATION ROADMAP (JUNE 2014)

Standards, codes, and conformity assessment programs offer significant opportunities for energy and cost savings, and improved energy efficiency capabilities for our nation's buildings. As the technical underpinning of products, services, and systems, standardization is an important tool that can be used to address market barriers, reduce costs, speed time-to-market, and accelerate the uptake of energy efficiency technologies and processes.

The EESCC standardization roadmap identified many opportunities for improved energy and water efficiency through standardization, detailing 125 recommendations and timelines for action across 5 inter-related areas of focus:

- **Chapter One: Building Energy and Water Assessment and Performance Standards** outlined 46 recommendations to address identified standardization gaps in these areas
- **Chapter Two: System Integration and Systems Communications** detailed 9 recommendations examining how building sub-systems could be integrated in order to manage the energy use of a building or campus of buildings for maximum efficiency
- **Chapter Three: Building Energy Rating, Labeling, and Simulation** outlined 22 recommendations to address identified standardization gaps

[1] http://www.ansi.org/standards_activities/standards_boards_panels/eescc/Standardization_Roadmap.aspx

- **Chapter Four: Evaluation, Measurement, and Verification (EM&V)** detailed 32 recommendations to advance the field of EM&V
- **Chapter Five: Workforce Credentialing** put forth 16 overarching recommendations to advance workforce credentialing for the energy efficiency field

The roadmap identified standards, codes, and conformity assessment programs that were available or under development; gaps that existed; and recommended additional standardization activities to advance energy and water efficiency in the United States. In an effort to assist SDOs in identifying priority areas for work, and opportunities for collaboration, coordination, and harmonization, the roadmap also included recommended timelines for closing the identified standardization gaps in the near-term (0-2 years), mid-term (2-5 years), and long-term (5+ years).

About this Progress Report

This report highlights known progress to date to close the 109 standardization gaps outlined in chapters 1-4 in the roadmap. As Chapter Five, *Workforce Credentialing*, outlined overarching recommendations to advance workforce credentialing rather than specific standardization gaps, updates on Chapter Five are not included in this report.

For ease of comparison, this report provides updates by chapter, following the section numbering from the roadmap. Progress is reported only where known activities are underway to address gaps identified in the roadmap. For each gap discussed, the original roadmap text is provided, followed by the progress report update.

Appendix A summarizes all gaps from chapters 1-4 in the roadmap, including those for which there is no known progress at this time, so that readers may easily identify opportunities to take action on gaps.

About the EESCC

The EESCC is a cross-sector, neutral forum and focal point for broad-based coordination among energy and water efficiency activities involving or impacted by standardization (i.e., standards, codes, conformance activities), and regulations. A member-funded collaborative, the EESCC brings together experts from industry, federal agencies, standards and code developing organizations, energy and water efficiency-focused organizations, educational institutions, and other groups to shape the future of energy and water efficiency standardization. The EESCC is strictly a coordinating body and does not develop standards, nor does it assign responsibility for their development.

What Is a Gap?

In the context of the roadmap and this progress report, **a gap** refers to a significant issue that has been identified and that should be addressed in a standard, code, regulation, or conformity assessment program, but for which currently none is published or known to exist. Gaps can be filled through the creation of entirely new standards, code provisions, regulations, or conformity assessment programs, or through revisions to existing ones. In some cases, work may already be in progress to fill the gap.

A partial gap refers to a situation where a significant issue has been identified that is partially addressed by an existing standard, code, regulation, or conformity assessment program.

No gap means there is no significant issue that has been identified at this time or that is not already adequately covered by an existing standard, code, regulation, or conformity assessment program.

Chapter One: Building Energy and Water Assessment and Performance Standards

1.1 The Water–Energy Nexus

Roadmap Gap and Recommendation

A. Standards that address supply chain- and product-embedded water–energy evaluations

There is a need for standards that address supply chain- and product-embedded water–energy evaluations that can inform consumers of the energy and water intensity of the building systems, products, or services they buy. There is currently no recognized consistent methodology for the way building systems, products, and services are evaluated for their overall water and energy footprint. Architects, engineers, consumers, and companies wishing to proactively reduce their water and energy intensity often receive mixed messages as a result.

Developing uniform standards that address the water and energy embedded in a system's or product's supply chain would: (1) provide a needed consistent method that would allow proper cross-comparison of options for products and services; (2) smooth out the duplicative and competing footprint methodologies, some of which unfairly favor certain companies, processes, or products, and most of which do not correctly count both water and energy interactions back through the supply chain; and (3) allow a deeper focus on systems, products, and services in the commercial and industrial sectors where the combined water and energy savings potential is very high.

Recommended Timeline: While work should begin as soon as possible, this is a complex issue and is therefore a long-term effort: 5+ years.

***Progress Report Update*:**

The International Organization for Standardization (ISO) has published ISO 14046, *Environmental management - Water footprint -Principles, requirements and guidelines*, outlining principles, requirements and guidelines related to water footprint assessment of products, processes, and organizations based on life cycle assessment.

IAPMO has announced the introduction of WE-Stand,[2] a new Water Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS).

[2] http://www.iapmo.org/WEStand/Pages/default.aspx

ASTM Subcommittee E60.7 on Water Use and Conservation has established a task group to determine future work items related to water and energy efficiency.

B. Water and energy industry-accepted evaluation, measurement, and verification (EM&V) protocols

There is a need for water and energy industry-accepted evaluation, measurement, and verification (EM&V) protocols that can be utilized by standards developers to help make determinations on provisions where water and energy tradeoffs exist. Detailed EM&V protocols already exist for analyzing energy efficiency performance, but these protocols need to be revised to properly address the embedded energy savings emanating from water conservation and management programs. To date, only savings from hot water conservation programs have been included in these evaluation protocols. Interactive water and energy savings need to be properly documented where they occur, and greenhouse gas emission reduction calculation methodologies need to be revised to correctly recognize the contributions coming from the saved embedded energy in water supply, treatment, pumping, and consumer end-use consumption.

Recommended Timeline: While work should begin as soon as possible, this is a complex issue and is therefore a long-term effort: 5+ years.

Progress Report Update:

In July 2014, the U.S. Department of Energy (DOE) released *The Water Energy Nexus: Challenges and Opportunities*.[3] In chapter six of the report, DOE offers its vast capabilities in multi-system, multi-scale modeling, analysis, data management, and computation as an available resource. SDOs are encouraged to utilize these tools for the development of improved water-energy nexus technical provisions.

In 2015, The Climate Registry published a Water-Energy Greenhouse Gas Technical Brief,[4] which provides guidance to Southern California Edison businesses in measuring and managing carbon emissions associated with the water cycle. The metrics contained in the brief may be of use to SDOs.

1.2 Building Envelope

Roadmap Gap and Recommendation

A. Window installation guidance for effective energy, air, and moisture management

Within the building envelope, windows are often the most common source of heat loss, heat gain, and air leakage – often due to deficits in detailing and installation. Proper window installation is necessary to manage the heat transfer, air leakage, and water management in the building envelope. While activities are currently underway at ASTM and elsewhere,

[3] http://www.energy.gov/articles/department-energy-releases-water-energy-nexus-report
[4] http://www.theclimateregistry.org/thoughtleadership/water-energy-nexus-initiatives/

significant effort is needed to develop and deliver meaningful window installation guidance that could be adopted into voluntary programs as well as incorporated into building codes. In the field, training is needed with a specific focus on replacement window installation to deliver effective energy, air, and moisture management.

Recommended Timeline: These activities should be conducted in the near-term: 0-2 years.

***Progress Report Update*:**

A number of work items are being addressed to expand ASTM E2112, *Standard Practice for Installation of Exterior Windows, Doors and Skylights*. WK49750 is one such work item.

At ASHRAE, revisions are being considered to improve the building envelope through ASHRAE/IES 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*.

B. Lifecycle valuation of envelope improvements

All energy efficiency options must be considered when evaluating portfolios of materials, technologies, and methods in construction. There is currently a deficit in service life considerations as applied to total energy efficiency, particularly with regard to the long-term durability and performance of the building envelope. The building envelope is often undervalued because its permanence in the structure is not reflected in immediate resource savings. As codes and standards evolve, a life cycle assessment (LCA) methodology for valuing options should be given further consideration and should be included, where possible.

Recommended Timeline: These activities should be conducted in the mid-term: 2-5 years.

***Progress Report Update*:**

ASTM E2921, *Standard Practice for Minimum Criteria for Comparing Whole Building Life Cycle Assessments (LCA) for Use with Building Codes and Rating Systems*, is for a full building life cycle assessment; it is not applicable for individual component evaluations.

C. Standards that evaluate insulation material performance in reducing heat flow under dynamic conditions

The current industry-accepted standard, ASTM C-518, *Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus,* is a static test (steady-state) at one temperature that does not represent actual in-field conditions and material performance. A dynamic test standard is needed that accounts for a material's resistance to heat transfer and a material's heat capacity at a range of temperatures, relative humidity (%RH), and air flow infiltration rates through a material.

Recommended Timeline: This work should be conducted in the near-term: 0-2 years.

> ***Progress Report Update*:**
>
> Work to address this gap will be discussed by ASTM Committee C16 on Thermal Insulation at their spring 2016 meeting.

1.4 Cooling Systems

Roadmap Gap and Recommendation

A. Standards for energy performance

The codes and standards pertaining to the energy performance of individual air conditioning and cooling systems are well defined. Establishing independently developed performance metrics that specify the cost and efficiency benefits of the overall performance of integrated air conditioning and cooling systems would enhance the basis in which architects, designers, engineers, and builders incorporate these systems in residential, commercial, and industrial applications. ASHRAE is looking at this issue for potential inclusion in Standard 90.1-2016 for commercial and multi-family residential buildings over three stories.

Recommended Timeline: This work should be conducted in the mid-term: 2-5 years.

> ***Progress Report Update*:**
>
> Through the High-Performance Building Council (HPBC), the National Institute of Building Sciences (NIBS) is developing the National Performance Based Design Guide[5] (NPBDG), which is focused on performance criteria for multiple building attributes. NIBS has also been conducting activities to advance the focus on outcomes (actual, measured results rather than anticipated results from design) outlined in Whole Building Design Guide.[6] NIBS' efforts resulted in the inclusion of an outcome-based pathway in the 2015 International Green Construction Code (IgCC), and NIBS is working to get an outcome-based pathway into ASHRAE standard 189.1 and in the International Energy Conservation Code (IECC). NIBS is also participating in an Alliance to Save Energy (ASE) project with Lawrence Berkeley National Laboratory (LBNL) to look at systems-based approaches to design, and working with DOE to conduct a 2016 workshop on implementation of outcome-based policies to advance energy performance.
>
> ASHRAE is looking at this issue for inclusion in Standard 90.1-2016, *Energy Standard for Buildings Except Low-Rise Residential Buildings*.
>
> Internationally, there is movement on this issue through ISO Technical Committee (TC) 163, *Thermal performance and energy use in the built environment*, and ISO/TC 205, *Building environment design*, in cooperation with the European Committee for Standardization (CEN).

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[5] http://npbdg.wbdg.org/

[6] http://wbdg.org/resources/outcomebasedpathways.php

B. Standards for integrated control

Control standards for integrated air conditioning and cooling systems are needed so that the performance and use of the systems can be optimally controlled. ASHRAE is looking at this issue for potential inclusion in Standard 90.1-2016 for commercial and multi-family residential buildings over three stories.

Recommended Timeline: This work should be conducted in the mid-term: 2-5 years.

***Progress Report Update*:**

ASHRAE continues to look at this issue for inclusion in 90.1-2016 for commercial and multi-family residential buildings over three stories.

C. Standards for building air leakage testing (unique for various building types)

Test methods for measuring the air leakage rates of a building envelope have been established for many years. In recent history, the level of interest associated with this area of building construction (e.g., green program requirements, commissioning requirements) has sizably grown due to the establishment and refinement of green, sustainable, and high performance energy codes and standards. The current methods only apply a single standard to all building categories and thus, do not address the complexities and difficulties that are present within the array of structure types. In order to recognize each structure's applicable limitations, it is recommended that unique standards be developed for the various building construction types.

Recommended Timeline: This work should be conducted in the mid-term: 2-5 years.

***Progress Report Update*:**

ASTM Subcommittee E06.41 on Air Leakage and Ventilation Performance has two related work items underway: WK35913, *New Test Method for Whole Building Enclosure Air Tightness Compliance*, and WK45581, *Revision of E779 Standard Test Method for Determining Air Leakage Rate by Fan Pressurization*.

D. Partial load efficiencies for variable speed equipment

Air conditioning and cooling systems are sized to meet design conditions that occur at their rated, peak efficiencies (i.e., full load or capacity); however, in most instances, these systems only operate at partial load or capacity. For equipment that is able to vary its output capacity, efficiencies are needed that specify the systems' optimal conditions at partial load.

Recommended Timeline: This work should be conducted in the near-term: 0-2 years.

***Progress Report Update*:**

ASHRAE will address this issue in Standard 90.1-2016.

AHRI addresses part-load value (PLV) in AHRI Standard 210/240, *Performance Rating of Unitary Air-conditioning and Air-source Heat Pump Equipment*; ANSI/AHRI Standards 550/590 (I-P) and 551/591 (SI)-2011 with Addendum 3, *Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle*; ANSI/AHRI 1230-2010 with Addendum 2, *Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment*; ANSI/AHRI 340/360-2007 with Addendum 2, *Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*; and, ANSI/AHRI 390-2003, *Performance Rating of Single Package Vertical Air-Conditioners and Heat Pumps*.

1.5 Heating Systems

Roadmap Gap and Recommendation

A. Standards for energy performance

Codes and standards related to the energy performance of individual heating systems are well defined. Establishing independently developed performance metrics that specify the cost and efficiency benefits of the overall performance of integrated heating systems would enhance the basis in which architects, designers, engineers, and builders incorporate these systems in residential, commercial, and industrial applications. ASHRAE is looking at this issue for potential inclusion in Standard 90.1-2016 for commercial and multi-family residential buildings over three stories.

Recommended Timeline: This work should be conducted in the mid-term: 2- 5 years.

Progress Report Update:

Through the High-Performance Building Council (HPBC), the National Institute of Building Sciences (NIBS) is developing the National Performance Based Design Guide[7] (NPBDG), which is focused on performance criteria for multiple building attributes. NIBS has also been conducting activities to advance the focus on outcomes (actual, measured results rather than anticipated results from design) outlined in Whole Building Design Guide.[8] NIBS' efforts resulted in the inclusion of an outcome-based pathway in the 2015 International Green Construction Code (IgCC), and NIBS is working to get an outcome-based pathway into ASHRAE standard 189.1 and in the International Energy Conservation Code (IECC). NIBS is also participating in an Alliance to Save Energy (ASE) project with LBNL to look at systems-based approaches to design, and working with DOE to conduct a 2016 workshop on implementation of outcome-based policies to advance energy performance.

ASHRAE is looking at this issue for inclusion in Standard 90.1-2016.

[7] http://npbdg.wbdg.org/
[8] http://wbdg.org/resources/outcomebasedpathways.php

Internationally, there is movement on this issue through ISO TC 163, *Thermal performance and energy use in the built environment*, and ISO TC 205, *Building environment design*, in cooperation with the European Committee for Standardization (CEN).

B. Standards for integrated control

Control standards for integrated heating systems are needed so that the performance and use of the systems can be optimally controlled. ASHRAE is looking at this issue for potential inclusion in Standard 90.1-2016 for commercial and multi-family residential buildings over three stories.

Recommended Timeline: This work should be conducted in the mid-term: 2- 5 years.

***Progress Report Update*:**

ASHRAE is looking to address this gap in 90.1-2016.

C. Rating system for radiant windows

Radiant windows are increasingly being used for various heating applications in buildings. In addition to interior space heating applications, radiant windows are also being used to control the build-up of ice and snow on high-rise buildings. A standards development activity is needed to develop a consensus based rating system for radiant windows that will allow specifiers to compare the energy efficiency levels of various models.

Recommended Timeline: This activity should be conducted in the near-term: 0- 2 years.

***Progress Report Update*:**

IAPMO is reaching out to manufacturers and monitoring interest regarding the development of a consensus-based rating system.

D. Standards for building air leakage testing (unique for various building types)

Test methods for measuring the air leakage rates of a building envelope have been established for many years. In recent history, the level of interest associated with this area of building construction (e.g., green program requirements, commissioning requirements) has sizably grown due to the establishment and refinement of green, sustainable, and high performance energy codes and standards. The current methods only apply a single standard to all building categories and thus, do not address the complexities and difficulties that are present within the array of structure types. In order to recognize each structure's applicable limitations, it is recommended that unique standards be developed for the various building construction types.

Recommended Timeline: This activity should be conducted in the mid-term: 2-5 years.

***Progress Report Update*:**

ASTM Subcommittee E06.41 on Air Leakage and Ventilation Performance has two related work items underway: WK35913, *New Test Method for Whole Building Enclosure Air Tightness Compliance*; and WK45581, *Revision of E779 Standard Test Method for Determining Air Leakage Rate by Fan Pressurization*.

AHRI addresses part-load value (PLV) in AHRI Standard 210/240, *Performance Rating of Unitary Air-conditioning and Air-source Heat Pump Equipment*; ANSI/AHRI Standards 550/590 (I-P) and 551/591 (SI)-2011 with Addendum 3, *Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle*; ANSI/AHRI 1230-2010 with Addendum 2, *Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment*; ANSI/AHRI 340/360-2007 with Addendum 2, *Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*; and, ANSI/AHRI 390-2003, *Performance Rating of Single Package Vertical Air-Conditioners and Heat Pumps*.

ASHRAE will address this issue in Standard 90.1-2016.

E. Partial load efficiencies for variable speed equipment

Heating systems are sized to meet design conditions that occur at their rated, peak efficiencies (i.e., full load or capacity); however, in most instances, these systems only operate at partial load or capacity. For equipment that is able to vary its output speed, efficiencies are needed that specify the systems' optimal conditions at partial load.

Recommended Timeline: This work should be conducted in the near-term: 0-2 years.

***Progress Report Update*:**

AHRI addresses part-load value (PLV) in AHRI Standard 210/240, *Performance Rating of Unitary Air-conditioning and Air-source Heat Pump Equipment*; ANSI/AHRI Standards 550/590 (I-P) and 551/591 (SI)-2011 with Addendum 3, *Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle*; ANSI/AHRI 1230-2010 with Addendum 2, *Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment*; ANSI/AHRI 340/360-2007 with Addendum 2, *Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*; and, ANSI/AHRI 390-2003, *Performance Rating of Single Package Vertical Air-Conditioners and Heat Pumps*.

1.6 Mechanical Systems

Roadmap Gap and Recommendation

A. Heat energy as an underutilized resource

Thermal energy is a grossly underutilized resource in the United States relative to other developed countries. The development of an American National Standard for heat metering, led by ASTM International with cooperation from IAPMO, is currently underway. This standard will address a major gap in standardization, allowing for thermal technologies to be more easily utilized in residential and commercial buildings.

Geothermal and hydronic cooling and heating systems can provide significantly increased levels of efficiencies in both residential and commercial applications. Standards are required to help designers, engineers, and home builders better understand the long-term benefits of employing these technologies in buildings. CSA Group began the process of developing an ANSI/Standards Council of Canada bi-national standard, C448, *Design and Installation of Earth Energy Systems*, for the design and installation of geothermal ground heat pumps in response to needs that U.S. stakeholders identified.

Recommended Timeline: This work should be conducted in the mid-term: 2-5 years.

Progress Report Update:

In a joint effort between ASTM, IAPMO, and the U.S. Environmental Protection Agency (EPA), work to create a heat metering standard is underway within the ASTM Subcommittee E44.25 on Heat Metering. A subcommittee ballot on WK37953, *Standard Specification For Equipment and Instrumentation of Heat Metering Technologies*, will be issued in the spring of 2016.

For geothermal, ASTM Work Item WK46315, *New Practice for Installation, Testing, Commissioning and Maintenance of Closed Loop Geothermal Heat Exchangers*, in collaboration with the International Ground Source Heat Pump Association, is underway.

B. Duct leakage testing

i. Independently developed data pertaining to the practical levels of duct leakage testing

Forced-air heating and cooling systems use ducts to distribute conditioned air throughout the building. According to the EPA, about 20 percent of the air that moves through the duct system is lost due to leaks, holes, and poorly connected ducts in homes. Currently, there is considerable debate at codes and standards meetings in the industry regarding the minimum level of duct leakage testing that is required to improve efficiencies. Independently developed data pertaining to the practical levels of duct leakage testing is needed.

Recommended Timeline: This work should be conducted in the mid-term: 2-5 years.

Progress Report Update:

ASTM is addressing this gap through Subcommittee E06.41 on Air Leakage and Ventilation Performance, WK46791, *New Test Method for Determining the Measurement Uncertainty of Devices Used to Measure Airflow through Residential HVAC Terminals*.

ASHRAE is considering this for inclusion in 90.1-2016, and also developing SPC 215P, *Method of Test to Determine Leakage Airflows and Fractional Leakage of Operating Air-Handling Systems*.

ii. Testing protocols for whole HVAC duct system components

To improve energy efficiency, there is a need to develop testing protocols for whole HVAC duct system components. There is a high need for this as codes move toward requiring system testing prior to certificate of occupancy. There is also a need to standardize various techniques for measuring leakage in non-residential and multi-family air distribution and exhaust systems. Several standards developers are starting development on this topic, including ASHRAE, which is looking at this issue for potential inclusion in Standard 90.1-2016. Existing standards such ASTM E1554/E1554M, *Standard Test Methods for Determining Air Leakage of Air Distribution Systems by Fan Pressurization*, are being reviewed to improve understanding of precision and bias to aid in their use as code compliance tools.

Recommended Timeline: This work should be conducted in the mid-term: 2-5 years.

Progress Report Update:

The ASTM subcommittee E06.41 on Air Leakage and Ventilation Performance is addressing this gap through WK41649 Revision of E1554/E1554M, *Standard Test Methods for Determining Air Leakage of Air Distribution Systems by Fan Pressurization*.

C. Employing nontraditional and emerging technologies

The potential to use nontraditional and emerging technologies for improving efficiencies in mechanical systems should be addressed by standards developers. Solar air conditioning, which can utilize several processes to cool buildings (e.g., open desiccant cooling, passive solar, photovoltaic solar cooling, and solar closed loop absorption systems); transcritical CO_2 systems, where improvements to system components may yield new efficiencies; and heat from energy-generating microturbines are technologies where standardization activities can help determine the potential for improved levels of efficiency.

Recommended Timeline: This work is a long-term effort: 5+ years.

Progress Report Update:

ICC 900/SRCC 300-2015, *Solar Thermal Systems Standard Purpose*, from the International Code Council (ICC) sets forth minimum criteria for the design and installation of solar thermal systems. ICC 901/SRCC 100-2015, *Solar Thermal Collector Standard Purpose*, sets forth minimum durability, construction, performance criteria and procedures for characterizing the thermal performance and durability of solar collectors used in applications such as swimming pool heating, space heating, cooling, and water heating. Both were approved as American National Standards (ANS) in April 2015.

D. Fault detection in HVAC systems

Research has shown that component faults in HVAC systems that significantly diminish efficiencies are common and go mostly undetected. Standards are needed to quantify the benefits of installing fault detection technologies on mechanical systems that can alert building and home owners to malfunctioning components.

Recommended Timeline: This work should be conducted in the mid-term: 2-5 years.

Progress Report Update:

The IAPMO Green Technical Committee included updates in the Green Plumbing and Mechanical Code requiring the installation of HVAC system fault detection technologies in commercial buildings. The 2015 IAPMO Green Plumbing and Mechanical Code Supplement containing the provisions was published in February 2016.

1.7 Energy Storage

Roadmap Gap and Recommendation

A. Standards for system and installation safety for energy storage systems

Safety is a crucial element for the success of energy storage systems (ESS). Issues including ratings, markings, personnel barriers/setbacks, system access (e.g., entry and exit points), physical abuse, and temperature ratings come immediately to mind. These may be addressed by SDOs such as UL, the International Electrotechnical Commission (IEC), and others. The standards should make use of previously identified standards in SAE International and UL for battery components, should the system use batteries as the storage medium.

Recommended Timeline: This should be conducted in the near-term: 0-2 years.

Progress Report Update:

In Phase II of the EESCC's effort, this section was updated to address both the storage technology (system) and the installation of that system, and the title was updated accordingly. The original roadmap title was "Standards for system safety issues for energy storage systems."

The safety of ESS involves two related but distinctly different areas of focus. One involves the safety of the ESS (as a complete product or as it relates to the components that make up the system). The second is the relationship of the ESS as installed to the surrounding environment (e.g., in, on, or adjacent to buildings, facilities, and their support infrastructure). The safety of the ESS itself (i.e., as a product) involves how it is designed and constructed to ensure the product itself is safe. Standards developed by SDOs such as UL, ASME, CSA, IEC, and others provide a basis for ensuring the safety of the ESS as a system or the components that make up the ESS. The standards should make use of previously identified standards in SAE International and UL for battery components, should the system use batteries as the storage medium.

The safety of the ESS in relation to its installed environment involves standards and model codes that cover issues such as clearances, connection to other systems, location in relation to fire department access, egress, ventilation, and a number of other issues focused on ensuring the ESS as installed is safe (considering both the ESS as the instigator in an incident or simply as an innocent party to some other incident proximate to the ESS). These standards and model codes, developed by SDOs such as the National Fire Protection Association (NFPA), ICC, IEEE, and ASHRAE generally already exist and provide a foundation for ESS safety through the updating and enhancement of existing criteria to more appropriately address new ESS technologies and applications.

Related Standardization Efforts

In 2015, the DOE Office of Electricity's Energy Storage Program published an Energy Storage Safety (ESS) Strategic Plan. The focus of this plan was to identify, prioritize, and help foster the timely deployment of safe stationary energy storage systems. To support the implementation of this plan, an Energy Storage Safety working group was formed with three areas of activity (research, codes/standards and regulations, and education); all focused on safety. The DOE Energy Storage Safety Plan Codes and Standards Working Group (CSR WG) is focusing on activities related to the development of new standards and model codes as well as revisions to existing standards and model codes in support of the plan's focus – the timely deployment of safe ESS. For almost a year, that working group has been monitoring the activities of relevant SDOs in the U.S. and internationally to identify gaps and facilitate addressing those gaps. Where research and/or education are needed, the CSR WG communicates and coordinates with the working groups focusing on those issues as part of the plan. While there are existing standards and model codes, as listed below, that are undergoing revision to address ESS safety, there are also new standards underway. One such effort was fostered by a Single Installation Standard Task Group under the CSR WG. That group developed a single standard covering the installation of ESS, which in turn references relevant standards that address specific safety-related issues. It does not conflict with or 'reinvent' criteria in existing codes, standards, and regulations, but is intended to provide a singular document that ties other standards together and can serve as a single source of criteria for the safe installation of an ESS.

NFPA has proposed the initiation of a project to write a standard covering this subject and, if approved, plans to use the draft standard (pre-standard) developed by the task group. This is an example of how under the plan, initial work on standards and model code criteria can be developed and then deployed under the auspices of SDOs.

Another new standard is UL 9540, *Energy Storage Systems and Equipment*, which is expected to be published in 2016. This standard will provide the basis for documenting and validating the safety of an ESS as an entire system or product. Another new UL standard is 1974, which will cover the safety of repurposed (i.e., second use) batteries. UL has also initiated development of a new standard, UL 3001, covering distributed energy resource systems that will include among others, ESS.

At the international level, IEC TC 120, *Electrical Energy Storage (EES) Systems*, is addressing the need for new standards through IEC 62933, which will have five separate parts addressing terminology, general specifications, planning/installations, environmental issues, and safety.

Aside from new standards, there are a number of existing standards and model codes that are candidates for updating to address gaps. Those documents cover both the safety of the system or its components (i.e., as products) and the installation of the system or its components in, on, or around buildings. On the system or component side, UL 1973 provides a standard for ensuring batteries are safe. That standard was updated and a new edition was published in early 2016.

NFPA standards that are relevant to the safety of ESS installations include:

- NFPA 70, National Electrical Code® (NEC) – the revision process leading to the 2017 edition of the NEC includes consideration of several new requirements related to energy management and stored energy systems. A new article 706, *Energy Storage Systems*, has been proposed for the 2017 NEC; this article seeks to be helpful as requirements for methods of handling demand response issues arise. A new article 750, *Energy Management Systems*, was added to the 2014 NEC; the article established a hierarchy of which loads can be controlled through energy management and which loads cannot.

- NFPA 1, *Fire Code*, is also being updated during 2016, leading to a 2017 edition. The provisions currently in NFPA 1 that address ESS are being enhanced to address new technologies that were not readily available in the market when the last edition was developed.

- NFPA 5000, *Building Construction and Safety Code* – the next version will likely address ESS safety

- NFPA 101, *Life Safety Code*

ICC model codes that are relevant to the safety of ESS installation include the International Fire Code (IFC) and International Residential Code (IRC). Proposed changes (about forty) to the IFC and IRC that will be considered during 2016 are related to ESS and provide for additional criteria to address new ESS technologies.

NECA is in the process of developing NECA 416, *Recommended Practice for Installing Stored Energy Systems*. It is expected to be published before the end of 2016.

IEEE 2030.2, *Guide for the Interoperability of Energy Storage Systems Integrated with the Electric Power Infrastructure*, was published in 2015. The guide provides definitions for ESS characteristics, applications, and terminology. It is intended to simplify the task of defining system information and communications technology requirements so that requirements can be communicated more clearly and consistently in project specifications.

Also currently under development is IEEE P2030.3, *Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications*. This standard will establish test procedures for electric energy storage equipment and systems. Additionally, requirements on installation evaluation and periodic testing will be included. Proposed revisions are also under consideration for the IEEE National Electrical Safety Code (NESC) and IEEE 1635/ASHRAE Guideline 21 covering ventilation and thermal management of ESS.

ASME has formed a TES Safety Standards Committee for Thermal Energy Storage (TES) Systems. The TES committee aims to develop and maintain safety codes and standards covering the design, construction, testing, maintenance, operation of thermal energy storage systems for the life cycle of the equipment. A rough draft of a standard has been developed and will be further refined and enhanced during 2016 and should be published in 2017.

B. Standards for availability, reliability, and maintenance

Energy storage systems are envisioned to be controlled autonomously by a central energy management system or a building energy management system with little human interference on a regular basis. In order to make sure the energy storage systems are functioning as specified, standards need to be developed to determine:

- **Availability** – optimal times and levels of charge and discharge for the energy storage system based on physical location, historical patterns, and other relevant factors
- **Reliability** – determining the mean uptime and mean time to failure; the mean lifetime and cycle life of the energy storage system; and/or the storage medium component associated with the system
- **Maintenance** – determining what maintenance routines should be performed on the energy storage system and when

Recommended Timeline: This should be conducted in the mid-term: 2-5 years.

Progress Report Update:

Two existing standards that may help to address this gap in relation to reliability and maintenance include:

- NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*, which contains guidance on reliability, including mean uptime, mean time to failure, and general maintenance of different electrical components; the topics are addressed in relation to all types of energy systems including energy storage.
- NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*, which contains maintenance requirements specific to emergency energy storage systems.

The National Electrical Code® is being equipped with several new requirements related to energy management and stored energy systems, including NEC article 750, *Energy Management Systems*, to establish a hierarchy of which loads can be controlled through energy management and which loads cannot, as well as a proposed new NEC article 706, *Energy Storage Systems*, to provide methods of handling demand response issues.

Two standards currently under development by IEEE may also help to address this gap: IEEE P2030.2.1, *Guide for Design, Operation, Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems*, and IEEE 2030.3, *Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications*.

Aspects of maintenance will be addressed in IEC 62937, *Safety considerations related to the installation of grid integrated electrical energy storage (EES) systems*, and IEC 62936, *Environmental issues of EES systems*. These standards are anticipated to be published in 2016 and 2017 respectively.

The EPRI Energy Storage Integration Council (ESIC) is working on terminology, definitions, and test procedures for availability and reliability; these inputs will be published in the next revision of the DOE/EPRI Energy Storage Handbook.

StorageVET, a model to be available publicly in late 2016, is under development by EPRI, with ESIC review, under a contract with California Energy Commission. It is expected to provide transparent simulations to support understanding of availability and maintenance routine best practices in the context of storage project value optimization.

C. Standards for electromagnetic compatibility (EMC)

As information technology becomes layered over electrical components, it is essential that each Smart Grid component, including energy storage systems, is interoperable and that each component is appropriately shielded, insulated, or otherwise designed to reduce or prevent electromagnetic interference. Note that there are currently significant barriers to testing EMC in many instances.

Recommended Timeline: This work is a long-term effort: 5+ years.

Progress Report Update:

The IEC's International Special Committee on Radio Interference (CISPR) is addressing EMC issues that relate to Smart Grid technologies.[9]

D. Standards for load flow, protection coordination, automatic gain control

The need exists to limit or prevent electrical damage to the energy storage system through the development of standards for load flow, protection coordination, and automatic gain control.

Recommended Timeline: This should be conducted in the mid-term: 2-5 years.

Progress Report Update:

Two standards currently under development by IEEE may help to address this gap: IEEE P2030.2.1, *Guide for Design, Operation, Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems*, and IEEE 2030.3, *Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications*.

E. Standards for measuring and expressing system performance

Until recently, there was no methodology for comparing the performance attributes of energy storage systems. The DOE/PNNL *Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems*[10]can provide a basis for addressing this issue. It can be applied across systems that employ different types of storage mediums because it establishes a representative duty cycle for each possible energy storage system application.

A starting point for developing such a list of applications and/or use cases is the California Public Utility Commission (CPUC) *Energy Storage Staff Proposal*.[11] A series or family of standards specifying representative duty cycles and performance metrics applicable by representative duty cycle should be written that would foster the uniform and comparable measurement and expression of energy storage system performance. This series of standards would allow a customer or other end user to evaluate which product is best for their use, and to establish universal testing and reporting criteria.

Recommended Timeline: This should be conducted in the near-term: 0-2 years.

Progress Report Update:

In Phase II of the EESCC's effort, this section was updated to more clearly address standards for measuring and expressing system performance, and the title was changed accordingly.

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[9] http://www.iec.ch/emc/smartgrid/

[10] Pacific Northwest National Laboratory, "Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems," October 2012, http://www.pnl.gov/main/publications/external/technical_reports/PNNL-22010.pdf

[11] Elizaveta Malashenko et al., California Public Utility Commission, "Energy Storage Framework Staff Proposal," April 3, 2012, http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=3154.

The original title used in the roadmap was "Standards to identify representative duty cycles and performance metrics for each application and/or use case."

There is a need for all those involved with the design and application of an energy storage system to be able to effectively, consistently, and reliably communicate about how the system will perform. The lack of a standard method of test for measuring and expressing the performance of energy storage systems results in those communicating about system performance defining their own 'rules,' which in turn results in having multiple metrics and results to decipher. Beginning in 2012, with the support of the DOE Office of Electricity, the Pacific Northwest National Laboratory (PNNL) and Sandia National Laboratories (SNL) initiated an effort to engage all interested parties in the development of a protocol (pre-standard) to measure and express energy storage system performance. Released in late 2012 and updated in June 2014, the *Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems* has provided a basis for evaluating and comparing ESS performance for three ESS applications and a number of performance-related metrics. This document has also been put in "IEC format" and is the basis for a draft IEC standard being developed by IEC TC 120, *Electrical Energy Storage Systems*, which will address the same topic as the protocol. In addition, U.S.-based standards developers (NEMA for electric and ASME for thermal) are also using the protocol as a basis for initial drafts of formal standards.

Key to the development of the protocol has been the identification of applications/use cases for ESS and appropriate duty cycles for each. A starting point for developing such a list of applications and/or use cases was the California Public Utility Commission (CPUC) Energy Storage Staff Proposal. It was recommended by the CPUC that a series or family of standards specifying representative duty cycles and performance metrics applicable by representative duty cycle be written that would foster the uniform and comparable measurement and expression of ESS performance. This series of standards would allow a customer or other end user to evaluate which product is best for their use, and to establish universal testing and reporting criteria. As noted below, the second edition of the protocol will cover eight applications, each with its own unique duty cycle; the application of which provides the basis for determining duty-cycle driven performance metrics for an ESS used in any one of the eight applications covered by the protocol.

Related Standardization Efforts

The second edition of the *Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems* is scheduled for publication in April 2016. The second edition will include five new applications for ESS to go with the three already in the prior edition of the protocol, a number of new performance-related metrics, refinements to the criteria based on experiences using the protocol, and a new organizational structure to make it easier to understand and apply the document. As with prior versions of the protocol, it is hoped the document will help address the need for a common, uniform, consistent, and defensible method of test for ESS performance, both with standards developers and on a voluntary basis between proponents and users of ESS. In addition, the EPRI Energy Storage Integration Council (ESIC) is developing a series of test procedures adapted to utility lab and field contexts to apply energy storage testing. Comments from ESIC were provided to DOE on the protocol effort noted above and were considered in the development of the second edition of the protocol.

1.8 Water Heating

Roadmap Gap and Recommendation

A. Standards for heat metering and solar thermal systems

Consensus standards for heat metering and hot water solar thermal systems need to be completed to advance the use of thermal technologies for water heating applications. This represents a significant and very achievable advancement in energy efficiency.

Recommended Timeline: This work should be conducted in the mid-term: 2-5 years.

Progress Report Update:

In a joint effort between ASTM, IAPMO, and the U.S. Environmental Protection Agency (EPA), work to create a heat metering standard is underway within the ASTM Subcommittee E44.25 on Heat Metering; the work is expected to be completed in 2016. The standard will provide metrics that will help advance the solar thermal market.

ICC 900/SRCC 300-2015, *Solar Thermal Systems Standard*, developed by the International Code Council (ICC), sets forth minimum criteria for the design and installation of solar thermal systems, and describes the requirements and methodology for standardized solar thermal system design evaluation, including the analytical evaluation of its components. It applies to solar energy systems used in applications for heating, cooling, dehumidification, and co-generation.

ICC 901/SRCC 100-2015, *Solar Thermal Collector Standard*, sets forth minimum durability, construction, performance criteria, and procedures for characterizing the thermal performance and indicating the durability of solar collectors used in applications such as swimming pool heating, space heating, cooling, and water heating.

Currently under development by ICC is ICC 902/APSP/SRCC 400-201X, *Pool Solar Heating and Cooling Standard*. The standard will establish minimum requirements for the performance, design, and installation of solar thermal heating systems for heating water used within pools, spas, hot tubs, exercise spas, water parks, and spray grounds.

B. Design standards for plumbing systems

Design standards for architects and home builders are needed to illustrate how efficient building and home design can provide for greater efficiencies in water heating applications.

Recommended Timeline: This work should be conducted in the mid-term: 2-5 years.

Progress Report Update:

Gary Klein & Associates has developed a test apparatus in California that could be a resource for SDOs working to close this gap.

IAPMO has announced the introduction of WE-Stand, a new Water Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS).

C. Standards that address the location of the heating source and end-use point[12]

Standards are needed for water heating and delivery systems to address the location of the heating source and the end-of-use point to ensure that the most efficient system is installed while meeting consumers' hot water use expectations. Activity is currently under way within several codes and standards development venues, including the IgCC and IAPMO's Green Plumbing and Mechanical Code committees, to address the use of recirculation systems and length of pipe requirements, and to provide guidance on how to design the most efficient systems.

Recommended Timeline: This work should be conducted in the near-term: 0-2 years.

Progress Report Update:

IAPMO's Green Plumbing and Mechanical Code Supplement, published in December 2015, contains new provisions on hot water delivery efficiency.

IAPMO has announced the introduction of WE-Stand, a new Water Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS).

[12] Technology research needs related to water heating are discussed in the Bonneville Power Administration's (BPA) National Energy Efficiency Technology Roadmap Portfolio, March 2014 version. See section on "Commercial and Residential Water Heating" (pp. 222-239): http://www.bpa.gov/energy/n/emerging_technology/pdf/EE_Tech_RM_Portfolio.pdf.

1.9 Indoor Plumbing

Roadmap Gap and Recommendation

A. Research evaluating the impact of efficient plumbing component design on the plumbing system's overall performance

Current codes and standards continue to provide significant improvements in water and energy efficiency requirements for plumbing components used in plumbing systems. However, there is considerable pressure to further increase the water savings by requiring decreased flows and flush volumes. It has been shown that further reduction in water use can be achieved through more efficient plumbing component design. However, there is little research available today evaluating the impact of those designs on the plumbing system's overall performance due to reduced flows in the system, and particularly the drainage system. There are research projects underway in the U.S., notably the Plumbing Efficiency Research Coalition, that will help to determine "how low we can go" without negatively impacting public health and safety.

Recommended Timeline: While some research, as noted above, will be conducted in the short term: 0-2 years, achieving optimum efficiency levels in plumbing systems through standardization efforts that consider the entire plumbing system will be an ongoing, long-term project: 5+ years.

Progress Report Update:

The Plumbing Efficiency Research Coalition (PERC) Phase 2.0 Report, published in September 2015, provides guidance on the impact of reduced flows in building drains resulting from water efficiency provisions.[13]

IAPMO has announced the introduction of WE-Stand, a new Water Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS).

B. Revised pipe sizing calculation methods that take modern lower flow rates and lower waste discharges into account along with use patterns associated with building types

Another question currently being addressed through research is the ability to design plumbing systems using smaller diameter piping due to the decreased water demand and decreased volumes needed to supply residential buildings. While it is anticipated that this research will be completed within the next 1-2 years for residential applications, similar research efforts that study water use patterns associated with increasingly complex commercial buildings

[13] http://www.plumbingefficiencyresearchcoalition.org/

needs to be conducted so that pipe size reductions that deliver energy and water efficiencies throughout the life of the building at lower construction costs can be realized.

Recommended Timeline: This work constitutes a long-term project: 5+ years.

Progress Report Update:

IAPMO, ASPE, and the Water Quality Association (WQA) are coordinating a code change proposal to revise pipe sizing requirements for residential buildings for the 2018 code cycle. This development committee issued a white paper containing their recommendations, which is currently under peer review.

ASTM Subcommittee E60.07 on Water Use and Conservation is considering expanding items related to E2728-11, *Standard Guide for Water Stewardship in the Design, Construction, and Operation of Buildings*, on the use of pipe sizes related to different building types.

C. The combined energy and water savings associated with the use of thermal insulation on hot water pipes

No progress report update.

D. Reducing the potential for Legionellosis and other pathogenic outbreaks

Reducing hot water temperatures in plumbing systems has been proven to both reduce scalding incidences and to save energy. However, hot water temperature reductions also provide a perfect environment for opportunistic pathogens to grow in hot water pipes. ASHRAE is currently in the process of completing BSR/ASHRAE Standard 188P, *Prevention of Legionellosis Associated with Building Water Systems*, and the accompanying Guideline 12. When published, these guidance documents will provide facility managers with techniques that can be employed to mitigate Legionellosis outbreaks, as well as a set of best practices for when outbreaks occur.

Recommended Timeline: This work should be conducted in the near-term: 0-2 years.

Progress Report Update:

ASHRAE Standard 188-2015, *Legionellosis: Risk Management for Building Water Systems*, was published in June 2015 and is on continuous maintenance.

NSF International is considering standards for reducing pathogenic outbreaks.

Back to Table of Contents

1.10 Alternate Water Sources

Roadmap Gap and Recommendation

A. "Fit for use" standards that provide appropriate treatment requirements for the intended use of the water

The biggest challenge facing the expanded use of water from alternate water sources is the need for agreed-upon "fit for use" standards that provide appropriate treatment and water quality requirements for the intended use of the water regardless of the source, and that ensure health and safety. Several codes and standards organizations have made excellent progress toward creating classifications of alternate water sources and corresponding applications, as well as treatment strategies. However, a one-size-fits-all approach to design and treatment may be unachievable. For example, rainwater in one area of the country may have higher heavy metals contamination than rainwater in other areas, therefore requiring different treatment measures. Standards developers need to continue to expand their knowledge base and consider provisions that will foster increased use of alternate water sources.

Recommended Timeline: Improvements to alternate water use standards should be an ongoing process with advancements made by consensus and achieved in the short-, mid-, and long- term.

Progress Report Update:

Relevant to this gap, IAPMO has announced the introduction of WE-Stand, a new Water Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS).

B. Comprehensive stormwater standard

There is a need to develop a comprehensive stormwater standard. There is great potential for stormwater to be better utilized as an important alternate water source. Current stormwater infrastructure serves only to carry stormwater away from developed areas as quickly as possible. However, stormwater is a valuable resource that, when utilized properly, can buffer runoff and combined sewer overflows and replenish aquifers through irrigation, soak-away pits, rain gardens, and other designed stormwater features. ASPE, ARCSA, and ICC are currently developing a stormwater harvesting design standard, which may address this gap. A national standard for green infrastructure/low impact design has been provided for federal facilities by implementation of the *Energy Independence and Security Act of 2007*, Section 438.

Recommended Timeline: Development of these standards will necessitate collaboration between water use experts, civil engineers, and other stakeholders. This is a long-term effort: 5+ years.

Progress Report Update:

Existing standards that may help address this gap include:

ARCSA/ASPE 78-2015, *Stormwater Harvesting System Design for Direct End-Use Applications*, which provides guidance on how to install and maintain a safe alternative to utility-provided water and how to optimize stormwater utilization to reduce dependence on municipal potable water systems.

IAPMO Green Supplement has end use, non-potable water quality standards, which are similar to those in Texas, and cited by the EPA Wet Weather document[14] for harvesting and use.

ICC/CSA 805-201x, *Standard for Rainwater Collection System Design and Installation*, under development by ICC for publication in 2016, applies to the design, installation, and maintenance of rainwater collection systems and is intended to collect, store, treat, distribute, and utilize rainwater for potable and non-potable applications.

ASTM E2727, *Standard Practice for Assessment of Rainwater Quality*, and ASTM E2635, *Standard Practice for Water Conservation in Buildings Through In-Situ Water Reclamation*, may have application in this area. Additionally, ASTM Subcommittee E60.07 on Water Use and Conservation is considering water qualifications requirements for use outside the building.

Revisions to ARCSA/ASPE Standard 63, *Rainwater Catchment Systems*, are currently under development.

1.11 Landscape Irrigation

Roadmap Gap and Recommendation

A. Standards for design practices and validating product performance

Additional standards for landscape irrigation systems would be useful in establishing minimum safety requirements and validating performance claims of products. Standards facilitate the comparison of different products to aid the consumer in making a selection for a particular application. PINS[15] have been filed with ANSI for controllers and rain sensors, but no committees have been formed to develop the standards. ICC is currently developing an irrigation emission device standard, which may address this gap.

[14] http://www.epa.gov/npdes/npdes-experts-forum-public-health-impacts-wet-weather-blending-documents

[15] At the initiation of a project to develop or revise an American National Standard, notification is transmitted to ANSI using the Project Initiation Notification System (PINS) form.

The following gaps are becoming apparent as competing green codes are being developed with regard to landscape irrigation. Because landscape irrigation is the assembly of various components to create a system, the system needs to be designed, installed, and maintained properly.

While there are documents that have been created by industry to identify best practices for each of these areas, the potential exists to create standards out of the identified best practices that could be referenced in the codes. Such standards could eliminate conflicting or differing provisions, and thus minimize confusion in the marketplace. This would allow the green codes to be less prescriptive in nature and move more toward performance-based outcomes in managing resources. Some prescriptive irrigation provisions within the green codes conflict with implementing best practices that should be used to address the unique challenges of individual landscapes. Standards should enhance the development of a quality irrigation system that would be based on well-developed best practices for:

- Designing an irrigation system
- Installing/commissioning an irrigation system
- Long-term maintenance of an irrigation system for optimal performance

One challenge of developing standards for design, installation, and maintenance is the perceived notion that by following a standard, an untrained person can achieve the desired results, the same as a qualified professional. The reality is that each landscape project is unique, and the professional applies standards to achieve the desired outcome. Care should be taken so that standards do not become training manuals for design, installation, or maintenance.

Recommended Timeline: This work should be conducted in the mid-term: 2-5 years.

Progress Report Update:

ASABE/ICC 802-2014, *Standard for Landscape Irrigation Sprinklers and Emitters*, outlines minimum requirements for landscape irrigation devices to ensure adequate safety and performance.

ASABE S623, *Estimating Landscape Plant Water Demand*, provides an estimate of plant water demands of permanently installed, non-production-based, established landscape materials.

Standards currently under development in collaboration with EPA include ASABE X626, *Auditing Landscape Irrigation Systems*; ASABE X627, *Testing Environmentally Responsive Controllers*; and, ASABE X633, *Testing of Soil Moisture Sensors*.

Relevant to this gap, IAPMO has announced the introduction of WE-Stand, a new Water Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS).

B. Standards for landscape sustainability and ecosystem services

Other gaps in standards for landscape irrigation are interrelated, but currently not enough information or research has been done to provide guidance for standards development.

1. A standard is needed for evaluating all water sources so that the most sustainable water source(s) would be used for irrigation. This standard would address the water-energy nexus and would be useful in evaluating the embedded energy in all potential irrigation water sources.

2. A standard is needed that would address the benefits derived from an irrigated landscape compared to the resources used to maximize the ecosystem services from the managed urban landscape.

Recommended Timeline: If standards are developed, they should address the process to follow in making the evaluation. This work constitutes a long-term effort: 5+years.

Progress Report Update:

ASABE/ICC 802-2014, *Standard for Landscape Irrigation Sprinklers and Emitters*, outlines minimum requirements for landscape irrigation devices to ensure adequate safety and performance.

Relevant to this gap, IAPMO has announced the introduction of WE-Stand, a new Water Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS).

1.12 Swimming Pools, Hot Tubs, Spas, Aquatic Features

Roadmap Gap and Recommendation

A. Standards for filters and filter media testing that address water efficiency

Standards are needed to evaluate the water consumption of a pool and spa filtration system. The efficiency of a filter's backwash ability is critical to its water consumption. The industry often uses the backwash to help eliminate contaminates in the pool. The backwash water is sent to waste and new water – "make up water" – is added to dilute contaminates. This industry best practice will need to be addressed, but the need for backwash efficiency still exists.

Recommended Timeline: This should be done in the near-term: 0-2 years.

***Progress Report Update*:**

A forthcoming version of NSF Standard 50, *Equipment for Swimming Pools, Spas, Hot Tubs and other Recreational Water Facilities*, will include energy water filtration efficiency criteria. The revisions are expected to be published in 2018.

Relevant to this gap, IAPMO has announced the introduction of WE-Stand, a new Water Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS).

B. Standards for UV systems that address energy efficiency

No progress report update.

C. Standards for testing the energy efficiency of disinfection systems (ozone generators, electrolytic chlorinators, and copper and silver ionizers)

No progress report update.

D. Standards for testing the efficiency of pool covers and liquid barriers

Pool covers and liquid barriers represent a significant opportunity to minimize pool energy use by reducing heat loss and evaporation. However, they cannot provide efficiencies if they are not utilized. Research is needed to investigate the behavioral aspects of pool cover use by homeowners and facility managers, and to determine realistic potential for efficiency gains. Where research shows that efficiency gains can be reasonably expected from the use of pool covers or liquid barriers, regional construction codes and best practice maintenance guidelines should be developed that require their use.

Recommended Timeline: This should be done in the mid-term: 2-5 years.

***Progress Report Update*:**

NSF/ANSI 50, *Equipment for Swimming Pools, Spas, Hot Tubs and other Recreational Water Facilities*, includes requirements for material health effects requirements for pool covers. Health effects risk assessment requirements for chemicals like liquid barriers were incorporated in 2015.

Heat retention efficiency evaluation methods and criteria need to be developed; an issue paper was submitted to the NSF/ANSI 50 committee in 2015.

1.13 Commissioning

Roadmap Gap and Recommendation

A. Commissioning practices

Currently, there appears to be much confusion on what constitutes quality commissioning practices, how it can be incorporated into codes and other standards, and the identification of quality commissioning providers. Many of these questions have been addressed by commissioning industry organizations, but not in an organized fashion. Addressing these issues in the short-term will be essential to the widespread and productive use of commissioning, and the achievement of the anticipated levels of building system and utility cost performance. Many of the organizations identified above have agreed to work collectively to address these issues. ICC is currently developing a standard to address these issues as they relate to the International Codes, which may address this gap. Additionally, ASTM and the National Institute of Building Sciences (NIBS) have begun the process of developing a set of standards and guidelines that may help to address this concern through a process referred to as building enclosure commissioning (BECx).[16]

Recommended Timeline: These activities should be conducted in the near-term: 0-2 years.

Progress Report Update:

The NIBS' Commissioning Industry Leaders Council was established to help facilitate development of educational materials focused at commissioning users. Relevant materials include the Better Buildings Workforce Guidelines (BBWG)[17] and the Whole Building Design Guide (WBDG).[18] The NIBS Commercial Workforce Credentialing Council, in partnership with DOE and commissioning-related certification organizations, has developed a common set of knowledge, skills, and abilities (KSAs) and job task analyses (JTAs) to establish baseline levels of competence for commissioning providers and others. Certifications that utilize JTAs are obtaining accreditation under ISO 17024.

ICC 1000-201x, *Standard for Commissioning*, is currently under development by ICC and is expected to be published in 2016. The standard provides requirements relating to the application of the overall commissioning process described in commissioning process standards.

The Building Commissioning Association (BCxA) has begun to develop a database of buildings, both new and existing, that have been commissioned to track everything from basic build demographics, to systems commissioning, to who provided the commissioning service and

[16] The first of those standards to be published was ASTM E2813, *Standard Practice for Building Enclosure Commissioning (BECx)*. ASTM has published the new standard E2947, *Standard Guide for Building Enclosure Commissioning*, which will replace NIBS GL-3 and be available to the industry as a complement to ASTM E2813.
[17] https://www.nibs.org/?page=cwcc
[18] http://wbdg.org/project/buildingcomm.php

what contracting and certification they were required to have to get the work.

NECA 90, *Recommended Practices for Commissioning Building Electrical Systems*, has been significantly revised and expanded. The standard describes procedures for commissioning newly installed or retrofitted building electrical systems, defines the process of commissioning building electrical systems, and provides sample guidelines for attaining optimum system performances. NECA is also in the final stages of developing a new national electrical installation standard (NEIS) titled NECA 504, *Recommended Practice for Installing Indoor Lighting Control Devices and Systems*, which includes information related to current lighting technologies and controls that include managing and controlling energy use. This standard should be published in mid-2016.

ASTM E2813, *Standard Practice for Building Enclosure Commissioning*, is intended to serve as a technically sound practice for building enclosure commissioning (BECx).

Three NFPA standards that relate to the commissioning and integrated testing of fire protection and life safety systems or emergency storage systems include: NFPA 3, *Recommended Practice for Commissioning of Fire Protection and Life Safety Systems,* NFPA 4, *Standard for Integrated Fire Protection and Life Safety Systems Testing, and* NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*.

B. Education and training on commissioning process

There is a lack of understanding of the commissioning process among many commissioning users, such as building owners, facility managers, and personnel. There needs to be education, documentation, and training developed for commissioning users on the commissioning process, deliverables, and expected results. Having educated consumers is equally important to a quality process and providers. ASTM and NIBS have begun development of a Building Enclosure Certification and Training Program, which may help to address this need. The program[19] will be developed in accordance with ISO 17024, *Conformity assessment – General requirements for bodies operating certification of persons*, which will be a requirement of the new ICC 1000, *Standard for Commissioning*, and the Better Buildings Workforce Guidelines project, an initiative led by NIBS and the U.S. Department of Energy.

Recommended Timeline: These activities should be conducted in the near-term: 0-2 years.

Progress Report Update:

As noted above, the NIBS' Commissioning Industry Leaders Council was established to facilitate development of educational materials focused at commissioning users. Relevant materials

[19] Certification levels and the pre-requisites required to achieve certification will be based on the minimum "core competencies" outlined in ASTM E2813, *Standard Practice for Building Enclosure Commissioning*, which include: Building and Materials Science, Procurement and Project Delivery, Contract Documents and Construction Administration, and Performance Test Standards and Methodology.

include the Better Buildings Workforce Guidelines (BBWG)[20] and the Whole Building Design Guide (WBDG).[21] The NIBS Commercial Workforce Credentialing Council, in partnership with DOE and commissioning-related certification organizations, has developed a common set of knowledge, skills, and abilities (KSAs) and job task analyses (JTAs) to establish baseline levels of competence for commissioning providers and others. Certifications that utilize JTAs are obtaining accreditation under ISO 17024.

ASTM and NIBS continue work on Building Enclosure Certification and Training Program.

BCxA is developing a position paper on hiring a qualified provider for an owner's project, which supports a qualification-based selection process. BCxA is also working with ASHRAE and APPA: Leadership in Educational Facilities on guidelines for the end user or owners on the commissioning process and hiring guidelines.

NECA 90, *Recommended Practices for Commissioning Building Electrical Systems*, has been significantly revised and expanded. The standard describes procedures for commissioning newly installed or retrofitted building electrical systems and defines the process of commissioning building electrical systems and provides sample guidelines for attaining optimum system performances. NECA is also in the final stages of development of a new NEIS titled NECA 504, *Recommended Practice for Installing Indoor Lighting Control Devices and Systems*, which includes information related to current lighting technologies and controls that include managing and controlling energy use. This standard should be published in mid-2016.

C. Methods for third-party provider conformity assessment and accreditation

Research, guidance, and common agreement are needed regarding the methods for third-party provider conformity assessment and accreditation. Additionally, data is needed on commissioning results and how the practices can enhance building performance and safety.[22]

Recommended Timeline: This work should be conducted in the mid-term: 2-5 years.

Progress Report Update:

The NIBS' Commercial Workforce Credentialing Council is working with the Department of Energy to develop baseline level criteria for certification of commissioning providers. The compliant certification providers will follow ISO 17024.

ICC 1000-201x, *Standard for Commissioning*, is currently under development by the ICC and expected to be published in 2016. The standard provides requirements relating to the

[20] https://www.nibs.org/?page=cwcc
[21] http://wbdg.org/project/buildingcomm.php
[22] The core competencies outlined in ASTM E2813, *Standard Practice for Building Enclosure Commissioning*, are included by reference in the recently published IAS/IEC AC476, *Accreditation Criteria for Organizations Providing Training and/or Certification of Commissioning Personnel*, and the standard is currently under consideration for inclusion in ICC 1000, *Standard for Commissioning*. Both documents will be available to local jurisdictions and code enforcement officials through the International Code Council (ICC) for adoption, and will require personnel certification of commissioning and building enclosure commissioning service-providers in conformance with ISO 17024. The U.S. Department of Energy will also include similar requirements for ISO 17024 accreditation under its Better Buildings Workforce Guidelines project.

Back to Table of Contents

application of the overall commissioning process described in commissioning process standards. This standard establishes minimum requirements for the application of the process of commissioning as required by the local jurisdiction having authority. Currently, the working draft references IAS Acceptance Criteria AC 476, *Accreditation Criteria for Organizations Providing Training and/or Certification of Commissioning Personnel*.

BCxa has developed a Certified Commissioning Professional program for individuals who lead, plan, coordinate, and manage a commissioning team to implement commissioning processes in new and existing buildings.

As related to the evaluation of electrical equipment, NFPA 790, *Standard for Competency of Third-Party Field Evaluation Bodies*, contains requirements relating to the criteria and considerations that must be taken into account for a third-party assessment and evaluation of electrical equipment in order to determine that it is safe for use.

D. Commissioning standards and guidelines for building systems

While standards and guidelines now exist for the commissioning process and many building systems have been included as identified above, several additional building systems can and should be commissioned. Standards and guidelines will need to be developed or adapted in these areas, including irrigation and decorative water systems; on-site renewable energy systems; integrated energy systems; indoor environmental quality systems; building enclosures; fire alarm, security systems, and IT systems; vertical conveyance (elevators); and integrated building automation/energy management systems.

The gap that currently exists with regard to building enclosure commissioning includes the development of a consensus guide for the implementation of the building enclosure commissioning process, which differs slightly from ASHRAE Guideline 0 and ASHRAE Standard 202, in that it speaks specifically to commissioning of the materials, components, systems, and assemblies that comprise the exterior enclosure of a building or structure. ASTM, in cooperation with NIBS, will address this gap in the Spring/Summer of 2014 with the publication of a new ASTM Standard Guide for Building Enclosure Commissioning, which will replace NIBS Guideline 3, *Building Enclosure Commissioning Process BECx*.

Recommended Timeline: These activities should be conducted in the mid-term: 2-5 years.

***Progress Report Update*:**

NIBS developed Guideline 3 to serve as guidance for commissioning of the building enclosure. Guideline 3 recently went through the standards development process at ASTM to become a standard. It is now E2947, *Standard Guide for Building Enclosure Commissioning*. In addition to the standard, ASTM is developing a certification program around building enclosure commissioning. NIBS is developing educational programs in support of the building enclosure certification program, and training materials are being rolled out to Building Enclosure Councils nationwide who will be able to conduct training at the local level. NIBS is also encouraging discipline-specific organizations to develop commissioning programs focused on individual systems, but ideally based on ASHRAE Guideline 0/Standard 202 as the underlying process.

ASTM E2947, *Standard Guide for Building Enclosure Commissioning*, provides recommendations for the enclosure commissioning process from project planning through design, construction, and occupancy and operation phases.

The American Society of Plumbing Engineers (ASPE) is working on a standard, ASPE 100, which would provide direction and guidelines for building systems relative to commissioning. ASPE is currently developing standards on plumbing systems commissioning utilizing ASHRAE Guidelines 0, 1.1, and 1.5 as a template. The goal is to provide specific guidance on applying the commissioning process to plumbing systems in commercial, healthcare, and laboratory buildings and facilities, as well as fuel gas piping and fire protection systems.

NECA 90, *Recommended Practices for Commissioning Building Electrical Systems*, has been significantly revised and expanded. The standard describes procedures for commissioning newly installed or retrofitted building electrical systems, defines the process of commissioning building electrical systems, and provides sample guidelines for attaining optimum system performances.

IES currently has a Design Guide (DG-29), *Commissioning Process Applied to Lighting and Control Systems*, which closely mirrors ASHRAE Guideline 0-2005, *The Commissioning Process*, in its format but is specific to lighting, including daylighting.

For guidance on the commissioning and integrated testing of all fire protection, life safety, and premise security systems, NFPA standards include:

- NFPA 3, *Recommended Practice for Commissioning of Fire Protection and Life Safety Systems*
- NFPA 4, *Standard for Integrated Fire Protection and Life Safety Systems Testing*
- NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*
- NFPA 110, *Standard for Emergency and Standby Power Systems*
- NFPA 72®, *National Alarm and Signaling Code®*
- NFPA 730, *Guide for Premises Security*
- NFPA 731, *Standard for the Installation of Electronic Premises Security Systems*

In 2016, AHRI expects to publish new versions of the following standards, which include efficiency ratings; the goal is to provide rating points for manufacturers to use for operating equipment at less than 100% capacity: ANSI/AHRI Standards 550/590 (I-P) and 551/591 (SI)-2011 with Addendum 3, *Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle*, ANSI/AHRI 340/360-2007 with Addendum 2. Additional AHRI standards include AHRI Standard 210/240, *Performance Rating of Unitary Air-conditioning and Air-source Heat Pump Equipment*; AHRI 1230-2010 with Addendum 2, *Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment*; AHRI 340/360-2007 with Addendum 2, *Performance Rating of Commercial* *and Industrial Unitary Air-Conditioning and Heat Pump Equipment*; and, AHRI 390-2003, *Performance Rating of Single Package Vertical Air-Conditioners and Heat Pumps*.

1.14 Conformity Assessment

A. Gaps in the actual accreditation standards

There are various standards such as the ISO/IEC 17000 series that are designed to work together with technical standards in the energy efficiency field. The 17000 standards have systematic reviews that take place five years after publication. If they are reaffirmed, the standards are reviewed five years later unless a new work item proposal (NWIP) is proposed earlier by a CASCO member and approved by CASCO for a compelling need. The gaps from this perspective are addressed through the systematic reviews.

Recommended Timeline: This depends on ISO's systematic review process; however, some of these standards such as ISO/IEC 17011 and ISO/IEC 17000 are in need of update as soon as possible. This should be conducted in the near-term: 0-2 years.

Progress Report Update:

Two standards used to determine conformity that are currently being updated include ISO/IEC CD 17011, *Conformity assessment -- Requirements for accreditation bodies accrediting conformity assessment bodies*, and ISO/IEC CD 17025, *General requirements for the competence of testing and calibration laboratories*.

The ISO Committee on Conformity Assessment (CASCO) endorsed a medium-term plan on how to sequence and when to undertake future systematic reviews of ISO and ISO/IEC documents related to conformity assessment. This plan is a 'living' document, and is endorsed annually at the CASCO plenary meeting. The CASCO Road Map acts as an indication of any future CASCO work and provides early notice of when international standards and guides are likely to be revised. The CASCO Road Map also indicates relations with other ISO technical committees' documents, which helps to sequence other international standards development activities. In principle, each document is subject to a five-year systematic review (Technical Specifications are reviewed every three years), as prescribed in the ISO/IEC Directives. However, as approved by the 2003 CASCO plenary, minor timing adjustments allow the review of interrelated international standards and guides together as necessary. As a result, related documents can be revised within the same period of time and in the context of a single working group. This process allows for a more efficient use of expertise and a satisfactory level of compatibility between various documents.

Chapter Two: System Integration and Systems Communications

2.3 System Integration and Systems Communications

Roadmap Gap and Recommendation

A. Common information models and taxonomies

Standards are needed around common information models and taxonomies using common protocols to transmit data between the building and the Smart Grid, so that Smart Grid service providers can utilize data in a consistent way.

Recommended Timeline: This work should be conducted in the near-term: 0-2 years.

> ***Progress Report Update*:**
>
> IEC 61970, *Common Information Model (CIM)/Energy Management*, developed by IEC TC 57, *Power systems management and associated information exchange*, is being extended to cover both wholesale and retail demand response in a manner consistent with other market standardization work being done by the IEC.
>
> Published in 2015, IEC Technical Specification (TS) 62746-3:2015, *Systems interface between customer energy management system and the power management system - Part 3: Architecture*, establishes an architecture that is supportive of interfaces between the customer energy management system and the power management system.
>
> IEC Technical Report (TR) 62939, *Smart grid user interface - Part 1: Interface overview and country perspectives*, published by IEC Project Committee (PC) 118, *Smart grid user interface*, presents a vision for a Smart Grid User Interface (SGUI) including SGUI requirements distilled from use cases for communications across the customer interface.
>
> IEC PC 118, *Smart grid user interface*, has also developed an IEC Publicly Available Specification 62746-10-1, *Systems interface between customer energy management system and the power management system - Part 10-1: Open Automated Demand Response*, which is intended as a flexible data model to facilitate common information exchange between electricity service providers, aggregators, and end users.
>
> IEC PC 118 is also working on another document based on an OASIS standard that addresses modeling and communication protocols for more general building (residential, commercial, industrial) to grid communication and services.

B. Communication between building energy management systems and the grid

As standards are implemented to support communication between building energy management systems and the grid, there will be an ongoing need for standards to support communication.

Recommended Timeline: This work should be conducted in the mid-term: 2-5 years, with ongoing attention to evolving needs.

Progress Report Update:

As noted above, IEC 61970, Common Information Model (CIM)/Energy Management, is being extended to cover both wholesale and retail demand response in a manner consistent with other market standardization work being done by the IEC.

Published in 2015, IEC TS 62746-3:2015, *Systems interface between customer energy management system and the power management system - Part 3: Architecture*, establishes an architecture that is supportive of interfaces between the customer energy management system and the power management system.

IEC Technical Report 62939, *Smart grid user interface - Part 1: Interface overview and country perspectives*, published by IEC PC 118, presents a vision for a Smart Grid User Interface (SGUI), including SGUI requirements distilled from use cases for communications across the customer interface.

IEC PC 118 has also developed an IEC Publicly Available Specification 62746-10-1, S*ystems interface between customer energy management system and the power management system - Part 10-1: Open Automated Demand Response*, which is intended as a flexible data model to facilitate common information exchange between electricity service providers, aggregators, and end users.

IEC PC 118 is also working on another document based on an OASIS standard that addresses modeling and communication protocols for more general building (residential, commercial, industrial) to grid communication and services.

C. Consistent data communication

No progress report update.

D. Methodology and identification of energy data formats and attributes

There is a need for standards that provide for the development of the methodology and identification of the commonly exchanged device, asset, process, and system integration parameters and specifications (data formats and attributes) related to significant energy uses or objectives of an energy management system.

Recommended Timeline: This work should be conducted in the near-term: 0-2 years.

Progress Report Update:

In June 2014, ISO TC 242, *Energy Management*, initiated a standardization activity to address this gap, and is currently developing ISO/AWI 50008, *Commercial building energy data* *management for energy performance -- Guidance for a systemic data exchange approach*. ISO TC 242 Working Group (WG) 6 meetings were held in Merida, Mexico, in June 2015, and in Atlanta, GA, in January 2016. The next meeting is scheduled in Sweden in June 2016. The plan is to circulate a committee draft after the June 2016 meeting.

Other relevant standards include:

- ISO 20140, *Automation systems and integration - Evaluating energy efficiency and other factors of manufacturing systems that influence the environment - Part 1: Overview and general principles*
- ISO 20140, *Automation systems and integration - Evaluating energy efficiency and other factors of manufacturing systems that influence the environment - Part 5: Environmental influence evaluation data*. The document has been circulated for a three-month comment period starting February 3, 2016. The ISO 20140-5 committee draft for voting has a series of similarities with the data exchange described in the ISO 50008 working draft.
- ASHRAE/NEMA Standard 201, *Facility Smart Grid Information Model*

E. Measurement and monitoring protocols for energy data

There is a need for standards to establish measurement and monitoring protocols, including the recognition of security protocols, to support energy data.

Recommended Timeline: This work should be conducted in the near-term: 0-2 years.

***Progress Report Update*:**

ODVA has developed the Common Industrial Protocol (CIP), a specification for communicating energy information and control data and commands over a standard network interface (EtherNet/IP protocol) for industrial applications.

Other relevant standards include, as noted above:

- ISO 20140, *Automation systems and integration - Evaluating energy efficiency and other factors of manufacturing systems that influence the environment - Part 1: Overview and general principles*
- ASHRAE/NEMA Standard 201, *Facility Smart Grid Information Model*

F. Methodology for energy information sharing

There is a need for standards that provide a methodology for energy information sharing within a building, facility, or group of facilities, as well as with the grid.[23]

Recommended Timeline: This work should be conducted in the mid-term: 2-5 years.

> ***<u>Progress Report Update</u>*:**
>
> IEC 61970, *Common Information Model (CIM)/Energy Management*, developed by IEC TC 57, is being extended to cover both wholesale and retail demand response in a manner consistent with other market standardization work being done by the IEC.
>
> Published in 2015, IEC TS 62746-3:2015, *Systems interface between customer energy management system and the power management system - Part 3: Architecture*, establishes an architecture that is supportive of interfaces between the customer energy management system and the power management system.
>
> ISO/ WD 17800 *Facility Smart Grid Information Model* is currently under development by ISO TC 205, *Building environment design*. This international effort is closely linked to the draft ASHRAE/NEMA standard 201P, *Facility Smart Grid Information Model*.

G. Methodology of integrating the building sub-systems into an energy system

There is a need for a technical guide that provides for the development of a methodology for integrating building sub-systems into an energy system in a manner that serves the mutual interests of each sub-system to perform and the overall building energy efficiency.[24]

Recommended Timeline: This should be conducted in the near-term: 0-2 years.

> ***<u>Progress Report Update</u>*:**
>
> Relevant standards include:
>
> - ISO 20140, *Automation systems and integration - Evaluating energy efficiency and other factors of manufacturing systems that influence the environment - Part 1: Overview and general principles*
> - IEC TR 62837, *Energy efficiency through automation systems*
> - ASHRAE/NEMA Standard 201, *Facility Smart Grid Information Model*

[23] In this usage, "building" refers to the structure of building envelope. For details on building energy information, visit http://www.wbdg.org/bim/nibs_bim.php.

[24] Technology research needs related to this discussion are highlighted in the Bonneville Power Administration's (BPA) *National Energy Efficiency Technology Roadmap Portfolio*, March 2014 version. See section on "Enterprise and Maintenance Management Systems (1 of 9)" (pp. 394-394): http://www.bpa.gov/energy/n/emerging_technology/pdf/EE_Tech_RM_Portfolio.pdf.

Chapter Three: Building Energy Rating, Labeling, and Simulation

3.1.5 Rating and Labeling Programs

Roadmap Gap and Recommendation

A. Data availability

Operational ratings and labeling programs rely on data that is representative of the existing building and industrial plant stock. As noted earlier, data sources such as the Residential Energy Consumption Survey (RECS), Commercial Building Energy Consumption Survey (CBECS), Manufacturing Energy Consumption Survey (MECS), and the Census of Manufacturing are commonly used for operational rating development. However, these data sets are frequently limited in the number and types of buildings included in the surveys, the granularity of building characteristics, robustness of the sample, and timeliness of the data.

There are many issues due to limited data sets. One critical issue is that limitations in the amount and quality of data in the CBECS and RECS studies can impact the consistency within a rating system. CBECS results for specific building types can vary significantly from survey to survey. This creates changes in the rating scores for buildings with no action taken by the owner. A high scoring building may become a low scoring building. Investment in additional data collection will reduce this noise and increase trust in the ratings.

In addition, many building types have insufficient data on which to base a rating program. This is most evident in the commercial building arena, but also affects mixed use and multi-family building types. An expansion in the types of buildings included in the consumption surveys listed above would help to remedy this situation. Additional data sets could also benefit asset ratings by providing more robust information on which to base standard occupancy assumptions.

In recent years, funding for building energy surveys has been questioned, and in some cases, reduced. If further development or refinement of existing operational ratings is to take place, additional steps should be taken to expand or establish new data sets that can be used to create operational ratings. Additionally, steps could be taken to establish criteria or standards for guiding data collection by organizations seeking to collect building performance data for operational rating development.

Recommended Timeline: Existing efforts underway need to be accelerated in the near-term: 0-2 years. However, this is an ongoing need that is going to exist in the long-term. Those organizations in charge of collecting data (e.g., U.S. Energy Information Administration, Census) should continue to solicit feedback from stakeholders with each iteration of their surveys in order to improve the data collected and the collection process.

Progress Report Update:

In 2015, the U.S. Energy Information Administration (EIA) published the latest version of CBECS building characteristics and summary tables. Preliminary consumption data estimates were released in February 2016 with detailed tables released in March 2016. Consumption microdata is expected in April 2016.[25]

B. Taxonomy and terminology

Currently, different systems use different definitions for common terms such as baseline, benchmark, label, reference, etc. As a result, it can be difficult to compare or quickly understand the structure and design of various rating systems. Further dialogue (and consensus where possible) is needed to clarify terminology used in this field.

Recommended Timeline: This should be conducted in the near-term: 0-2 years.

Progress Report Update:

ASHRAE 214P, *Standard for Measuring and Expressing Building Energy Performance in a Rating Program*, which is currently under development, may help to address this gap.

BEDES (Building Energy Data Exchange Specification), developed by the U.S. Department of Energy, also offers relevant taxonomy and terminology for rating and labeling tools.

3.2 Building Energy Simulation

3.2.1.1.1 Commercial Buildings

Roadmap Gap and Recommendation

A. Single rule set

All codes and beyond-code programs should use a single rule set for performance-path modeling.

Recommended Timeline: This process should be initiated in the near-term: 0-2 years, but may not be fully implemented for 2-5 years.

Progress Report Update:

This gap is addressed through an addendum BM to ASHRAE Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, which was published in the ASHRAE 90.1 2013 Supplement.

A proposal is being introduced to the IECC to use the ASHRAE approach for the 2018 edition. USGBC has expressed interest in using the new ASHRAE approach for LEED certification. It is

[25] For more details, visit http://www.eia.gov/consumption/commercial.

uncertain whether the IECC proposal will be successful. Several other energy codes and beyond code programs are exploring the use of the addendum BM approach. For this recommendation to be fully realized, the approach will need to be embraced by other codes (Title 24 and other state-specific and beyond-code programs).

B. Prescriptive baselines

The prescriptive baseline should not change with improvements to codes and standards. Rather than ratcheting up prescriptive baselines, standards should advance by ratcheting up performance increases over a fixed prescriptive baseline. In this setup, different standards could continue to set and advance performance increments independently and even set minimum prescriptive responses independently.

Recommended Timeline: This should be conducted in the near-term: 0-2 years.

Progress Report Update:

This gap is addressed through an addendum BM to ASHRAE Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, which was published in the ASHRAE 90.1 2013 Supplement.

A proposal is being introduced to the IECC to use the ASHRAE approach for the 2018 edition. USGBC has expressed interest in using the new ASHRAE approach for LEED certification. It is uncertain whether the IECC proposal will be successful. Several other energy codes and beyond code programs are exploring the use of the addendum BM approach. For this recommendation to be fully realized, the approach will need to be embraced by other codes (Title 24 and other state-specific and beyond-code programs).

C. Comprehensive, robust rule sets

Rule sets need to be better defined, more comprehensive, and more robust.

Recommended Timeline: This should be conducted in the near-term: 0-2 years.

Progress Report Update:

The ASHRAE Standard 90.1 Addendum BM creates a unified code compliance/beyond-code path.

On the side of rule set detail, the COMNET Modeling Guidelines and Procedures (MGP) prescribes additional modeling assumptions and could eventually be adopted or referenced by ASHRAE standards.

DOE, through PNNL, is also expanding on the work done by COMNET to develop the rule set into a detailed software specification.

3.2.1.1.2 Residential buildings

Roadmap Gap and Recommendation

A. Standards for software tools used in different rating purposes

Recognizing that increased cost effectiveness of rating delivery can be improved by data and process integration, it is recommended that standards be identified and developed that consider different rating purposes (e.g., real estate transaction, posting on multiple listing service (MLS) or commercial listing service, energy audit, new home, financial incentive applications).

Recommended Timeline: This should be conducted in the near-term: 0-2 years. Identification could be completed within 1 year and standards could be developed within 2 years.

***Progress Report Update*:**

A standard that may help to address this gap is NIBS's National Building Information Modeling Standard (NBIMS) Version 3, which provides a basis for interoperability of building data across the entire life cycle from design through operations.

Note: In Phase II, the EESCC updated the title of the gap for clarity, as the recommendation is for standards for the software tools used by rating systems. The original title used in the roadmap was "Standards for different rating purposes."

3.2.1.1.4 Data Centers

Roadmap Gap and Recommendation

A. Standard for data centers

If possible, ASHRAE should seek to publish the first version of the 90.4 standard by the next update cycle in 2016. This first version should, to the extent possible, align with the protocols and methodologies of the 90.1 standard.

Recommended Timeline: This should be conducted in the mid-term: 2-5 years.

***Progress Report Update*:**

ASHRAE Standard 90.4P, *Energy Standard for Data Centers and Telecommunications Buildings*, is currently under development for targeted publication in late 2016.

3.2.1.2 Energy Simulation for Whole-Building Energy Efficiency Incentives

3.2.1.2.1 Commercial Buildings

Roadmap Gap and Recommendation

A. Simulation methodologies and protocols[26]

The proposed standard, ASHRAE Standard 209P, *Energy Simulation Aided Design for Buildings Except Low-Rise Residential Buildings*, is designed to fill the modeling protocol gap above. A reasonable goal is for a first version of the standard to be published along with the next update to ASHRAE Standard 90.1 in 2016. ASHRAE Standard 140 will eventually address the simulation tool suitability gap, but the effort to bring the standard to the necessary level will require a significant volume of detailed measured data, and therefore may evolve slowly. Accelerating the development of the standard – specifically on the data gathering and model reconciliation activities that underlie the standard – will require substantial resources.

Recommended Timeline: This should be conducted in the mid-term: 2-5 years.

Progress Report Update:

ASHRAE Standard 209P, *Energy Simulation Aided Design for Buildings Except Low-Rise Residential Buildings*, is currently under development for publication in 2016. Its purpose is to define minimum requirements for providing energy design assistance using building energy simulation and analysis.

3.2.1.2.2 Residential Buildings

Roadmap Gap and Recommendation

A. Develop standardized definitions for energy conservation measures, standard protocols for simulation, and standard implementations of those protocols

The recommendation is to align the BEDES, BPI 2100/2200, measure cutsheet, NREMDB, and BCL projects, potentially using ASHRAE Standard 209P as a standards vehicle for the simulation protocols. HERS BESTEST, BPI 2400, and the RESNET extensions to HERS BESTEST for heating plant, distribution system, DHW (domestic hot water), and improvement measure interaction need to be expanded, especially in the HVAC space, to support this effort. This is a cascading, multi-step effort that could take 5-10 years to complete.

Recommended Timeline: This is a long-term work effort and should be completed in 5+years.

[26] Technology research needs related to this discussion are highlighted in the Bonneville Power Administration's (BPA) *National Energy Efficiency Technology Roadmap Portfolio*, March 2014 version. See the reference to the R&D Program "More variability, determined automatically in simulation for more realistic systems modeling" in the section "Modeling, Lab and Field Testing (1 of 9)" (pp. 326-327): http://www.bpa.gov/energy/n/emerging_technology/pdf/EE_Tech_RM_Portfolio.pdf.

Progress Report Update:

BEDES, developed by the U.S. Department of Energy, offers relevant taxonomy and terminology for rating and labeling tools. The tools will be updated and extended on an ongoing basis.

B. Develop a standardized procedure for simulation model review

No progress report update.

C. Develop standard methods for estimating uncertainty in energy-savings calculations as well as acceptability ranges for uncertainty

Ad hoc tools for uncertainty analysis are very close and should help. However, there is some research to be done before a sound, useful, comprehensive framework is put in place 3-5 years from now.

Progress Report Update:

During the EESCC's Phase II, this gap was confirmed to apply to both residential and commercial buildings. In the June 2014 roadmap, it was identified as an area for residential buildings only.

3.2.1.2.3 Multi-family Buildings

Roadmap Gap and Recommendation

A. Standardized modeling requirements for multi-family buildings

New work on multi-family modeling should be done to develop standardized modeling requirements.

Recommended Timeline: Work to address this should gap begin immediately and should be completed in the mid-term: 2-5 years.

Progress Report Update:

BPI-1105-S-201x, *Standard Practice for Multifamily Energy Auditing*, which is currently under development by the Building Performance Institute (BPI), may help to address this gap. This standard defines minimum criteria for conducting a building-science-based evaluation of existing multi-family buildings and provides technical procedures to conduct a multi-family building energy audit as necessary to define the minimum skills required by a BPI Multifamily Energy Auditor.

3.2.1.3 Building Energy Simulation for Use in Evaluation, Measurement, and Verification

3.2.1.3.1 Commercial Buildings

Roadmap Gap and Recommendation

A. Explicit linkages for standards specifying building simulation

Standards specifying building simulation software should provide explicit linkages to other standards providing specifics related to calibration, training, and certification of software, including ASHRAE Guideline 14 (calibration), ASHRAE Standard 140 (software certification), BPI 2400-S-2011 (calibration), and the California Evaluation Framework and Protocols (training).[27]

Recommended Timeline: This should be conducted in the near-term: 0-2 years.

Progress Report Update:

ASHRAE bEQ has initiated a research project with the purpose of understanding the differences between empirical and modeled baselines for building energy performance and to identify sets of building operation inputs for schedules, plug loads, ventilation rates, etc., that when used with energy models provide better agreement with the empirical data. The research also aims to lead to consistency of energy performance metrics for a number of ASHRAE standards.

Note: This gap is closely related to Gap 3.2.1.3.2 A for residential buildings and is likely to be addressed by the same action.

3.2.1.3.2 Residential Buildings

Roadmap Gap and Recommendation

A. Explicit linkages for standards specifying building simulation

Standards specifying building simulation software should provide explicit linkages to other standards providing specifics related to calibration, training, and certification of software, including ASHRAE Guideline 14 (calibration), ASHRAE Standard 140 (software certification), BPI 2400-S-2011 (calibration), and the California Evaluation Framework and Protocols (training).[28,29]

Recommended Timeline: This should be addressed in the near-term: 0-2 years.

Progress Report Update:

ASHRAE bEQ has initiated a research project with the purpose of understanding the differences between empirical and modeled baselines for building energy performance and to

[27] Software certification is discussed in Section 3.2.2, *Energy Simulation Software Capabilities and Accuracy*.

[28] TecMarket Works, "The California Evaluation Framework,"June 2004.

[29] TecMarket Works, "California Energy Efficiency Program Evaluation Protocols: Technical, Methodological, and Reporting Requiremnts for Evaluation Professionals," April 2006.

identify sets of building operation inputs for schedules, plug loads, ventilation rates, etc., that when used with energy models provide better agreement with the empirical data. The research also aims to lead to consistency of energy performance metrics for a number of ASHRAE standards.

Note: This gap is closely related to Gap 3.2.1.3.1 A for commercial buildings and is likely to be addressed by the same action.

3.2.2 Energy Simulation Software Capabilities and Accuracy

3.2.2.1 Commercial and Residential Buildings

Roadmap Gap and Recommendation

A. Roadmap for improving the coverage and physical fidelity of energy simulation engine tests

The recommendation is to develop a roadmap for improving the coverage and physical fidelity of energy simulation engine tests, including expanding the range of tests for existing buildings and potentially including reference results from empirical measurements. This activity would use the growing collection of test facility data to characterize and benchmark the simulated accuracy of major building-physics phenomena and common HVAC system types, and create a prioritized list of missing or lagging simulation capabilities combined with measurement experiments needed to resolve or upgrade them.[30]

Recommended Timeline: This should be completed in the mid-term: 2-5 years.

Progress Report Update:

In 2015, Lawrence Berkeley National Laboratory (LBNL), Oak Ridge National Laboratory, the National Renewable Energy Laboratory (NREL) and Argonne National Laboratory were awarded a three-year, $2.7M grant to develop a framework and initial set of experiments for empirical validation and uncertainty characterization of building energy modeling engines. The results will be channeled into ASHRAE Standard 140, *Method of Test for Evaluation of Building Energy Analysis Computer Programs*.

B. Tests for energy simulation software and supporting software

There is a need to develop and reference suites of tests for energy simulation software and supporting software – potentially with accuracy guidelines – that are appropriate for specific use cases. Each suite should be designed to: (1) be applicable to market uses and/or connected to standard program types such as residential, commercial, new, existing, whole building, retro-commissioning, code compliance, ratings, incentives; and (2) where appropriate, explicitly test before- and after-simulation of efficiency measures associated with these use cases.

[30] Technology research needs related to this discussion are highlighted in the Bonneville Power Administration's (BPA) *National Energy Efficiency Technology Roadmap Portfolio*, March 2014 version. See the section on "Modeling, Lab and Field Testing" (pp. 326-345): http://www.bpa.gov/energy/n/emerging_technology/pdf/EE_Tech_RM_Portfolio.pdf.

Such test suites should be designed to: (a) assess accuracy and coverage of software capabilities; (b) standardize the level of effort required by software vendors to test software; and (c) foster development and implementation of third-party validation methods/systems.

In regulated contexts, credentials for the accuracy of savings calculations are extremely valuable. Utility programs rely on state-level technical reference manuals to approve calculation methodologies. The manuals, which often include references to standards as opposed to specific tools, could cite these standard suites of tests along with acceptability/accuracy criteria that meet the programs' needs.

This would parallel the simulation accuracy benchmarking activity described above. It could be led by a standards organization whose published scope covers this type of activity.

Recommended Timeline: This should be completed in the mid-term: 2-5 years.

Progress Report Update:

As noted above, in 2015, LBNL, Oak Ridge National Laboratory, NREL, and Argonne National Laboratory were awarded a three-year, $2.7M grant to develop a framework and initial set of experiments for empirical validation and uncertainty characterization of building energy modeling engines. The results will be channeled into ASHRAE Standard 140, *Method of Test for Evaluation of Building Energy Analysis Computer Programs*.

C. Develop a robust and low-cost testing procedure for model-input calibration

This is a 1-2 year activity already undertaken by RESNET, which has formed a working group to generalize and codify the BESTEST-EX methodology for calibrating energy model inputs using measured data, e.g., utility bill data.

Recommended Timeline: This should be completed in the near-term: 0-2 years.

Progress Report Update:

RESNET is continuing its work in this area. The method of test for calibration procedures under development elaborates on the "pure" test method mentioned in BESTEST-EX.

3.2.3 Energy Simulation Professionals

Roadmap Gap and Recommendation

3.2.3.1 Commercial Buildings

A. Harmonize – or at least differentiate – the BESA™ and BEMP certificates

The relationship between the BEMP and BESA™ certificates is not clear, although the BESA™ certificate requires less experience for qualification.

Recommended Timeline: Differentiation is a near-term goal: 0-2 years. Harmonization is a long-term goal: 5+ years

> ***Progress Report Update*:**
>
> During the EESCC's Phase II, this gap was confirmed to apply to both residential and commercial buildings. In the June 2014 roadmap, it was identified as a gap for commercial buildings only.

B. Any simulation used for code compliance or asset rating should be overseen by a credentialed simulation professional

Beginners should not be responsible for simulations that explicitly support regulatory or financial transactions. However, they do have to learn somewhere, and furthermore, to learn by doing. The apprenticeship and responsibility structure should track that which is used in other engineering fields. An engineer in training may do the work, but a credentialed engineer (i.e., a PE) reviews it, stamps it, and is ultimately responsible for it. A timeframe for enforcing this requirement generally should be at least five years, because the number of credentialed simulation professionals is currently small.

Recommended Timeline: This is a long-term work effort and should be completed in 5+ years.

> ***Progress Report Update*:**
>
> During the EESCC's Phase II, this gap was confirmed to apply to both residential and commercial buildings. In the June 2014 roadmap, it was identified as a gap for commercial buildings only.

3.2.3.2 Residential Buildings

A. Standardized methods for credentialing

Standardized methods of credentialing qualified users of residential energy simulation software should be created to address this gap.

Recommended Timeline: This should be conducted in the near-term: 0-2 years.

> ***Progress Report Update*:**
>
> During the EESCC's Phase II, this gap was confirmed to apply to both residential and commercial buildings. In the June 2014 roadmap, it was identified as an area for residential buildings only.

CHAPTER FOUR: EVALUATION, MEASUREMENT, AND VERIFICATION (EM&V)

4.1.1 Baselines

Roadmap Gap and Recommendation

E. Automatic benchmarking of commercial and residential buildings

The advent of higher resolution data and more complete data sets describing buildings has opened the possibility of building energy management systems (EMSs) themselves "automatically" benchmarking a building by recording energy use and being programmed to estimate equations describing building energy use.[31] The advantages are that the EMS would have a basis for diagnosing building performance. For EM&V, a "baseline" of pre-upgrade performance would automatically be available. If many buildings in a given program had this capability, EM&V approaches could be modified to use larger samples (of self-benchmarking buildings), but at potentially different accuracy at each individual building. While this is an interesting possibility for developing faster, less costly EM&V, it relies on the quality of the benchmark the building's EMSs are creating. The gap is that metrics or testing procedures to assess the accuracy of these self-created benchmarks do not exist. Some initial work in this regard has been done,[32] but more must be done for self-benchmarking buildings to provide a reliable basis for EM&V. Organizations with access to high-resolution building energy usage should research automatic benchmarking approaches to determine suitable metrics for the accuracy of self-benchmarking algorithms. This should be done with industry input regarding the purpose and use of the self-benchmarking capability.

Recommended Timeline: This should be conducted in the mid-term: 2-5 years.

Progress Report Update:

Lawrence Berkeley National Laboratory (LBNL) has tested various approaches and published several research papers on automatic benchmarking, automatic measurement, and verification of energy usage changes, and on assessing or comparing different analytic tools. Work is continuing.

[31] The Bonneville Power Administration's (BPA) *National Energy Efficiency Technology Roadmap Portfolio*, March 2014 version, highlights technology research needs related to energy management. See the section "Real-time Smart Electric Power Measurement of Facilities (1 of 3)" (pp. 388-389): http://www.bpa.gov/energy/n/emerging_technology/pdf/EE_Tech_RM_Portfolio.pdf.

[32] A fact sheet with links to published results can be found at http://www.etcc-ca.com/reports/commercial-building-energy-baseline-modeling-software-performance-metrics-and-method-testing.

4.1.4 Technical Reference Manuals (TRMs)

Roadmap Gap and Recommendation

A. Establish a standard format and content guide

In order to promote consistency and wider adoption of TRMs, establish a standard format and content guide. The format could be developed by an independent contractor (national lab, university, industry group) acting under an advisory group of TRM users. Such a guide could come in the form of model business practices, business practice standards, or through other stakeholder-led processes. One area to explore that may create consistency in this area is to define the component factors of the TRMs that may be established as state or federal policy objectives rather than objective engineering analysis. In this manner there would be transparency on the differences between TRMs, rather than the assumption that the fundamental engineering analysis is not applicable across sectors or regions.

Recommended Timeline: This effort is on several stakeholders' work plans, though is yet to be completed. This is an area that is ripe for standardization and considered a near-term priority. This work should be conducted in the near-term: 0-2 years.

Progress Report Update:

The Northeast Energy Efficiency Partnerships (NEEP) is exploring interest in the Northeast region on digitizing existing TRMs, possibly using a platform recently built for Rhode Island, Massachusetts, and Connecticut.

The State and Local Energy Efficiency Action Network (SEE Action) is developing a document on best practices and recommendations for TRMs, including a TRM template (what TRMs should include), based on directives from the EPA's Clean Power Plan.

E Source's *Measure Insights* consolidates publicly available TRM data in an online database of deemed savings values and other measure-specific assumptions on which utilities base their demand-side management program calculations.

The North American Energy Standards Board (NAESB) is considering potential work in this area.

4.2.1 Tracking Systems

Roadmap Gap and Recommendation

A. Set of standard terms and definitions that can be applied nationally

A set of standard terms and definitions for designating and reporting energy efficiency program and project data at all levels (from technologies to projects to programs to portfolios) that can be applied nationally is recommended. This project would leverage the new work being planned under BEDES and coordinate with SEE Action to establish standard reporting requirements for energy efficiency projects and programs.

Recommended Timeline: This should be accomplished in the mid-term: 2-5 years.

***Progress Report Update*:**

BEDES, developed by the U.S. Department of Energy, establishes terms, definitions and field formats covering building characteristics, efficiency measures, and energy use, for commercial, single family, and multi-family buildings. It is intended to be used in tools and activities that help stakeholders make energy investment decisions, track building performance, and implement energy efficient policies and programs. It will be updated and extended on an ongoing basis.

NAESB is considering potential work in this area.

4.2.2 Standardized Data Collection

Roadmap Gap and Recommendation

B. Standardizing reporting characteristics of audit and implementation data

An additional gap was identified regarding standardizing reporting characteristics of audit and implementation data which may be routinely communicated to evaluation professionals, including how installation of individual EE measures is tracked. Standardization could improve data quality, EM&V implementation timelines, and reduce cost in the preparation of that data for EM&V purposes. This could be considered as part of future EM&V standardization.

Recommended Timeline: This should be done in the mid-term: 2-5 years.

***Progress Report Update*:**

The Standard Energy Efficiency Data (SEED) Platform has been established as a collaborative between DOE, the Institute of Market Transformation, the National League of Cities, the National Association of State Energy Officials (NASEO), and the Natural Resources Defense Council (NRDC) to look at new use of data, how to exchange best practices with new availability of data, and to provide platform in which to exchange the data.

NEEP is developing standardized EM&V methods reporting and is currently in the process of piloting forms.

The Climate Registry, six states, and NASEO are developing a national energy efficiency registry[33] that will allow states to track initiatives within their own programs as well as demonstrate compliance with the Clean Power Plan.

Bonneville Power Administration (BPA), Cadmus, the Northwest Power and Conservation Council, and others have been partnering on an effort to collect and merge regional data in the Northwest using a taxonomy that mapped data from sector to end use. The Northwest Power and Conservation Council's Seventh Power Plan was adopted in February 2016.[34]

LBNL is developing an energy efficiency reporting tool, which is expected to be released in the near future.

[33] https://www.theclimateregistry.org/thoughtleadership/energy-efficiency/

[34] https://www.bpa.gov/EE/Utility/toolkit/Pages/Six-Going-On-Seven.aspx

NAESB is considering potential work in this area.

4.4.1 Role of Conformity Assessment/Accreditation

Roadmap Gap and Recommendation

A. Establish relationship between conformity assessment standards that impact energy efficiency at a more global level, as well as its impact in risk and financial management

While the conformity assessment standards are equally related to applications in the compliance and enforcement of standards and workforce credentialing, and are covered in Chapters 1 and 5 respectively, it is important to establish the relationship between the different conformity assessment standards that impact EE at a more global level. In addition, it is important to establish the relationship between conformity assessment and its impact in risk and financial management.

Recommended Timeline: This should be done in the near-term: 0-2 years.

Progress Report Update:

NEEP is facilitating a small project at the request of the U.S. Department of Energy to explore the possible components of and approaches to certifying EM&V professionals performing energy efficiency program impact analysis, which should be completed the summer of 2016.

In 2015, the NIBS Council on Finance, Insurance, and Real Estate (CFIRE) released a report on financing small commercial energy efficiency retrofit projects and identified challenges and recommended action.

On the Horizon

Energy efficiency is a complex, cross-cutting issue that impacts all industry sectors, government policy, and consumers. The aim of the EESCC, standardization roadmap, and progress report is to help facilitate and coordinate the development of standardization activities and raise awareness of the standardization community's efforts to address the roadmap gaps.

Depending on the needs of stakeholders and available resources, periodic progress updates on significant energy efficiency standardization activities to address roadmap gaps may be made. Issues that are new or that require further discussion may also be explored. The goal behind any such efforts will be to continue to help guide, coordinate, and enhance the standardization landscape to support energy and water efficiency in the United States.

Appendix A: Summary of Updates Addressing Original Roadmap Gaps/Recommendations

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
Chapter One: Building Energy and Water Assessment and Performance Standards	Water-Energy Nexus	1.1	**A. Standards that address supply chain- and product- embedded water–energy evaluations** There is a need for standards that address supply chain- and product-embedded water–energy evaluations that can inform consumers of the energy and water intensity of the building systems, products, or services they buy. There is currently no recognized consistent methodology for the way building systems, products, and services are evaluated for their overall water and energy footprint. Architects, engineers, consumers, and companies wishing to proactively reduce their water and energy intensity often receive mixed messages as a result. Developing uniform standards that address the water and energy embedded in a system's or product's supply chain would: (1) provide a needed consistent method that would allow proper cross-comparison of options for products and services; (2) smooth out the duplicative and competing footprint methodologies, some of which unfairly favor certain companies, processes, or products, and most of which do not correctly count both water and energy interactions back through the supply chain; and (3) allow a deeper focus on systems, products, and services in the commercial and industrial sectors where the combined water and energy savings potential is very high. **Original Roadmap Recommended Timeline:** While work should begin as soon as possible, this is a complex issue and is therefore a long-term effort: 5+ years.	The International Organization for Standardization (ISO) has published ISO 14046, *Environmental management - Water footprint - Principles, requirements and guidelines*, outlining principles, requirements and guidelines related to water footprint assessment of products, processes, and organizations based on life cycle assessment. IAPMO has announced the introduction of WE-Stand,[35] a new Water Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS). ASTM Subcommittee E60.7 on Water Use and Conservation has established a task group to determine future work items related to water and energy efficiency.
Chapter One: Building Energy and Water Assessment and Performance Standards	Water-Energy Nexus	1.1	**B. Water and energy industry-accepted EM&V protocols** There is a need for water and energy industry-accepted evaluation, measurement, and verification (EM&V) protocols that can be utilized by standards developers to help make determinations on provisions where water and energy tradeoffs exist. Detailed EM&V protocols already exist for analyzing energy efficiency performance, but these protocols need to	In July 2014, the U.S. Department of Energy (DOE) released *The Water Energy Nexus: Challenges and Opportunities*.[36] In chapter six of the report, DOE offers its vast capabilities in multi-system, multi-scale modeling, analysis, data management, and computation as an available resource. SDOs are encouraged to utilize these tools for the

[35] http://www.iapmo.org/WEStand/Pages/default.aspx
[36] http://www.energy.gov/articles/department-energy-releases-water-energy-nexus-report

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			be revised to properly address the embedded energy savings emanating from water conservation and management programs. To date, only savings from hot water conservation programs have been included in these evaluation protocols. Interactive water and energy savings need to be properly documented where they occur, and greenhouse gas emission reduction calculation methodologies need to be revised to correctly recognize the contributions coming from the saved embedded energy in water supply, treatment, pumping, and consumer end use consumption. **Original Roadmap Recommended Timeline:** While work should begin as soon as possible, this is a complex issue and is therefore a long-term effort: 5+ years.	development of improved water-energy nexus technical provisions. In 2015, The Climate Registry published a Water-Energy Greenhouse Gas Technical Brief,[37] which provides guidance to Southern California Edison businesses in measuring and managing carbon emissions associated with the water cycle. The metrics contained in the brief may be of use to SDOs.
Chapter One: Building Energy and Water Assessment and Performance Standards	Building Envelope	1.2	**A. Window installation guidance for effective energy, air, and moisture management** Within the building envelope, windows are often the most common source of heat loss, heat gain, and air leakage – often due to deficits in detailing and installation. Proper window installation is necessary to manage the heat transfer, air leakage, and water management in the building envelope. While activities are currently underway at ASTM and elsewhere, significant effort is needed to develop and deliver meaningful window installation guidance that could be adopted into voluntary programs as well as incorporated into building codes. In the field, training is needed with a specific focus on replacement window installation to deliver effective energy, air, and moisture management. **Original Roadmap Recommended Timeline:** These activities should be conducted in the near-term: 0-2 years.	A number of work items are being addressed to expand ASTM E2112, *Standard Practice for Installation of Exterior Windows, Doors and Skylights*. WK49750 is one such work item. At ASHRAE, revisions are being considered to improve the building envelope through ASHRAE/IES 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*.
Chapter One: Building Energy and Water Assessment and Performance Standards	Building Envelope	1.2	**B. Lifecycle valuation of envelope improvements** All energy efficiency options must be considered when evaluating portfolios of materials, technologies, and methods in construction. There is currently a deficit in service life considerations as applied to total energy efficiency, particularly with regard to the long-term durability and performance of the building envelope. The building envelope is often undervalued because its permanence in the structure is not reflected in immediate resource savings. As codes and standards evolve, a life cycle assessment (LCA) methodology for valuing options should be given further consideration and should be included, where possible.	ASTM E2921, *Standard Practice for Minimum Criteria for Comparing Whole Building Life Cycle Assessments (LCA) for Use with Building Codes and Rating Systems*, is for a full building life cycle assessment; it is not applicable for individual component evaluations.

[37] http://www.theclimateregistry.org/thoughtleadership/water-energy-nexus-initiatives/

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			Original Roadmap Recommended Timeline: These activities should be conducted in the mid-term: 2-5 years.	
Chapter One: Building Energy and Water Assessment and Performance Standards	Building Envelope	1.2	**C. Standards that evaluate insulation materials performance in reducing heat flow under dynamic conditions** The current industry accepted standard, ASTM C-518, is a static test (steady-state) at one temperature that does not represent actual in-field conditions and material performance. A dynamic test standard is needed that accounts for a material's resistance to heat transfer and a material's heat capacity at a range of temperatures, relative humidity (%RH), and air flow infiltration rates through a material. **Original Roadmap Recommended Timeline:** This work should be conducted in the near-term: 0-2 years.	Work to address this gap will be discussed by ASTM Committee C16 on Thermal Insulation at their spring 2016 meeting.
Chapter One: Building Energy and Water Assessment and Performance Standards	Building Envelope	1.3	**No gap**	N/A
Chapter One: Building Energy and Water Assessment and Performance Standards	Cooling Systems	1.4	**A. Standards for energy performance** The codes and standards related to the energy performance of individual air-conditioning and cooling systems are well defined. Establishing independently developed performance metrics that specify the cost and efficiency benefits of the overall performance of integrated air-conditioning and cooling systems would enhance the basis in which architects, designers, engineers, and builders incorporate these systems in residential, commercial, and industrial applications. ASHRAE is looking at this issue for potential inclusion in Standard 90.1-2016 for commercial and multi-family residential buildings over three stories. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2-5 years.	Through the High-Performance Building Council (HPBC), the National Institute of Building Sciences (NIBS) is developing the National Performance Based Design Guide[38] (NPBDG), which is focused on performance criteria for multiple building attributes. NIBS has also been conducting activities to advance the focus on outcomes (actual, measured results rather than anticipated results from design) outlined in Whole Building Design Guide.[39] NIBS' efforts resulted in the inclusion of an outcome-based pathway in the 2015 International Green Construction Code (IgCC), and NIBS is working to get an outcome-based pathway into ASHRAE standard 189.1 and in the International Energy Conservation Code (IECC). NIBS is also participating in an Alliance to Save Energy (ASE) project with Lawrence Berkeley National Laboratory (LBNL) to look at systems-based approaches to design, and working with DOE to conduct a 2016 workshop on implementation of outcome-based policies to advance energy performance. ASHRAE is looking at this issue for inclusion in Standard 90.1-2016,

[38] http://npbdg.wbdg.org/
[39] http://wbdg.org/resources/outcomebasedpathways.php

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
				Energy Standard for Buildings Except Low-Rise Residential Buildings. Internationally, there is movement on this issue through ISO Technical Committee (TC) 163, *Thermal performance and energy use in the built environment*, and ISO/TC 205, *Building environment design*, in cooperation with the European Committee for Standardization (CEN).
Chapter One: Building Energy and Water Assessment and Performance Standards	Cooling Systems	1.4	**B. Standards for integrated control** Control standards for integrated air-conditioning and cooling systems are needed so that the performance and use of the systems can be optimally controlled. ASHRAE is looking at this issue for potential inclusion in Standard 90.1-2016 for commercial and multi-family residential buildings over three stories. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2-5 years.	ASHRAE continues to look at this issue for inclusion in 90.1-2016 for commercial and multi-family residential buildings over three stories.
Chapter One: Building Energy and Water Assessment and Performance Standards	Cooling Systems	1.4	**C. Standards for building air leakage testing (unique for various building types)** Test methods for measuring the air leakage rates of a building envelope have been established for many years. In recent history, the level of interest associated with this area of building construction (e.g., green program requirements, commissioning requirements) has sizably grown due to the establishment and refinement of green, sustainable, and high performance energy codes and standards. The current methods only apply a single standard to all building categories and thus, do not address the complexities and difficulties that are present within the array of structure types. In order to recognize each structure's applicable limitations, it is recommended that unique standards be developed for the various building construction types. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2-5 years.	ASTM Subcommittee E06.41 on Air Leakage and Ventilation Performance has two related work items underway: WK35913, *New Test Method for Whole Building Enclosure Air Tightness Compliance*, and WK45581, *Revision of E779 Standard Test Method for Determining Air Leakage Rate by Fan Pressurization*.
Chapter One: Building Energy and Water Assessment and Performance Standards	Cooling Systems	1.4	**D. Partial load efficiencies for variable speed equipment** Air conditioning and cooling systems are sized to meet design conditions that occur at their rated, peak efficiencies (i.e., full load or capacity); however, in most instances, these systems only operate at partial load or capacity. For equipment that is able to vary its output capacity, efficiencies are needed that specify the systems' optimal conditions at partial load.	ASHRAE will address this issue in Standard 90.1-2016. AHRI addresses part-load value (PLV) in AHRI Standard 210/240, *Performance Rating of Unitary Air-conditioning and Air-source Heat Pump Equipment*; ANSI/AHRI Standards 550/590 (I-P) and 551/591 (SI)-2011 with Addendum 3, *Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle*; ANSI/AHRI 1230-2010 with Addendum 2,

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			Original Roadmap Recommended Timeline: This work should be conducted in the near-term: 0-2 years.	*Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment*; ANSI/AHRI 340/360-2007 with Addendum 2, *Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*; and, ANSI/AHRI 390-2003, *Performance Rating of Single Package Vertical Air-Conditioners and Heat Pumps*.
Chapter One: Building Energy and Water Assessment and Performance Standards	Heating Systems	1.5	**A. Standards for energy performance** The codes and standards related to the energy performance of individual heating systems are well defined. Establishing independently developed performance metrics that specify the cost and efficiency benefits of the overall performance of integrated heating systems would enhance the basis in which architects, designers, engineers, and builders incorporate these systems in residential, commercial, and industrial applications. ASHRAE is looking at this issue for potential inclusion in Standard 90.1-2016 for commercial and multi-family residential buildings over three stories. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2- 5 years.	Through the High-Performance Building Council (HPBC), the National Institute of Building Sciences (NIBS) is developing the National Performance Based Design Guide[40] (NPBDG), which is focused on performance criteria for multiple building attributes. NIBS has also been conducting activities to advance the focus on outcomes (actual, measured results rather than anticipated results from design) outlined in Whole Building Design Guide.[41] NIBS' efforts resulted in the inclusion of an outcome-based pathway in the 2015 International Green Construction Code (IgCC), and NIBS is working to get an outcome-based pathway into ASHRAE standard 189.1 and in the International Energy Conservation Code (IECC). NIBS is also participating in an Alliance to Save Energy (ASE) project with LBNL to look at systems-based approaches to design, and working with DOE to conduct a 2016 workshop on implementation of outcome-based policies to advance energy performance. ASHRAE is looking at this issue for inclusion in Standard 90.1-2016. Internationally, there is movement on this issue through ISO TC 163, *Thermal performance and energy use in the built environment*, and ISO TC 205, *Building environment design*, in cooperation with the European Committee for Standardization (CEN).
Chapter One: Building Energy and Water Assessment and Performance Standards	Heating Systems	1.5	**B. Standards for integrated control** Control standards for integrated heating systems are needed so that the performance and use of the systems can be optimally controlled. ASHRAE is looking at this issue for potential inclusion in Standard 90.1-2016 for commercial and multi-family residential buildings over three stories. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2- 5 years.	ASHRAE is looking to address this gap in 90.1-2016.

[40] http://npbdg.wbdg.org/
[41] http://wbdg.org/resources/outcomebasedpathways.php

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
Chapter One: Building Energy and Water Assessment and Performance Standards	Heating Systems	1.5	**C. Rating system for radiant windows** Radiant windows are increasingly being used for various heating applications in buildings. In addition to interior space heating applications, radiant windows are also being used to control the build-up of ice and snow on high-rise buildings. A standards development activity is needed to develop a consensus based rating system for radiant windows that will allow specifiers to compare the energy efficiency levels of various models. **Original Roadmap Recommended Timeline:** This activity should be conducted in the near-term: 0- 2 years.	IAPMO is reaching out to manufacturers and monitoring interest regarding the development of a consensus-based rating system.
Chapter One: Building Energy and Water Assessment and Performance Standards	Heating Systems	1.5	**D. Standards for building air leakage testing (unique for various building types)** Test methods for measuring the air leakage rates of a building envelope have been established for many years. In recent history, the level of interest associated with this area of building construction (e.g., green program requirements, commissioning requirements) has sizably grown due to the establishment and refinement of green, sustainable, and high performance energy codes and standards. The current methods only apply a single standard to all building categories and thus, do not address the complexities and difficulties that are present within the array of structure types. In order to recognize each structure's applicable limitations, it is recommended that unique standards be developed for the various building construction types. **Original Roadmap Recommended Timeline:** This activity should be conducted in the mid-term: 2-5 years.	ASTM Subcommittee E06.41 on Air Leakage and Ventilation Performance has two related work items underway: WK35913, New Test Method for Whole Building Enclosure Air Tightness Compliance; and WK45581, Revision of E779 Standard Test Method for Determining Air Leakage Rate by Fan Pressurization. AHRI addresses part-load value (PLV) in AHRI Standard 210/240, *Performance Rating of Unitary Air-conditioning and Air-source Heat Pump Equipment*; ANSI/AHRI Standards 550/590 (I-P) and 551/591 (SI)-2011 with Addendum 3, *Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle*; ANSI/AHRI 1230-2010 with Addendum 2, *Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment*; ANSI/AHRI 340/360-2007 with Addendum 2, *Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*; and, ANSI/AHRI 390-2003, *Performance Rating of Single Package Vertical Air-Conditioners and Heat Pumps*. ASHRAE will address this issue in Standard 90.1-2016.
Chapter One: Building Energy and Water Assessment and Performance Standards	Heating Systems	1.5	**E. Partial load efficiencies for variable speed equipment** Heating systems are sized to meet design conditions that occur at their rated, peak efficiencies (i.e., full load or capacity); however, in most instances, these systems only operate at partial load or capacity. For equipment that is able to vary its output speed, efficiencies are needed that specify the systems' optimal conditions at partial load. **Original Roadmap Recommended Timeline:** This work should be conducted in the near-term: 0-2 years.	AHRI addresses part-load value (PLV) in AHRI Standard 210/240, *Performance Rating of Unitary Air-conditioning and Air-source Heat Pump Equipment*; ANSI/AHRI Standards 550/590 (I-P) and 551/591 (SI)-2011 with Addendum 3, *Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle*; ANSI/AHRI 1230-2010 with Addendum 2, *Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment*; ANSI/AHRI 340/360-2007 with Addendum 2, *Performance Rating of Commercial and*

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
				Industrial Unitary Air-Conditioning and Heat Pump Equipment; and, ANSI/AHRI 390-2003, *Performance Rating of Single Package Vertical Air-Conditioners and Heat Pumps*.
Chapter One: Building Energy and Water Assessment and Performance Standards	Mechanical Systems	1.6	**A. Heat energy as an underutilized resource** Thermal energy is a grossly underutilized resource in the United States relative to other developed countries. The development of an American National Standard for heat metering, led by ASTM International with cooperation from the International Association of Plumbing and Mechanical Officials (IAPMO), is currently underway and will address a major gap in standardization that will allow for thermal technologies to be more easily utilized in residential and commercial buildings. Geothermal and hydronic cooling and heating systems can provide significantly increased levels of efficiencies in both residential and commercial applications. Standards are required to help designers, engineers, and home builders better understand the long-term benefits of employing these technologies in buildings. CSA Group began the process of developing an ANSI/Standards Council of Canada bi-national standard, C448 Design and Installation of Earth Energy Systems, for the design and installation of geothermal ground heat pumps in response to needs that U.S. stakeholders identified for a bi-national design / installation standard. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2-5 years.	In a joint effort between ASTM, IAPMO, and the U.S. Environmental Protection Agency (EPA), work to create a heat metering standard is underway within the ASTM Subcommittee E44.25 on Heat Metering. A subcommittee ballot on WK37953, *Standard Specification For Equipment and Instrumentation of Heat Metering Technologies*, will be issued in the spring of 2016. For geothermal, ASTM Work Item WK46315, *New Practice for Installation, Testing, Commissioning and Maintenance of Closed Loop Geothermal Heat Exchangers*, in collaboration with the International Ground Source Heat Pump Association, is underway.
Chapter One: Building Energy and Water Assessment and Performance Standards	Mechanical Systems	1.6	**B. Duct leakage testing** **i. Independently developed data pertaining to the practical levels of duct leakage testing** Forced-air heating and cooling systems utilize ducts to distribute conditioned air throughout the building. According to the EPA, about 20 percent of the air that moves through the duct system is lost due to leaks, holes, and poorly connected ducts in homes. Currently, there is considerable debate at codes and standards meetings in the industry regarding the minimum level of duct leakage testing that is required to improve efficiencies. Independently developed data pertaining to the practical levels of duct leakage testing is needed. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2-5 years.	ASTM is addressing this gap through Subcommittee E06.41 on Air Leakage and Ventilation Performance, WK46791, *New Test Method for Determining the Measurement Uncertainty of Devices Used to Measure Airflow through Residential HVAC Terminals*. ASHRAE is considering this for inclusion in 90.1-2016, and also developing SPC 215P, *Method of Test to Determine Leakage Airflows and Fractional Leakage of Operating Air-Handling Systems*.

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
Chapter One: Building Energy and Water Assessment and Performance Standards	Mechanical Systems	1.6	**B. Duct leakage testing** **ii. Testing protocols for whole HVAC duct system components** To improve energy efficiency, there is a need to develop testing protocols for whole HVAC duct system components. There is a high need for this as codes move toward requiring system testing prior to certificate of occupancy. There is also a need to standardize various techniques for measuring leakage in non-residential and multi-family air distribution and exhaust systems. Several standards developers are starting development on this topic, including ASHRAE, which is looking at this issue for potential inclusion in Standard 90.1-2016. Existing standards such ASTM E1554/E1554M are being reviewed to improve understanding of precision and bias to aid in their use as code compliance tools. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2-5 years.	The ASTM subcommittee E06.41 on Air Leakage and Ventilation Performance is addressing this gap through WK41649 Revision of E1554/E1554M, *Standard Test Methods for Determining Air Leakage of Air Distribution Systems by Fan Pressurization*.
Chapter One: Building Energy and Water Assessment and Performance Standards	Mechanical Systems	1.6	**C. Employing nontraditional and emerging technologies** The potential to use nontraditional and emerging technologies for improving efficiencies in mechanical systems should be addressed by standards developers. Solar air conditioning, which can utilize several processes to cool buildings (e.g., open desiccant cooling, passive solar, photovoltaic solar cooling, and solar closed loop absorption systems); transcritical CO_2 systems, where improvements to system components may yield new efficiencies; and heat from energy-generating microturbines are technologies where standardization activities can help determine the potential for improved levels of efficiency. **Original Roadmap Recommended Timeline:** This work should be conducted in the long-term: 5+ years.	ICC 900/SRCC 300-2015, *Solar Thermal Systems Standard Purpose*, from the International Code Council (ICC) sets forth minimum criteria for the design and installation of solar thermal systems. ICC 901/SRCC 100-2015, *Solar Thermal Collector Standard Purpose*, sets forth minimum durability, construction, performance criteria and procedures for characterizing the thermal performance and durability of solar collectors used in applications such as swimming pool heating, space heating, cooling, and water heating. Both were approved as American National Standards (ANS) in April 2015.
Chapter One: Building Energy and Water Assessment and Performance Standards	Mechanical Systems	1.6	**D. Fault detection in HVAC systems** Research has shown that component faults in HVAC systems that significantly diminish efficiencies are common and go mostly undetected. Standards are needed to quantify the benefits of installing fault detection technologies on mechanical systems that can alert building and home owners to malfunctioning components. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2-5 years.	The IAPMO Green Technical Committee included updates in the Green Plumbing and Mechanical Code requiring the installation of HVAC system fault detection technologies in commercial buildings. The 2015 IAPMO Green Plumbing and Mechanical Code Supplement containing the provisions was published in February 2016.
Chapter One: Building Energy and Water Assessment and	Energy Storage	1.7	**A. Standards for system safety issues for energy storage systems** Safety is a crucial element for the success of energy storage systems (ESS). Issues including ratings, markings, personnel barriers/setbacks,	**Note: In Phase II of the EESCC's effort, this section was updated to address both the storage technology (system) and the installation of that system, and the title was updated accordingly to "Standards**

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
Performance Standards			system access (e.g., entry and exit points), physical abuse, and temperature ratings come immediately to mind. These may be addressed by SDOs such as UL, the International Electrotechnical Commission (IEC), and others. The standards should make use of previously identified standards in SAE International and UL for battery components, should the system use batteries as the storage medium. **Original Roadmap Recommended Timeline:** This should be conducted in the near-term: 0-2 years.	**for system and installation safety for energy storage systems."** The safety of ESS involves two related but distinctly different areas of focus. One involves the safety of the ESS (as a complete product or as it relates to the components that make up the system). The second is the relationship of the ESS as installed to the surrounding environment (e.g., in, on, or adjacent to buildings, facilities, and their support infrastructure). The safety of the ESS itself (i.e., as a product) involves how it is designed and constructed to ensure the product itself is safe. Standards developed by SDOs such as UL, ASME, CSA, IEC, and others provide a basis for ensuring the safety of the ESS as a system or the components that make up the ESS. The standards should make use of previously identified standards in SAE International and UL for battery components, should the system use batteries as the storage medium. The safety of the ESS in relation to its installed environment involves standards and model codes that cover issues such as clearances, connection to other systems, location in relation to fire department access, egress, ventilation, and a number of other issues focused on ensuring the ESS as installed is safe (considering both the ESS as the instigator in an incident or simply as an innocent party to some other incident proximate to the ESS). These standards and model codes, developed by SDOs such as the National Fire Protection Association (NFPA), ICC, IEEE, and ASHRAE generally already exist and provide a foundation for ESS safety through the updating and enhancement of existing criteria to more appropriately address new ESS technologies and applications. **Refer to progress report section for full update on related standardization efforts.**
Chapter One: Building Energy and Water Assessment and Performance Standards	Energy Storage	1.7	**B. Standards for availability, reliability, and maintenance** Energy storage systems are envisioned to be controlled autonomously by a central energy management systems or a building energy management system with little human interference on a regular basis. In order to make sure the energy storage systems are functioning as specified, standards need to be developed to determine: ▪ **Availability –** optimal times and levels of charge and discharge for the energy storage system based on physical location,	Two existing standards that may help to address this gap in relation to reliability and maintenance include: - NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*, which contains guidance on reliability, including mean uptime, mean time to failure, and general maintenance of different electrical components; the topics are addressed in relation to all types of energy systems including energy storage. - NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*, which contains maintenance requirements

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			historical patterns, and other relevant factors ▪ **Reliability** – determining the mean uptime and mean time to failure; the mean lifetime and cycle life of the energy storage system; and/or storage medium component associated with the system ▪ **Maintenance** – determining what maintenance routines should be performed on the energy storage system and when **Original Roadmap Recommended Timeline:** This should be conducted in the mid-term: 2-5 years.	specific to emergency energy storage systems. The National Electrical Code® is being equipped with several new requirements related to energy management and stored energy systems, including NEC article 750, *Energy Management Systems*, to establish a hierarchy of which loads can be controlled through energy management and which loads cannot, as well as a proposed new NEC article 706, *Energy Storage Systems*, to provide methods of handling demand response issues. Two standards currently under development by IEEE may also help to address this gap: IEEE P2030.2.1, *Guide for Design, Operation, Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems*, and IEEE 2030.3, *Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications*. Aspects of maintenance will be addressed in IEC 62937, *Safety considerations related to the installation of grid integrated electrical energy storage (EES) systems*, and IEC 62936, *Environmental issues of EES systems*. These standards are anticipated to be published in 2016 and 2017 respectively. The EPRI Energy Storage Integration Council (ESIC) is working on terminology, definitions, and test procedures for availability and reliability; these inputs will be published in the next revision of the DOE/EPRI Energy Storage Handbook. StorageVET, a model to be available publicly in late 2016, is under development by EPRI, with ESIC review, under a contract with California Energy Commission. It is expected to provide transparent simulations to support understanding of availability and maintenance routine best practices in the context of storage project value optimization.
Chapter One: Building Energy and Water Assessment and Performance Standards	Energy Storage	1.7	**C. Standards for electromagnetic compatibility (EMC)** As information technology becomes layered over electrical components, it is essential that each smart grid component, including energy storage systems, is interoperable and that each component is appropriately shielded, insulated, or otherwise designed to reduce or prevent electromagnetic interference. Note that there are currently significant	The IEC's International Special Committee on Radio Interference (CISPR) is addressing EMC issues that relate to Smart Grid technologies.[42]

[42] http://www.iec.ch/emc/smartgrid/

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			barriers to testing electromagnetic compatibility in many instances. **Original Roadmap Recommended Timeline:** This work is a long-term effort: 5+ years.	
Chapter One: Building Energy and Water Assessment and Performance Standards	Energy Storage	1.7	**D. Standards for load flow, protection coordination, automatic gain control** The need exists to limit or prevent electrical damage to the energy storage system through the development of standards for load flow, protection coordination, and automatic gain control. **Original Roadmap Recommended Timeline:** This should be conducted in the mid-term: 2-5 years.	Two standards currently under development by IEEE may help to address this gap: IEEE P2030.2.1, *Guide for Design, Operation, Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems*, and IEEE 2030.3, *Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications*.
Chapter One: Building Energy and Water Assessment and Performance Standards	Energy Storage	1.7	**E. (Partial Gap) Standards to identify representative duty cycles and performance metrics for each application and/or use case** Until recently there was no methodology for comparing the performance attributes of energy storage systems. The DOE/PNNL *Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems* can provide a basis for addressing this issue. It can be applied across systems that employ different types of storage mediums because it establishes a representative duty cycle for each possible energy storage system application. A starting point for developing such a list of applications and/or use cases is the California Public Utility Commission (CPUC) *Energy Storage Staff Proposal*. A series or family of standards specifying representative duty cycles and performance metrics applicable by representative duty cycle should be written that would foster the uniform and comparable measurement and expression of energy storage system performance. This series of standards would allow a customer or other end user to evaluate which product is best for their use, and to establish universal testing and reporting criteria. **Original Roadmap Recommended Timeline:** This should be conducted in the near-term: 0-2 years.	**Note: In Phase II of the EESCC's effort, this section was updated to more clearly address standards for measuring and expressing system performance, and the title was changed accordingly to "Standards for measuring and expressing system performance."** There is a need for all those involved with the design and application of an energy storage system to be able to effectively, consistently, and reliably communicate about how the system will perform. The lack of a standard method of test for measuring and expressing the performance of energy storage systems results in those communicating about system performance defining their own 'rules,' which in turn results in having multiple metrics and results to decipher. Beginning in 2012, with the support of the DOE Office of Electricity, the Pacific Northwest National Laboratory (PNNL) and Sandia National Laboratories (SNL) initiated an effort to engage all interested parties in the development of a protocol (pre-standard) to measure and express energy storage system performance. Released in late 2012 and updated in June 2014, the *Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems* has provided a basis for evaluating and comparing ESS performance for three ESS applications and a number of performance-related metrics. This document has also been put in "IEC format" and is the basis for a draft IEC standard being developed by IEC TC 120, *Electrical Energy Storage Systems*, which will address the same topic as the protocol. In addition, U.S.-based standards developers (NEMA for electric and ASME for thermal) are also using the protocol as a basis for initial drafts of formal

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
				standards. Key to the development of the protocol has been the identification of applications/use cases for ESS and appropriate duty cycles for each. A starting point for developing such a list of applications and/or use cases was the California Public Utility Commission (CPUC) Energy Storage Staff Proposal. It was recommended by the CPUC that a series or family of standards specifying representative duty cycles and performance metrics applicable by representative duty cycle be written that would foster the uniform and comparable measurement and expression of ESS performance. This series of standards would allow a customer or other end user to evaluate which product is best for their use, and to establish universal testing and reporting criteria. As noted below, the second edition of the protocol will cover eight applications, each with its own unique duty cycle; the application of which provides the basis for determining duty-cycle driven performance metrics for an ESS used in any one of the eight applications covered by the protocol. **Related Standardization Efforts** The second edition of the *Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems* is scheduled for publication in April 2016. The second edition will include five new applications for ESS to go with the three already in the prior edition of the protocol, a number of new performance-related metrics, refinements to the criteria based on experiences using the protocol, and a new organizational structure to make it easier to understand and apply the document. As with prior versions of the protocol, it is hoped the document will help address the need for a common, uniform, consistent, and defensible method of test for ESS performance, both with standards developers and on a voluntary basis between proponents and users of ESS. In addition, the EPRI Energy Storage Integration Council (ESIC) is developing a series of test procedures adapted to utility lab and field contexts to apply energy storage testing. Comments from ESIC were provided to DOE on the protocol effort noted above and were considered in the development of the second edition of the protocol.
Chapter One: Building Energy and Water	Water Heating	1.8	**A. Standards for heat metering and solar thermal systems** Consensus standards for heat metering and hot water solar thermal	In a joint effort between ASTM, IAPMO, and the U.S. Environmental Protection Agency (EPA), work to create a heat metering standard is

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
Assessment and Performance Standards			systems need to be completed to advance the use of thermal technologies for water heating applications. This represents a significant and very achievable advancement in energy efficiency. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2-5 years.	underway within the ASTM Subcommittee E44.25 on Heat Metering; the work is expected to be completed in 2016. The standard will provide metrics that will help advance the solar thermal market. ICC 900/SRCC 300-2015, *Solar Thermal Systems Standard*, developed by the International Code Council (ICC), sets forth minimum criteria for the design and installation of solar thermal systems, and describes the requirements and methodology for standardized solar thermal system design evaluation, including the analytical evaluation of its components. It applies to solar energy systems used in applications for heating, cooling, dehumidification, and co-generation. ICC 901/SRCC 100-2015, *Solar Thermal Collector Standard*, sets forth minimum durability, construction, performance criteria, and procedures for characterizing the thermal performance and indicating the durability of solar collectors used in applications such as swimming pool heating, space heating, cooling, and water heating. Currently under development by ICC is ICC 902/APSP/SRCC 400-201X, *Pool Solar Heating and Cooling Standard*. The standard will establish minimum requirements for the performance, design, and installation of solar thermal heating systems for heating water used within pools, spas, hot tubs, exercise spas, water parks, and spray grounds.
Chapter One: Building Energy and Water Assessment and Performance Standards	Water Heating	1.8	**B. Design standards for plumbing systems** Design standards for architects and home builders are needed to illustrate how efficient building and home design can provide for greater efficiencies in water heating applications. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2-5 years.	Gary Klein & Associates has developed a test apparatus in California that could be a resource for SDOs working to close this gap. IAPMO has announced the introduction of WE-Stand, a new Water Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS).
Chapter One: Building Energy and Water Assessment and Performance Standards	Water Heating	1.8	**C. Standards that address the location of the heating source and end-use point** Standards are needed for water heating and delivery systems to address the location of the heating source and the end-of-use point to ensure that	IAPMO's Green Plumbing and Mechanical Code Supplement, published in December 2015, contains new provisions on hot water delivery efficiency. IAPMO has announced the introduction of WE-Stand, a new Water

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			the most efficient system is installed while meeting consumers' hot water use expectations. Activity is currently under way within several codes and standards development venues, including the IgCC and IAPMO's Green Plumbing and Mechanical Code committees, to address the use of recirculation systems and length of pipe requirements, and to provide guidance on how to design the most efficient systems. **Original Roadmap Recommended Timeline:** This work should be conducted in the near-term: 0-2 years.	Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS).
Chapter One: Building Energy and Water Assessment and Performance Standards	Indoor Plumbing	1.9	**A. Research evaluating the impact of efficient plumbing component design on the plumbing system's overall performance** Current codes and standards continue to provide significant improvements in water and energy efficiency requirements for plumbing components used in plumbing systems. However, there is considerable pressure to further increase the water savings by requiring decreased flows and flush volumes. It has been shown that further reduction in water usage can be achieved through more efficient plumbing component design. However, there is little research available today that evaluating the impact of those designs on the plumbing system's overall performance due to reduced flows in the system, particularly the drainage system. There are research projects underway in the U.S., notably the Plumbing Efficiency Research Coalition, that will help to determine "how low we can go" without negatively impacting public health and safety. **Original Roadmap Recommended Timeline:** While some research will be conducted in the short term: 0-2 years, achieving optimum efficiency levels in plumbing systems through standardization efforts that consider the entire plumbing system will be an ongoing, long-term project: 5+ years.	The Plumbing Efficiency Research Coalition (PERC) Phase 2.0 Report, published in September 2015, provides guidance on the impact of reduced flows in building drains resulting from water efficiency provisions.[43] IAPMO has announced the introduction of WE-Stand, a new Water Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS).
Chapter One: Building Energy and Water Assessment and Performance Standards	Indoor Plumbing	1.9	**B. Revised pipe sizing calculation methods that take modern lower flow rates and lower waste discharges into account along with use patterns associated with building types** Another question currently being addressed through research is the ability to design plumbing systems using smaller diameter piping due to the decreased water demand and decreased volumes needed to supply residential buildings. While it is anticipated that this research will be	IAPMO, ASPE, and the Water Quality Association (WQA) are coordinating a code change proposal to revise pipe sizing requirements for residential buildings for the 2018 code cycle. This development committee issued a white paper containing their recommendations, which is currently under peer review. ASTM Subcommittee E60.07 on Water Use and Conservation is considering expanding items related to E2728-11, *Standard Guide for*

[43] http://www.plumbingefficiencyresearchcoalition.org/

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			completed within the next 1-2 years for residential applications, similar research efforts that study water use patterns associated with increasingly complex commercial buildings needs to be conducted so that pipe size reductions that deliver energy and water efficiencies throughout the life of the building at lower construction costs can be realized. **Original Roadmap Recommended Timeline:** This work constitutes a long-term project: 5+ years.	*Water Stewardship in the Design, Construction, and Operation of Buildings*, on the use of pipe sizes related to different building types.
Chapter One: Building Energy and Water Assessment and Performance Standards	Indoor Plumbing	1.9	**C. The combined energy and water savings associated with the use of thermal insulation on hot water pipes** Hot water delivery systems routinely use thermal insulation (pipe insulation) to maintain the temperature of the water as it travels from the source (the water heater) to the destination (the faucet at the sink). All current energy codes and standards require some degree of thermal insulation on potable hot water piping. However, the requirements between codes vary, and most requirements are normally considered minimum levels. Existing research has not considered the value of water when making the business case for putting additional pipe insulation on hot water piping, increasing the thickness of insulation or identifying a scope of work for insulation installation. While studies have looked at energy efficiency, they have not addressed the short-term economics, which depend on frequency, duration, and pattern of usage, and remain the overriding consideration for most building owners. **Original Roadmap Recommended Timeline:** This work should be conducted in the near-term: 0-2 years.	No progress report update.
Chapter One: Building Energy and Water Assessment and Performance Standards	Indoor Plumbing	1.9	**D. Reducing the potential for Legionellosis and other pathogenic outbreaks** Reducing hot water temperatures in plumbing systems has been proven to both reduce scalding incidences and to save energy. However, hot water temperature reductions also provide a perfect environment for opportunistic pathogens to grow in hot water pipes. ASHRAE is currently in the process of completing BSR/ASHRAE Standard 188P, *Prevention of Legionellosis Associated with Building Water Systems*, and the accompanying Guideline 12. When published, these guidance documents will provide facility managers with techniques that can be employed to mitigate Legionellosis outbreaks, as well as a set of best practices for when outbreaks occur. **Original Roadmap Recommended Timeline:** This work should be	ASHRAE Standard 188-2015, *Legionellosis: Risk Management for Building Water Systems*, was published in June 2015 and is on continuous maintenance. NSF International is considering standards for reducing pathogenic outbreaks.

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			conducted in the near-term: 0-2 years.	
Chapter One: Building Energy and Water Assessment and Performance Standards	Alternate Water Sources	1.10	**A. "Fit for use" standards that provide appropriate treatment requirements for the intended use of the water** The biggest challenge facing the expanded use of water from alternate water sources is the need for agreed-upon "fit for use" standards that provide appropriate treatment and water quality requirements for the intended use of the water regardless of the source, and that ensure health and safety. Several codes and standards organizations have made excellent progress toward creating classifications of alternate water sources and corresponding applications, as well as treatment strategies. However, a one-size-fits-all approach to design and treatment may be unachievable. For example, rainwater in one area of the country may have higher heavy metals contamination than rainwater in other areas, therefore requiring different treatment measures. Standards developers need to continue to expand their knowledge base and consider provisions that will foster increased use of alternate water sources. **Original Roadmap Recommended Timeline:** Improvements to alternate water use standards should be an ongoing process with advancements made by consensus, and achieved in the short-, mid-, and long- term.	Relevant to this gap, IAPMO has announced the introduction of WE-Stand, a new Water Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS).
Chapter One: Building Energy and Water Assessment and Performance Standards	Alternate Water Sources	1.10	**B. Comprehensive stormwater standard** There is a need to develop a comprehensive stormwater standard. There is great potential for stormwater to be better utilized as an important alternative water source. Current stormwater infrastructure serves only to carry stormwater away from developed areas as quickly as possible. However, stormwater is a valuable resource that, when utilized properly, can buffer runoff and combined sewer overflows and replenish the aquifers through irrigation, soak-away pits, rain gardens, and other designed stormwater features. ASPE, ARCSA, and ICC are currently developing a stormwater harvesting design standard which may address this gap. A national standard for green infrastructure/low impact design has been provided for federal facilities by implementation of EISA Section 438. **Original Roadmap Recommended Timeline:** Development of these standards will necessitate collaboration between water use experts, civil engineers, and other stakeholders. This is a long-term effort: 5+ years.	Existing standards that may help address this gap include: ARCSA/ASPE 78-2015, *Stormwater Harvesting System Design for Direct End-Use Applications*, which provides guidance on how to install and maintain a safe alternative to utility-provided water and how to optimize stormwater utilization to reduce dependence on municipal potable water systems. IAPMO Green Supplement has end use, non-potable water quality standards, which are similar to those in Texas, and cited by the EPA Wet Weather document[44] for harvesting and use. ICC/CSA 805-201x, *Standard for Rainwater Collection System Design and Installation*, under development by ICC for publication in 2016, applies to the design, installation, and maintenance of rainwater collection systems and is intended to collect, store, treat, distribute, and utilize rainwater for potable and non-potable applications. ASTM E2727, *Standard Practice for Assessment of Rainwater Quality*,

[44] http://www.epa.gov/npdes/npdes-experts-forum-public-health-impacts-wet-weather-blending-documents

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
				and ASTM E2635, *Standard Practice for Water Conservation in Buildings Through In-Situ Water Reclamation*, may have application in this area. Additionally, ASTM Subcommittee E60.07 on Water Use and Conservation is considering water qualifications requirements for use outside the building. Revisions to ARCSA/ASPE Standard 63, *Rainwater Catchment Systems*, are currently under development.
Chapter One: Building Energy and Water Assessment and Performance Standards	Landscape Irrigation	[**1.11**]	**A. Standards for design practices and validating product performance** Additional standards for landscape irrigation systems would be useful in establishing minimum safety requirements and validating performance claims of products. Standards facilitate the comparison of different products to aid the consumer in making a selection for a particular application. PINS have been filed with ANSI for controllers and rain sensors, but no committees have been formed to develop the standards. ICC is currently developing an irrigation emission device standard, which may address this gap. The following gaps are becoming apparent as competing green codes are being developed with regard to landscape irrigation. Because landscape irrigation is the assembly of various components to create a system, the system needs to be designed, installed, and maintained properly. While there are documents that have been created by industry to identify best practices for each of these areas, the potential exists to create standards out of the identified best practices that could be referenced in the codes. Such standards could eliminate conflicting or differing provisions, and thus minimize confusion in the marketplace. This would allow the green codes to be less prescriptive in nature and move more toward performance-based outcomes in managing resources. Some prescriptive irrigation provisions within the green codes conflict with implementing best practices that should be used to address the unique challenges of individual landscapes. Standards should enhance the development of a quality irrigation system that would be based on well-developed best practices for: ▪ Designing an irrigation system ▪ Installing/commissioning an irrigation system ▪ Long-term maintenance of an irrigation system for optimal performance	ASABE/ICC 802-2014, *Standard for Landscape Irrigation Sprinklers and Emitters*, outlines minimum requirements for landscape irrigation devices to ensure adequate safety and performance. ASABE S623, *Estimating Landscape Plant Water Demand*, provides an estimate of plant water demands of permanently installed, non-production-based, established landscape materials. Standards currently under development in collaboration with EPA include ASABE X626, *Auditing Landscape Irrigation Systems*; ASABE X627, *Testing Environmentally Responsive Controllers*; and, ASABE X633, *Testing of Soil Moisture Sensors*. Relevant to this gap, IAPMO has announced the introduction of WE-Stand, a new Water Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS).

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			One challenge of developing standards about design, installation, and maintenance is the perceived notion that by following a standard, an untrained person can achieve the desired results, the same as a qualified professional. The reality is that each landscape project is unique and the professional applies standards to achieve the desired outcome. Care should be taken so that standards do not become training manuals for design, installation, or maintenance. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2-5 years	
Chapter One: Building Energy and Water Assessment and Performance Standards	Landscape Irrigation	[1.11]	**B. Standards for landscape sustainability and ecosystem services** Gaps in standards for landscape irrigation are interrelated, but currently not enough information or research has been done to provide guidance for standards development. 1. A standard is needed for evaluating all water sources so that the most sustainable water source(s) would be used for irrigation. This standard would address the water-energy nexus, and would be useful in evaluating the embedded energy in all potential irrigation water sources. 2. A standard is needed that would address the benefits derived from an irrigated landscape compared to the resources used to maximize the ecosystem services from the managed urban landscape. **Original Roadmap Recommended Timeline:** If standards are developed, they should address the process to follow in making the evaluation. This work constitutes a long-term effort: 5+years.	ASABE/ICC 802-2014, *Standard for Landscape Irrigation Sprinklers and Emitters*, outlines minimum requirements for landscape irrigation devices to ensure adequate safety and performance. Relevant to this gap, IAPMO has announced the introduction of WE-Stand, a new Water Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS).
Chapter One: Building Energy and Water Assessment and Performance Standards	Swimming Pools, Hot Tubs, Spas, Aquatic Features	[1.12]	**A. Standards for filters and filter media testing that address water efficiency** Standards are needed to evaluate the water consumption of a pool and spa filtration system. The efficiency of a filter's backwash ability is critical to its water consumption. The industry often uses the backwash to help eliminate contaminates in the pool. The backwash water is sent to waste and new water – "make up water" – is added to dilute contaminates. This industry best practice will need to be addressed, but the need for backwash efficiency still exists. **Original Roadmap Recommended Timeline:** This should be done in the near-term: 0-2 years.	A forthcoming version of NSF Standard 50, *Equipment for Swimming Pools, Spas, Hot Tubs and other Recreational Water Facilities*, will include energy water filtration efficiency criteria. The revisions are expected to be published in 2018. Relevant to this gap, IAPMO has announced the introduction of WE-Stand, a new Water Efficiency and Sanitation standard that will be developed as an American National Standard (ANS). We-Stand will be the first ANS to focus exclusively on water efficiency and sanitation provisions. Anticipated for publication in 2017, the standard will use as its basis the water provisions within IAPMO's 2015 Green Plumbing and Mechanical Code Supplement (GPMCS).

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
Chapter One: Building Energy and Water Assessment and Performance Standards	Swimming Pools, Hot Tubs, Spas, Aquatic Features	1.12	**B. Standards for UV systems that address energy efficiency** Currently there are no existing standards to cover the energy efficiency for UV light generators. Standards are needed to evaluate the energy efficiency through analysis of the power delivery level and flow rates. **Original Roadmap Recommended Timeline:** This should be done in the near-term: 0-2 years.	No progress report update.
Chapter One: Building Energy and Water Assessment and Performance Standards	Swimming Pools, Hot Tubs, Spas, Aquatic Features	1.12	**C. Standards for testing the energy efficiency of disinfection systems (ozone generators, electrolytic chlorinators, and copper and silver ionizers)** Standards are needed to test the energy efficiency of disinfection systems (ozone generators, electrolytic chlorinators, and copper and silver ionizers) to determine the energy use at integral power levels of chemical output. **Original Roadmap Recommended Timeline:** This should be done in the near-term: 0-2 years.	No progress report update.
Chapter One: Building Energy and Water Assessment and Performance Standards	Swimming Pools, Hot Tubs, Spas, Aquatic Features	1.12	**D. Standards for testing the efficiency of pool covers and liquid barriers** Pool covers and liquid barriers represent a significant opportunity to minimize pool energy use by reducing heat loss and evaporation. However, they cannot provide efficiencies if they are not utilized. Research is needed to investigate the behavioral aspects of pool cover use by homeowners, and facility managers and to determine realistic potential for efficiency gains. Where research shows that efficiency gains can be reasonably expected from the use of pool covers or liquid barriers, regional construction codes and best practice maintenance guidelines should be developed that require their use. **Original Roadmap Recommended Timeline:** This should be done in the mid-term: 2-5 years.	NSF/ANSI 50, *Equipment for Swimming Pools, Spas, Hot Tubs and other Recreational Water Facilities*, includes requirements for material health effects requirements for pool covers. Health effects risk assessment requirements for chemicals like liquid barriers were incorporated in 2015. Heat retention efficiency evaluation methods and criteria need to be developed; an issue paper was submitted to the NSF/ANSI 50 committee in 2015.
Chapter One: Building Energy and Water Assessment and Performance Standards	Commissioning	1.13	**A. Commissioning practices** Currently, there appears to be much confusion on what constitutes quality commissioning practices, how it can be incorporated into codes and other standards, and the identification of quality commissioning providers. Many of these questions have been addressed by commissioning industry organizations, but not in an organized fashion.	The NIBS' Commissioning Industry Leaders Council was established to help facilitate development of educational materials focused at commissioning users. Relevant materials include the Better Buildings Workforce Guidelines (BBWG)[45] and the Whole Building Design Guide (WBDG).[46] The NIBS Commercial Workforce Credentialing Council, in partnership with DOE and commissioning-related

[45] https://www.nibs.org/?page=cwcc
[46] http://wbdg.org/project/buildingcomm.php

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			Addressing these issues in the short-term will be essential to the widespread and productive use of commissioning and the achievement of the anticipated levels of building system and utility cost performance. Many of the organizations identified above have agreed to work collectively to address these issues. ICC is currently developing a standard to address these issues as they relate to the International Codes, which may address this gap. Additionally, ASTM and the National Institute of Building Sciences (NIBS) have begun the process of developing a set of standards and guidelines that may help to address this concern through a process referred to as building enclosure commissioning (BECx). **Original Roadmap Recommended Timeline:** These activities should be conducted in the near-term: 0-2 years.	certification organizations, has developed a common set of knowledge, skills, and abilities (KSAs) and job task analyses (JTAs) to establish baseline levels of competence for commissioning providers and others. Certifications that utilize JTAs are obtaining accreditation under ISO 17024. ICC 1000-201x, *Standard for Commissioning*, is currently under development by ICC and is expected to be published in 2016. The standard provides requirements relating to the application of the overall commissioning process described in commissioning process standards. The Building Commissioning Association (BCxA) has begun to develop a database of buildings, both new and existing, that have been commissioned to track everything from basic build demographics, to systems commissioning, to who provided the commissioning service and what contracting and certification they were required to have to get the work. NECA 90, *Recommended Practices for Commissioning Building Electrical Systems*, has been significantly revised and expanded. The standard describes procedures for commissioning newly installed or retrofitted building electrical systems, defines the process of commissioning building electrical systems, and provides sample guidelines for attaining optimum system performances. NECA is also in the final stages of developing a new national electrical installation standard (NEIS) titled NECA 504, *Recommended Practice for Installing Indoor Lighting Control Devices and Systems*, which includes information related to current lighting technologies and controls that include managing and controlling energy use. This standard should be published in mid-2016. ASTM E2813, *Standard Practice for Building Enclosure Commissioning*, is intended to serve as a technically sound practice for building enclosure commissioning (BECx). Three NFPA standards that relate to the commissioning and integrated testing of fire protection and life safety systems or emergency storage systems include: NFPA 3, *Recommended Practice for Commissioning of Fire Protection and Life Safety Systems,* NFPA 4, *Standard for Integrated Fire Protection and Life Safety Systems Testing, and* NFPA 111, *Standard on Stored Electrical Energy*

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
				Emergency and Standby Power Systems.
Chapter One: Building Energy and Water Assessment and Performance Standards	Commissioning	1.13	**B. Education and training on commissioning process** There is a lack of understanding of the commissioning process among many commissioning users, such as building owners, facility managers, and personnel. There needs to be education, documentation, and training developed for commissioning users on the commissioning process, deliverables and expected results. Having educated consumers is equally important to a quality process and providers. ASTM and NIBS have begun development of a Building Enclosure Certification and Training Program, which may help to address this need. The program will be developed in accordance with ISO 17024, *Conformity assessment – General requirements for bodies operating certification of persons*, which will be a requirement of the new ICC 1000, Standard for Commissioning, and the Better Buildings Workforce Guidelines project, an initiative led by NIBS and the U.S. Department of Energy. **Original Roadmap Recommended Timeline:** These activities should be conducted in the near-term: 0-2 years.	As noted in section 1.13 A, the NIBS' Commissioning Industry Leaders Council was established to facilitate development of educational materials focused at commissioning users. Relevant materials include the Better Buildings Workforce Guidelines (BBWG)[47] and the Whole Building Design Guide (WBDG).[48] The NIBS Commercial Workforce Credentialing Council, in partnership with DOE and commissioning-related certification organizations, has developed a common set of knowledge, skills, and abilities (KSAs) and job task analyses (JTAs) to establish baseline levels of competence for commissioning providers and others. Certifications that utilize JTAs are obtaining accreditation under ISO 17024. ASTM and NIBS continue work on Building Enclosure Certification and Training Program. BCxA is developing a position paper on hiring a qualified provider for an owner's project, which supports a qualification-based selection process. BCxA is also working with ASHRAE and APPA: Leadership in Educational Facilities on guidelines for the end user or owners on the commissioning process and hiring guidelines. NECA 90, *Recommended Practices for Commissioning Building Electrical Systems*, has been significantly revised and expanded. The standard describes procedures for commissioning newly installed or retrofitted building electrical systems and defines the process of commissioning building electrical systems and provides sample guidelines for attaining optimum system performances. NECA is also in the final stages of development of a new NEIS titled NECA 504, *Recommended Practice for Installing Indoor Lighting Control Devices and Systems*, which includes information related to current lighting technologies and controls that include managing and controlling energy use. This standard should be published in mid-2016.
Chapter One: Building Energy and Water Assessment and Performance Standards	Commissioning	1.13	**C. Methods for third-party provider conformity assessment and accreditation** Research, guidance and common agreement are needed regarding the methods for third-party provider conformity assessment and	The NIBS' Commercial Workforce Credentialing Council is working with the Department of Energy to develop baseline level criteria for certification of commissioning providers. The compliant certification providers will follow ISO 17024.

[47] https://www.nibs.org/?page=cwcc
[48] http://wbdg.org/project/buildingcomm.php

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			accreditation. Additionally, data is needed on commissioning results and how the practices can enhance building performance and safety. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2-5 years.	ICC 1000-201x, *Standard for Commissioning*, is currently under development by the ICC and expected to be published in 2016. The standard provides requirements relating to the application of the overall commissioning process described in commissioning process standards. This standard establishes minimum requirements for the application of the process of commissioning as required by the local jurisdiction having authority. Currently, the working draft references IAS Acceptance Criteria AC 476, *Accreditation Criteria for Organizations Providing Training and/or Certification of Commissioning Personnel*. BCxa has developed a Certified Commissioning Professional program for individuals who lead, plan, coordinate, and manage a commissioning team to implement commissioning processes in new and existing buildings. As related to the evaluation of electrical equipment, NFPA 790, *Standard for Competency of Third-Party Field Evaluation Bodies*, contains requirements relating to the criteria and considerations that must be taken into account for a third-party assessment and evaluation of electrical equipment in order to determine that it is safe for use.
Chapter One: Building Energy and Water Assessment and Performance Standards	Commissioning	1.13	**D. Commissioning standards and guidelines for building systems** While standards and guidelines now exist for the commissioning process and many building systems have been included as identified above, several additional building systems can and should be commissioned. Standards and guidelines will need to be developed or adapted in these areas, including irrigation and decorative water systems; on-site renewable energy systems; integrated energy systems; indoor environmental quality systems; building enclosures; fire alarm, security systems and IT systems; vertical conveyance (elevators); and integrated building automation/energy management systems. The gap that currently exists with regard to building enclosure commissioning includes the development of a consensus guide for the implementation of the building enclosure commissioning process, which differs slightly from ASHRAE Guideline 0 and ASHRAE Standard 202, in that it speaks specifically to commissioning of the materials, components, systems and assemblies that comprise the exterior enclosure of a building or structure. ASTM, in cooperation with NIBS, will address this gap in the	NIBS developed Guideline 3 to serve as guidance for commissioning of the building enclosure. Guideline 3 recently went through the standards development process at ASTM to become a standard. It is now E2947, *Standard Guide for Building Enclosure Commissioning*. In addition to the standard, ASTM is developing a certification program around building enclosure commissioning. NIBS is developing educational programs in support of the building enclosure certification program, and training materials are being rolled out to Building Enclosure Councils nationwide who will be able to conduct training at the local level. NIBS is also encouraging discipline-specific organizations to develop commissioning programs focused on individual systems, but ideally based on ASHRAE Guideline 0/Standard 202 as the underlying process. ASTM E2947, *Standard Guide for Building Enclosure Commissioning*, provides recommendations for the enclosure commissioning process from project planning through design, construction, and occupancy and operation phases.

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			Spring/Summer of 2014 with the publication of a new ASTM Standard Guide for Building Enclosure Commissioning, which will replace NIBS Guideline 3, Building Enclosure Commissioning Process BECx. **Original Roadmap Recommended Timeline:** These activities should be conducted in the mid-term: 2-5 years.	The American Society of Plumbing Engineers (ASPE) is working on a standard, ASPE 100, which would provide direction and guidelines for building systems relative to commissioning. ASPE is currently developing standards on plumbing systems commissioning utilizing ASHRAE Guidelines 0, 1.1, and 1.5 as a template. The goal is to provide specific guidance on applying the commissioning process to plumbing systems in commercial, healthcare, and laboratory buildings and facilities, as well as fuel gas piping and fire protection systems. NECA 90, *Recommended Practices for Commissioning Building Electrical Systems*, has been significantly revised and expanded. The standard describes procedures for commissioning newly installed or retrofitted building electrical systems, defines the process of commissioning building electrical systems, and provides sample guidelines for attaining optimum system performances. IES currently has a Design Guide (DG-29), *Commissioning Process Applied to Lighting and Control Systems*, which closely mirrors ASHRAE Guideline 0-2005, *The Commissioning Process*, in its format but is specific to lighting, including daylighting. For guidance on the commissioning and integrated testing of all fire protection, life safety, and premise security systems, NFPA standards include: - NFPA 3, *Recommended Practice for Commissioning of Fire Protection and Life Safety Systems* - NFPA 4, *Standard for Integrated Fire Protection and Life Safety Systems Testing* - NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems* - NFPA 110, *Standard for Emergency and Standby Power Systems* - NFPA 72®, *National Alarm and Signaling Code®* - NFPA 730, *Guide for Premises Security* - NFPA 731, *Standard for the Installation of Electronic Premises Security Systems* In 2016, AHRI expects to publish new versions of the following standards, which include efficiency ratings; the goal is to provide rating points for manufacturers to use for operating equipment at less than 100% capacity: ANSI/AHRI Standards 550/590 (I-P) and

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
				551/591 (SI)-2011 with Addendum 3, *Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle*, ANSI/AHRI 340/360-2007 with Addendum 2. Additional AHRI standards include AHRI Standard 210/240, *Performance Rating of Unitary Air-conditioning and Air-source Heat Pump Equipment*; AHRI 1230-2010 with Addendum 2, *Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment*; AHRI 340/360-2007 with Addendum 2, *Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*; and, AHRI 390-2003, *Performance Rating of Single Package Vertical Air-Conditioners and Heat Pumps*.
Chapter One: Building Energy and Water Assessment and Performance Standards	Commissioning	**1.13**	**E. Communications from and to building equipment, sensors, and security protocols** Ongoing commissioning will depend on monitoring of all building systems in order to assure that the systems are operating in a manner consistent with the owner's current facility performance requirements. This will require the standardization of communications from and to building equipment and sensors and security protocols to allow any alteration of building systems electronically. Commissioning practices that ensure proper communication with energy providers and energy efficient operation in a smart grid environment will need to be developed. Increased understanding of the linkages between building systems and their contributions to total building performance will be necessary. This includes the development of metrics and methods to support such whole building assessments and existing building commissioning process. **Original Roadmap Recommended Timeline:** These activities should be completed in the long-term: 5+ years.	No progress report update.
Chapter One: Building Energy and Water Assessment and Performance Standards	Conformity Assessment in Building Energy and Water Assessment and Performance Standards	**1.14**	**A. Gaps in the actual accreditation standards** There are various standards such as the ISO/IEC 17000 series that are designed to work together with technical standards in the energy efficiency field. The 17000 standards have systematic reviews that take place five years after publication. If they are reaffirmed, the standards are reviewed five years later unless a new work item proposal (NWIP) is proposed earlier by a CASCO member and approved by CASCO for a compelling need. The gaps from this perspective are addressed through the systematic reviews.	Two standards used to determine conformity that are currently being updated include ISO/IEC CD 17011, *Conformity assessment -- Requirements for accreditation bodies accrediting conformity assessment bodies*, and ISO/IEC CD 17025, *General requirements for the competence of testing and calibration laboratories*. The ISO Committee on Conformity Assessment (CASCO) endorsed a medium-term plan on how to sequence and when to undertake future systematic reviews of ISO and ISO/IEC documents related to conformity assessment. This plan is a 'living' document, and is

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			Original Roadmap Recommended Timeline: This depends on ISO's systematic review process; however, some of these standards such as ISO/IEC 17011 and ISO/IEC 17000 are in need of update as soon as possible. This should be conducted in the near-term: 0-2 years.	endorsed annually at the CASCO plenary meeting. The CASCO Road Map acts as an indication of any future CASCO work and provides early notice of when international standards and guides are likely to be revised. The CASCO Road Map also indicates relations with other ISO technical committees' documents, which helps to sequence other international standards development activities. In principle, each document is subject to a five-year systematic review (Technical Specifications are reviewed every three years), as prescribed in the ISO/IEC Directives. However, as approved by the 2003 CASCO plenary, minor timing adjustments allow the review of interrelated international standards and guides together as necessary. As a result, related documents can be revised within the same period of time and in the context of a single working group. This process allows for a more efficient use of expertise and a satisfactory level of compatibility between various documents.
Chapter One: Building Energy and Water Assessment and Performance Standards	Conformity Assessment in Building Energy and Water Assessment and Performance Standards	1.14	**B. Gaps in the implementation of accreditation** Accreditation is a tool for decision makers/regulators to assist in risk reduction. Some product characteristics are vital for safe and effective performance; however, many of these characteristics cannot be reasonably evaluated simply by observation or examining the product in the marketplace. Such characteristics need to be determined and assessed, and assurance needs to be provided to the buyer (or other interested party) that the product conforms to requirements and that conformance is consistent from product to product. The following are specific areas to be addressed: • Need of consensus standards in the different areas of energy efficiency: this is being addressed in this roadmap by identifying areas where standardization is needed to advance energy efficiency. • Research on applications and emerging technologies related to inspection, testing, and monitoring of energy efficiency devices and equipment. • Research on traceability measurement for energy efficiency. Traceable measurements must have both the correct equipment and be used in the correct ways in a valid method. Questions that should be considered include: *Are the current testing methods appropriate to the test, and are the compliance*	No progress report update.

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			specifications appropriate for the current technologies and market needs? • Research on the application of calibration of energy efficiency equipment. • Documentation of accreditation best practices to demonstrate to regulators and other stakeholders the increase to the bottom-line. • Documentation of how accreditation increases market value and confidence, and how governments can be involved and use accreditation to increase their confidence. • Documentation of how accreditation increases market value in international trade. • Reinforcement of the body of knowledge related to the implementation of accreditation standards such as laboratory accreditation (17025), product certification (17065), and inspection bodies (17020). **Refer to roadmap section for full gap analysis/recommendation.** **Original Roadmap Recommended Timeline:** This should be conducted in the mid-term: 2-5 years.	
Chapter Two: System Integration and Systems Communications	System Integration and Systems Communications	2.3	**A. Common information models and taxonomies** Standards are needed around common information models and taxonomies using common protocols to transmit data between the building and the smart grid, so that smart grid service providers can utilize data in a consistent way. **Original Roadmap Recommended Timeline:** This work should be conducted in the near-term: 0-2 years.	IEC 61970, *Common Information Model (CIM)/Energy Management*, developed by IEC TC 57, *Power systems management and associated information exchange*, is being extended to cover both wholesale and retail demand response in a manner consistent with other market standardization work being done by the IEC. Published in 2015, IEC Technical Specification (TS) 62746-3:2015, *Systems interface between customer energy management system and the power management system - Part 3: Architecture*, establishes an architecture that is supportive of interfaces between the customer energy management system and the power management system. IEC Technical Report (TR) 62939, *Smart grid user interface - Part 1: Interface overview and country perspectives*, published by IEC Project Committee (PC) 118, *Smart grid user interface*, presents a vision for a Smart Grid User Interface (SGUI) including SGUI requirements distilled from use cases for communications across the customer

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
				interface. IEC PC 118, *Smart grid user interface*, has also developed an IEC Publicly Available Specification 62746-10-1, *Systems interface between customer energy management system and the power management system - Part 10-1: Open Automated Demand Response*, which is intended as a flexible data model to facilitate common information exchange between electricity service providers, aggregators, and end users. IEC PC 118 is also working on another document based on an OASIS standard that addresses modeling and communication protocols for more general building (residential, commercial, industrial) to grid communication and services.
Chapter Two: System Integration and Systems Communications	System Integration and Systems Communications	2.3	**B. Communication between building energy management systems and the grid** As standards are implemented to support communication between building energy management systems and the grid, there will be an ongoing need for standards to support communication. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2-5 years, with ongoing attention to evolving needs.	As noted in section 2.3 A, IEC 61970, Common Information Model (CIM)/Energy Management, is being extended to cover both wholesale and retail demand response in a manner consistent with other market standardization work being done by the IEC. Published in 2015, IEC TS 62746-3:2015, *Systems interface between customer energy management system and the power management system - Part 3: Architecture*, establishes an architecture that is supportive of interfaces between the customer energy management system and the power management system. IEC Technical Report 62939, *Smart grid user interface - Part 1: Interface overview and country perspectives*, published by IEC PC 118, presents a vision for a Smart Grid User Interface (SGUI), including SGUI requirements distilled from use cases for communications across the customer interface. IEC PC 118 has also developed an IEC Publicly Available Specification 62746-10-1, *Systems interface between customer energy management system and the power management system - Part 10-1: Open Automated Demand Response*, which is intended as a flexible data model to facilitate common information exchange between electricity service providers, aggregators, and end users. IEC PC 118 is also working on another document based on an OASIS standard that addresses modeling and communication protocols for more general building (residential, commercial, industrial) to grid communication and services.

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
Chapter Two: System Integration and Systems Communications	System Integration and Systems Communications	2.3	**C. Consistent data communication** Standards are needed to support more consistent data communication back to the utility or service provider. **Original Roadmap Recommended Timeline:** This work should be conducted in the near-term: 0-2 years.	No progress report update.
Chapter Two: System Integration and Systems Communications	System Integration and Systems Communications	2.3	**D. Methodology and identification of energy data formats and attributes** There is a need for standards to provide for the development of the methodology and identification of the commonly exchanged device, asset, process, and system integration parameters and specifications (data formats and attributes) related to significant energy uses or objectives of an energy management system. **Original Roadmap Recommended Timeline:** This work should be conducted in the near-term: 0-2 years.	In June 2014, ISO TC 242, *Energy Management*, initiated a standardization activity to address this gap, and is currently developing ISO/AWI 50008, *Commercial building energy data management for energy performance -- Guidance for a systemic data exchange approach*. ISO TC 242 Working Group (WG) 6 meetings were held in Merida, Mexico, in June 2015, and in Atlanta, GA, in January 2016. The next meeting is scheduled in Sweden in June 2016. The plan is to circulate a committee draft after the June 2016 meeting. Other relevant standards include: - ISO 20140, *Automation systems and integration - Evaluating energy efficiency and other factors of manufacturing systems that influence the environment - Part 1: Overview and general principles* - ISO 20140, *Automation systems and integration - Evaluating energy efficiency and other factors of manufacturing systems that influence the environment - Part 5: Environmental influence evaluation data*. The document has been circulated for a three-month comment period starting February 3, 2016. The ISO 20140-5 committee draft for voting has a series of similarities with the data exchange described in the ISO 50008 working draft. - ASHRAE/NEMA Standard 201, *Facility Smart Grid Information Model*
Chapter Two: System Integration and Systems Communications	System Integration and Systems Communications	2.3	**E. Measurement and monitoring protocols for energy data** There is a need for standards to establish measurement and monitoring protocols to support energy data. **Original Roadmap Recommended Timeline:** This work should be conducted in the near-term: 0-2 years.	ODVA has developed the Common Industrial Protocol (CIP), a specification for communicating energy information and control data and commands over a standard network interface (EtherNet/IP protocol) for industrial applications. Other relevant standards include, as noted in section 2.3 D: - ISO 20140, *Automation systems and integration - Evaluating energy efficiency and other factors of manufacturing systems that influence the environment - Part 1: Overview and general principles*

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
				- ASHRAE/NEMA Standard 201, *Facility Smart Grid Information Model*
Chapter Two: System Integration and Systems Communications	System Integration and Systems Communications	2.3	**F. Methodology for energy information sharing** There is a need for standards that provide a methodology for energy information sharing within a building, facility, or group of facilities, as well as with the grid. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2-5 years.	IEC 61970, *Common Information Model (CIM)/Energy Management*, developed by IEC TC 57, is being extended to cover both wholesale and retail demand response in a manner consistent with other market standardization work being done by the IEC. Published in 2015, IEC TS 62746-3:2015, *Systems interface between customer energy management system and the power management system - Part 3: Architecture*, establishes an architecture that is supportive of interfaces between the customer energy management system and the power management system. ISO/ WD 17800 *Facility Smart Grid Information Model* is currently under development by ISO TC 205, *Building environment design*. This international effort is closely linked to the draft ASHRAE/NEMA standard 201P, *Facility Smart Grid Information Model*.
Chapter Two: System Integration and Systems Communications	System Integration and Systems Communications	2.3	**G. Methodology of integrating the building sub-systems into an energy system** There is a need for a technical guide to provide for the development of the methodology of integrating the building sub-systems into an energy system serving the mutual interests of each sub-system's to perform and the overall building energy efficiency. **Original Roadmap Recommended Timeline:** This should be conducted in the near-term: 0-2 years.	Relevant standards include: - ISO 20140, *Automation systems and integration - Evaluating energy efficiency and other factors of manufacturing systems that influence the environment - Part 1: Overview and general principles* - IEC TR 62837, *Energy efficiency through automation systems* - ASHRAE/NEMA Standard 201, *Facility Smart Grid Information Model*
Chapter Two: System Integration and Systems Communications	System Integration and Systems Communications	2.3	**H. Standards to provide for a building energy information model** There is a need for standards to provide for a building energy information model, consisting of a series of use cases, to shape future standards related to building energy performance and management, and to test that the content of the standard provides for all of the information needed to optimize the energy performances of the building. **Original Roadmap Recommended Timeline:** This should be conducted in the near-term: 0-2 years.	No progress report update.
Chapter Two: System Integration and Systems Communications	System Integration and Systems Communications	2.3	**I. Workforce training and certification programs** A better integration of automation and controls into the skills standards underlying workforce training and certification programs is needed. **Original Roadmap Recommended Timeline:** This should be conducted in	No progress report update.

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			the mid-term: 2-5 years.	
Chapter Three: Building Energy Rating, Labeling, and Simulation	Rating and Labeling Programs	3.1.5	**A. Data availability** Operational ratings and labeling programs rely on data that is representative of the existing building and industrial plant stock. As noted earlier, data sources such as the Residential Energy Consumption Survey (RECS), Commercial Building Energy Consumption Survey (CBECS), Manufacturing Energy Consumption Survey (MECS), and the Census of Manufacturing are commonly used for operational rating development. However, these data sets are frequently limited in the number and types of buildings included in the surveys, the granularity of building characteristics, robustness of the sample, and timeliness of the data. There are many issues due to limited data sets. One critical issue is that limitations in the amount and quality of data in the CBECS and RECS studies can impact the consistency within a rating system. CBECS results for specific building types can vary significantly from survey to survey. This creates changes in the rating scores for buildings with no action taken by the owner. A high scoring building may become a low scoring building. Investment in additional data collection will reduce this noise and increase trust in the ratings. In addition, many building types have insufficient data on which to base a rating program. This is most evident in the commercial building arena, but also affects mixed use and multi-family building types. An expansion in the types of buildings included in the consumption surveys listed above would help to remedy this situation. Additional data sets could also benefit asset ratings by providing more robust information on which to base standard occupancy assumptions. In recent years, funding for building energy surveys has been questioned, and in some cases, reduced. If further development or refinement of existing operational ratings is to take place, additional steps should be taken to expand or establish new data sets that can be used to create operational ratings. Additionally, steps could be taken to establish criteria or standards for guiding data collection by organizations seeking to collect building performance data for operational rating development. **Original Roadmap Recommended Timeline:** Existing efforts underway need to be accelerated in the near-term: 0-2 years. However, this is an ongoing need that is going to exist in the long-term. Those organizations in charge of collecting data (U.S. Energy Information Administration, Census) should continue to solicit feedback from	In 2015, the U.S. Energy Information Administration (EIA) published the latest version of CBECS building characteristics and summary tables. Preliminary consumption data estimates were released in February 2016 with detailed tables released in March 2016. Consumption microdata is expected in April 2016.[49]

[49] For more details, visit http://www.eia.gov/consumption/commercial.

Chapter	Issue Area	Section	Original Roadmap Gap/Recommendation	Progress Report Update
			stakeholders with each iteration of their surveys in order to improve the data collected and the collection process.	
Chapter Three: Building Energy Rating, Labeling, and Simulation	Rating and Labeling Programs	3.1.5	**B. Taxonomy and terminology** Currently, different systems use different definitions for common terms such as baseline, benchmark, label, reference, etc. As a result, it can be difficult to compare or quickly understand the structure and design of various rating systems. Further dialogue (and consensus where possible) is needed to clarify terminology used in this field. There is at least one standard under development that might be able to address this.[50] **Original Roadmap Recommended Timeline:** This should be conducted in the near-term: 0-2 years.	ASHRAE 214P, *Standard for Measuring and Expressing Building Energy Performance in a Rating Program*, which is currently under development, may help to address this gap. BEDES (Building Energy Data Exchange Specification), developed by the U.S. Department of Energy, also offers relevant taxonomy and terminology for rating and labeling tools.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Rating and Labeling Programs	3.1.5	**C. Rating and labeling directory** Through the process of inventorying operational rating and labeling systems, it became clear that there is no central resource or catalogue that outlines existing programs and their focus. There is an opportunity for the establishment of a consistently updated "rating and labeling directory" that catalogues different programs and discusses each program's design and focus in a systematic format. **Original Roadmap Recommended Timeline:** This should be conducted in the near-term:0-2 years; however, it will require update over time.	No progress report update.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Code Compliance and Asset Rating: Commercial Buildings	3.2.1.1.1	**A. Single rule set** All codes and beyond-code programs should use a single rule set for performance-path modeling. **Original Roadmap Recommended Timeline:** This process should be initiated in the near-term: 0-2 years, but may not be fully implemented for 2-5 years.	This gap is addressed through an addendum BM to ASHRAE Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, which was published in the ASHRAE 90.1 2013 Supplement. A proposal is being introduced to the IECC to use the ASHRAE approach for the 2018 edition. USGBC has expressed interest in using the new ASHRAE approach for LEED certification. It is uncertain whether the IECC proposal will be successful. Several other energy codes and beyond code programs are exploring the use of the addendum BM approach. For this recommendation to be fully realized, the approach will need to be embraced by other codes (Title 24 and other state-specific and beyond-code programs).

[50] ASHRAE 214P, *Standard for Measuring and Expressing Building Energy Performance in a Rating Program*.

Chapter Three: Building Energy Rating, Labeling, and Simulation	**Energy Simulation for Code Compliance and Asset Rating: Commercial Buildings**	3.2.1.1.1	**B. Prescriptive baselines** The prescriptive baseline should not change with improvements to codes and standards. Rather than ratcheting up prescriptive baselines, standards should advance by ratcheting up performance increases over a fixed prescriptive baseline. In this setup, different standards could continue to set and advance performance increments independently and even set minimum prescriptive responses independently. **Original Roadmap Recommended Timeline:** This should be conducted in the near-term: 0-2 years.	This gap is addressed through an addendum BM to ASHRAE Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, which was published in the ASHRAE 90.1 2013 Supplement. A proposal is being introduced to the IECC to use the ASHRAE approach for the 2018 edition. USGBC has expressed interest in using the new ASHRAE approach for LEED certification. It is uncertain whether the IECC proposal will be successful. Several other energy codes and beyond code programs are exploring the use of the addendum BM approach. For this recommendation to be fully realized, the approach will need to be embraced by other codes (Title 24 and other state-specific and beyond-code programs).
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Code Compliance and Asset Rating: Commercial Buildings	3.2.1.1.1	**C. Comprehensive, robust rule sets** Rule sets need to be better defined, more comprehensive, and more robust. **Original Roadmap Recommended Timeline:** This should be conducted in the near-term: 0-2 years.	The ASHRAE Standard 90.1 Addendum BM creates a unified code compliance/beyond-code path. On the side of rule set detail, the COMNET Modeling Guidelines and Procedures (MGP) prescribes additional modeling assumptions and could eventually be adopted or referenced by ASHRAE standards. DOE, through PNNL, is also expanding on the work done by COMNET to develop the rule set into a detailed software specification.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Code Compliance and Asset Rating: Residential Buildings	3.2.1.1.2	**A. Standards for different rating purposes** Recognizing that increased cost effectiveness of rating delivery can be improved by data and process integration, it is recommended that standards be identified and developed that consider different rating purposes (e.g., real estate transaction, posting on multiple listing service (MLS) or commercial listing service, energy audit, new home, financial incentive applications). **Original Roadmap Recommended Timeline:** This should be conducted in the near-term: 0-2 years. Identification could be completed within 1 year and standards could be developed within 2 years. **Note: In Phase II, the EESCC updated the title of the gap for clarity, as the recommendation is for standards for the software tools used by rating systems. The new title used is "Standards for software tools used in different rating purposes."**	A standard that may help to address this gap is NIBS's National Building Information Modeling Standard (NBIMS) Version 3, which provides a basis for interoperability of building data across the entire life cycle from design through operations.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Code Compliance and Asset Rating: Data Centers	3.2.1.1.4	**A. Standard for data centers** If possible, ASHRAE should seek to publish the first version of the 90.4 standard by the next update cycle in 2016. This first version should, to the extent possible, align with the protocols and methodologies of the 90.1	ASHRAE Standard 90.4P, *Energy Standard for Data Centers and Telecommunications Buildings*, is currently under development for targeted publication in late 2016.

			standard. **Original Roadmap Recommended Timeline:** This should be conducted in the mid-term: 2-5 years.	
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Whole-Building Energy Efficiency Incentives: Commercial Buildings	3.2.1.2.1	**A. Simulation methodologies and protocols** Energy design assistance program implementation details vary, but most programs confront the same standards gaps. Specifically, simulation methodologies and protocols need to be included in published standards so that they can be referenced in contracts for design work. ASHRAE has proposed a standard on simulation-driven design assistance, but publication of that standard is several years away. While there are a number of sophisticated simulation tools on the market, it is less clear which tools are appropriate for use with different design elements, especially HVAC system types. The current ASHRAE Standard 140 is not sufficiently comprehensive for this purpose at this time. The proposed standard, ASHRAE Standard 209P, is designed to fill the modeling protocol gap described above. A reasonable goal is for a first version of the standard to be published along with the next update to Standard 90.1 in 2016. ASHRAE Standard 140 will eventually address the simulation tool suitability gap, but the effort to bring the standard to the necessary level will be highly data-driven, and therefore may evolve slowly. Accelerating the development of the standard – specifically on the data gathering and model reconciliation activities that underlie the standard – will require substantial resources. **Original Roadmap Recommended Timeline:** This should be conducted in the mid-term: 2-5 years.	ASHRAE Standard 209P, *Energy Simulation Aided Design for Buildings Except Low-Rise Residential Buildings*, is currently under development for publication in 2016. Its purpose is to define minimum requirements for providing energy design assistance using building energy simulation and analysis.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Whole-Building Energy Efficiency Incentives: Residential Buildings	3.2.1.2.2	**A. Develop standardized definitions for energy conservation measures, standard protocols for simulation, and standard implementations of those protocols** The recommendation is to cascade the BEDES, BPI 2100/2200, measure cutsheet, NREMDB, and BCL projects, potentially using ASHRAE Standard 209P as a standards vehicle for the simulation protocols. HERS BESTEST, BPI 2400, and the RESNET extensions to HERS BESTEST for heating plant, distribution system, DHW (domestic hot water), and improvement measure interaction need to be expanded, especially in the HVAC space, to support this effort. This is a cascading, multi-step effort that could take 5-10 years to complete. **Original Roadmap Recommended Timeline:** This is a long-term priority and should be completed in 5+years.	BEDES, developed by the U.S. Department of Energy, offers relevant taxonomy and terminology for rating and labeling tools. The tools will be updated and extended on an ongoing basis.

Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Whole-Building Energy Efficiency Incentives: Residential Buildings	3.2.1.2.2	**B. Develop a standardized procedure for simulation model review** Model review, including benchmarking, can be built into the modeling but the entire review and acceptance framework needs to be agreed upon. An initial framework can likely be put together in about 2 years. **Original Roadmap Recommended Timeline:** This is a near-term priority and should be conducted in 0-2 years.	No progress report update.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Whole-Building Energy Efficiency Incentives: Residential Buildings	3.2.1.2.2	**C. Develop standard methods for estimating uncertainty in energy-savings calculations as well as acceptability ranges for uncertainty** Ad hoc tools for uncertainty analysis are very close and should help. However, there is some research to be done before a sound, useful, comprehensive framework is put in place 3-5 years from now. **Original Roadmap Recommended Timeline:** This is an urgent priority; however, it will not likely be fully resolved in the near-term. Conversations should begin immediately, and work should be completed in the mid-term: 2-5 years.	During the EESCC's Phase II, this gap was confirmed to apply to both residential and commercial buildings. In the June 2014 roadmap, it was identified as an area for residential buildings only.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Whole-Building Energy Efficiency Incentives: Multi-family Buildings	3.2.1.2.3	**A. Standardized modeling requirements for multi-family buildings** New work on multi-family modeling should be done to develop standardized modeling requirements. **Original Roadmap Recommended Timeline:** Work to address this should gap begin immediately and should be completed in the mid-term: 2-5 years.	BPI-1105-S-201x, *Standard Practice for Multifamily Energy Auditing*, which is currently under development by the Building Performance Institute (BPI), may help to address this gap. This standard defines minimum criteria for conducting a building-science-based evaluation of existing multi-family buildings and provides technical procedures to conduct a multi-family building energy audit as necessary to define the minimum skills required by a BPI Multifamily Energy Auditor.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Building Energy Simulation for Use in Evaluation, Measurement, and Verification: Commercial Buildings	3.2.1.3.1	**A. Explicit linkages for standards specifying building simulation** Standards specifying building simulation software should provide explicit linkages to other standards providing specifics related to calibration, training, and certification of software, including ASHRAE Guideline 14 (calibration), ASHRAE Standard 140 (software certification), BPI 2400-S-2011 (calibration), and the California Evaluation Framework and Protocols (training). Software certification is discussed in Section 3.2.2, *Energy Simulation Software Capabilities and Accuracy*. **Original Roadmap Recommended Timeline:** This should be conducted in the near-term: 0-2 years.	ASHRAE bEQ has initiated a research project with the purpose of understanding the differences between empirical and modeled baselines for building energy performance and to identify sets of building operation inputs for schedules, plug loads, ventilation rates, etc., that when used with energy models provide better agreement with the empirical data. The research also aims to lead to consistency of energy performance metrics for a number of ASHRAE standards. Note: This gap is closely related to Gap 3.2.1.3.2 A for residential buildings and is likely to be addressed by the same action.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Building Energy Simulation for Use in Evaluation, Measurement, and Verification:	3.2.1.3.2	**A. Explicit linkages for standards specifying building simulation** Standards specifying building simulation software should provide explicit linkages to other standards providing specifics related to calibration, training, and certification of software, including ASHRAE Guideline 14 (calibration), ASHRAE Standard 140 (software certification), BPI 2400-S-	ASHRAE bEQ has initiated a research project with the purpose of understanding the differences between empirical and modeled baselines for building energy performance and to identify sets of building operation inputs for schedules, plug loads, ventilation rates, etc., that when used with energy models provide better agreement

	Residential Buildings		2011 (calibration), and the California Evaluation Framework and Protocols (training). **Original Roadmap Recommended Timeline:** This should be addressed in the near-term: 0-2 years.	with the empirical data. The research also aims to lead to consistency of energy performance metrics for a number of ASHRAE standards. Note: This gap is closely related to Gap 3.2.1.3.1 A for commercial buildings and is likely to be addressed by the same action.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Building Energy Simulation for Use in Evaluation, Measurement, and Verification: Residential Buildings	3.2.1.3.2	**B. EM&V simulation standards are needed for multi-family buildings** BPI 2400 applies to 1-4 unit residential buildings, but no standards currently exist for larger multi-family buildings. **Original Roadmap Recommended Timeline:** Work to address this gap should be conducted in the near-term: 0-2 years.	No progress report update.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation Software Capabilities and Accuracy: Commercial and Residential Buildings	3.2.2.1	**A. Roadmap for improving the coverage and physical fidelity of energy simulation engine tests** The recommendation is to develop a roadmap for improving the coverage and physical fidelity of energy simulation engine tests, including expanding the range of tests for existing buildings and potentially including reference results from empirical measurements. This activity would use the growing collection of test facility data to characterize and benchmark the simulated accuracy of major building-physics phenomena and common HVAC system types, and create a prioritized list of missing or lagging simulation capabilities combined with measurement experiments needed to resolve or upgrade them. **Original Roadmap Recommended Timeline:** This should be completed in the mid-term: 2-5 years.	In 2015, Lawrence Berkeley National Laboratory (LBNL), Oak Ridge National Laboratory, the National Renewable Energy Laboratory (NREL) and Argonne National Laboratory were awarded a three-year, $2.7M grant to develop a framework and initial set of experiments for empirical validation and uncertainty characterization of building energy modeling engines. The results will be channeled into ASHRAE Standard 140, *Method of Test for Evaluation of Building Energy Analysis Computer Programs*.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation Software Capabilities and Accuracy: Commercial and Residential Buildings	3.2.2.1	**B. Tests for energy simulation software and supporting software** There is a need to develop and reference suites of tests for energy simulation software and supporting software – potentially with accuracy guidelines – that are appropriate for specific use cases. Each suite should be designed to: (1) be applicable to market uses and/or connected to standard program types such as residential, commercial, new, existing, whole building, retro-commissioning, code compliance, ratings, incentives; and (2) where appropriate, explicitly test before- and after-simulation of efficiency measures associated with these use cases. Such test suites should be designed to: (a) assess accuracy and coverage of software capabilities; (b) standardize the level of effort required by software vendors to test software; and (c) foster development and implementation of third-party validation methods/systems. In regulated contexts, credentials for the accuracy of savings calculations	As noted in section 3.2.2.1 A, in 2015, LBNL, Oak Ridge National Laboratory, NREL, and Argonne National Laboratory were awarded a three-year, $2.7M grant to develop a framework and initial set of experiments for empirical validation and uncertainty characterization of building energy modeling engines. The results will be channeled into ASHRAE Standard 140, *Method of Test for Evaluation of Building Energy Analysis Computer Programs*.

			are extremely valuable. Utility programs rely on state-level technical reference manuals to approve calculation methodologies. The manuals, which often include references to standards as opposed to specific tools, could cite these standard suites of tests along with acceptability/accuracy criteria that meet the programs' needs. This would parallel the simulation accuracy benchmarking activity described above. It could be led by a standards organization whose published scope covers this type of activity. **Original Roadmap Recommended Timeline:** This should be completed in the mid-term: 2-5 years.	
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation Software Capabilities and Accuracy: Commercial and Residential Buildings	3.2.2.1	**C. Develop a robust and low-cost testing procedure for model-input calibration** This is a 1-2 year activity already undertaken by RESNET, which has formed a working group to generalize and codify the BESTEST-EX methodology for calibrating energy model inputs using measured data, e.g., utility bill data. **Original Roadmap Recommended Timeline:** This should be completed in the near-term: 0-2 years.	RESNET is continuing its work in this area. The method of test for calibration procedures under development elaborates on the "pure" test method mentioned in BESTEST-EX.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation Professionals: Commercial Buildings	3.2.3.1	**A. Harmonize – or at least differentiate – the BESA™ and BEMP certificates** The relationship between the BEMP and BESA™ certificates is not clear, although the BESA™ certificate requires less experience for qualification. **Original Roadmap Recommended Timeline:** Differentiation is a near-term goal: 0-2 years. Harmonization is a long-term goal: 5+ years.	During the EESCC's Phase II, this gap was confirmed to apply to both residential and commercial buildings. In the June 2014 roadmap, it was identified as a gap for commercial buildings only.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation Professionals: Commercial Buildings	3.2.3.1	**B. Any simulation used for code compliance or asset rating should be overseen by a credentialed simulation professional** Beginners should not be responsible for simulations that explicitly support regulatory or financial transactions. However, they do have to learn somewhere, and furthermore, to learn by doing. The apprenticeship and responsibility structure should track that which is used in other engineering fields. An engineer in training may do the work, but a credentialed engineer, e.g., a PE, reviews it, stamps it, and is ultimately responsible for it. A time frame for enforcing this requirement generally should be at least five years because the number of credentialed simulation professionals is currently small. **Original Roadmap Recommended Timeline:** This is a long-term priority and should be completed in 5+years.	During the EESCC's Phase II, this gap was confirmed to apply to both residential and commercial buildings. In the June 2014 roadmap, it was identified as a gap for commercial buildings only.
Chapter Three: Building Energy Rating, Labeling,	Energy Simulation Professionals:	3.2.3.2	**A. Standardized methods for credentialing** A standardized process for credentialing qualified users of residential	During the EESCC's Phase II, this gap was confirmed to apply to both residential and commercial buildings. In the June 2014 roadmap, it

and Simulation	Residential Buildings		energy simulation software currently does not exist. Standardized methods of credentialing qualified users of residential energy simulation software should be created to address this gap. **Original Roadmap Recommended Timeline:** This should be conducted in the near-term: 0-2 years.	was identified as an area for residential buildings only.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Measurement and Verification Methodological Approaches: Baselines	4.1.1	**A. Selecting between existing conditions baselines and common practice baselines** While the documents listed in this discussion indicate "best practice" in determining a baseline, one area that could use further clarification is when there are two possible approaches to determining the baseline. This occurs when a code or legal standard (e.g., for new construction) or industry common practice could be used to determine a baseline, or a baseline could be determined using the specific circumstances at the retrofit site (existing conditions baseline). Determining if a project or measure triggers a Code/ISP baseline or an existing conditions baseline is often determined through governing rules, as in the NAESB standards and ISO markets, or may require a degree of evaluator judgment. Except in the case when there are governing rules (e.g., the NAESB case), existing literature provides little guidance in these areas. These considerations necessarily require a degree of evaluator judgment and do not lend themselves to a fully prescriptive approach. The best option may be to address these types of occurrences through nonbinding guidance documents rather than formal standards in unregulated environments. **Original Roadmap Recommended Timeline:** This is a long-term priority: 5+ years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Measurement and Verification Methodological Approaches: Baselines	4.1.1	**B. Treatment of dual baselines** When an EE program induces the replacement of equipment before it would otherwise have been replaced; an issue arises as to whether the applicable baseline should be based on the efficiency of the replaced equipment, or an applicable standard or industry best practice at the time of replacement. According to the Pennsylvania TRM, "Retrofit measures have a dual baseline: for the estimated remaining useful life of the existing equipment the baseline is the existing equipment; afterwards the baseline is the applicable code, standard, and standard practice expected to be in place at the time the unit would have been naturally replaced." While this theoretical construct has always been well understood, it has	No progress report update.

			been common practice in impact evaluation to determine the first year energy savings from energy efficiency measures and, then to multiply this savings by the effective useful life of the measure to obtain lifetime savings. If the existing equipment would have failed in five years, a more reasonable estimate of the lifetime impact of the measure is obtained by using an existing conditions baseline for the remaining years of useful life, and then using a code or industry common practice baseline for the remainder of the measure life. This approach is not required by most jurisdictions outside of California, though there is some indication that other jurisdictions are beginning to adopt it. Finally, the use of dual baselines only applies to measures with early replacement. The gap is that there are no unequivocal methods for determining how long the functioning equipment would have operated. Inconsistent application of this approach hinders comparability of savings across jurisdictions. However, as the treatment of baselines are often embedded in jurisdiction-specific protocols, such as state TRMs and state evaluation frameworks, treating the issue in a national or international standard is recommended. **Original Roadmap Recommended Timeline:** This should be conducted in the mid-term: 2-5 years.	
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Measurement and Verification Methodological Approaches: Baselines	4.1.1	**C. Industrial baselines** In industrial retrofits, when production levels change, there has been inconsistent guidance on establishing a baseline. In California and New York, the baseline accounts for production increases differently if the measure allowed production to increase versus if the production increase occurred due to market forces only. If market forces drove the increase, the lifetime impacts are based on post-installation production levels. If the measure allowed production to increase, pre-installation levels are the basis of the savings. Other jurisdictions are largely silent on baseline estimation given externalities that impact savings. Given the standard evaluation practice of establishing energy savings based on post-intervention operating conditions, most jurisdictions may not be consistent with California and New York in the treatment of projects that allow for production increases. Inconsistent definitions for baseline production levels hinder comparability of savings across jurisdictions. However, as the treatments of baselines are often embedded in jurisdiction-specific protocols, it is recommended that the issue be treated in a national or international standard. **Original Roadmap Recommended Timeline:** This should be conducted in	No progress report update.

			the mid-term: 2-5 years.	
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Measurement and Verification Methodological Approaches: Baselines	4.1.1	**D. Non-direct dependence on production levels** Baselines are sometimes defined in terms of a metric that is a form of energy use per unit of production. This energy use index is then applied to the post-installation production levels, or to a typical production level, in order to obtain an estimate of the baseline energy use. The implicit assumption is that the energy use is linearly related to production, and that the energy use tends toward "0" when production is "0." This assumption is almost never explicitly stated, and the assumption may be incorrect. A relationship between energy input and production output can typically be determined, but it is rarely of a form that is both linear and is zero with no production. Practice in this area should be examined, and to the extent possible, standardized. If that proves infeasible, standards should be developed to describe the method or procedure used so that there is transparency. **Original Roadmap Recommended Timeline:** This should be conducted in the mid-term: 2-5 years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Measurement and Verification Methodological Approaches: Baselines	4.1.1	**E. Automatic benchmarking of commercial and residential buildings** The advent of higher resolution data and more complete data sets describing buildings has opened the possibility of building energy management systems (EMSs) themselves "automatically" benchmarking a building by recording energy use and being programmed to estimate equations describing building energy use. The advantages are that the EMS would have a basis for diagnosing building performance. For EM&V, a "baseline" of pre-upgrade performance would automatically be available. If many buildings in a given program had this capability, EM&V approaches could be modified to use larger samples (of self-benchmarking buildings), but at potentially different accuracy at each individual building. While this is an interesting possibility for developing faster, less costly EM&V, it relies on the quality of the benchmark the building's EMSs are creating. The gap is that metrics or testing procedures to assess the accuracy of these self-created benchmarks do not exist. Some initial work in this regard has been done, but more must be done for self-benchmarking buildings to provide a reliable basis for EM&V. Organizations with access to high-resolution building energy usage should research automatic benchmarking approaches to determine suitable metrics for the accuracy of self-benchmarking algorithms. This should be done with industry input regarding the purpose and use of the self-benchmarking capability.	Lawrence Berkeley National Laboratory (LBNL) has tested various approaches and published several research papers on automatic benchmarking, automatic measurement, and verification of energy usage changes, and on assessing or comparing different analytic tools. Work is continuing.

			Original Roadmap Recommended Timeline: This should be conducted in the mid-term: 2-5 years.	
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining Annual Savings	4.1.2	**A. Potentially inconsistent savings estimates** 1. The issue of consistency requires that the data and a description of the methodology be available to replicate the savings calculation. As a first step, the information required for replication of the energy savings result should routinely be available. This has the advantage of allowing annual savings calculations to be auditable. 2. Another important step would be to analyze and provide guidance on how a comparison of two annual savings results could be done, provided that all the information needed to replicate each is available. For example, starting with UMP use cases, a study could be conducted to consider whether it is possible to develop a transparent, standard approach to comparing the savings estimates in different locations. This could be a step-wise change of one location's data and measurement approach to the other, with each step following a logical progression, and the change in the annual savings figure provided and compared to previous and subsequent values. The analysis could also indicate when a logical, transparent comparison was not feasible. After the UMP use cases were explored, other annual savings calculation approaches could be examined. The objective would be to define a comparison methodology that is as broad as possible. The result would be that when a comparison is undertaken, the method employed by the comparison would not be a source of difference between the two compared results. 3. A final step would be to consider the development of standardized testing procedures for energy savings determination methodologies. The California Emerging Technologies Coordinating Council (ETCC) details initial work in this direction, in which standard datasets are used to compare different energy savings approaches. This approach or another could be examined, including the development of criteria for assessing savings approaches, model or sample test procedures, etc. The goal would be to understand from an objective, quantifiable perspective the qualities of a given method. This could be first undertaken with the more simple annual savings calculation methodologies, and could take advantage of the increasing availability of larger datasets and computing power. **Original Roadmap Recommended Timeline:** This should be conducted in the near-term: 0-2 years.	No progress report update.

Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining Annual Savings: Site-Specific Verification, IPMVP Option A, B, C, and D	4.1.2.1	**A. Explore and refine the calibration requirements of Option D** Exploring additional standardization of calibration requirements used in Option D could increase understanding of the usefulness of EM&V results obtained with this method. Areas to be explored could include a description of how and why the simulation model was modified to achieve calibration, as well as graphical or other approaches to comparing the calculated energy use values and the actual energy use values. The goal is for users of the method to fully understand the accuracy and applicability of the calibrated model. Standardized documentation of the calibration process and data should include sufficient information so that a qualified third party could verify the results. **Original Roadmap Recommended Timeline:** This should be conducted in the near-term: 0-2 years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining Annual Savings: Statistical Methodologies	4.1.2.2	**A. Quantifying uncertainty in regression models for all time periods (e.g., monthly, daily, hourly)** Leveraging the California Evaluation Framework requirements on presenting uncertainty, a voluntary standard should be developed that would apply to regression models. **Original Roadmap Recommended Timeline:** This should be addressed in the mid-term: 2-5 years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining Annual Savings: Statistical Methodologies	4.1.2.2	**B. Quantifying uncertainty in energy simulation models, including standard reporting and documentation of parameter assumptions** Guidelines should be developed that would provide model users information on: (1) how well a given model replicates known building energy use; and (2) what the sensitivity of the model outputs to changes in the model inputs is. For example, if hours of occupancy change, what is the energy use change in a fully specified building energy model? **Original Roadmap Recommended Timeline:** This should be addressed in the mid-term: 2-5 years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining Annual Savings: Statistical Methodologies	4.1.2.2	**C. General reporting of the identification and quantification of uncertainty beyond sampling error and aggregating all areas of uncertainty in one analysis framework** This could be a voluntary framework. Development could start with the requirements in the California Evaluation Framework. **Original Roadmap Recommended Timeline:** This should be addressed in the mid-term: 2-5 years.	No progress report update.
Chapter Four: Evaluation,	Methods for Determining Annual	4.1.2.3	**A. Standards for data collection and the appropriate forms of the statistical analyses to be used on these data**	No progress report update.

Measurement, and Verification (EM&V)	Savings: Whole Building Metered Analysis		For analysis that uses monthly-metered data and survey data about the premises, there is a need to develop standards for data collection and the appropriate forms of the statistical analyses to be used on these data. DOE's Uniform Methods Project for residential whole buildings may provide a starting point for formal standards development. **Original Roadmap Recommended Timeline:** This work should be conducted in the mid-term: 2-5 years.	
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining Annual Savings: Whole Building Metered Analysis	4.1.2.3	**B. New statistical approaches using high-resolution usage data require additional validation** New statistical approaches using high-resolution usage data require additional validation for more formal acceptance. This activity could be addressed in the near-term through the development of datasets of the high-resolution energy usage of many buildings with known equipment and usage. Although a single model may not be suitable for all applications, a matrix of acceptable models may be developed through a series of generally accepted automated modeling approaches to identify best fit. Initial proof of concept could be developed using synthetic "data" from building simulation models as a first step to testing with actual building data. Such activities would need research support prior to the development of actual standards. **Original Roadmap Recommended Timeline:** This should be conducted in the near-term: 0-2 years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining Annual Savings: Whole Building Metered Analysis	4.1.2.3	**C. Standardization of methods for automated analysis approaches** If suitable data sets and testing procedures can be developed, the standardization of methods for automated analysis approaches that provide performance metrics could be developed. **Original Roadmap Recommended Timeline:** This should be conducted in the mid-term: 2-5 years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining Annual Savings: Methodologies Used for Large, Complex Retrofits	4.1.2.4	**A. Guidance on the evaluation of projects that include multiple heterogeneous measures** There is sufficient guidance on sampling within similar sets of measures for a given project, but little guidance exists on how to treat projects that include multiple unique measures. ▪ Do savings need to be determined for each measure individually? This partly depends on the evaluation framework in place in the jurisdiction. If measure-level savings are required, each measure may need to be evaluated. If only the project-level savings are required, then measures that	No progress report update.

			contribute smaller portions of the savings may not need to be verified. ▪ If individual measures are to be evaluated, what guidance can be used to select the most representative measures to accurately determine overall project savings? The selection process is complicated by variances in savings magnitude, use conditions, and measurement error. ▪ What levels of uncertainty are introduced when project -level savings are developed using combinations of deemed savings, partly deemed savings, and directly measured savings? ▪ How can "value of information" principles be applied? Guidance should be developed over the long-term on the evaluation of projects that include multiple heterogeneous measures. **Original Roadmap Recommended Timeline:** Guidance should be developed over the long-term (5+ years) on the evaluation of projects that include multiple heterogeneous measures.	
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining Annual Savings: Methodologies Used for Large, Complex Retrofits	4.1.2.4	**B. Guidance on how to present the results of complex site-specific engineering analysis** There is little guidance on how to present the results of complex site-specific engineering analysis (M&V). Verification of such activities is difficult, due to the requirement to replicate prior analyses rather than capture and validate results based on common specifications. This adds significant cost to the EM&V process and increases error, as additional analysis of unique, non-standard operations may introduce additional sources of error. While existing EM&V resources generally do not address transparency, the IPMVP, NAESB standards, and ISO/RTO manuals contain requirements for M&V reports that include reporting the raw data and the justification for any corrections made to observed data. This guidance is generally sufficient, but local jurisdictions may wish to formalize requirements for transparency and reporting specifications (see Section 4.2.3, *Reporting*). **Original Roadmap Recommended Timeline:** This work should be conducted in the long-term: 5+ years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Duration of Savings: Effective Useful Life	4.1.3	**A. Straw guidance on the treatment of EULs** In the near term, a group of EM&V practitioners should convene to develop straw guidance on the treatment of EULs, including terminology and reporting or presentation practice. This guidance should be vetted and incorporated into protocols especially for technical reference	No progress report update.

			manuals. **Original Roadmap Recommended Timeline:** This should be done in the near-term: 0-2 years.	
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Duration of Savings: Effective Useful Life	4.1.3	**B. Assessing feasibility and usefulness of single national study using survival analysis** Practitioners should identify several measures, which produce significant portions of the savings in programs nationally, to assess whether a single national study using survival analysis would be feasible or useful given the long lives of many measures and rapid technological change. **Original Roadmap Recommended Timeline:** This should be done in the near-term: 0-2 years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Duration of Savings: Effective Useful Life	4.1.3	**C. Studies of EUL** Several studies of EUL should be undertaken to determine if survival studies could add accuracy to the determination of EULs in a manner that could be standardized and lead to protocols on how such studies could be undertaken in the future. As the EUL of a measure depends on the application of that measure, this is particularly complex. **Original Roadmap Recommended Timeline:** This should be done in the mid-term: 2-5 years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Technical Reference Manuals (TRMs)	4.1.4	**A. Establish a standard format and content guide** In order to promote consistency and wider adoption of TRMs, establish a standard format and content guide. The format could be developed by an independent contractor (National Lab, University, Industry Group) acting under an Advisory Group of TRM Users. Such a guide could come in the form of model business practices, business practice standards, or through other stakeholder-led processes. One area to explore that may create consistency in this area is to define the component factors of the TRMs that may be established as state or federal policy objectives rather than objective engineering analysis. In this manner there would be transparency on the differences between TRMs rather than the assumption that the fundamental engineering analysis is not applicable across sectors or regions. **Original Roadmap Recommended Timeline:** This effort is on several stakeholders' work plans, though is yet to be completed. This is an area that is ripe for standardization and considered a near-term priority. This work should be conducted in the near-term: 0-2 years.	The Northeast Energy Efficiency Partnerships (NEEP) is exploring interest in the Northeast region on digitizing existing TRMs, possibly using a platform recently built for Rhode Island, Massachusetts, and Connecticut. The State and Local Energy Efficiency Action Network (SEE Action) is developing a document on best practices and recommendations for TRMs, including a TRM template (what TRMs should include), based on directives from the EPA's Clean Power Plan. E Source's *Measure Insights* consolidates publicly available TRM data in an online database of deemed savings values and other measure-specific assumptions on which utilities base their demand-side management program calculations. The North American Energy Standards Board (NAESB) is considering potential work in this area.
Chapter Four: Evaluation,	Reporting and Tracking Systems:	4.2.1	**A. Set of standard terms and definitions that can be applied nationally** A set of standard terms and definitions for designating and reporting	BEDES, developed by the U.S. Department of Energy, establishes terms, definitions and field formats covering building characteristics,

Measurement, and Verification (EM&V)	Tracking Systems		energy efficiency program and project data at all levels (from technologies to projects to programs to portfolios) that can be applied nationally is recommended. This project would leverage the new work being planned under BEDES and coordinate with SEE Action to establish standard reporting requirements for energy efficiency projects and programs. **Original Roadmap Recommended Timeline:** This should be accomplished in the mid-term: 2-5 years.	efficiency measures, and energy use, for commercial, single family, and multi-family buildings. It is intended to be used in tools and activities that help stakeholders make energy investment decisions, track building performance, and implement energy efficient policies and programs. It will be updated and extended on an ongoing basis. NAESB is considering potential work in this area.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Reporting and Tracking Systems: Standardized Data Collection	4.2.2	**A. Collaborative effort to address central data needs for calculating savings** A single standard taxonomy (and XML specification) does not exist that covers central data needs for calculating savings. In the near term, a collaborative effort should be begun to: 1. Examine and consolidate the existing (BPI, BEDES, others) taxonomies of data used in energy efficiency savings calculations 2. Work with stakeholders to refine these definitions to those which are material for different analytic methods 3. Publish a data dictionary and XML specification for use in describing and communicating data 4. Consider "locking down" the agreed-upon data standard through an ANSI-approved standards process under an ANSI-accredited organization 5. Track the development of new EM&V methods to determine whether a new data type is being used that can be included in the data specification and establish a continuous update process to manage evolving changes **Original Roadmap Recommended Timeline:** This should be done in the near-term: 0-2 years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Reporting and Tracking Systems: Standardized Data Collection	4.2.2	**B. Standardizing reporting characteristics of audit and implementation data** An additional gap was identified regarding standardizing reporting characteristics of audit and implementation data which may be routinely communicated to evaluation professionals, including how installation of individual EE measures is tracked. Standardization could improve data quality, EM&V implementation timelines, and reduce cost in the preparation of that data for EM&V purposes. This could be considered as part of future EM&V standardization.	The Standard Energy Efficiency Data (SEED) Platform has been established as a collaborative between DOE, the Institute of Market Transformation, the National League of Cities, the National Association of State Energy Officials (NASEO), and the Natural Resources Defense Council (NRDC) to look at new use of data, how to exchange best practices with new availability of data, and to provide platform in which to exchange the data. NEEP is developing standardized EM&V methods reporting and is currently in the process of piloting forms.

			Original Roadmap Recommended Timeline: This should be done in the mid-term: 2-5 years.	The Climate Registry, six states, and NASEO are developing a national energy efficiency registry[51] that will allow states to track initiatives within their own programs as well as demonstrate compliance with the Clean Power Plan. Bonneville Power Administration (BPA), Cadmus, the Northwest Power and Conservation Council, and others have been partnering on an effort to collect and merge regional data in the Northwest using a taxonomy that mapped data from sector to end use. The Northwest Power and Conservation Council's Seventh Power Plan was adopted in February 2016.[52] LBNL is developing an energy efficiency reporting tool, which is expected to be released in the near future. NAESB is considering potential work in this area.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Reporting and Tracking Systems: Reporting	4.2.3	**A. A series of analyses and discussions should be undertaken to:** 1. Assess the needs of each of the general types of users of EE reported information, and identify what the parameters are that could be reported that would meet those needs. The analysis could first identify the types of users, for example, program implementers, entities that oversee program implementers, energy system manager and planners, and air quality regulators. It could then identify the information about EE activities most useful to each category of user. 2. Determine, within each category of user, if there was agreement on program type categories, definitions, data and results to report that would more efficiently meet that user category's needs. The need to more efficiently crosscheck data and to accurately share data across organizations should also be met during this stage. An important question to address is whether data collection can be done in a collaborative manner. 3. Explore issues surrounding transferability of the some of the data collection tools/databases in place to support broader coordination across the country. Consideration should be also given throughout to opportunities to take advantage of new technologies for data gathering and sharing. **Original Roadmap Recommended Timeline:**	No progress report update.

[51] https://www.theclimateregistry.org/thoughtleadership/energy-efficiency/
[52] https://www.bpa.gov/EE/Utility/toolkit/Pages/Six-Going-On-Seven.aspx

			Activities 1 and 2 (near-term) should be completed in the next two years through formal, collaborative efforts. Note several organizations with wide reach in the programmatic energy efficiency industry are pursuing this issue.[53] **Activity 3** (long-term) should be completed after the first two are complete, and within 5 years, also through formal, collaborative efforts.	
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Other Evaluation Methodological Approaches: Top-Down and Bottom-Up Methodological Approaches	4.3.1	**A. Build a consistent, logical approach to "top-down" analysis using the expertise of current practitioners, recording current best practice with the following steps:** 1. Characterize several important "use cases" for analyzing energy use, including whether the use case is for purely historical analysis or if it also includes use in forecasting. These could be for a single region, a single industry, a comparison of two or more regions, and a comparison of two or more industries. 2. For each use case the essential explanatory variables need to be described as specifically as possible. Develop standards on how to obtain this data. 3. For each use case, specify preferred functional forms for the equations to estimate. If the use case includes forecasting, include base case development and forecast variable development guidelines relevant to the specific use case. 4. Develop guidance on how to use the estimated top-down model to address particular energy use questions. 5. Develop criteria for assessing the accuracy of the resulting analysis, and guidelines on their presentation. **Original Roadmap Recommended Timeline:** This is a long-term effort and should be accomplished in 5-7 years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Other Evaluation Methodological Approaches: Use of Evaluation in Financial Risk Analysis	4.3.2	**A. Systematic framework for analyzing the parametric uncertainty of energy efficiency projects and programs** The development of a systematic framework for analyzing the parametric uncertainty of energy efficiency projects and programs is recommended. Use a stakeholder process to establish acceptable tools and methods for calculating and documenting a characterization of program and project savings, particularly uncertainty in underlying parameters. This process	No progress report update.

[53] These organizations are the American Council for an Energy Efficient Economy, the Consortium for Energy Efficiency, Lawrence Berkeley National Laboratory, and the Northeast Energy Efficiency Partnership.

			would leverage work on Monte Carlo analysis, the Building Performance Database, and the Investor Confidence Project. **Original Roadmap Recommended Timeline:** This should be accomplished in the mid-term: 2-5 years.	
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Other Evaluation Methodological Approaches: Use of Evaluation in Financial Risk Analysis	4.3.2	**B. Systematic framework for translating engineering uncertainties into financial instrument ratings** The development of a systematic framework for translating engineering uncertainties into financial instrument ratings is recommended. Use a stakeholder process to establish repeatable, transparent methods for assigning financial risk metrics to specific programs and projects, based on reported parametric uncertainties. These metrics should be developed in with input from the potential users of the information – the financial community. **Original Roadmap Recommended Timeline:** This should be accomplished in the mid-term: 2-5 years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Other Evaluation Methodological Approaches: Use of Evaluation in Financial Risk Analysis	4.3.2	**C. Stakeholder process to assess needs** Based on the above two recommendations, a stakeholder process should review the methods used to do EM&V at that time (i.e., in 2 or 3 years) to assess what modifications or additions would be needed to provide the information of use to conduct financial analysis. **Original Roadmap Recommended Timeline:** This should be accomplished in the mid-term: 2-5 years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Emerging Issue Areas: Role of Conformity Assessment/Accreditation	4.4.1	**A. Establish relationship between conformity assessment standards that impact energy efficiency at a more global level, as well as its impact in risk and financial management** While the conformity assessment standards are equally related to applications in the compliance and enforcement of standards and workforce credentialing, and are covered in Chapters 1 and 5 respectively, it is important to establish the relationship between the different conformity assessment standards that impact EE at a more global level. In addition, it is important to establish the relationship between conformity assessment and its impact in risk and financial management. **Original Roadmap Recommended Timeline:** This should be done in the near-term: 0-2 years.	NEEP is facilitating a small project at the request of the U.S. Department of Energy to explore the possible components of and approaches to certifying EM&V professionals performing energy efficiency program impact analysis, which should be completed the summer of 2016. In 2015, the NIBS Council on Finance, Insurance, and Real Estate (CFIRE) released a report on financing small commercial energy efficiency retrofit projects and identified challenges and recommended action.
Chapter Four: Evaluation, Measurement, and	Technology-Specific Areas: Behavior-	4.4.2.1	**A. Randomized controlled trials** Randomized controlled trials (RCTs) are the preferred design for behavior-based programs. To the extent that an RCT is not feasible, quasi-	No progress report update.

Verification (EM&V)	Based (BB) Programs		experimental designs as outlined in the SEE Action report are the preferred alternative. **Original Roadmap Recommended Timeline:** This should be done in the near-term: 0-2 years.	
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Technology-Specific Areas: Behavior-Based (BB) Programs	4.4.2.1	**B. Impact evaluation approach** The impact evaluation approach should be decided during the initial design of the program. This provides the opportunity for the design to reflect the evaluation approach, and minimizes the likelihood of "conformity bias" (i.e., the tendency for a third-party evaluator to excessively explore various statistical models for the purpose of finding savings agreeable to the client and implementer). **Original Roadmap Recommended Timeline:** This should be done in the near-term: 0-2 years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Technology-Specific Areas: Behavior-Based (BB) Programs	4.4.2.1	**C. Methods to allow for assessing impacts** Methods are needed that would allow for assessing the impacts of these programs more broadly without the significant expense of extensive site-specific analysis. **Original Roadmap Recommended Timeline:** This should be done in the near-term: 0-2 years.	No progress report update.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Evaluating Emerging EE Technologies	4.4.2.2	**No gap**	N/A
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Technology-Specific Areas: Energy Performance Indicators (EnPIs)	4.4.2.3	**A. Future revisions of protocols (ASHRAE, IPMVP, others) should be coordinated** Future revisions of the SEP M&V protocols, or development of the protocols supporting ISO 50001 can coordinate with a wider circle of EM&V professionals to ensure that the SEP protocols are a subset of current practice, or a superset. In either case, there should be no additional burden on participants of utility programs or in SEP. **Original Roadmap Recommended Timeline:** This should be done in the near-term: 0-2 years.	No progress report update.

Appendix B: Index of Acronyms and Abbreviations

A

A2LA – American Association for Laboratory Accreditation

ACCA – Air Conditioning Contractors of America

AEA – American Evaluation Association

AHRI – Air-Conditioning, Heating, and Refrigeration Institute

ANSI – American National Standards Institute

ARCSA – American Rainwater Catchment Systems Association

ASABE – American Society of Agricultural and Biological Engineers

ASHRAE – American Society of Heating, Refrigerating, and Air-Conditioning Engineers

ASME – American Society of Mechanical Engineering

ASPE – American Society of Plumbing Engineers

ASTM – ASTM International

ATIS – Alliance for Telecommunications Industry Solutions

AWS – American Welding Society

B

BCxA – Building Commissioning Association

BECx – Building Enclosure Commissioning

BEDES – Building Energy Data Exchange Specification

bEQ – Building Energy Quotient

BESTEST – Building Energy Simulation Test

C

CBECS – Commercial Building Energy Consumption Survey

CEC – California Energy Commission

CEN – European Committee for Standardization

CIP – Common Industrial Protocol

CPUC – California Public Utility Commission

D

DER – Distributed Energy Resource

DHW – Domestic Hot Water

DOE – U.S. Department of Energy

DOL – U.S. Department of Labor

E

ECMs – Energy Conservation Measures

EDA – Energy Design Assistance

EE – Energy Efficiency

EIA – U.S. Energy Information Administration

EISA – Energy Independence and Security Act of 2007

EMC – Electromagnetic Compatibility

EM&V – Evaluation, Measurement, and Verification

EnMS – Energy Management System

EPA – U.S. Environmental Protection Agency

EPRI – Electric Power Research Institute

ESIC – Energy Storage Integration Council

EVO – Efficiency Valuation Organization

F

FEM – Federal Energy Management

FEMP – Federal Energy Management Program

FSGIM – Facility Smart Grid Information Model

G

GBI – Green Building Initiative

GBCI – Green Building Certification Institute

GPMCS – Green Plumbing and Mechanical Code Supplement

H

HERS – Home Energy Rating System

HVAC – Heating, Ventilation, and Air Conditioning

HUD – U.S. Department of Housing and Urban Development

I

IA – Irrigation Association

IAF – International Accreditation Forum

IAPMO – International Association of Plumbing and Mechanical Officials

IAS – International Accreditation Service

ICC – International Code Council

ICE – Institute for Credentialing Excellence

IEC – International Electrotechnical Commission

IECC – International Energy Conservation Code

IES – Illuminating Engineering Society

IgCC – International Green Construction Code

ILAC – International Laboratory Accreditation Cooperation

IMC – International Mechanical Code

IREC – Interstate Renewable Energy Council

ISO – International Organization for Standardization

ISO/CASCO – ISO Committee on Conformity Assessment

J

JTAs – Job Task Analyses

K

KSAs – Knowledge, Skills, and Abilities

L

LBNL – Lawrence Berkeley National Laboratory

LEED – Leadership in Energy and Environmental Design

M

M&V – Measurement and Verification

MECS – Manufacturing Energy Consumption Survey

N

NAESB – North American Energy Standards Board

NAICS – North American Industry Classification System

NAPEE – National Action Plan for Energy Efficiency

NASEO – National Association of State Energy Officials

NEC® – National Electrical Code®

NECA – National Electrical Contractors Association

NEEC– Northwest Energy Efficiency Council

NEEP – Northeast Energy Efficiency Partnerships

NEIC – National Electrical Installation Standard

NFPA – National Fire Protection Association

NIBS – National Institute of Building Sciences

NIST – National Institute of Standards and Technology

NRDC – National Resources Defense Council

NREL – National Renewable Energy Laboratory

NWPCC – Northwest Power Planning Conservation Council

P

PC – Project Committee

PNNL – Pacific Northwest National Laboratory

Q

QA – Quality Assurance

R

RECS – Residential Energy Consumption Survey

RESNET – Residential Energy Services Network

S

SCTE – Society of Cable Telecommunications Engineers

SDOs – Standards Developing Organizations

SEE Action – State and Local Energy Efficiency Action Network

SEED – Standard Energy Efficiency Data

SGIP – Smart Grid Interoperability Panel

SGUI – Smart Grid User Interface

SMACNA – Sheet Metal and Air Conditioning Contractors' National Association

T

TIA – Telecommunications Industry Association

TC – Technical Committee

TR – Technical Report

TRM – Technical Reference Manual

TS – Technical Specification

W

WBDG – Whole Building Design Guide

WQA – Water Quality Association

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