Standardization Roadmap

Energy Efficiency in the Built Environment

Prepared by the

Energy Efficiency Standardization Coordination Collaborative

of the **American National Standards Institute**

Version 1.0, Draft for Internal Comment

December 2013

American National Standards Institute

TABLE OF CONTENTS

ACKNOWLEDGMENTS

The following professionals are acknowledged for their contributions to the development of this roadmap and for their participation in project workshops, meetings, and web conferences. Sincere thanks are given for support and participation of all the organizations that dedicated experts to this initiative. Without the contributions of these individuals and their collective expertise, particularly those who chaired the various working groups and participated actively, this roadmap would not have been possible. The roadmap was developed based on their collective input following a consensus process, and does not necessarily reflect the view of the organizations listed. The employment status and affiliations of individual participants are subject to change.

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- Very special appreciation and acknowledgement are given to the EESCC public-sector co-chair, Benjamin Goldstein of the U.S. Department of Energy (DOE), and to John Tuccillo, the EESCC private-sector co-chair from Schneider Electric. Their leadership in shaping and guiding this initiative has been instrumental to its success.

- Sincere thanks are due to the chairs of the EESCC working groups (WGs), who dedicated considerable time and effort in leading working group proceedings and building consensus:

    - WG 1: Building energy and water assessment and performance standards
        - Pete DeMarco, IAPMO
        - Stephanie Reiniche, ASHRAE

    - WG 2: Systems integration and systems communications
        - Henry Green, National Institute of Building Sciences (NIBS)

    - WG 3: Building energy rating, labeling, and simulation
        - Wayne Stoppelmoor, Schneider Electric

    - WG 4: Evaluation, measurement, and verification
        - Kevin Cooney, Navigant Consulting
        - Bill Miller, Lawrence Berkeley National Laboratory

    - WG 5: Workforce credentialing
        - Christine Niero, Professional Testing, Inc.
        - Jane Weissman, International Renewable Energy Council, Inc. (IREC)

- Special thanks are due to EESCC special advisor Alec McMillan and to Dan Manole, who served as special technical advisor to WG2: Systems integration and systems communications.

- Appreciation is given to the American National Standards Institute (ANSI) for guiding the initiative to a successful outcome through effective project management, particularly from Jana Zabinski and Jessica Carl.

- Acknowledgement is also due to the many individuals who provided input on standards, codes, and conformity assessment programs in the EESCC Inventory Database, a cornerstone tool in the roadmap's development and the recommendations contained herein.

EXECUTIVE SUMMARY

Energy efficiency holds enormous promise to advance the nation's energy, economic, and environmental goals. A vast and cost-effective resource, its full potential remains yet untapped. Advancements in energy efficiency can help power the U.S. economy and job creation, boost energy security and independence, and bolster U.S. competitiveness by powering economic activity with less energy, at less cost.

The more efficient use of energy in the buildings in which we work, live, study, and do business can significantly reduce the nation's energy cost and consumption, freeing up billions of dollars to invest in American business growth and job creation. According to the U.S. Department of Energy (DOE), the nation's buildings consume more than 70 percent of total U.S. electricity use and roughly 40 percent of the nation's total energy bill at a cost of $400 billion dollars per year.[1] With 20 percent or more of this energy wasted, comparable reductions in energy could save an estimated $80 billion annually.[2]

Given the large-scale opportunity for increased energy efficiency within the built environment – and the benefits that can be achieved from the strategic use of supporting standards, codes, and conformity assessment solutions – the cross-sector ANSI Energy Efficiency Standardization Coordination Collaborative (EESCC) developed this roadmap to serve as a resource for policymakers and the broad energy efficiency market on the range of standardization tools that are currently available or in development to support energy efficiency in this area. The roadmap discusses the relevant standards, codes, and conformity assessment programs that are available or under development, identifies where there are gaps, and recommends where additional standardization activities are needed to advance energy efficiency in the built environment.

At present, this roadmap outlines **118 recommendations** to advance energy efficiency within the built environment and recommended timelines for action, where appropriate.

- **CHAPTER ONE**: Identifies 43 gaps and associated recommendations in the area of building energy and water assessment and performance standards.
- **CHAPTER TWO**: Details 9 gaps and recommendations to advance systems integration and systems communications.
- **CHAPTER THREE**: Puts forth 20 gaps and recommendations in the area of building energy rating, labeling, and simulation.
- **CHAPTER FOUR**: Identifies 30 gaps and recommendations to advance evaluation, measurement and verification (EM&V).
- **CHAPTER FIVE**: Lays out 16 overarching recommendations to advance workforce credentialing for the energy efficiency field.

[1] U.S. Department of Energy, "Securing America's Future with Energy Efficient Buildings," last modified January 28, 2013, http://www1.eere.energy.gov/buildings/about.html.

[2] Ibid.

A table summarizing all recommendations is included in the Roadmap Appendix A. Additionally, this roadmap is supplemented by the ANSI EESCC Inventory Database[3] – an open, online source of information on relevant standards, codes, guidelines, regulations, and conformity assessment programs.

Next Steps

While this roadmap represents a specific snapshot in time, it is envisioned as an ongoing effort that will evolve in tandem with market and standardization needs. Given the complexity of the energy efficiency space and the number of stakeholders involved, V1.0 of the EESCC Roadmap will be issued for public comment to provide an opportunity for broad review and feedback on the EESCC's findings and recommendations before its final publication in mid-2014.

The recommendations detailed in V1.0 of the roadmap are expected to see broad adoption and implementation. Following publication, the EESCC will actively monitor implementation of the roadmap's recommendations and follow updates on work to close identified gaps. The aim is to provide a living document that will help guide, coordinate, and enhance the standardization landscape to support energy efficiency in the United States. Organizations interested in carrying out standardization work to close a gap identified in this roadmap are asked to notify the EESCC[4] so that the collaborative can monitor the roadmap's implementation and assist with coordination of standardization activities, as appropriate.

[3] The EESCC Inventory Database is available at: http://toolswiki.ansi.org/tiki-index.php?page=EESCCTabs.

[4] Contact eescc@ansi.org.

INTRODUCTION

Energy efficiency holds enormous promise to advance the nation's energy, economic, and environmental goals. A vast and cost-effective resource, its full potential remains yet untapped.

Advancements in energy efficiency can help power the U.S. economy and job creation, boost energy security and independence, and bolster U.S. competitiveness by powering economic activity with less energy, at less cost.

Energy efficiency is a critical component of the nation's clean energy agenda, and the opportunities that standardization offers to help achieve it are real. The President's Climate Action Plan sets the goal of doubling the nation's energy productivity by 2030,[5] and promotes standards and practices that would cut energy waste equivalent to the energy produced by more than 650 mid-size power plants[6] within the same time period.

The more efficient use of energy in the buildings in which we work, live, study, and do business can significantly reduce the nation's energy cost and consumption, freeing up billions of dollars to invest in American business growth and job creation. According to the U.S. Department of Energy (DOE), the nation's buildings consume more than 70 percent of total U.S. electricity use and roughly 40 percent of the nation's total energy bill at a cost of $400 billion dollars per year.[7] With 20 percent or more of this energy wasted, comparable reductions in energy could save an estimated $80 billion annually.[8]

ROADMAP GOALS

Given the large-scale opportunity for increased energy efficiency within the built environment – and the benefits that can be achieved from the strategic use of supporting standards, codes, and conformity assessment solutions – this roadmap is intended to serve as a resource for policymakers and the broad energy efficiency market on the range of standardization tools that are currently available or in development to support energy efficiency in this area. This roadmap discusses the relevant standards, codes, and conformity assessment programs that are available or under development, identifies where there are gaps, and recommends where additional standardization activities are needed to advance energy efficiency in the built environment.

At present, this roadmap outlines **118 recommendations** to advance energy efficiency within the built environment and recommended timelines for action, where appropriate.

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[5] Executive Office of the President, "The Presidents Climate Action Plan," June 2013, p9. http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf.

[6] Ibid, p19.

[7] U.S. Department of Energy, "Securing America's Future with Energy Efficient Buildings," last modified January 28, 2013, http://www1.eere.energy.gov/buildings/about.html.

[8] Ibid.

This roadmap was developed by the Energy Efficiency Standardization Coordination Collaborative (EESCC), a cross-sector group convened by the American National Standards Institute (ANSI),[9] with support from DOE and participating organizations.

The EESCC recognizes that there are a number of very important public- and private-sector initiatives currently underway to advance energy efficiency. This roadmap is intended to augment and raise awareness of these activities, and to highlight areas where additional standardization is needed.

The goals of this standardization roadmap are to:

- Serve as a resource for U.S. industry, government, and consumers on the range of standards, codes, and conformity assessment activities that can be leveraged to advance energy efficiency in the built environment
- Raise awareness and effective deployment of standardization activities among the public and private sectors
- Identify where gaps exist, so that the standardization community can respond with appropriate standards- and conformity assessment–based solutions
- Help federal agencies zero in on where they may be able to assist the standardization community in responding to standardization needs

What Is a Gap?

In the context of this roadmap, **a gap** refers to a significant issue that has been identified and that should be addressed in a standard, code, regulation, or conformance program, but for which currently none is published or known to exist that adequately addresses the issue.

Gaps can be filled through the creation of entirely new standards, code provisions, regulations, or conformance 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 conformance 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 conformance program.

Strictly a coordinating body, the EESCC does not develop standards, nor does it assign responsibility for their development. The actual development of standards is carried out by various standards developing organizations (SDOs).

[9] ANSI is a non-profit organization that coordinates the U.S. private-sector standards and conformance system – a system that relies upon close collaboration and partnership between the public and private sectors. ANSI represents thousands of member companies, organizations, and individuals who rely upon standards and conformance to increase efficiency, create market acceptance, improve competitiveness, and foster international commerce. For more than ninety years, ANSI and its members have worked to demonstrate the strength of private-sector-led and public-sector-supported, market-driven, standards-based solutions that are characterized by consensus, openness, and balance. ANSI is the U.S. member of the International Organization for Standardization (ISO) and, via the U.S. National Committee, the International Electrotechnical Commission (IEC).

UNDERSTANDING THE ROLE OF STANDARDS AND CONFORMITY ASSESSMENT

Standards and conformity assessment activities – collectively referred to as "standardization" – are critically linked to all facets of our national economy and are vital to the global competitiveness of U.S. industry.

Impacting more than 80 percent of global commodity trade,[10] standardization is essential to the success of U.S. products, personnel, and services in the marketplace. Standardization underpins global trade and commerce, supports technological innovation, and impacts the strength of the American workforce.

As the technical underpinning of many products, services, and systems, standards are key to helping U.S. industry tap into new and expanding technologies and bringing them to the market.

In the energy efficiency space, standards and codes are critical tools for enabling greater efficiencies, reducing costs, and helping to accelerate the uptake of the next generation of energy efficiency technologies and processes. But just as important are conformity assessment activities like testing, inspection, certification, and accreditation.

Conformity assessment forms the vital link between standards – which define characteristics or requirements – and the products, systems, or personnel themselves.[11]

As energy efficiency technologies continue to evolve, the marketplace is becoming increasingly reliant on the methods used to ensure that products, personnel, and services comply with the requirements of those standards.

Conformity assessment programs play an important role in all of the topical areas discussed in this roadmap, and are an intrinsic part of determining the actual energy efficiency attributes of products and systems, as well as the credentialing of individuals working in specific energy efficiency fields. The task of assessing compliance to a standard may rest with the manufacturer,

What Are Standards?

Behind the scenes, standards make everyday life work. They establish the size, shape, or capacity of a product or system. They specify performance of products, processes, or personnel. They also define terms so that there is no misunderstanding among those using the standard.

What Is Conformity Assessment?

Conformity assessment is a demonstration that specified requirements (often via a standard or standards) relating to a product, process, system, person, or body are fulfilled. Conformance activities include accreditation, certification, inspection, registration, supplier's declaration of conformity, and testing.

[10] United States Department of Commerce, "Standards and Competitiveness – Coordinating for Results," Washington, DC May 2004, p1: http://ita.doc.gov/td/standards/pdf%20files/Standards%20and%20Competitiveness.pdf.

[11] For information on conformity assessment and related principles, see *The United States Conformity Assessment Principles*: http://publicaa.ansi.org/sites/apdl/Documents/News%20and%20Publications/Brochures/USCAP%202011.pdf.

necessitate an independent third party like an auditor or a testing lab, or be specified by an official like a building code inspector.

Certification bodies, testing laboratories, and inspectors have a critical role to play in assuring that products, personnel, and services comply with standards. Accreditation – an independent, third-party assessment of a certification body's competency – is another key element that plays an important role in increasing marketplace confidence. Multilateral Recognition Agreement – like those established by the International Laboratory Accreditation Cooperation (ILAC) and the International Accreditation Forum (IAF) – reinforce the value of accreditation on an international scale, eliminating the need for costly multiple assessments and reducing technical barriers to trade.[12]

Market-driven and highly diversified, the private sector–led U.S. voluntary standardization system thrives on the active participation and engagement of all affected stakeholders, both public and private. Government use of standards has been reflected for over thirty years in federal policy, as outlined in the *National Technology Transfer and Advancement Act of 1995* (NTTAA),[13] the Office of Management and Budget (OMB) Circular A-119,[14] and, most recently, in a suite of recommendations from the Office of Science and Technology Policy in the White House (OSTP) encouraging federal engagement in standards activities addressing national priorities.[15]

Accordingly, the objective of this roadmap is to raise awareness and effective deployment of standardization activities among the public and private sectors in a manner consistent with the NTTAA, OMB Circular A-119, and the principles outlined in *The United States Standards Strategy* (USSS).[16]

[13] Through *The National Technology Transfer and Advancement Act of 1995* (NTTAA), Public Law 104-113, the government affirmed its commitment to using standards developed by private-sector standards bodies to carry out policy objectives or activities, whenever possible. The NTTAA directs all federal government agencies to use, wherever feasible, standards and conformity assessment solutions, and directs them to do so lieu of developing government-unique standards or regulations: http://www.nist.gov/standardsgov/nttaa-act.cfm#.

[14] OMB Circular A-119, *Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities,* establishes government policy on the use of and support for voluntary consensus standards. According to the circular, close interaction and cooperation between the public and private sectors is critical to developing and using standards that serve national needs and support innovation and competitiveness: http://www.whitehouse.gov/omb/circulars_a119/.

[15] The Office of Science and Technology Policy, *Principles for Federal Engagement in Standards Activities to Address National Priorities,* Washington DC, January 2011, page 2: http://www.whitehouse.gov/sites/default/files/omb/memoranda/2012/m-12-08.pdf.

[16] *The United States Standards Strategy (USSS)* articulates the principles that guide how the U.S. develops standards and participates in the international standards-setting process:
http://publicaa.ansi.org/sites/apdl/Documents/Standards%20Activities/NSSC/USSS_Third_edition/USSS%202010-sm.pdf.

Roadmap Audience

This roadmap is targeted toward end users of energy efficiency–related standards, codes, and conformity assessment programs in both the public and private sectors. This broad audience includes private industry; policymakers at the federal, state, and local levels; building owners, operators, and purchasers; architects and engineers; and standards developing organizations (SDOs).

Private industry

The roadmap can be used as a tool by industry to identify the various existing and forthcoming standards, codes, and conformity assessment programs that can be used in the marketplace to enable greater efficiencies and energy cost savings. It can also help industry to target standards participation efforts, and aid in the development of energy-efficient technologies and related conformity assessment programs. It will also enable industry to identify commercial opportunities, and gain insights to support business strategies.

U.S. federal, state, and municipal government

This roadmap is intended to raise awareness among policymakers of existing and forthcoming standards, codes, and conformity assessment programs, and help to support their implementation at the federal, state, and local levels. It can also assist federal and state government entities in supporting or tracking the progress of associated technical activities.

Standards developing organizations (SDOs)

This roadmap can assist SDOs in identifying priority areas, establishing boundaries, and identifying opportunities for collaboration, consolidation, and harmonization. With specific gaps identified in this roadmap, it will be easier for SDOs to prioritize their activities over the near-term (0-2 years), mid-term (2-5 years), and long-term (5+ years).

Roadmap Boundaries

Several high-level boundaries were established by the EESCC to guide the development of this roadmap, and the parameters for what was established as within and outside of scope are described below. Specifically, the focus of this roadmap is on energy efficiency in the built environment, within five distinct areas: 1) building energy and water assessment and performance standards; 2) systems integration and systems communications; 3) building energy rating, labeling, and simulation; 4) evaluation, measurement, and verification; and 5) workforce credentialing. Primary focus is given to U.S. standardization activities and the standards and conformity assessment activities that have direct applicability to the U.S. market.

Within the Scope of the EESCC:

- All types of energy consumption, from the service entry throughout the building, from the meter to the plug.
- Standards to enable "smart" operations and communications between individual devices or appliances are in scope. Beyond these parameters, the EESCC points to the work being done by the Smart Grid Interoperability Panel (SGIP).
- Energy distribution within the building.
- Thermal heating and cooling building technologies (excluding specific appliances) that offset on-site energy consumption.
- Standards for on-site combined heat and power, given that thermal heat recovery is a type of energy efficiency.

Outside the Scope of the EESCC:

- Individual product and appliance standards.
- Source energy, energy generation, transmission, and distribution.
- Distributed energy generation, including solar PV, small wind, methane capture and combustion, and fuel cells.

Background on How the EESCC Roadmap Was Developed

The ANSI Energy Efficiency Standardization Coordination Collaborative (EESCC) was established to carry out the development of this standardization roadmap assessing energy efficiency within the built environment. In establishing the collaborative, ANSI sought the input of a broad spectrum of stakeholders in a series of needs-focused meetings, including an April 2012 exploratory event,[17] to assess how the collaborative could best help to catalyze energy efficiency for the United States. These meetings culminated in the decision to prioritize the five topical areas discussed in this roadmap, and working groups were organized to conduct the standardization needs assessment for each area of focus.

More than 50 member organizations and four federal agencies, involving over 150 experts from industry, standards and code developing organizations, energy efficiency–focused organizations, educational institutions, and other groups have been involved in the effort. Throughout, the roadmap development process was characterized by open participation and consensus-based decision-making.

The EESCC working groups began meeting via web conferencing in December 2012 and convened a full plenary in January 2013 to lay the essential groundwork for the roadmap. Subsequently, the working groups continued their standards needs assessment via biweekly web conferences and a series of in-person workshops held in June and July 2013. Working independently or in teams, working group members drafted sections of the roadmap, which were subsequently reviewed, edited, and discussed at working group web meetings.

Assessing the Standardization Landscape – EESCC Inventory Database

As a key part of its efforts to assess the energy efficiency standardization landscape, the EESCC launched the EESCC Inventory Database[18] and issued a broad call for input on existing and forthcoming standards, codes, guidelines, and conformity assessment programs related to energy efficiency standardization in the built environment, as well as perceived gaps. During its information-gathering phase, the collaborative collected input on more than 520 documents, 160 conformity assessment programs, and a dozen perceived gaps via the EESCC Inventory Database.

The EESCC Inventory Database served as a cornerstone tool of the working groups' efforts to inventory existing and forthcoming standards, codes, and conformity assessment programs, and to identify gaps and areas of continued need.

The EESCC gathered input directly from the organizations responsible for the development of a document or conformity assessment program and from expert standards volunteers involved or highly knowledgeable of a program or tool. The documents and conformity assessment programs listed in the EESCC Inventory and the roadmap appendices represent the best efforts of the EESCC to inventory the current standardization landscape, and may not be completely exhaustive.

[17] For the meeting event page, visit http://www.ansi.org/meetings_events/events/2012/eesp_meeting.aspx.

[18] The EESCC Inventory Database is available at: http://toolswiki.ansi.org/tiki-index.php?page=EESCCTabs.

How Standards Are Treated in the Roadmap

The U.S. standardization system is market-driven and highly diversified; there are multiple standards developing organizations in this country, each working in response to a specific marketplace need. It is up to the marketplace to choose standards that best meet market needs.

Accordingly, this roadmap is not intended to displace work that is being done, or to select "preferred" standards, codes, or conformity assessment programs. Rather, the intent is to augment and raise awareness of these activities.

It should also be noted that different versions of a standard or code may be in use simultaneously in the market; likewise, various jurisdictions may have adopted different versions of a code or standard. For the purposes of this roadmap, the most recent version of a document is listed so that stakeholders are aware of the most currently available tool.

Roadmap Structure

This roadmap is organized into chapters covering five distinct areas of focus. Chapters 1-4 provide an assessment of what additional standardization activities are needed to advance these areas and include recommended timelines for addressing standardization gaps in the near-term (0-2 years), mid-term (2-5 years), and long-term: 5+ years. Chapter 5 provides overarching recommendations to advance credentialing for the energy efficiency workforce, and is intended to guide stakeholders in understanding, identifying, and selecting quality credentials.

- **Chapter One:** Building energy and water assessment and performance standards
- **Chapter Two:** Systems integration and systems communications
- **Chapter Three:** Building energy rating, labeling, and simulation
- **Chapter Four:** Evaluation, measurement, and verification
- **Chapter Five:** Workforce credentialing

Included in the Roadmap Appendix is a table summarizing recommendations from all five chapters, as well as a listing of relevant international standardization activities, U.S. federal agency programs, and other standards-based, cross-sector initiatives of interest.

The EESCC roadmap is supplemented by the ANSI EESCC Inventory Database – an open, online source of information on relevant standards, codes, guidelines, regulations, and conformity assessment programs.

CHAPTER ONE: BUILDING ENERGY AND WATER ASSESSMENT AND PERFORMANCE STANDARDS

1.0 Introduction

More than 40 percent of all energy consumption in the U.S. comes from residential and commercial buildings.[19] By 2035, approximately three-quarters of the built environment will be new or renovated.[20] This means that there are substantial opportunities for reducing energy consumption in buildings by optimizing systems for energy and water efficiency.

Most of the standards identified in this roadmap are intended to improve the energy and water efficiency of systems in buildings while continuing to ensure health, safety, and comfort of the occupants.

Established as Within Scope:

- Water-Energy Nexus
- Building Envelope/Enclosure
- Lighting
- Air Conditioning/Cooling Systems
- Heating Systems
- Energy Storage
- Mechanical Systems
- Water Heating
- Indoor Plumbing
- Alternate Water Sources
- Landscape Irrigation
- Swimming Pools, Hot Tubs, Spas, Aquatic Features
- Commissioning
- Conformity Assessment

Established as Outside of Scope:

- Appliance and Product specific standards
- Indoor Air Quality Standards
- Standards outside the meter
- Source energy, energy generation, transmission and distribution
- Distributed energy generation

In determining the scope of topics covered in this chapter, the EESCC leadership decided early in the roadmap planning process to only consider standards, codes, and guidelines that impact energy and water efficiency "between the meter and the plug" in a building. As a result, many standards and guidelines that pertain to energy and water use beyond the plug (or the water "stub-out" to cite the correct plumbing equivalent of a plug) are not addressed in the roadmap even though they indeed do impact the energy and water efficiency of a building after construction. This includes product and appliance standards.

It should be noted that there is a great deal of information pertaining to products and appliances readily available and that great advances in energy and water efficiency for products and appliances have already been achieved, partially as a result of programs such as the U.S. Environmental Protection Agency's (EPA) ENERGY STAR® and WaterSense® programs. This roadmap will focus on *systems* in buildings that pertain to energy and water efficiency. Such systems are built into the building and will deliver various levels of energy and water efficiency, in most cases for the entire life of the structure. Regardless, all of the standards, even those outside the scope that were submitted, are shown in the ANSI EESCC Inventory Database, though they

[19] U.S. Energy Information Administration, Electric Power Annual, 2011, last modified January 2013, http://www.eia.gov/electricity/annual/.

[20] Architecture 2035, accessed November 2013, http://architecture2030.org/the_solution/buildings_solution_how.

are not specifically addressed in the roadmap. The standards and codes relevant to each issue area discussed in this chapter – and which were considered in determining the gap analyses – can be found by performing a keyword search in the EESCC Inventory Database[21] according to the section name (i.e., “building envelope” or “lighting”). In addition to focusing on building systems, it was recognized that commissioning, maintenance, and conformity assessment also play a significant role in the furtherance of energy and water efficiency and are thus covered in this chapter.

The gaps identified provide an opportunity for legislators, standards developers, laboratories, engineers, contractors, and the general public to work on ways to fill the gaps in the energy and water efficiency standardization arena. The gaps can be filled by requesting updates to current legislation, developing new documents, and/or providing necessary research to find ways to fill gaps where data is currently lacking.

It is critical to consider water and energy together when looking at energy efficiency as these are mutually dependent resources: the generation of energy often requires large volumes of water, while water distribution and treatment systems require high amounts of energy.

Regardless of how much effort is put into the development of science-based codes and standards, and regardless of how efficient well-designed and installed building systems are, society will not reap the full benefit of the resulting efficiencies unless our buildings are also properly maintained as they age. Currently, no consensus standards are available that address building maintenance requirements. This is not viewed as a gap in standardization however, as maintenance requirements for buildings will vary greatly depending on the type, age, and location of the building, as well as on the type and age of the installed equipment and systems. In fact, deviating from manufacturer-recommended maintenance procedures can result in voiding warranties for building products and systems. Therefore, the development of a consensus-based standard on maintenance would be difficult and possibly counter-productive.

Commissioning, retro-commissioning, and ongoing commissioning, as discussed later in this chapter, are tools to assist building owners in assuring that the building and its systems are operating as initially designed and providing the levels of performance (including energy and water) that the building owner desires. However, there are resources available for building owners and facility managers to reference that offer building maintenance best practices. On the National Institute of Building Sciences (NIBS) website, the Whole Building Design Guide (WBDG) includes a Facilities Operations & Maintenance section[22] and a Sustainable Operations & Maintenance Practices section.[23]

[21] The EESCC Inventory Database is available at http://toolswiki.ansi.org/tiki-index.php?page=EESCCTabs.

[22] National Institute of Building Sciences, Whole Building Design Guide, “Facilities Operations & Maintenance”, last modified October 2013, http://wbdg.org/om/om.php.

[23] National Institute of Building Sciences, Whole Building Design Guide, “Sustainable O&M Practices”, last modified July 2010, http://wbdg.org/resources/sustainableom.php?r=om.

In addition, the Federal Energy Management Program's (FEMP) Operations & Maintenance Best Practices Guide[24] and the NASA Reliability Centered Maintenance Guide[25] are cited in the NIBS WBDG Operations & Maintenance sections as the "gold standard" in providing comprehensive guidance and best practices regarding building maintenance.

1.1 The Water–Energy Nexus

The water–energy nexus is a term increasingly used to describe the interdependencies between water and energy resources. When considered at the highest levels, it is easy to understand that huge volumes of water are consumed in the energy sector for generating electricity, natural gas, and other fuels used in buildings. At the same time, significant energy is used to pump, treat, and use the water that is consumed in buildings and protect the health of its occupants.

However, the water–energy nexus extends beyond the generation of energy and the distribution of water, and its implications need to be better understood in order to provide guidance to standards developers on beneficial strategies for the efficient management of energy and water in our nation's buildings. A better understanding of water–energy nexus implications on various building systems and products used in buildings would clearly be instructive for standards developers when considering new provisions that address energy and water efficient building design. In this regard, the following issues are brought forward as gaps that should be addressed by standardization activities.

Gap Analysis and Recommendations

A. 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 as to 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 serve several purposes: 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 sector 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 therefore should be conducted in the long-term: 5+ years.

[24] U.S. Department of Energy, Federal Energy Management Program, "Operations & Maintenance Best Practices", last modified August 2010, http://www1.eere.energy.gov/femp/pdfs/omguide_complete.pdf.

[25] NASA, "RCM Guide – Reliability-Centered Maintenance Guide," last modified September 2008, http://www.hq.nasa.gov/office/codej/codejx/Assets/Docs/NASARCMGuide.pdf.

B. 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 therefore should be considered in the long-term: 5+ years.

1.2 Building Envelope

The building envelope – sometimes referred to as the building enclosure – is the interface between the interior of the building and the outdoor environment, or between two environmentally distinct spaces within the same building. At the boundary layer between the building interior and outdoor environment, the envelope of a building generally includes any building element that encloses conditioned spaces, including above-grade exterior walls, roofs, floors, doors, windows, and skylights, as well as below-grade foundation walls and floors. It serves as a building's thermal barrier and plays an important role in determining the amount of energy necessary to maintain a comfortable indoor environment relative to the outside environment. Minimizing heat transfer across the building envelope is critical to reducing energy use in a building and the costs associated with space heating and cooling. In cold climates, the building envelope can reduce the amount of energy required for heating; in hot climates, the building can reduce the amount of energy required for cooling. This is important as heating, cooling, and ventilation account for the largest amount of end-use energy consumption in both commercial and residential buildings. In the commercial sector these account for more than one-third of energy used on site and more than one-third of primary energy use. Daylighting and the appropriate use of glazing can reduce the artificial light requirements for the building, which also account for another significant portion of energy consumption. A further discussion on lighting is provided in Section 1.2.

Site and building orientation, ratio of glass to opaque wall area, material selection, and detailing at interface conditions necessary to ensure the effective management of heat, air, and moisture transfer across the building envelope is critical to achieving fully integrated, whole building performance, and must be responsive to the unique demands associated with the geographic region or climate in which the building will be located. Climate-specific building envelope designs that include efficient windows, doors, and skylights – in some designs coupled with appropriately positioned and detailed active and passive solar shading devices, spectrally-selective coatings on glass, super-insulated façade, walls and roofs, cool roofs, reflective roof membranes, and similar technologies – can significantly reduce the demand on the mechanical systems selected and sized for space heating and cooling, thereby improving energy efficiency and reducing operating costs and long-term cost of ownership.

Building envelope design is a specialized area of architectural and engineering practice that draws from all areas of building science and indoor climate control, and must be very carefully considered.

Standards and codes are playing an increasingly important role in establishing both baseline and benchmark requirements for building envelope design, construction, and performance verification – a step intended to lead to higher performing, energy-efficient buildings and structures.

Gap Analysis and Recommendations

A. Detailing and integration of the building envelope at interface conditions

There is a need to address detailing and integration of the building envelope at interface conditions – quite literally the 'gaps' between materials, components, and systems in a building enclosure. Perhaps more than any other single aspect of design and construction, improper detailing and installation at these conditions is the most common source of improperly managed heat/air/moisture transfer and a corresponding increase in energy use, operation, and maintenance costs over the lifecycle of a building. Alignment of the environmental control layers necessary to effectively manage heat/air/moisture transfer in any exterior wall or roof assembly (i.e. continuity/alignment of thermal insulation layer, air barrier, drainage planes within a given exterior wall/roof assembly) is critical to building performance. Air infiltration/exfiltration in particular will directly influence energy use in buildings. Alignment and continuity are often most difficult to achieve at the following interface conditions, as these are the areas that are directly impacted by the aesthetic or functional requirements of the building:

- Wall-to-roof transitions
- All types of exterior enclosure penetrations (including windows, doors, anchor penetrations, utility lines/ducted ventilation and similar)

Chapter 1 of the International Building Code (IBC) from the International Code Council (ICC) already includes requirements for effective detailing of these conditions. Unfortunately, that chapter is not always adopted by local code jurisdictions or otherwise considered persuasive in the broader context of building enclosure design and construction. ASTM International is contemplating the development of an *ASTM Standard Guide* that might address these conditions for the most commonly used/specified exterior cladding systems and assemblies (i.e. clay brick masonry cavity wall construction, architectural precast concrete, metal panel rainscreen systems, stucco, EIFS, etc.). The industry has already developed many proprietary details (often in 3-D) that are quite good and available to architects. The Guide would focus on the need for environmental control layer continuity and alignment, and would include examples of common wall systems and assemblies to illustrate those concepts. New standards that are rooted in the fundamentals of building science and provide technically sound guidance to designers and builders regarding climate-specific material selection, design, and construction should result in substantially improved building enclosure integration, durability, and performance.

Recommended Timeline: Work to address this gap should be conducted in the near-term: 0-2 years.

1.3 Lighting

The U.S. Energy Information Administration (EIA) estimates that in 2011, about 461 billion kilowatt-hours (kWh) of electricity were used for lighting by the residential and commercial sectors. This was equal to about 17 percent of the total electricity consumed by both of these sectors and about 12 percent of total U.S. electricity consumption. Residential lighting consumption was about 186 billion kWh, or 13 percent of all residential electricity consumption. The commercial sector, which includes commercial and institutional buildings, as well as public street and highway lighting, consumed about 275 billion kWh for lighting, or 21 percent of commercial sector electricity consumption in 2011.[26]

Many studies have shown that retrofitting the existing lighting from one type of illumination source to another can significantly reduce energy consumption. Most common is retrofitting incandescent or fluorescent to either fluorescent or LEDs (Light Emitting Diodes). Linear fluorescent lighting is the most prevalent interior light source in commercial buildings, and thus the most common retrofit is to change from T12 tubes to T8, which involves changing from magnetic ballasts to electronic ballasts. Incandescent is typically changed to either LED or compact fluorescent lighting (CFLs). Retrofit kits for luminaires need to be tested and certified for the application to ensure the safety of the installation is not compromised.

While a typical incandescent lamp uses 60 watts of power to generate light, the current state of LED technology can produce the same light for less than 10 watts. However, interchangeability specifications are needed for LED light engines made by different manufacturers. This is a critical stepping stone toward devising practical field replacement systems for light engines comparable to those for Edison base lamps in traditional incandescent luminaires. Defined-fit systems need to define sufficient design parameters to ensure the interchangeability of modular components within a fit specification. The fit-systems would form the basis for developing safety and performance standards around predictable parameters for this class of products. These standards are under development by Zhaga,[27] a core group of lighting companies founded in 2010.

The EPA recently released the updated ENERGY STAR® Luminaires Specification Version 1.2, and anticipates that the changes and clarifications will help simplify the use of the ENERGY STAR® Luminaire Specification and should result in an increase in the number of ENERGY STAR® certified luminaires.

Lighting controls play an important role in reducing energy use and have become very sophisticated. More building automation systems now contain integrated lighting controls. Typical types of controls

[26] U.S. Energy Information Administration, "How much electricity is used for lighting in the United States?," last modified January 2013, http://www.eia.gov/tools/faqs/faq.cfm?id=99&t=3.

[27] For information on Zhaga, visit www.zhagastandard.org.

used are motion sensors, time switches, and daylighting controls. Compatibility of the dimmers with the type of illumination is critical for safety and to avoid the problems of the light not dimming all of the way or flickering. Also, the illumination source needs to be suitable for dimming. Additional savings on energy consumption can be realized by using special application controls for lighting, such as for hotel and motel guest rooms, display cases, tasks, food warming, and plants.

Daylighting – using natural light through skylights and windows – is becoming more popular, as it can reduce lighting and internal heat loads. Due to fluctuations on the amount of light that is transmitted, properly designed and calibrated automatic daylighting controls are necessary to operate artificial lighting to provide sufficient illumination for the area.

Any reduction or adjustments in illumination levels to address energy efficiency needs to be tempered by the impact on safety and security. The reliability and proper illumination is critical for means of egress in order to ensure a safe and orderly evacuation of the building. Sufficient lighting is necessary to provide personal safety in areas such as streets and parking structures. Lighting is also used in theft prevention, such as in retail stores and car dealerships.

Gap Analysis and Recommendations

The lighting industry – including manufacturers, designers, and installers – has been diligent in addressing gaps in the applicable codes (the International Energy Conservation Code (IECC), the International Green Construction Code (IgCC), ASHRAE 90.1, and ASHRAE 189.1) through the normal code development process, as well as through clarifications or adjustments to LEED and ENERGY STAR.®

Technology has not produced anything significant that would cause the lighting industry to be able to increase efficiencies (power), with the one option of changing out existing installations to more efficient sources when possible. The only other option is to reduce energy consumption using control systems, including daylighting controls. As such, a more “systems approach” is being used to address energy efficiency for lighting, rather than regulating individual lighting methods. This approach is focused on lighting controls, and standards are currently up to date with the latest technology. As for existing lighting installations, requirements have already been established to address retrofitting lighting to more efficient lighting methods.

(No gap): At this time, existing standardization activities adequately address lighting. No known gaps currently exist.

1.4 Cooling Systems

The utilization of an air conditioning unit or cooling system allows for a building’s temperature to be cooled and conditioned (removal or addition of moisture as needed) to a desired level, depending on the building’s use and occupancy. In many instances, this is accomplished by allowing a working medium (e.g., liquid refrigerant, water, or mix of water and glycol) to act as a heat sink and remove thermal energy (heat) from the air that is being provided to the enclosed space.

Cooling systems can come in a variety of sizes, capacities, and configurations. In very large structures, such as high-rise multifamily housing or commercial buildings, cooling is typically provided from a centralized unit, where the cooled air is generated at a discrete location and distributed to other locations via ductwork, vents, and/or plenums. In applications such as these, the refrigeration equipment falls into two types of categories: vapor-compression refrigerant cycle chillers and absorption chillers. Both chiller types have unique advantages and disadvantages, which are largely dependent upon climatic temperature zone, end use, and lifecycle costs.

The cooling system may also come in the form of a decentralized system, which is common in residential heating, ventilation, and air conditioning (HVAC) systems, heat pumps, and ductless mini-split systems, and evaporative coolers. All of these units operate using the vapor-compression refrigerant cycle and consist of a condenser, compressor, evaporator, and expansion valve. In most areas of the United States, the primary system used to cool homes is the air conditioning portion of a residential HVAC system; however, in climates with mild winters, heat pumps can provide higher efficiency in both the heating and cooling seasons. For occupants interested in an efficient system that is capable of cooling a single room, ductless mini-split systems have become more popular in recent years.

The Air Conditioning Contractors of America (ACCA) develops standards that are designed to assist professionals with the quality design, sizing, installation, and testing HVAC systems. Manual J (Residential Load Calculation), Manual D (Residential Duct Systems), and Manual S (Equipment Selection) have been adopted into code. For residential applications, and in partnership with ASHRAE for commercial applications, ACCA has developed uniform and effective maintenance, design, and installation standards in documents such as *Restoring the Cleanliness of HVAC Systems*, *Maintenance for Residential HVAC Systems*, *HVAC Quality Installation Specification*, and *Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems*. These are intended to ensure that the systems are safe for occupants, service technicians, and the general public, and to allow for cost-effective and innovative design, installation, owner education, and operations management.

Gap Analysis and Recommendations

The performance ratings and product method of testing standards for Heating Ventilation Air Conditioning and Refrigeration (HVACR) equipment are primarily developed by the Air conditioning, Heating, and Refrigeration Institute (AHRI) and ASHRAE. These two entities combined provide a robust, dynamic standards development infrastructure that is vital in the advancement of residential, commercial, and industrial HVACR systems. Presently, the energy performance of individual air conditioning and cooling systems is well defined; however, a standardization gap does exist in the integration of these individual components to form a system and for midrange efficiency in variable speed equipment. Additional efforts to address specific gaps related to integrated air conditioning and cooling systems are described below.

A. Standards for energy performance

The codes and standards related to the energy performance of individual air conditioning and cooling systems is 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 will serve to only 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 inclusion in Standard 90.1-2016.

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

B. Standards for integrated control

Control standards for integrated air conditioning and cooling systems are needed so that the performance and usage of the systems can be optimally controlled. ASHRAE is looking at this issue for inclusion in Standard 90.1-2016.

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

1.5 Heating Systems

Heating systems are used to maintain acceptable indoor temperatures, which can vary depending on the occupancy and use within a structure. For example, when comparing the operating conditions of a hospital's baby nursery to those of a warehouse storing general cleaning supplies, it is easy to believe that the heating set point of the nursery will be higher and more rigorously monitored as compared to the temperature of the warehouse.

The generation of heat is accomplished by converting the chemical energy of a fuel source into thermal energy. A variety of fuels or heating mediums may be used to produce the desired heat; for example: fossil fuels (natural gas, coal, or fuel oil), renewable resources (solar or geothermal), electricity (electrical resistance or heat pumps), solid fuel (wood or pellets), or hydronics (water or steam). These systems are used in an array of applications, and due to their broad use, undertaking effective methods to more efficiently utilize this thermal energy has the potential to reduce the consumption, costs, and emissions associated with the consumed fuel source or heating medium.

In residential, commercial, and industrial applications, the heat provided is typically generated at a centralized unit and then distributed by forced air to other locations via ductwork, vents, and/or plenums. In the United States, furnaces and boilers are the primary means of heating structures for residential and commercial and industrial applications, respectively. However, the use of alternative heating systems varies greatly, depending on a number of key factors, including: climate zones, end use, working medium, and lifecycle costs.

ACCA develops standards that are designed to assist professionals with the quality design, sizing, installation, and testing HVAC systems. Manual J (Residential Load Calculation) and Manual D (Residential Duct Systems), and Manual S (Equipment Selection) have been adopted into code. As mentioned above, ACCA has developed uniform and effective maintenance, design, and installation standards for residential applications, as well as commercial applications in partnership with ASHRAE.

Gap Analysis and Recommendations

ASHRAE and the Air conditioning, Heating, and Refrigeration Institute (AHRI) are two primary entities working to develop the performance ratings and product method of testing standards for HVACR equipment. Combined, AHRI and AHSRAE provide a robust, dynamic standards development infrastructure that is vital in the advancement of residential, commercial, and industrial HVACR systems. At the moment, the energy performance of individual heating systems is well defined; however, a standardization gap does exist in the integration of these individual components to form a system and for midrange efficiency in variable speed equipment. Additional efforts to address specific gaps related to integrated heating systems are described below.

A. Standards for energy performance

The codes and standards related to the energy performance of individual heating systems is well defined. Establishing independently developed performance metrics that specify the cost and efficiency benefits of the overall performance of integrated heating systems will serve to only 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 inclusion in Standard 90.1-2016.

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

B. Standards for integrated control

Control standards for integrated heating systems are needed so that the performance and usage of the systems can be optimally controlled. ASHRAE is looking at this issue for inclusion in Standard 90.1-2016.

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

1.6 Mechanical Systems

Mechanical systems are a vital component of most buildings. The term mechanical system generally applies to the equipment in a building, along with the controllers of that equipment that regulate ventilation, heating and cooling. Typically consisting of the HVAC system in residential, commercial, institutional, educational, and healthcare buildings, mechanical systems can also include process piping and equipment in commercial and industrial manufacturing and processing facilities. Energy is required to power mechanical systems, and many mechanical systems use water or steam to provide heating, cooling, or other functions. Thus, energy and water efficiency is an important consideration for mechanical systems.

Mechanical systems are designed and sized for efficiency based on the ventilation, heating, and cooling loads that the building is expected to encounter. These include both external loads relating to the influence of climate through the building envelope, as well as internal loads generated by the users of the building and the equipment contained within.

Primary standards for mechanical systems include the ASHRAE series and ACCA Manuals. The ICC's International Mechanical Code (IMC) and the International Association of Plumbing and Mechanical Official's (IAPMO) Uniform Mechanical Code (UMC) are widely used across the United States and provide baseline requirements for mechanical systems in the built environment. Both contain extensive references to additional standards that apply to mechanical systems. In addition, the IAPMO Green

Plumbing and Mechanical Code Supplement and ICC's International Green Construction Code (IgCC) provide a comprehensive set of code provisions for the installation of higher efficiency mechanical systems.

Gap Analysis and Recommendations

There are numerous codes and standards that address the design, installation, operation and maintenance components of energy efficiency in both commercial and residential building mechanical systems. The model Mechanical, Electrical, and Plumbing (MEP) codes and standards all contain installation and/or maintenance-operation performance requirements, and recent editions of these codes and standards have resulted in considerable efficiencies being realized. However, additional efforts to address specific technology gaps are detailed below.

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 in efficiencies in both residential and commercial applications. Standards that provide independently developed cost / benefit metrics are required to help designers, engineers, and home builders better understand the long term benefits of employing these technologies in buildings.

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

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 to guide standards developers to determine cost-effective provisions while avoiding unnecessary cost.

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

ii. Testing protocols for whole HVAC duct system components

To improve energy efficiency even more, there is a need to develop testing protocols for whole HVAC duct system components. There is a high need for this as codes move towards requiring system testing prior to certificate of occupancy. There is also a need to standardize various techniques for measuring leakage in non-residential and multifamily air distribution and exhaust systems. Several standards developers are starting development on this topic, including ASHRAE, which is looking at this issue for inclusion in Standard 90.1-2016.

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

iii. Research on the cost effectiveness of conducting leakage tests on HVAC systems operating in the field

There is a need to develop research on the cost effectiveness of conducting leakage tests on HVAC systems operating in the field. Although a process for evaluating the energy impact of single-family ducts leaks is well documented in ASHRAE Standard 152, there is no commonly accepted yardstick for determining the energy impact of leaks in non-residential and multifamily buildings, and therefore no good way to evaluate the cost effectiveness of testing. This research would eventually add to the existing standards on duct leakage testing, and in the future, HVAC total system leakage testing.

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

C. Employing non-traditional and emerging technologies

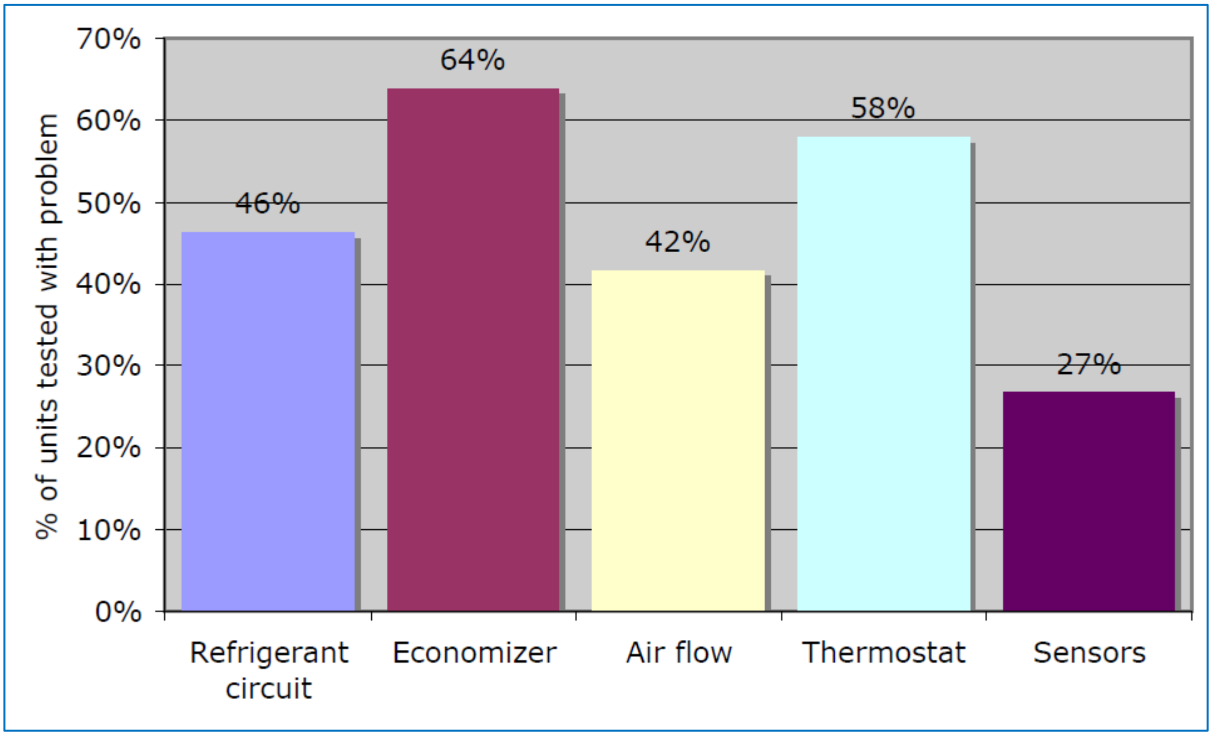
The potential to use non-traditional and emerging technologies for improving efficiencies in mechanical systems should be addressed by standards developers. Solar air conditioning – which can utilize several processes to cool buildings (i.e., open desiccant cooling, passive solar, photovoltaic (PV) solar cooling, and solar closed loop absorption systems) – transcritical CO_2 systems, and employing heat from energy generating microturbines, are technologies where additional information is required to determine the cost effectiveness of use in various applications.

Recommended Timeline: This work should be conducted in the long-term: 5+ years.

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 developers should consider the cost and benefits of requiring the installation of fault detection technologies on mechanical systems that can alert building owners of malfunctioning components.

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



How Prevalent are These Faults?

Source: New Building Institute[28]

1.7 Energy Storage

Energy storage systems are a critical element for the realization of the Smart Grid, microgrids, and energy efficient buildings. The development of codes and standards regarding these systems is complex because it involves a large range of capacities from residential implementations "behind the meter" – or on the load side of the meter" – to grid-scale implementations associated with wind farms, utility-scale solar PV installations, or campus-style microgrids. Energy storage systems also cover a range of technologies including, but not limited to: batteries, flow batteries, pumped hydro, compressed air, and flywheels. Moreover, these systems can be either shipped as a system near final assembly or constructed on site, both using a variety of components from multiple vendors. At the moment, standardization is arguably in its infancy in the industry.

In light of these considerations, a few broad categories of needs in codes and standards can be easily identified:

- **Safety** – how to lower financial and operational risk and increase reliability
- **Communications** – how to ensure interoperability
- **Performance** – how to express system characteristics and ratings

[28] New Building Institute, *Review of Recent Commercial Roof Top Unit Field Studies in the Pacific Northwest and California* (Cowan, 2004).

Safety of installations behind the meter will generally be codified in the National Electric Code (NEC), NFPA 70. At the component level, UL and IEC standards will specify the design and production criteria for elements of an energy storage system.

Communications protocols are needed to ensure interoperability with other grid components and to enable two-way power flow. This sector represents the most advanced state of standardization, as typified by IEEE 1547, *Interconnecting Distributed Resources,* IEEE P2030.3, *Standard for Test Procedures for Electrical Energy Storage Equipment and Systems for Electric Power Systems Performance*, ASHRAE/NEMA 201P, *Facility Smart Grid Information Model*, and the IEC 61850 suite of substation communication automation standards.

Performance standards are critical for measuring and expressing the characteristics of energy storage systems. They also allow disparate systems to be compared against one another, allowing a customer to select which system will best suit their needs. The most recent effort to date in this field is the DOE/PNNL *Protocol for Measuring and Expressing the Performance of Energy Storage Systems*, which will form the basis for a suite of U.S. standards and inform the U.S. position to the International Electrotechnical Commission (IEC). This document is organized by application, with each application specifying its own generic charge and discharge duty cycle, and the needed measurements to express the behavior of the system. Currently, peak shaving and frequency regulation applications are laid out. Additional applications which contemplate regulating the fluctuations in renewable energy generation, thermal storage, and energy storage in microgrids are under development.

Gap Analysis and Recommendations

There are various codes and standards that address the components that constitute the "black box" of energy storage defined as all between the point of common coupling, but very few that address the system as a whole. This does not fully take into account PUC-type regulations or commercial considerations, but rather technical or semi-technical standards needs for energy storage systems. Energy storage is a very new concept and thus, almost all areas of standards for systems can be considered true gaps.

A. Standards for system safety issues for energy storage systems

Safety is a crucial element for the success of energy storage standards in the wake of recent fires and accidents. Issues including ratings, markings, personnel barriers/set backs, system entry and exit points, physical abuse, and temperature ratings come immediately to mind. These may be addressed by SDOs like UL, IEC, and others. The standards should make use of previously identified standards in SAE and UL for battery components, should the system use batteries as the storage medium.

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

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 systems are functioning as specified, standards need to be developed to determine:

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

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

C. Standards for electromagnetic compatibility (EMC)

As information technology becomes layered over electrical components, it is essential that each smart grid component is interoperable and that each component is appropriately shielded, insulated, or otherwise designed to reduce or prevent electromagnetic interference.

Recommended Timeline: This should be done in the long term: 5+ years. There are significant barriers to testing EMC in many instances currently.

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, automatic gain control.

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

E. (Partial Gap) Standards to identify representative duty cycles and performance metrics for each application and/or use case

Prior to 2012, there was no methodology for comparing the performance attributes of energy storage systems. The Pacific Northwest National Laboratory (PNNL) *Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems*[29] lays out a convenient framework for accomplishing this. Notably, it can be applied across systems that employ different types of storage mediums by establishing representative duty cycles by application. A starting point developing such a list of applications and/or use cases is the California Public Utility Commission (CPUC) *Energy Storage Staff Proposal*.[30] Figure 4 from that report which is freely available on the internet, is reproduced below. A series or family of standards specifying representative duty cycles and performance metrics applicable by representative duty cycle should be written. This family 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 done in the near-term: 0-2 years.

[29] 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.

[30] Elizaveta Malashenko et al., California Public Utility Commission, "Energy Storage Framework Staff Proposal," April 3, 2012, http://*www.cpuc.ca.gov/NR/.../0/EnergyStorage_FinalStaffProposal.docx*.

Energy Storage "End Use"		Scenarios			
		A. Renewables Support/ Dispatchability	B. Distributed Storage	C. Demand-side Management	D. Ancillary Services
1	Ancillary services: frequency regulation				X
2	Ancillary services: spin/ non-spin/ replacement reserves			x	X
3	Ancillary services: ramp			x	X
4	Black start				
5	Real time energy balancing				x
6	Energy price arbitrage		x		
7	Resource Adequacy		x		
8	Intermittent resource integration (ramp/voltage support)	X			
9	Intermittent resource integration (time shift, voltage sag, rapid demand support)	X			
10	Supply firming	X			
11	Peak shaving		x		
12	Transmission peak capacity support				
13	Transmission operation				
14	Transmission congestion relief				
15	Distribution peak capacity support (upgrade deferral)		X		
16	Distribution operation (voltage / VAR support)		X		
17	Outage mitigation: micro-grid		x	x	
18	TOU energy cost management			X	
19	Power quality			X	
20	Back-up power			X	

Figure 4: Energy Storage Deployment Scenarios

Source: California Public Utilities Commission

F. Standards to address the energy storage system's energy efficiency and its potential

Standards are needed to evaluate the energy efficiency of an energy storage system to enable a larger system (e.g. the public electricity grid or an industrial facility grid) to use the system as an energy efficiency enhancement means.

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

1.8 Water Heating

The heating and delivery of water for potable water applications in a building represents one of the key areas where energy and water efficiency concerns converge into what is referred to as the energy-water nexus. It represents a prime example of how system design and delivery mechanisms, combined with sound public health and safety principles, can lead to an increased reduction in both the use of water and the reduction of energy consumption.

Debate over the energy and water efficiency benefits of point-of-use versus conventional tank storage water heaters continues. Research conducted to date indicates that the resulting efficiencies are related to use patterns in the home or building, rather than to the water heaters themselves. As a result, this may not be a gap that can be addressed by standards developers without additional research guidance. Note: a discussion of pathogens and Legionellosis are covered in Section 1.9, Indoor Plumbing.

Gap Analysis and Recommendations

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 utilization 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.

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.

C. Standards that address the location of the heating source and end use point

Standards are needed for water heating and delivery systems that address the location of the heating source and the end-of-use point to ensure that the most efficient system is installed to save energy while meeting the 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 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.

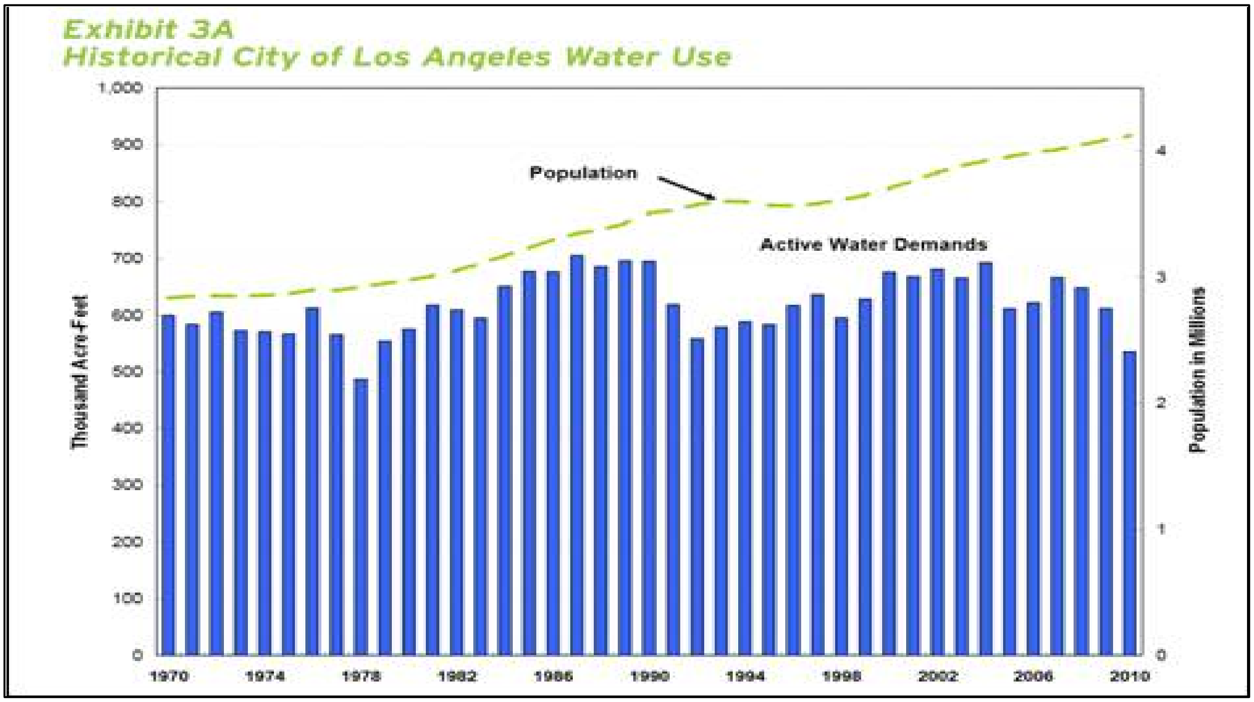
1.9 Indoor Plumbing

The American Society of Plumbing Engineers (ASPE) defines "plumbing systems" as the "fluid and/or gas (including medical gas) supply and distribution systems and associated waste disposal systems, including piping, plumbing fixtures and traps, and drainage and vent pipes, including their respective joints, connections, devices, receptacles, and appurtenances." By definition, indoor plumbing systems are critical to ensuring efficient operations of the building, and have a potential impact on almost every aspect of the building design and operation.

As shown in the chart below from the Los Angeles Department of Water and Power (LADWP), the United States has made good progress towards reducing the amount of potable water we consume in our homes and buildings. As illustrated in the chart, in spite of L.A.'s population growth, potable water consumption has remained relatively constant over the course of the past 20 years. Similar results have been reported across the country. This is attributed to utility-based public awareness campaigns that emphasize the need to conserve water – especially in times of shortages; incentive programs that foster the installation of water efficient plumbing fixtures and appliances; and efficiency provisions contained in standards, plumbing codes, and regulations such as the Energy Policy Act of 1992, which addressed plumbing products.

The design, installation, operation, and maintenance of plumbing systems provide significant additional opportunities for reducing water consumption and energy usage. Examples of current initiatives that are impacting the design of plumbing systems are plumbing fixtures, fittings, and appliances that provide reduced flow rates and reduced flush volumes, as well as the increased use of water re-use and rainwater catchment systems. Due to the significant impact indoor plumbing can have on both water and energy efficiency it is often the area most looked at to obtain certain and cost effective improvements.

Although there has been a significant amount of work completed or in progress related to energy and water efficiency standards for indoor plumbing systems, there is a need to address in standards development activities issues related to: 1) the impact of reduced flows on the ability of plumbing systems to remove waste; 2) ongoing maintenance of the plumbing systems; and 3) the balance of energy and water efficiency (see Section 1.1, Water-Energy Nexus).



Source: Los Angeles Department of Water and Power (LADWP) Urban Water Management Plan (2010)

Gap Analysis and Recommendations

The relationship between indoor plumbing systems – both for commercial and residential applications – and codes and standards is well established, and has provided the foundation for the design, installation, and maintenance of plumbing systems that deliver and remove liquid and gas media in a manner that protects the public health and safety. In addition, there has been significant work completed or in progress related to codes and standards addressing the energy and water efficiency of the plumbing system itself and the components used in plumbing systems. While the efficiencies associated with components used in plumbing systems are outside of the "meter to plug" scope of this roadmap, the systemic nature of plumbing necessitates that the impact of these devices on the efficacy of the system be considered in this discussion.

Today, there are four standardization gaps in what currently exists and what will be needed in the future to ensure that plumbing systems are designed as efficiently as possible, while continuing to protect the public health and safety. These are outlined below.

A. Plumbing system efficiency standards in combination with the current component standards

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. Nevertheless, there is little research available today that evaluates the impact of those designs on the plumbing system's overall performance due to reduced flows in the system, and especially 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.

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 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.

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.[31]

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

D. Reducing the potential for Legionellosis and other pathogenic outbreaks

Reducing hot water temperatures in plumbing systems has been proven to 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. The publication of these guidance documents will assist 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.

1.10 Alternate Water Sources

Energy is used to pump potable drinking water at all phases: from its initial source to water treatment plants; to buildings for domestic and process uses to wastewater treatment; and finally, back into a lake, river, or the ocean. Currently an under-utilized resource in the United States, the effective use of alternate water supplies has the potential to significantly improve water and energy efficiency by reducing the demand for energy laden, treated potable water. Fortunately, the use of alternative water supply sources is growing. Common types of alternative water supply sources include municipally-treated wastewater, graywater, rainwater harvesting, stormwater harvesting, HVAC system condensate collection including cooling tower blowdown sources, onsite wastewater treatment systems, and desalination.

The primary consideration regarding the use of an alternate water source is the intended end use of the water such that the level of treatment matches the application. For example, an alternate water source intended for sub-surface mulch bed irrigation requires less treatment than water intended to be used indoors for flushing toilets. Most alternate water sources are well suited for non-potable applications; however, some alternate water sources – such as rainwater – can also be safely used for potable purposes with adequate and consistent treatment.

Alternate water systems vary greatly in size and complexity, ranging from small, passive domestic rainwater barrel systems used exclusively for residential irrigation purposes to complex, multi-building

[31] For a discussion on the need for research toward improved pipe sizing methods and the use of thermal insulation, refer to the Nationals Institute of Building Sciences' (NIBS) 2012 report: *Moving Forward: In-Depth Findings and Recommendations from the Consultative Council*: http://c.ymcdn.com/sites/www.nibs.org/resource/resmgr/CC/NIBS_2012_CC_Report.pdf?hhSearchTerms=2012+and+moving+and+forward.

“campus” systems that collect several types of alternate water sources and treat the water for various uses. Municipally treated wastewater, often referred to as reclaimed or recycled water, is treated to drinking water purity levels and is only available when a municipality or utility supplies both the infrastructure and the treated water. At this time, municipally-supplied wastewater is used for non-potable applications only, such as for landscape irrigation or flushing toilets and urinals.

Currently, the 2012 Uniform Plumbing Code contains extensive installation and use provisions for alternate water sources systems contained within the body of that code. The 2012 International Plumbing Code also has provisions contained in the appendix. Additionally, NSF International has published NSF 350, *Onsite Residential and Commercial Reuse Treatment Systems*. The American Rainwater Catchment Systems Association (ARCSA) and the American Society of Plumbing Engineers (ASPE) are currently developing a design standard for rainwater catchment systems – an effort sponsored by IAPMO and NSF. The ICC and CSA are also developing a standard for rainwater catchment systems.

Gap Analysis and Recommendations

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 to develop 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 – 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 and therefore require different treatment measures than rainwater in other areas. 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 as consensus, achieved in the short-, mid-, and long- terms.

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 and ARCSA are currently developing a stormwater harvesting design standard which may address this gap.

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.

1.11 Landscape Irrigation

In many parts of the country, especially arid areas, supplemental irrigation is relied upon to maintain healthy plants and turfgrasses used in the managed landscape. A healthy landscape provides many functional benefits such as cooling, erosion control, pollution mitigation (air and noise), habitat for wildlife, recreational areas, creating safety zones, and fire protection. A well-designed and managed landscape can help mitigate the impacts of buildings and the associated traffic on a site, as well as create a healthy and pleasant environment for the community. While plants don't require potable water, they do need water of sufficient quality to not cause harm. Developing alternate water sources on site, such as rainwater harvesting, collecting and using stormwater, recycling or reusing water, or using reclaimed water, can ease the burden on the potable water system, including energy inputs for treatment and pumping.

Existing standards/codes that address energy and water efficiency of landscape irrigation include ASHRAE 189.1, the IAPMO Green Plumbing and Mechanical Supplement, and the IgCC. These model codes have provisions to reduce or eliminate the use of potable water for landscape irrigation and have provisions for the use of alternate water sources for landscape irrigation. Additionally, some codes strive to reduce the use of water for landscapes with provisions about the type of plants used in the landscape or the amount of area used for lawns.

Gap Analysis and Recommendations

A. Current standards development for irrigation products and practices

While the green codes have provisions to address some aspects of landscape irrigation, each has some unique criteria for the same issue (such as the maximum application rate for sloped areas). The model codes related to energy- or water-use efficiency do not reference any standards for landscape irrigation because they do not exist. The irrigation industry has relied upon the competitive forces within the marketplace for product development. The products have been innovative and the quality and performance of the products have had to meet market demands.

This gap was identified several years ago and American National Standards specifically about landscape irrigation are currently being developed. Product standards are being developed by American Society of Agricultural and Biological Engineers (ASABE) and ICC, and cover:

- Landscape irrigation sprinklers and emitters
- Environmentally responsive irrigation controllers
- Auditing procedures for landscape irrigation systems
- Estimating landscape plant water use
- Testing of soil moisture sensors for controlling landscape irrigation

Recommended Timeline: These standards are in progress with committees actively working, and are near-term priorities: 0-2 years.

B. Standards for design practices and validating product performance

Additional standards for landscape irrigation products 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[32] have been filed with ANSI for controllers and rain sensors, but no committees have been formed to develop the standards.

The following gaps are becoming apparent as competing green codes are being developed in 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 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.

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

C. Standards for landscape sustainability and ecosystem services

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

[32] 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.

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 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.

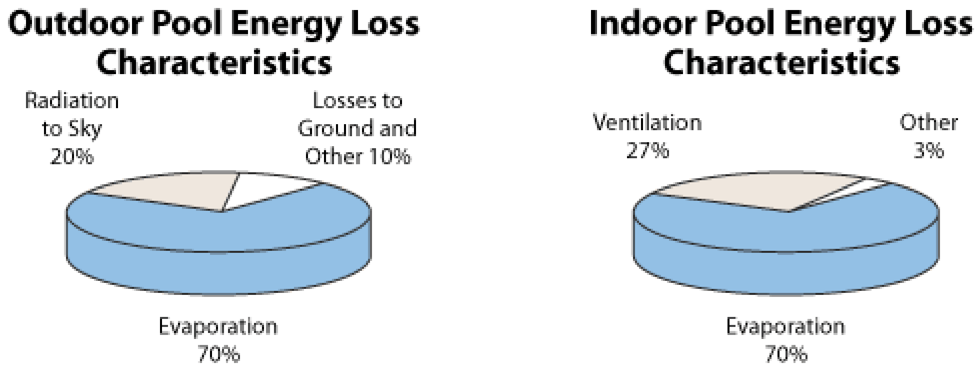
Recommended Timeline: If standards are developed they should address the process to follow in making the evaluation. This work is for the long-term: 5+years.

1.12 Swimming Pools, Hot Tubs, Spas, Aquatic Features

As people use swimming pools, hot tubs, and spas regularly for recreation and leisure, safety is properly regarded by codes and standards developers as the main concern. As a result, energy and water efficiency is often overlooked. There are several different codes and standards that set requirements for products that are used in aquatic facilities. The diversity and the complexity of these components make it challenging to understand the compliance process that ensures both safety and efficiency. The focus areas highlighted below will help provide a better understanding of the issues that codes and standards developers are currently addressing to ensure the safety of these products while also focusing on energy and water use efficiency.

The main components that are considered when evaluating energy and water efficiency with recreational water facilities are water pumps, piping systems, filtration systems, temperature control measures, means of heating and cooling the water, and preventative maintenance and operational best practices. In addition, ventilation and de-humidification systems are additional considerations for indoor pools. There are several model and state building codes that highlight the need for using pumps with ENERGY STAR® classification. When considering water efficiency, the type of filtration system used or the use of pool covers and liquid barriers can significantly impact water use. Water conservation features should be considered. For example, filters that require backwashing require more water use than other filtration systems, and the use of pool covers or liquid barriers help prevent evaporation.

Aquatic features also require evaluation when considering energy and water efficiency. These aquatic features may include indoor or outdoor fountains, waterfalls, water jets, or water sprays that are solely intended to wet the individual playing in the spray stream, as well as fountains or other water installations, such as decorative or interactive installations, in which only incidental water contact occurs. The main components identified above for evaluating the energy and water efficiency of recreational water facilities are also applicable to aquatic features. In addition to the conservation actions noted above, UV light disinfection systems and solar water heating systems can significantly impact energy use.



"Swimming pools lose energy in a variety of ways, but evaporation is by far the largest source of energy loss. It only takes 1 Btu (British thermal unit) to raise 1 pound of water 1 degree, but each pound of 80ºF water that

Image Courtesy of the U.S. Department of Energy[33]

Gap Analysis and Recommendations

There are various codes and standards that address the public health and safety of the above-listed water features; however, few also address water and energy efficiency issues.

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.

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.

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

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

Standards are needed to test the energy efficiency of these disinfection systems to determine the energy consumption at integral power levels of chemical output.

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

[33] U.S. Department of Energy, "Pool Covers," accessed November 2013, http://energy.gov/energysaver/articles/swimming-pool-covers.

D. **Standards for energy efficient pumps, skimmers, overflow grates and gutters, valves, suction fittings, return fittings, and eyeball-nozzles**

While primary design consideration of these devices is appropriately focused on safety performance aspects, these products can contribute to the total pumping loss or TDH (total dynamic head) of circulation systems in all aquatic facilities. These products can be redesigned to reduce the pumping loss. NSF 50 includes validation of the head loss, and work can be done to help classify products with preferred performance characteristics. These products can also be lifecycle tested along with requiring best practice maintenance guidelines to minimize leakage and reduce water consumption.

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

E. **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. Standards are needed to evaluate the efficiency of pool covers and liquid barriers through ongoing testing for evaporation rates and heat loss. In addition, these standards should offer best practice maintenance guidelines to reduce energy loss due to damaged or misused pool covers and liquid barriers.

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

1.13 Commissioning

Commissioning is a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria (namely, the owner's project requirements). Depending on when the commissioning activities occur in a building's lifecycle, they may be called commissioning (new facilities and additions); retro-commissioning (commissioning of an existing building that has not been commissioned previously), re-commissioning (the commissioning of an existing building that has undergone prior commissioning) and ongoing commissioning (a process of commissioning a building on a regular basis including frequent evaluation of certain building components). Commissioning serves as the linkage between the design or project team, the building owner, and the facility operation team. It provides building or project documentation, as well as training of operations and maintenance personnel and occupants.

The use of commissioning has grown as building owners and policymakers look for increased assurance of building performance. ASHRAE Guideline 0, and now ASHRAE Standard 202, establish the overall process for conducting commissioning activities. For individual building systems, commissioning criteria are defined by relevant SDOs, with most referencing back to the process defined in Guideline 0.

At a building system level, commissioning guidelines and standards have been or are being developed by SDOs including ASTM (building enclosures), ASHRAE (HVAC and smoke control), ASPE (plumbing), IES (lighting), NFPA (fire and life safety systems), SMACNA (HVAC) and NECA (electrical). Additional guidance, including personnel certification programs, are provided by organizations who support the achievement of building and system performance such as AABC Commissioning Group (ACG), ACCA, ICC, the National Environmental Balancing Bureau (NEBB), RCI Engineering, the Building Commissioning Association (BCxA), and TABB Commissioning.

Many codes and standards including ASHRAE Standard 189.1, the IgCC, and the IAPMO Green Plumbing and Mechanical Code Supplement, along with green building rating systems are currently incorporating commissioning requirements. However, it is important to note that commissioning as a process is not intended to be a surrogate for verification of code compliance.

Given the relatively new practice of building commissioning, the adherence to minimum commissioning process requirements and the identification of qualified providers has been a challenge. DOE, NIBS, and the International Accreditation Service are in the process of developing methods for recognizing competent providers.

Gap Analysis and Recommendations

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.

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

B. Education and training on commissioning process

There is a lack of understanding of the commissioning process and how to utilize it among many commissioning users, such as building owners, facility managers, and personnel. There needs to be education, documentation, and training developed for the commissioning users on the commissioning process, deliverables and expected results. Having educated consumers is equally important to a quality process and providers.

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

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.

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

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.

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

E. Communications from and to building equipment, sensors, and security protocol

Over the long-term, commissioning will increasingly become a regular part of building and project completion, as well as operations and maintenance. Ongoing commissioning will depend on monitoring of all building systems in order to assure that the systems are operating 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. 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 whole building assessments and existing building commissioning process.

Recommended Timeline: These activities should be completed in the long-term: 5+ years.

1.14 Conformity Assessment

Energy and water performance standards play a key role in advancing energy efficiency and enabling industry and consumers to adopt more energy efficient technologies. These standards communicate the expectations of the marketplace regarding safety, performance, compatibility, sustainability, and efficiency. But the proper implementation of these standards is fundamental to achieve ultimate energy efficiency results. Conformity assessment plays an important role in the proper and consistent compliance and implementation of standards, and therefore is instrumental in the enforcement of these standards when they become regulations. The tenets outlined in the United States Conformity Assessment Principles (USCAP) can be applied to any of the different types of conformity assessment activities (accreditation, certification, inspection, registration, supplier's declaration of conformity, and testing), and can be beneficial to first, second, or third parties,34 or to government users of conformity assessment.

Accreditation – an independent, third-party assessment or verification of a program's or institution's competency to meet established quality standards – plays a critical role in increasing marketplace confidence and proper enforcement of codes and regulations.

The most appropriate and cost-effective mix of these approaches should be used for each conformity assessment activity. This mix will be different for different types of conformity programs performed by

[34] As defined by the USCAP, "*The first party is generally the person or organization that provides the object, such as the supplier. The second party is usually a person or organization that has a user interest in the product, such as the customer. The third party is a person or body that is recognized as being independent of the person or organization that provides the object, as well as the user or customer of the object.*"

conformity assessment bodies. Conformity assessment activities that pose a higher risk of incurring significant costs of failure (i.e., producing harm to human safety, health, or environment) generally will need greater assurance of conformity and thus, second- or third-party forms of conformity assessment are most appropriate.

The standards used to determine conformity that have a general application in verifying energy efficiency can be found in the International Organization for Standardization's (ISO) Conformity Assessment Committee (CASCO) Toolbox and the EESCC Inventory Database, and include:

1. ISO/IEC 17021:2011, *Conformity assessment – Requirements for bodies providing audit and certification of management systems*
2. ISO/IEC 17025:2005, *Conformity assessment – General requirements for the competence of testing and calibration laboratories*
3. ISO/IEC 17024:2012, *Conformity assessment – General requirements for bodies operating certification of persons*
4. ISO/IEC 17020:2012, *Conformity assessment – Requirements for the operation of various types of bodies performing inspection*
5. ISO/IEC 17065:2012, *Conformity assessment – Requirements for bodies certifying products, processes and services*

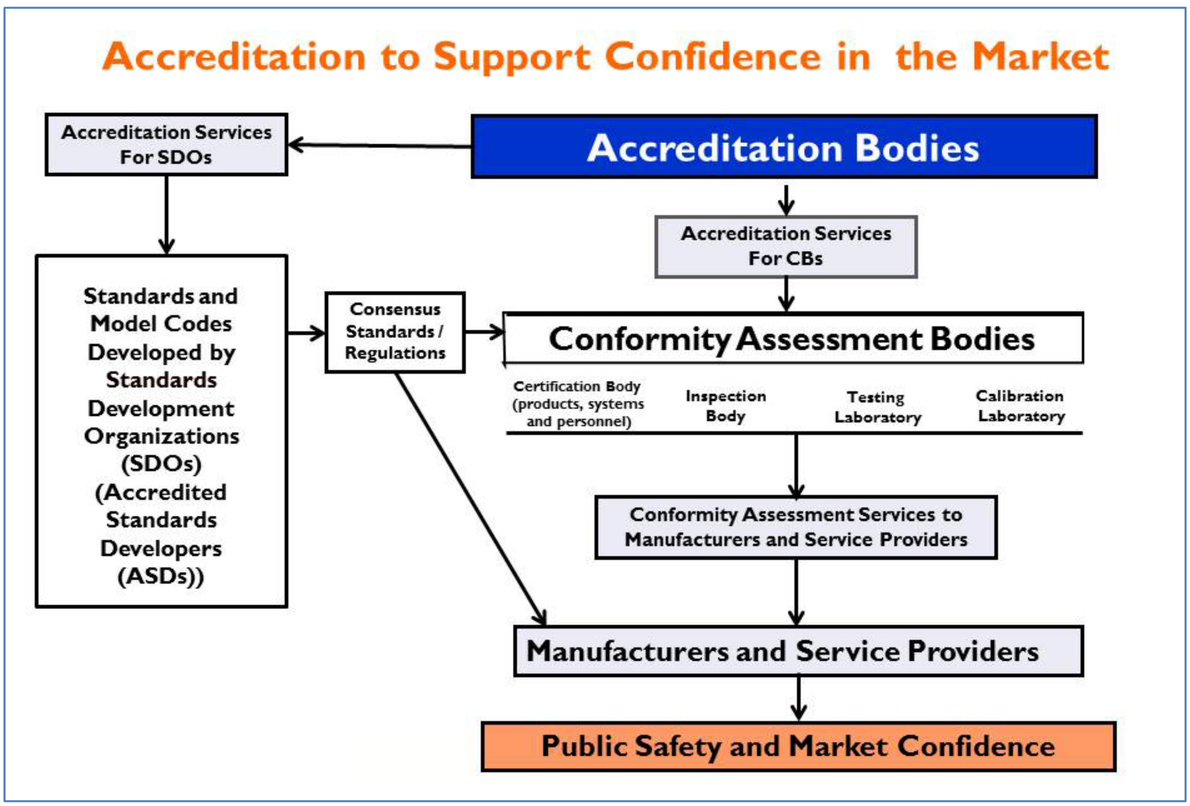


Image courtesy of A2LA

Gap Analysis and Recommendations

The following represents a gap analysis for conformity assessment accreditation in the energy efficiency field. Two perspectives have been considered to identify the gaps:

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 the 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.

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.

Regulators may be unaware of internationally-recognized accreditation bodies such as those recognized by the International Laboratory Accreditation Cooperation (ILAC) and the International Accreditation Forum (IAF), such as the American National Standards Institute (ANSI), the American Association for Laboratory Accreditation (A2LA), the National Voluntary Laboratory Accreditation Program (NVLAP), and others. Third-party accreditation of testing and calibration laboratories, inspection bodies, and product certification bodies is an option that is sometimes overlooked.

The most appropriate and cost-effective mix of these approaches should be used for each conformity assessment activity. This mix will be different for different types of conformity programs performed by the conformity assessment bodies. Conformity assessment activities that pose a higher risk of incurring significant costs of failure (i.e., producing harm to human safety, health, or environment) generally will need greater assurance of conformity and thus, second- or third-party forms of conformity assessment are most appropriate.

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 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 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).

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

CHAPTER TWO: SYSTEMS INTEGRATION AND SYSTEMS COMMUNICATIONS

2.0 Introduction

Today, various sub-systems[35] within buildings operate in a mostly fractured environment. Building sub-systems – such as heating, ventilation, and lighting – consume energy, but they do not communicate their energy usage with each other. In the future, systems integration will be key to enabling more cost-effective operations. Future gains in energy efficiency require an understanding of the total system energy profile of the sub-systems in a building or campus of buildings. Building designers, constructors, service providers, as well as contractors, owners, operators, and managers are all impacted by the integration of systems that may control and/or report information relative to the building's operational systems. In this chapter, the EESCC systems integration and systems communications working group examines how building sub-systems could be integrated in order to manage the energy usage of a building or campus of buildings for maximum efficiency.

The system approach to addressing energy efficiency of a building makes use of terms that can have different meanings depending on which context they are used. For example, the term energy management system could be understood as a Smart Grid automation technology, a real-time control system designed to automate operations (i.e., a building automation system), a set of elements of an organization establishing energy policy and objectives, or as a process of continuous improvement, such as that defined by ISO 50001.[36]

In the context of this document, the building energy management system (EnMS) is the set of hardware and software that performs the inventory of all energy flows, users, and uses, and determines the building operating parameters

Established as Within Scope:

- machine-to-machine communications
- standards for the integration of products and/or appliances within a building structure or with the energy management system
- standards that impact the design, operation, or energy management of a building
- telecommunications wiring infrastructure that affects how much energy a system consumes, and the related telecommunications standards for connectivity of networks

Established as Outside of Scope:

- appliance and product specific standards
- human-to-human communications
- vehicle-to-building-to grid communications
- industrial floor automation

[35] Alternate terms for sub-systems in buildings are functions, building activities, and end use.

[36] Developed by the International Organization for Standardization (ISO), ISO 50001, *Energy management systems - Requirements with guidance for use*, specifies requirements for establishing, implementing, maintaining, and improving an energy management system. For more information, visit http://webstore.ansi.org/RecordDetail.aspx?sku=ISO+50001%3A2011.

based on a set of prescribed optimization factors.

As defined by this working group, **systems integration and systems communications** encompasses communications between building automation/operation systems and equipment/appliances within a single building and/or between buildings, such as across facilities and campuses. The working group established additional boundaries around its scope of work, as detailed in the text box.

To carry out its assessment and develop the recommendations outlined in this chapter, the EESCC systems integration and systems communications working group conducted a review of applicable standards and codes with the aim of identifying what additional standardization is needed to advance this area. The results of the working group's review are included in the chapter appendices.

2.1 Coordination with the Smart Grid Interoperability Panel

While the EESCC systems integration and systems communications working group is focused specifically on energy efficiency and energy management within a building or group of buildings (i.e., facilities and campuses), a complementary coordination effort – the Smart Grid Interoperability Panel (SGIP) – is focused on standards, testing, and certification efforts that enable interoperable communications between internal building EnMS with external grid service providers. Throughout its assessment, the EESCC systems integration and systems communications working group coordinated with the SGIP to ensure that the respective efforts would remain complementary and not overlap in scope.

Established to support the National Institute of Standards and Technology (NIST) in the fulfillment of its responsibilities under The Energy Independence and Security Act of 2007 (EISA), the SGIP provides a framework for coordinating Smart Grid stakeholders to accelerate standards harmonization and advance the interoperability of Smart Grid devices and systems. The Smart Grid Conceptual Model (Fig. 2a) illustrates the core areas of technological focus – or "domains" – of the SGIP, and is used as a tool for visualizing the structure and operation of the power system.

Of particular importance to the EESCC systems integration and systems communications working group is the customer domain (Fig. 2b), where electricity is consumed. Actors[37] in the customer domain enable customers to manage their energy usage and generation. Some actors also provide control and information flow between the customer and the other domains. The boundaries of the customer domain are typically considered to be the utility meter and the Energy Services Interface (ESI) (see Fig. 2c). The ESI provides a secure interface for utility-to-consumer interactions, and can act as a bridge to facility-based systems such as a building automation system (BAS).

As illustrated in Figure 2b, the customer domain is segmented into sub-domains: home, commercial/institutional, and industrial. Each sub-domain has a diverse set of actors, applications, and technology. This diversity results in a challenge for grid-side service providers to engage with a range of customer systems and devices managed for different purposes, using a wide variety of communication

[37] As defined by the "NIST Framework and Roadmap for Smart Grid Interoperability Standards, "**actors**" may be devices, computer systems or software programs and/or the organizations that own them. Actors have the capability to make decisions and exchange information with other actors through interfaces: NIST Special Publication 1108R2, "NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0," February 2012, page 40, http://www.nist.gov/smartgrid/upload/NIST_Framework_Release_2-0_corr.pdf.

protocols. The customer interface needs to accept and adapt to this customer diversity in order to achieve scalability and a high level of acceptance.

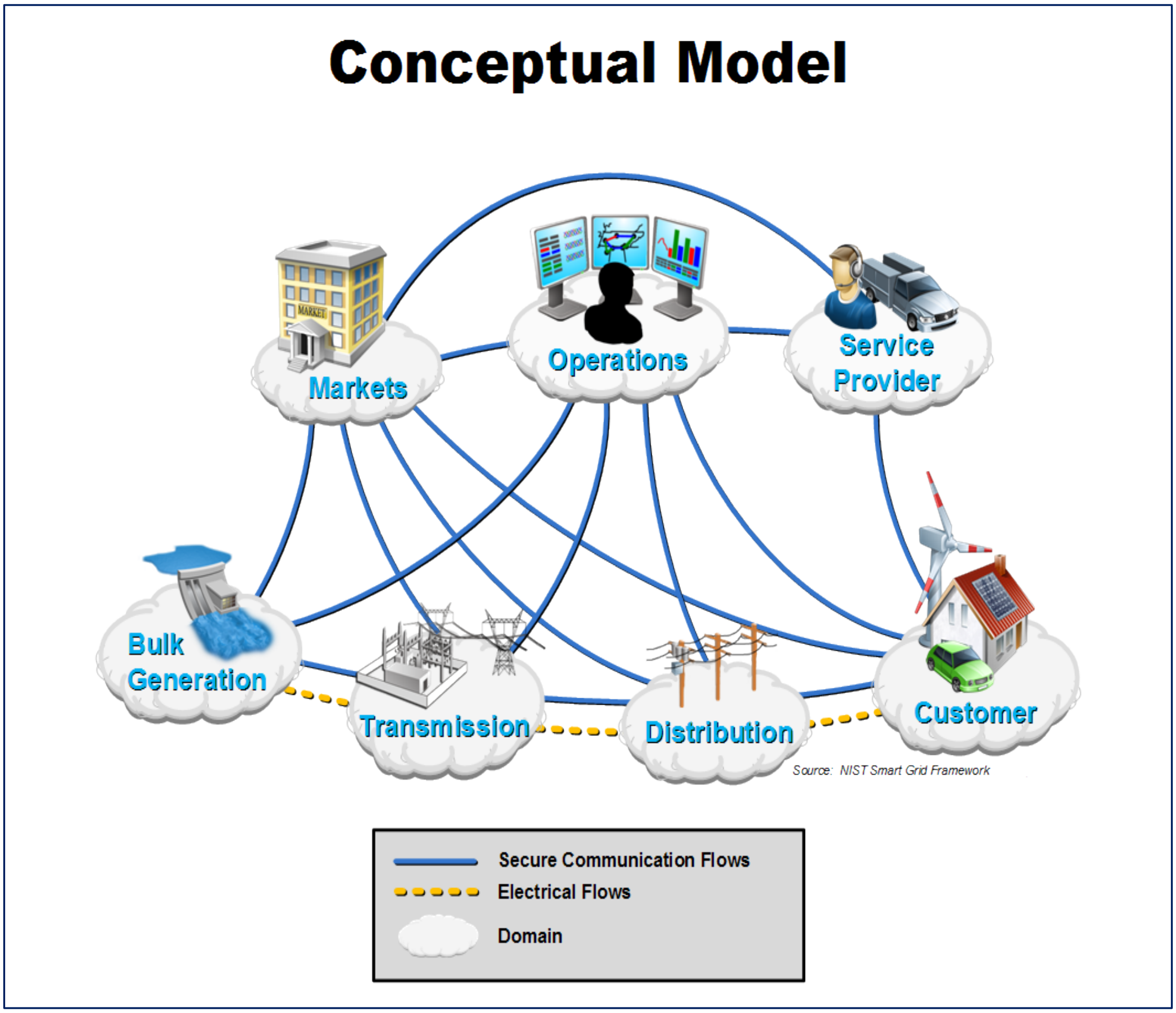


Fig 2a, NIST Smart Grid Conceptual Model[38]

[38] NIST Special Publication 1108R2, "NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0," February 2012, page 42, http://www.nist.gov/smartgrid/upload/NIST_Framework_Release_2-0_corr.pdf.

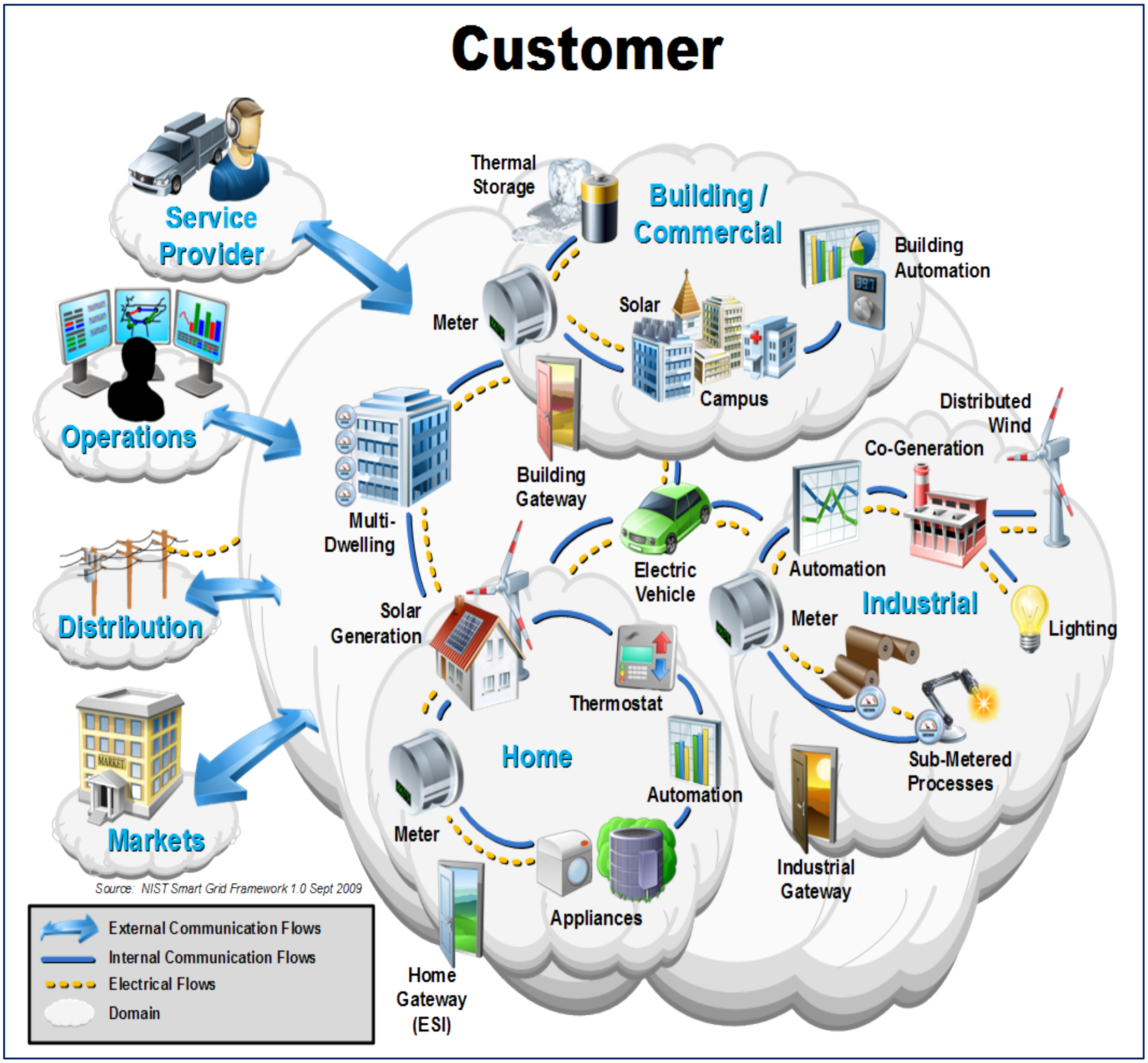


Figure 2b, Customer Domain[39]

As demonstrated in Figure 2c, the ESI supports the exchange of data and information elements between the grid and customers required to enable a grid-interactive building by satisfying a set of use cases, which are detailed in Appendix 2B. Some of these SGIP use cases, such as Facility Energy Management (FEM), are supported by applications that also support energy efficiency. Demand response also involves external inputs that affect the management of internal facility loads.

[39] NIST Special Publication 1108R2, "NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0," February 2012, page 211, http://www.nist.gov/smartgrid/upload/NIST_Framework_Release_2-0_corr.pdf.

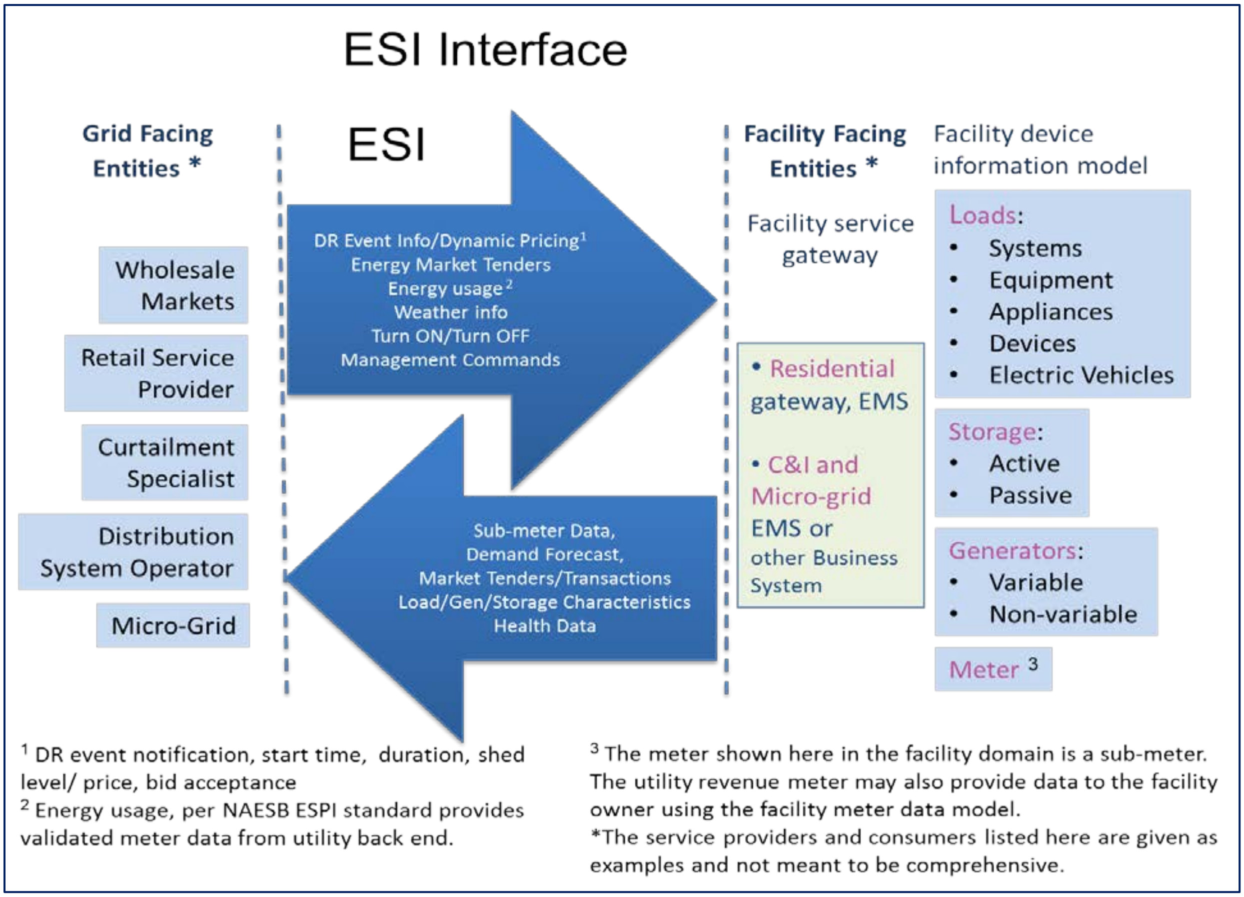


Figure 2c, ESI Interface

While the scopes of the SGIP and the EESCC systems integration and systems communications working group are distinct, there are instances of possible connection points that impact both and may require the coordination of new standards or extensions to existing standards. One example of a potential connection point is the modeling of building or facility energy information that is used for monitoring energy for improving efficiency, as well as monitoring energy for the demand response SGIP use.

2.2 Understanding a System Approach to Energy Management within a Building

As discussed above, the Smart Grid seeks to reduce energy losses during electric power transmission and distribution. Residential and commercial buildings use nearly 75 percent of the nation's electricity, and are thus the major energy users connected to the grid.[40] Reducing those losses would require large investments in reactive power compensation, phase shifting transformer, and power electronics steering and control. And yet, these investments may not be recovered from reduced losses alone during the lifetime of the system. Alternatively, two-way communication between the Smart Grid and buildings could better control the reactive power and ensure an even loading of transmission and

[40] In 2011, the residential sector constituted 38.2% of retail sales; the commercial sector constituted 35.4%. Source: DOE/EIA, "Annual Energy Review 2011," September 2012, Table 8.9., page 253: http://www.eia.gov/totalenergy/data/annual/index.cfm.

distribution connections.

For the Smart Grid, energy management is a bidirectional flow of information and electricity. Energy management within a building on the other hand is more complex. Energy flows through the building in a variety of forms, including heat, steam, compressed air, and electricity. Even if two buildings have identical structure and envelope, the system energy profile will be unique due to variances in tenant use and occupancy. The Smart Grid determines a demand response strategy based on data from the building that lead to the reduction of losses during electric power transmission and distribution. Other strategies, such as the transactive approach, can be used as well.

A building system is made up of a number of different sub-systems, such as HVAC, lighting, electric power, or security. Each sub-system has a defined function, importance, and a set of energy performance indicators. A 'system approach' to a building considers how the sub-systems influence each other within the building system as a whole, and can determine whether an improvement in one area may adversely affect another area of the building system.

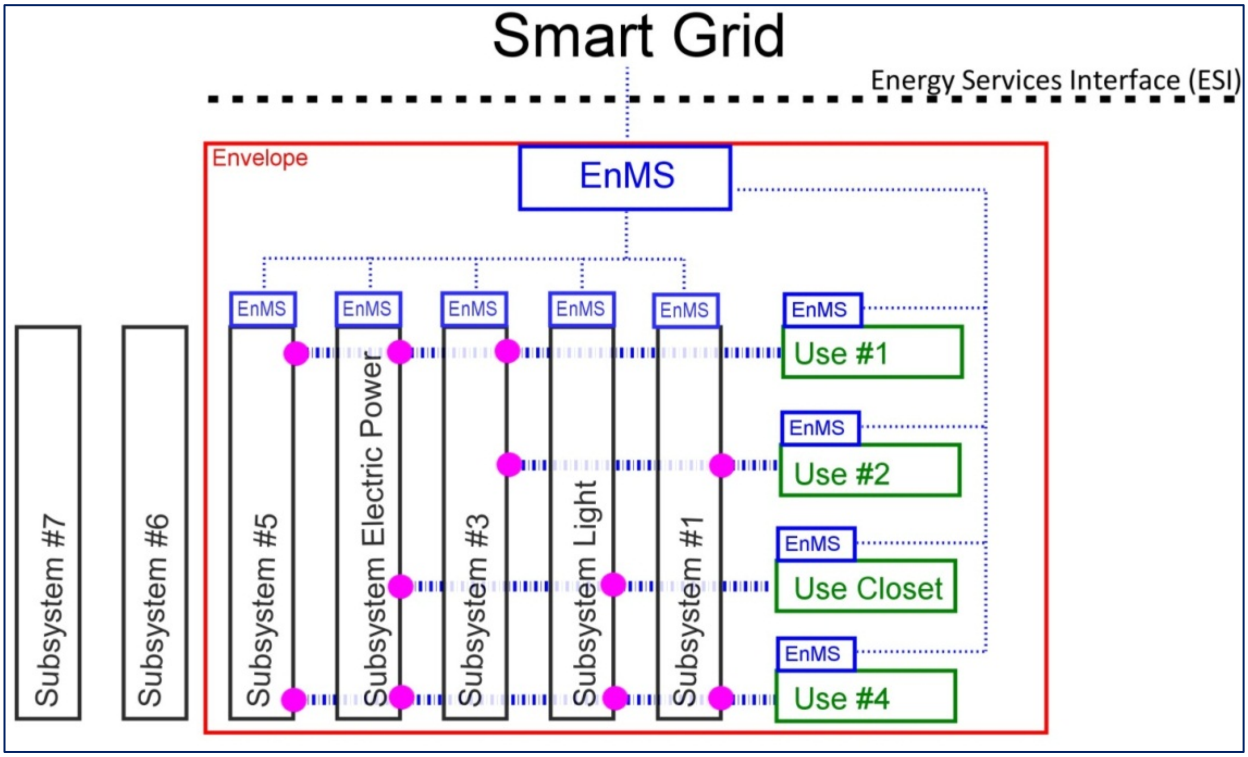


Figure 2d, A Model of the Building Energy System

Figure 2d provides a model of a commercial building with a building automation system. This model is used to illustrate the interaction among building system components and the interaction between the building and Smart Grid. The terms and interactions described in relation to this model can also be applied to smaller commercial buildings that do not have building automation systems.
The building envelope – also sometimes referred to as the building fabric or structure – consists of walls, foundation, stairs, doors, windows, etc. Basic functions of the building envelope include adding

structural support, controlling moisture and humidity, regulating temperature, and controlling air pressure changes. By serving these different functions, the envelope also affects ventilation and energy use within the building. The sub-systems installed in a building depend on the building's function; for example, whether it is a hospital or a library.

The spaces in the building modeled in Figure 2d can have various 'uses.'[41] Commercial buildings enable a wide variety of 'uses,' from providing a space to work or be educated, to places for health care, storage, shopping, and lodging. A 'use' exchanges energy with a combination of sub-systems necessary for its activity. Figure 2d illustrates the example for a storage closet 'use' that exchanges energy with only two sub-systems: light and electric power. In Figure 2d, two sub-systems (#6 and #7) are not part of a specific building system.

An EnMS can be implemented in order to optimize the energy profile for each 'use' in Figure 2d. Data exchanged by the 'use' is very valuable to the building EnMS because it contains information about the 'use' type and energy usage profile. The standard ISO 50001 provides a comprehensive methodology for energy management systems. The ISO 50001 methodology can be applied at the building system level or it can be scaled down and applied at the 'use' level. The energy data exchanged within the building system can be used for compiling the building system's energy profile in a format compatible with the Smart Grid communication protocols and transaction strategies. The energy data exchanged among the building sub-systems and 'uses' can be used for generating ISO 50001 reports.

The building system model represented in Figure 2d also illustrates – via the dotted blue lines – the energy data exchanged among the building sub-systems and 'uses.' A building sub-system can exchange energy data with other sub-systems, with the 'use,' and with the building EnMS. The building EnMS has access to a database of reference data containing the energy profile of the building envelope (e.g. physical properties, building codes constraints), and energy data exchanged among the building sub-systems and the 'uses.' Finally, communication with the Smart Grid is managed by the building EnMS.

2.3 Gap Analysis and Recommendations for Systems Integration and Systems Communications

To improve energy efficiency within the built environment, it is important to establish metrics to measure and evaluate energy consumption and the methods used to achieve efficiency while assuring the methods employed do not hamper occupant comfort, productivity, or business operations. While there are a multitude of programs used to collect energy data and to manage energy usage, most are proprietary in nature and may not communicate across multiple data sets. Because of the complexity of this communication, there is a need to establish standards for information exchange, eliminate duplicative collection efforts, and provide for a system of information sharing within a building, facility or group of facilities, as well as with the grid.

[41] Alternate terms for 'use' in buildings are application, building type, use case, use type, business type, and use class. The U.S. Energy Information Administration (EIA) characterizes and defines these commercial building 'uses' as 'building types,' and they are regularly used in DOE and EIA analyses. For more information, see EIA's "Building Type Definitions" at http://www.eia.gov/consumption/commercial/building-type-definitions.cfm.

Data can serve different needs within a building, including for example, energy management, occupant comfort, and facility operations. Standards are needed in these areas to ensure that different data sets are not duplicative or exclusionary. These data sets should also be compatible with the information transfer to the grid without the need for duplicative collection efforts.

Part of the data that is collected within the building may be needed for energy management from a grid perspective. Building operational data may be used to inform grid operators, alerting them to the larger possibilities of energy consumption control across a grid based on building or facility operational needs.

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.

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 evolve to support communication.

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

The utility can acquire energy data from a commercial building by directly monitoring building power meters or by communicating with the building's EnMS and building automation system. Energy data collection is used in several applications, including measurement of building performance and grading analysis of buildings. Acquired energy data can be processed by statistical tools to identify and quantify specific energy uses in the building that affect the Smart Grid performances. Subsequently, the Smart Grid can provide to the building EnMS recommendations to adjust its energy consumption profile. Two factors influence the accuracy and effectiveness of the recommendations provided by the Smart Grid to the building: 1) The consistency and accuracy of the energy data acquired from the building; and 2) The availability of relevant building energy use information that can indicate the potential of the building to modify its energy demand in order to meet the Smart Grid's energy supply (e.g. the specific energy-using equipment that the EnMS could shut down or have its energy consumption modulated).

C. Consistent data communication

Standards are needed to support more consistent data communication back to the utility.

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

Often, building operational data is used for access control, productivity increases, and maintenance functions. These data sets can be used to inform building operators about how energy consumption impacts the overall operation of a building and grid operators about energy distribution limitations or timing that might be counterproductive to a building owner's comfort, operational, or business needs.

Advancing the increased use of data collection and utilization to improve energy efficiency will require a robust cost benefit/return on investment assessment to inform building owners, operators, and tenants about the value of such systems that capture, communicate, and evaluate energy consumption information within buildings. Potential building investors, owners, and operators will demand more market information to provide evidence that these systems can produce more efficient buildings, resulting in a better business investment.

In addition to numerous industrial process and automation communication protocols, there are more than 30 commonly used communication network protocols for building automation, substation automation, and automatic meter reading.[42] It would seem to follow that there is a large amount of data being exchanged in a building, depending on the level of building automation.

The U.S. Department of Energy (DOE) supports ISO 50001 broad implementation to achieve benefits to U.S. businesses and to the nation.[43] However, ISO 50001 can be perceived by some to be difficult to implement because of a lack of available data. Implementation of other energy management systems may also pose difficulty in accessing data exchanged among the devices operating in the building.

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.

E. Measurement and monitoring protocols for energy data

There is a need for standards to establish measurement and monitoring protocols to support energy data.

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

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.[44]

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

An energy management system standard like ISO 50001 is a framework for industrial plants, commercial facilities, or entire organizations to manage energy. Even after collecting and processing data, organizations still need to know what the different building sub-systems need to perform and how to

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[42] Wikipedia, The Free Encyclopedia, "List of automation protocols," last modified August 5, 2013, http://en.wikipedia.org/wiki/List_of_automation_protocols.

[43] U.S. Department of Energy, "About DOE and ISO 50001," last modified December 20, 2012, http://www1.eere.energy.gov/energymanagement/about.html.

[44] 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.

manage those sub-systems. Integration and communication among building sub-systems could dramatically reduce the cost of performing energy efficiency or energy performance assessments. Where possible, design and product performance standards should be "forward-thinking" and be attuned to smart communications and systems integration and operation.

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.

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

Recommendations D and G indicate methodologies that enable the industry to close specific gaps. Those methodologies refer to data exchange formats and attributes, and to sub-systems that are integral parts of the building energy system. It is considered to be worth replicating the success of SGIP PAP17 NEMA/ASHRAE SPC201 in developing the Facility Smart Grid Information Model (FSGIM). ASHRAE SPC201 identifies the data types and attributes exchanged in relevant use cases. Though different than an energy management system framework, the ASHRAE SPC201 use cases indicate how devices can be controlled for the benefit of managing the energy efficiency on the grid side of the building. Those use cases are complex because of modeling information collected by the Smart Grid from meters, devices, and components in a building. A building energy information model is expected to be simpler because it serves only the needs of the building. By the same token, a building energy information model will not take into account data security and integrity issues specific to communications outside of the building and within the energy distribution infrastructure.

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 as a test to be sure the content of the standard provides for all of the information needed to optimize the energy performance of the building.

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

Currently, there is workforce expertise to design, build, maintain, and manage each building sub-system; however, the sub-systems' integration and configuration into a system – as well as managing the system's energy as a whole – requires intelligent devices and therefore a workforce with advanced skills in automation and controls.

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.

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

Appendix 2A: Breakdown of Standards and Codes in the EESCC Inventory Database

Table 2A, Breakdown of Applicable Standards and Codes in the EESCC Inventory Database

Type	Number of documents
Energy efficiency within a specific sub-system	11
Communication with a building system, including communication with SGIP	37
Energy performance reporting from a system point of view (a minimum of two sub-systems or 'uses')	6
Energy management methodology from a system point of view (a minimum of two sub-systems or 'uses')	1
Envelope, sub-system, and 'use' design specifications	41
Installation and maintenance	17

Table 2B, Standards Addressing Energy Efficiency in Buildings

Organization	Records	Focus
International Association of Plumbing and Mechanical Officials (IAPMO)	5	Buildings
International Code Council, Inc. (ICC)	8	Buildings
National Electrical Contractors Association (NECA)	2	Buildings
National Fire Protection Association (NFPA)	3	Buildings
Society of Cable Telecommunications Engineers (SCTE)	2	Buildings
American Society of Mechanical Engineering (ASME)	9	Energy
California Energy Commission (CEC)	4	Energy
International Electrotechnical Commission (IEC)	19	Energy and Interfaces
The International Organization for Standardization (ISO)	5	Energy Management
Air Conditioning Contractors of America (ACCA)	19	HVAC
ASHRAE	9	HVAC&R and Buildings
Alliance for Telecommunications Industry Solutions (ATIS)	17	Telecommunications
Telecommunications Industry Association (TIA)	4	Telecommunications
American Welding Society (AWS)	1	Buildings

Organization	Records	Focus
United States Code (USC)	2	Energy
The Sustainable Technology Environments Program (STEP) Foundation	1	Energy
Electric Investor-Owned Utilities (IOU)	0	Energy
Deputy Under Secretary of Defense for Installations and Environment, Business Enterprise Integration Directorate (DUSD(I&E)-BEI)	1	Energy Management
California Air Resources Board (CARB)	0	Energy Management
InfoComm International	1	Telecommunications
Project-Haystack.org	1	Telecommunications

Appendix 2B: Customer Interface Use Cases and Corresponding Information Elements

Use Case Classes	Description	Customer Interface Required Information Elements
Energy Market Transactions	Balancing and trading power, externally with electricity, gas and other energy markets, and internally balancing energy sources.	Energy supply cost data (including electricity price forecasts), market transactions (indications of interest, bids, and transactions). Demand forecasts also require weather forecast data.
Demand Response	Demand Response: Day ahead capacity DR and Day-of DR; Fast-DR (ancillary services); and price communications. Includes event communications, supporting services, feedback and measurement and verification.	DR event information (start time, duration, and level/amount), price and product, event status, market context, resource ID and service location. Support information includes: registration, opt in/out, availability, event response and meter data for M&V.
Direct Load Control (DLC)	Direct control of facility loads	Commands to turn on/turn off end node, or more sophisticated generator/storage control signals.
Facility Energy Management (FEM)	Energy management of facility loads, storage and generation for monitoring and planning of facility energy use.	Validated meter data, energy cost data (including electric price forecasts), weather forecasts.
Transaction based controls	Techniques for managing the generation, consumption or flow of electric power within an electric power system through the use of economic or market based constructs while considering grid reliability constraints. The term "transactive" comes from considering that decisions are made based on a value. These decisions may be analogous to or literally economic transactions.[45]	Market signals (price, payments, carbon intensity) enabling end-use customers to transact with the Smart Grid and realize value from doing so; means of financial settlement; and elements from Demand Response.
FEM Measurement and Validation	Internal measurement and validation: display of facility energy usage for tracking energy consumption, allocating energy costs, monitoring emissions and power quality, and benchmarking.	Validated energy usage data, emissions data, and energy cost data.
Remote System Monitoring and Management	Monitoring and management of system health by service providers to allow system diagnostics and remote energy management.	High-frequency meter data, power quality data and sub-system status. Remote FEM may require additional building system data (occupancy schedules, process schedules, business planning, etc.)
Integration of Distributed Energy Resources[46]	Exchange of grid and distributed energy resource (DER) status.	Grid power voltage and quality forecasts, generation and storage status (available power, charge level, ramp rates, availability schedule, priority, present demand, forecast demand, etc.) Alternatively, DER integration may be enabled via market transactions or DR signals.

[45] Gridwise Architecture Council, definition of Transactive Energy: http://www.gridwiseac.org/about/transactive_energy.aspx.

[46] Distributed energy resources are outside the scope of WG2 but have been included as part of this table for the sake of completeness.

Appendix 2C: HVAC Case Study

The following case study demonstrates the need for standards on data exchange. The HVAC sub-system can be used as a simple example of exchanged energy data used by the sub-system EnMS. The EnMS in this example is a computerized control system and the energy data includes inputs to the computerized controllers, output from the computerized controllers, and software points used within the computerized controllers. This specific example has being chosen for the purpose of indicating the variety, quantity, and the type of energy data exchanged within a sub-system. It is important to realize that a small commercial building may not have more energy data to record than the reading from the meter on the wall and the AC thermostat setting.

Input points can be of the analog type obtained from transducers and measurement devices. Examples of Analog Inputs (AI) include:

- Temperature sensors
- Humidity sensors
- Pressure sensors
- Flow meters
- CO2 sensors

Input points can also be of the binary type, typically correlated to the status of a switch or relay. Examples of Binary Inputs (BI) include:

- Status – On/Off
- Level switch
- Low temperature limit switch, (freeze-stat)
- High Pressure Limit Switch
- Fault

Output points are commands sent to system components and can be binary or analog. Binary Outputs (BO) points include:

- Start/Stop
- Open/Closed

Analog Output (AO) points typically modulate a component/device, for example:

- Valve position
- Damper position
- Variable Frequency Drive (VFD)

The above AI points, BI points, AO points and BO points are hardware points; they physically exist and consist of wires from the BAS to some physical device. The previous list is not inclusive. Software points reside within the BAS and consist of the set-points, time delays and intermediate values either calculated or used in calculations. In order for data from the BAS to be used for Automated Fault Diagnostics (AFD) tools, the taxonomy of all these various points must be standardized or else AFDs cannot be deployed in an enterprise manner.

CHAPTER THREE: BUILDING ENERGY RATING, LABELING, AND SIMULATION

3.0 Introduction

Buildings consume about 40 percent of all energy in the United States. In order to reduce the amount of energy consumed in residential, commercial, and industrial buildings, energy rating and labeling programs have been developed to make energy usage and/or energy performance of a building more visible. Building energy simulation tools have been created to help engineers, architects, and building professionals model the performance of a building to optimize the building design and energy use.

This chapter examines both building rating and labeling and building energy simulation, with an eye toward identifying where additional standardization activities may be needed to advance energy efficiency.

3.1 Rating and Labeling Programs

Energy rating and labeling programs provide an analysis of a building's energy consumption or energy features and allow comparison to similar buildings. The comparison may be to a median building, specific reference points (e.g., built to specific code, technical potential rating), or to a distribution of building performance (percentile rating), generally by building type. The ability to compare buildings can help place a premium on energy efficient buildings, thereby encouraging building owners to implement energy efficient measures in existing buildings and design future buildings to be more energy efficient.

Building energy rating and labeling programs are generally classified as either **operational ratings** or **asset ratings**, and can apply to residential, commercial, and industrial buildings. Operational ratings usually rely on the actual, metered energy consumption of the building to establish the rating. Asset ratings typically use energy simulation tools to estimate the energy performance of the building's envelope, mechanical systems, and electrical systems independent of the behavior of the building occupants. With both operational and asset ratings, a qualified professional may be required to collect, review, or submit data, assess the building, and/or carry out other quality assurance procedures as required by the rating system.

Both operational and asset ratings may be used as the foundation for labeling and recognition programs. In such cases, the rating system usually establishes criteria or levels associated with one or more levels of recognition.

3.1.1 Operational Ratings and Labels

Operational rating programs evaluate building energy performance using actual, metered energy data and other characteristics to reflect both the structure of the building and how it is operated. Normally used for assessing existing buildings, operational rating programs focus on the performance of a building as a single system, although subsystem information may also be provided. The rating's baseline,[47] which provides the reference for evaluating performance, may be based on internal data from a single building, or external data from peer groups or national populations of similar space types. While operational ratings typically evaluate a 12-month period of past performance, the rating's baseline may be based on data from multiple years.

Operational ratings may use statistical models to normalize for significant variables that affect energy use, such as weather, production rates, or occupancy rates, depending on the space type or sector. Ratings that compare buildings against an external peer group or national population may conduct further normalization for differences in physical characteristics, such as size or specific building features (e.g. indoor pool), and operational characteristics, such as operating or production hours, occupant density, or product mix.

To rate performance, operational ratings establish criteria or a benchmark[48] that defines performance relative to the baseline. This criteria or benchmark may also provide the basis for determining eligibility for labeling programs that are based on the rating system. For example, performance might be indexed on a scale of 1 to 100, and the specific benchmark for efficiency pegged at 75 or greater. Alternatively, the scale might use letter grades from A to F, with A indicating the highest possible efficiency at zero net energy use.

Operational ratings are typically used on a recurring basis to monitor performance. Information learned through subsequent years of operational ratings and labels can provide building owners, managers, and maintenance staff with insight into how the building performs and opportunities for improving the building systems and operation. For owners with portfolios of multiple buildings, operational ratings can help to prioritize investment in energy efficiency improvements across multiple buildings.

Labeling programs based on operational ratings have been used to recognize top performing buildings and motivate building owners to make energy efficiency investments. More recently, operational ratings and labeling programs have been required as part of many building energy use disclosure regulations.

3.1.2 Asset Ratings and Labels

Asset rating programs evaluate a building based on the physical characteristics and major energy using systems independent of operational and occupancy factors. Asset ratings can be used to assess both new (less than 12 months of operation) and existing buildings and allow building owners to compare buildings on an equal basis by applying standard assumptions about occupant behavior, location, and operational factors. Asset ratings typically require an on-site assessment of a building's physical characteristics and major energy using systems (as built or as designed)—including mechanical systems, building envelope, orientation, lighting, and daylighting.

[47] For the purposes of this section, the term "baseline" describes the reference used for comparing the energy performance of the facility being rated. This reference can be defined in multiple ways.

[48] A benchmark is a specific level of energy performance relative to the baseline. It can be used to define energy efficiency or to calibrate a rating scale.

Asset ratings are generally calculated using energy simulation tools. The simulation tool uses data about the building's assets (e.g., envelope, lighting, mechanical systems), applies standard operating assumptions based on building type (e.g., office, retail, multifamily, single family), and translates the result of the simulation into a rating. Some asset ratings are based on a single energy simulation of the candidate building as compared to a fixed or calculated baseline; others are derived by comparing energy simulations of both the candidate building and a baseline building. Just as with operational rating programs, the fixed or calculated baseline may be based on internal data from a single building, or external data from peer groups or national populations of similar space types.

If it Looks Like a Label, is it a Label?
Terminology used in this arena is often unclear. One rating system's baseline may be another's reference point or benchmark. The term "label" in most cases is used to describe a plaque or other physical sign generated by a rating system. Labels usually designate some type of achievement (reaching a certain level of efficiency, number of points, etc.) as defined by the particular rating system.

Asset ratings can encourage building owners and operators to value the potential energy efficiency of a building and/or property – whether at the time of purchase or during ownership and operation. Since they apply standard assumptions about operations and other transitory factors, asset rating programs can be used to value building performance within a financial transaction, and could be a basis for energy efficiency code compliance or beyond-code new construction incentive programs.

Some asset ratings programs can provide insight into the efficiency of a building's individual systems by disaggregating energy information and identifying inefficient systems and potential opportunities for upgrade.

Table 3a highlights the major distinctions between asset and operational ratings, and suggests when each is most likely applicable in informing decisions.

Table 3a, Different Ratings for Different Purposes

Rating Type	Purpose	Likely Time to Use It
Asset	• Allows a building owner, buyer, lessee, or other stakeholder to understand how a building is likely to perform based on its physical characteristics and systems compared to similar building types under standard operating conditions	• During ownership, an asset rating can guide investment in capital improvements and efficiency upgrades • At point of sale, lease, or purchase of a building, an asset rating can be useful in highlighting the efficiency of a building's principal energy-related assets (e.g., envelope, heating, cooling) apart from current operations • As an alternative path to code compliance
Operational	• Allows a building owner, operator, buyer, or lessee to evaluate a building's actual energy performance over time and /or against similar building types	• During the operation of the building, operational ratings help guide energy management decisions, particularly those related to improving operations and maintenance • At point of sale, rental, or purchase, operational ratings provide information on how a building performs under current operating conditions

3.1.3 Defining Characteristics of Building Rating Systems

Each rating system applies a specific approach to calculating and displaying a building's rating. The diversity of current rating systems reflects, in part, the applicability of any given system to specific circumstances, needs, and market demand. The following discussion describes the defining characteristics of rating systems and how they vary. Table 3b shown at the end of this rating and labeling section provides greater detail on the defining characteristics of each of the major U.S. building rating systems.

- **Building Type Applicability**
  Rating systems are usually broadly applicable to residential, commercial, or industrial buildings. Within these broad categories, most rating systems make further distinctions based on physical aspects of the building or its primary use. For example, in the residential arena, multifamily buildings are frequently divided into two groups – those with four or more stories, and those with less than four stories. In the commercial building arena, ratings distinguish between building types based on use and design intent, such as office buildings, schools, or warehouses. Industrial rating system applicability is usually defined by sector North American Industry Classification System (NAICS) codes and/or the products that are produced.

  A further distinction is also made between the applicability for new construction while others are designed for existing buildings.

- **Calculation Method**
  Rating systems use a variety of methods for calculating ratings. Most asset rating systems rely on energy modeling to estimate energy use, while most operational rating systems use utility bill or metered data to generate a rating. Some asset rating systems require the use of one specific energy simulation tool, while others allow a variety of simulation tools to be used to calculate energy use and other values required to generate the rating. Operational ratings typically use statistical models to normalize for significant variables that affect energy use. These variables usually vary depending on the space type being rated.

- **Performance Measurement**
  Many ratings use an energy use metric (e.g., energy use per building; energy use per square foot) to measure or express energy performance. These metrics may be a simple ratio or be based on multiple variables. However, some labeling programs use a combination of performance metrics and other criteria to determine eligibility for labeling. For example, U.S. Green Building Council's LEED rating and the Green Building Initiative's (GBI) Green Globes are both calculated by adding up points related to a variety of different metrics (e.g., indoor air quality, energy performance, location).

- **Use of Site or Source Energy**
  Some rating systems convert energy used on site to "source" energy. Source or total primary energy adjusts for generation and distribution losses of purchased energy, namely electricity. However, other rating systems use only "site" energy which reflects the energy used on site.

- **Baseline Definition**
  To evaluate performance, rating systems usually rely on a baseline as the reference point for conducting comparisons. However, the methods used to establish or calculate the baseline vary significantly between operational and asset ratings as well as within these categories of rating systems. Consequently, the term "baseline" can mean different things depending on the rating system being used. For example, some rating systems use specific energy code as the "baseline" for

rating the building in question, while other ratings systems use a distribution of energy performance to establish a sector-wide baseline.

- **Relationship to Energy Code**
  Some rating systems assess buildings relative to a particular energy code. Most of these rating systems consider a building that meets the specific energy code as the "baseline" for rating the building in question. The rating then reflects how well the building as built or designed performs or is likely to perform relative to that baseline. Systems that rely on energy code as the basis for ratings are usually intended to inform new construction.

  Even rating systems that do not use energy code as a basis for calculating the rating may indicate where a typical building built to a specific code is likely to rate as a reference point.

- **Relationship to Existing Building Data**
  A number of rating systems rely on data collected by the federal government. Commonly used data sets include the Commercial Building Energy Consumption Survey (CBECS), Residential Energy Consumption Survey (RECS), and Manufacturing Energy Consumption Survey (MECS). These surveys, carried out every several years by the U.S. Energy Information Administration (EIA), collect energy usage, building characteristic information, and production data for facilities across the United States. This data is used by some rating systems to generate ratings by comparing the measured or modeled energy use of the building in question against a subset of the buildings in CBECS or RECS. The reference point may be the median performance of that specific subset of data. For example, after taking into account building location, size, type, and other factors, ENERGY STAR® Portfolio Manager scores the building in comparison to building data derived from CBECS. While many systems do not directly compare a building to CBECS or RECS data, these data sources are frequently used to help set the endpoints on rating scales, to generate reference points, create baselines, or provide other valuable input into the development of rating systems.

- **Scale**
  Ratings usually fit along some type of scale, whether absolute, relative, numeric, graduated, or some other type. Some scales are pegged to zero energy use or net zero energy use. In these cases, the rating system usually provides some type of credit for on-site renewable energy generation. Other scales focus solely on energy utilization and efficiency and index performance on a numerical scale or grading system.

  Scales also vary in terms of their levels of granularity. More granular systems are able to distinguish between buildings with relatively similar energy performance levels; consequently, these scales frequently require a greater level of data inputs. Some programs award a rating for buildings that exceed a certain threshold value using a pass/fail approach or have a limited number of delineations in the scale, thus grouping performance into broad "buckets." Other programs employ more levels or a continuous scale in order to more precisely distinguish building performance. Whether continuous or delineated, the scales may employ a non-linear function that rewards absolute differences in performance differently, depending on where along the scale those differences occur. This approach helps to better distinguish the top levels of performance.

- **Rater/Assessor Certification Requirements**
  Some systems have specific requirements for individuals who generate the ratings. In other words, only a qualified individual can conduct the analysis for rating a facility under some systems. Other rating systems have requirements for those verifying performance for labeling applications. Requirements can range from specific certifications recognized in the field to testing administered by the specific rating program. Some programs require a combination of certification and testing. The objective of requiring a certificated professional at some point in the rating and labeling process is to ensure that the integrity of the rating and labeling programs is maintained.

- **Quality Assurance Requirements**
  Quality assurance in the rating arena is distinct from quality assurance performed to verify installation of energy improvements. There are two distinct areas of quality assurance (QA) requirements in the rating arena. The first is the QA of the rating development process and the second is the QA of the rating submission for the building being rated. Quality assurance during the rating development process is conducted to verify that the rating process provides a reasonable, fair, and accurate rating process for the building type and rating process. Requirements generally include some sort of statistical analysis or simulation process and/or a review by industry experts or practitioners.

  Quality assurance for rating submissions is conducted to verify that the information being submitted accurately portrays and captures the data for that building. Requirements include a certified professional to perform the rating process, a paper review of ratings and documentation, and/or in-person, third-party review of the rated building. Where an in-person review is required, the program typically does not require 100 percent review, but rather a sampling of buildings rated. Some programs require that the person conducting the quality assurance be from a third-party organization.

- **Supplemental Information Provided**
  In addition to ratings, some programs provide supplemental information such as recommendations for energy improvements; a building's potential rating; evaluations of specific energy sub-systems; energy estimates by system; utility cost estimates; savings estimates; and indoor environmental quality screening/assessment. Some programs allow raters or assessors to generate their own recommendations or other information, separate from the rating. In these cases, the final report may or may not identify how the rater's recommended improvements would affect the building's potential rating.

- **Other Features**
  A number of other components vary among rating systems and may affect the degree to which they meet the objectives of those interested in a rating. These factors include but are not limited to the following:

  - **Ease and Cost of Generating the Rating**
    Data requirements, user interface, and other factors all affect the time and resources needed to generate a rating. Some systems also charge fees to access required software or to generate a rating.
    Some rating systems offer application programming interfaces (APIs) to simplify transfer and use of data required for the rating. APIs are particularly useful if the individual rating the building uses other software to collect and/or analyze data. In some cases, APIs can be licensed free of charge or require a one-time or recurring fee.

    While cost and ease of use may not be primary criteria for determining which system is most appropriate for a particular use, they do vary from system to system and are therefore worth noting.

  - **Public or Property Ratings**
    Some ratings have been created by public entities and submissions to that system are free. Others systems are proprietary and require a submission fee and/or a license to operate.

  - **Transparency**
    Some rating systems provide significant documentation concerning calculation methods, underlying assumptions, data sources, and other information regarding the algorithms used to calculate the rating. Documentation may also describe how the rating system was developed and tested prior to implementation.

  - **Understandability of rating**
    In order for a rating system to be effective, it must clearly communicate what the building rating means, and ideally motivate the user to invest in energy efficient buildings and/or improvements. While different approaches and systems are likely to appeal to different users, it is important that the rating be clear and meaningful to most users and to the public.

3.1.4 The Current Market: Different Systems, Few Linkages

As previously stated, a variety of rating systems have developed in part because different circumstances or objectives for the ratings systems exist. Furthermore, labeling, or disclosure regulations drive the use of specific rating systems.

Few linkages are readily available between existing systems and where linkages are possible; the information is complementary, not comparable. Because the underlying calculation methods, scales, and other system characteristics are not equivalent, one rating cannot be readily converted into another type of rating.

In the commercial building market, the ENERGY STAR® rating system offered through the Portfolio Manager tool has achieved the greatest market penetration with more than 45 percent of U.S. commercial building space using this system. ENERGY STAR® industrial energy rating systems have achieved wide spread market penetration in certain sectors. A few other rating systems dominate certain smaller markets (e.g., specific locations, new homes); however, none of the currently available rating systems are ubiquitous.

3.1.5 Gap Analysis and Recommendations: Rating and Labeling Programs

To evaluate the current landscape of operational rating and labeling programs, an inventory was conducted to identify different rating and labeling systems currently in the market or in later stages of development. The EESCC working group on building energy rating, labeling, and simulation then developed a matrix to further analyze the responses collected through the inventory and provide a starting point for discussion. This matrix is shown in Table 3b. From reviewing existing rating and labeling systems, the working group identified the following issues, gaps, and opportunities:

A. Data availability

Operational ratings and labeling programs rely on data that is representative of the existing building and industrial plant stock. As noted before, data sources such as 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. 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.

One of the critical issues 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.

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 stakeholders with each iteration of their surveys in order to improve the data collected and the collection process.

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.[49]

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

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 which programs exist and what their focus is. There is an opportunity for the establishment of a consistently updated "rating & labeling directory" that catalogues different programs and discusses each program's design and focus in a systematic format.

Recommended Timeline: This should be conducted in the near-term: 0-2 years, however it will require update over time.

[49] ASHRAE 214P, *Standard for Measuring and Expressing Building Energy Performance in a Rating Program*, https://www.ashrae.org/standards-research--technology/standards--guidelines/titles-purposes-and-scopes#spc214p.

Table 3b, U.S. Rating Systems: Summary of Major Characteristics

Rating System	Rating Type	Applicability	Calculation Method	Performance Metric Used to Rate Building	Scale	Certification Requirements	Quality Assurance (QA) Requirements	Supplemental Information Provided	Additional[50] Information
ASHRAE Building Energy Quotient (bEQ) Asset	Asset	New (constructed) & Existing	Allows multiple simulation tools to estimate EUI	Standardized as-built building EUI divided by standard/median EUI multiplied by 100. Result compared to a scale.	A+ thru F, with A+ representing a zero net energy building	Certified practitioner	All submissions are reviewed by ASHRAE staff.	Building receives approved workbook, dashboard, certificate, and label graphic file for plaque creation. Workbook includes all calculations and modeling inputs used to generate the rating.	Proprietary Workbook.
ASHRAE Building Energy Quotient (bEQ) Operational	Operational	Existing	Uses metered data and ENERGY STAR® Portfolio Manager	Metered building EUI divided by median EUI for that building type multiplied by 100. Result is to a scale.	A +thru F, with A+ representing a zero net energy building	Certified practitioner	All submissions are reviewed by ASHRAE staff.	Building receives approved workbook, dashboard, certificate, and label graphic file for plaque creation. Workbook includes all calculations and measurements used to generate a rating as well as the information from the ASHRAE Level 1 Energy Audit that provides suggestions to improve energy efficiency in the building and the IEQ screening.	Proprietary Workbook

[50] Unless otherwise, noted, all of these systems use standard calculation and scoring methods and are applicable nationally.

Rating System	Rating Type	Applicability	Calculation Method	Performance Metric Used to Rate Building	Scale	Certification Requirements	Quality Assurance (QA) Requirements	Supplemental Information Provided	Additional[50] Information
BOMA 360 Performance Program	Hybrid	Existing		ESPM Scores	Pass-Fail with minimum score for each section evaluated.		3rd party data evaluation & random on-site evaluation		Combines ENERGY STAR® ratings with best practice check lists.
EnergyScoreCards[51]	Operational	Existing	Statistical / regression based a database of ~5,000 large multifamily properties.	Overall index is based on EUI (kBTU/sq. ft./year), Heating Index is based on (BTU/ sq. ft. / HDD), Cooling Index is based on (BTU/ sq. ft. /CDD), Baseload Electric Index is based on (kWh/unit/ year), Baseload Fossil Fuel Index is based on (mmBTU/ bedroom/year), Water Index is based on (Gallons/ bedroom/day)	A,B,C,D on 6 metrics	Self	In-house Energy Analysts periodically review all user entered data and consult with the clients regularly on any inconsistencies seen.	Present the user with a scorecard in 6 metrics (overall, heating, cooling, baseload electric, baseload fossil fuel and water).	
ENERGY STAR® Commercial Energy Performance Ratings / Labels	Operational	Existing	Portfolio Manager uses building-specific statistical models (derived from CBECS data) to calculate a normalized annual energy use intensity (EUI) from measured energy use data submitted by users. This EUI is then compared to national distribution of energy performance of similar buildings which serves as the baseline and is indexed on the ENERGY STAR® performance scale of 1 to 100.	Source EUI	1 to 100; A score of 75 is used as the benchmark for top performance. Buildings score a 75 or higher are in the top quartile of performance relative to their peers.	Professional Engineers or Registered Architects conduction a verification process for buildings applying for ENERGY STAR® certification. IF all criteria are met, the PE or RA certifies at Statement of Energy Performance document.			Free web-based tool called Portfolio Manager. There is no fee for usage; but there can be costs for certification.

[51] Wegowise and EnergyScoreCards are examples of proprietary tools, of which there are a number.

Rating System	Rating Type	Applicability	Calculation Method	Performance Metric Used to Rate Building	Scale	Certification Requirements	Quality Assurance (QA) Requirements	Supplemental Information Provided	Additional[50] Information
ENERGY STAR® Industrial Energy Performance Ratings / Labels	Operational	Existing	ENERGY STAR® Plant Performance Indicators (EPIs) uses sector-specific statistical models to calculate a normalized annual energy use intensity (EUI) from data submitted by users. This EUI is then compared to national distribution of energy performance of industrial plants which serves as the baseline and is indexed on the ENERGY STAR® performance scale of 1 to 100.	Normalized Energy Use Intensity, such as MMBTU/unit of production.	1 to 100; Plants that score a 75 or higher are eligible for the ENERGY STAR® label.	Professional Engineers conduction a verification process for plants applying for ENERGY STAR® certification. IF all criteria are met, the PE certifies at Statement of Energy Performance document.	Statistical models used to generate ENERGY STAR® scores are test and reviewed by energy managers from the sectors benchmarked. Once EPA and the sector believe the models accurate measure performance, the rating is released.		Distribution of performance of similar industrial plants. Baseline data based on US Census data and data volunteered by industrial sectors.
ENERGY STAR® Home Energy Yard Stick	Operational	Existing	The Home yardstick Stick uses statistical models to calculate a normalized annual energy use intensity (EUI) from data submitted by users. This EUI is then compared to national distribution of energy performance which serves as the baseline and is indexed on a scale of 1 to 10.		1 to 10	None	None		Free, online tool

Rating System	Rating Type	Applicability	Calculation Method	Performance Metric Used to Rate Building	Scale	Certification Requirements	Quality Assurance (QA) Requirements	Supplemental Information Provided	Additional[50] Information
Green Globes for Continual Improvement of Existing Buildings (CIEB)	Hybrid	Existing	EPA ENERGY STAR® Performance Rating		Certification is awarded based on 1,000 possible points, across 6 categories. There are 4 levels of certification - 1 to 4 Green Globes.	A Green Globes certified 3rd party assessor is required to review documentation and visit the facility, with opportunities to interact with owner's representatives and staff. The assessor completes a final report and provides a final score.	3rd party assessor - a professional with credentials - professional judgment exercised.		
Green Globes New Construction	Hybrid	New	EPA ENERGY STAR® Performance Rating (target finder)			A Green Globes certified 3rd party assessor is required to review documentation and visit the facility, with opportunities to interact with owner's representatives and staff. The assessor completes a final report and provides a final score.			
Leadership in Energy Efficient Design (LEED) - 2009 NC	Hybrid	New	Allows multiple simulation tools to estimate EUI.	Points for energy efficient are based on either an ENERGY STAR® score or demonstrating a level of performance based on a prescribed method.		GBCI approved project reviewers and certified professionals.			

Rating System	Rating Type	Applicability	Calculation Method	Performance Metric Used to Rate Building	Scale	Certification Requirements	Quality Assurance (QA) Requirements	Supplemental Information Provided	Additional[50] Information
LEED for Existing Buildings: Operations & Maintenance (LEED EB: O&M)	Hybrid	Existing	Points in 7 categories; for energy category, uses ESPM.	LEED requires ENERGY STAR® score of 69. If the space type is not eligible data must still be input into Portfolio Manager, but there are alternative compliance paths.	4 Levels of Certification: Certified, Silver, Gold, Platinum	GBCI approved project reviewers and certified professionals.	Independent 3rd party reviewers are used.		Nine prerequisites must be met. Beyond those, points are awarded based on meeting the requirements of individual credits divided across the 7 categories. Based on the points achieved, the level of certification is awarded. A minimum of 40 points must be met to earn certification.
Massachusetts "Raising the BAR (Building Asset Rating)" Pilot – DOER	Asset	Existing	Allows multiple simulation tools to estimate EUI.	Site energy EUIs (kBTU/sq. ft.)	Absolute scale with EUI as the unit of measure.	Third-party			Web-based tool; proprietary software. state specific.
Multifamily Building Energy Performance Scoring Tool	Operational	Existing	Actual energy use per apartment is divided by "average" generated from scoring model for four specific characteristics, and this ratio is mapped to a scale of 1 - 100. Uses RECS 2005 multifamily data as point of comparison.	Total energy use per dwelling unit	1 to 100			Limited testing in Wisconsin has verified apparent ability to indicate likely energy savings potential for retrofits.	

Rating System	Rating Type	Applicability	Calculation Method	Performance Metric Used to Rate Building	Scale	Certification Requirements	Quality Assurance (QA) Requirements	Supplemental Information Provided	Additional[50] Information
RESNET/HERS	Asset	New and Existing	Approved software used to model energy use for the home; then compared to modeled energy use of the home if built to IECC 2006 code.	Energy use per square foot	HERS Index Scale; with zero equating to zero energy	Certified Practitioner/ Auditor	RESNET Quality Assurance Procedures and Software Tests		Proprietary software (several allowed).
Superior Energy Performance	Operational	existing	Statistical / regression based	EUI	Silver, Gold, Platinum	Certified Practitioner must verify performance.			SEP EM & V provides a calculation method for determining energy savings from baseline; Proprietary software.
U.S. DOE Commercial Building Energy Asset Score	Asset	New and Existing	A standard scoring tool estimates energy use by modeling the building given user-entered data and standard operational assumptions.	Source energy per square foot	1 to 100, with 100 representing most efficient buildings.	TBD for Verified Score	TBD for Verified Score	Provides preliminary upgrade recommendations.	There is no fee for usage; but there can be costs for verification. This rating system is currently under development.
						No requirements for Preliminary Score	No QA requirements for Preliminary Score		U.S. DOE Administered
U.S. DOE Home Energy Score	Asset	New and Existing	A standard scoring tool estimates energy use by modeling the building given user-entered data and standard operational assumptions.	Source energy for entire home (excluding baseload).	1 to 10, with 10 representing most efficient buildings.	Must be certified as a BPI Building Analyst OR HERS Rater. Must pass free DOE on-line exam **NOTE** Certification requirements are currently under review and may be modified in Spring 2014.	Requires that 5% of all homes scored must be rescored by another qualified assessor.	Provides preliminary upgrade recommendations.	Free tool; No fee for usage; but there can be costs for certification.

Rating System	Rating Type	Applicability	Calculation Method	Performance Metric Used to Rate Building	Scale	Certification Requirements	Quality Assurance (QA) Requirements	Supplemental Information Provided	Additional[50] Information
Wegowise[52]	Operational	Existing	For multifamily and single family residential properties, uses statistical regression based to proprietary database. For commercial properties, uses ENERGY STAR® score.	Measured EUI	Poor, Worse than Average, Better than Average, Excellent			Display to user and show percent difference to 50th and 25th percentile.	Proprietary software

[52] Wegowise and EnergyScoreCards are examples of proprietary tools, of which there are a number.

3.2 Building Energy Simulation

Building energy simulation is the physics-based software calculation of a building's energy consumption given a description of its physical assets, its occupancy and operation, and prevailing conditions.[53] A powerful tool for comparing design and operation alternatives, building energy simulation underpins many aspects of the building energy efficiency enterprise, including:

- integrated architectural, lighting, and mechanical system design for new construction and retrofits
- design of building control algorithms and model-predictive dynamic control
- building system commissioning, fault-detection, and diagnosis
- development of prescriptive energy efficiency codes, standards, and guidelines
- compliance with energy efficiency codes and standards
- building energy efficiency rating and labeling
- qualification for building energy efficiency rebates, tax credits, and other financial incentives
- evaluation, measurement, and verification

3.2.1 Specific Use Cases of Whole Building Simulation

This section focuses on two specific use cases: 1) energy simulation for code compliance and rating, and 2) energy simulation for evaluation, measurement, and verification. Energy simulation has a unique experimental capability that makes it valuable in these use cases; it can effectively isolate the impact of a building's physical assets from those of its occupancy and operation.

In order to serve as a sound basis for both regulatory and market-based programs and transactions, building energy simulation and its use cases must be standardized to establish comparative frameworks and regulated to prevent abuse of those frameworks. This section of the roadmap addresses standards for the use cases, for energy simulation software capabilities and data exchanges, and for energy simulation professionals.

Building energy simulation is most commonly used to address issues in the residential and commercial sectors. It can be used to address the building energy (primarily HVAC and envelope) aspects of industrial usage, but it does not address process uses such as motors, pumping, and compressed air.

3.2.1.1 Energy Simulation for Code Compliance and Asset Rating

Building energy efficiency codes typically provide multiple compliance paths. A "prescriptive" path supports line-by-line compliance with minimum prescriptive requirements. A "performance" path builds on the prescriptive path; it allows the use of simulation to demonstrate equivalent or better performance to a hypothetical "code baseline" version of the same building that meets the prescriptive requirements. The performance path is more involved but gives the designer-builder-owner greater flexibility in meeting code. Specifically, it allows the building to fail code in one part of the design while exceeding code by the same amount or more in another. Performance path code compliance enables

[53] Building energy can also be modeled using metered data analysis-- that approach is discussed in WG4.

both artistic, "signature" designs (e.g., glazing ratios of close to 100 percent) and more cost-effective buildings. Performance compliance paths will become more important as codes become more stringent and greater flexibility is needed to meet them in a cost-effective manner.

The mechanics of performance-path code compliance are often used as the basis for rating a building's inherent or asset energy efficiency; the rating is determined by the amount by which the building's performance exceeds that of a would-be code-minimum baseline. Ratings can also use simulation in a more direct, absolute fashion, by standardizing operational parameters and comparing buildings directly on the basis of simulated energy use intensity (EUI).

3.2.1.1.1 Commercial Buildings

In the commercial building space, multiple standards exist for simulation-based code compliance and beyond-code performance calculations. ASHRAE Standard 90.1 has parallel methods for each of these – the Chapter 11 "Energy Cost Budget" (ECB) procedure for code compliance, and the Appendix G "Performance Rating Method" (PRM) for beyond-code performance calculations. PRM prescribes and standardizes the baseline building more thoroughly than ECB; PRM standardizes constructions and glazing ratios whereas ECB does not, effectively giving the nominal building flexibility along additional design dimensions. ASHRAE Standard 189.1 and the International Code Council's (ICC) International Green Construction Code (IgCC) have performance-path compliance methods that are similar to PRM, while the International Energy Conservation Code (IECC) has a method that is similar to ECB. The COMNET Modeling Guidelines and Procedures (MGP) provide additional details that can be used with these rule sets, as well as an elaborated baseline building methodology based on ASHRAE's PRM. Starting in 2014, COMNET MGP will serve as the basis for California's Title 24 Alternative Calculation Method (ACM).

For asset ratings, LEED's Energy and Atmosphere Credit 1 is based on ASHRAE's 90.1 Appendix G, while Green Globes' GBI Energy Performance Credit provides multiple calculation paths, several of which are based on ASHRAE 90.1 Appendix G. DOE's Commercial Building Asset Score does not use a baseline building approach. Instead, it isolates the effect of the building's physical assets from those of its occupants and operators by using standard operating assumptions, including occupancy schedules and thermostat set-points, and then rates buildings based on calculated EUI.

Gap Analysis and Recommendations

A goal of any modeling procedure should be that given a specific building design, applying the rules should yield the same result (i.e., code pass/fail or building rating), regardless of the modeler or software used. To achieve this, a rule set needs to be sufficiently detailed to cover significant modeling inputs; for a commercial building these may number in the hundreds. California's Title 24 ACM details its code compliance modeling assumptions in a 250 page document.[54] On the other end of the spectrum, some modeling procedures do not have this level of detail and leave many inputs to the discretion of the modeler or the modeling software developer. For example, the 2012 IECC and the 2010 ASHRAE 90.1

[54] Draft version, "Nonresidential ACM Reference Manual," accessed November 2013, http://www.energy.ca.gov/title24/2013standards/implementation/documents/2013_nonres_ACM_reference/2012-10-26_2013_Nonres_ACM_Refernce_manual.pdf.

ECB describe their respective code compliance performance-approach procedures in seven and nine pages, and do not cover inputs such as HVAC equipment part-load curves, infiltration, and daylighting.

The COMNET Modeling Guidelines and Procedures (MGP) attempt to standardize the modeling procedures of several of the rule sets mentioned above.[55] COMNET has established detailed energy simulation input assumptions that address multiple simulation end uses, including establishing eligibility for federal tax deductions per $179D of the Internal Revenue Service (IRS), calculating percent savings for point eligibility for green building rating systems, and estimating annual energy use for a building in the design phase for the purpose of energy labeling. The COMNET MGP is referenced by the 2013 update of the Title 24 ACM. However, because it was developed outside the established procedures for enhancing ASHRAE or LEED standards, it has not yet been accepted by ASHRAE 90.1 or the IECC.

An equally significant gap is created by the multiplicity of performance path compliance methods and the prescriptive changes that accompany updates. Not only are simulation results using ASHRAE 90.1 Appendix G not directly comparable to those using California's Title24 ACM, but results using ASHRAE 90.1-2004 Appendix G are not directly comparable to those using 90.1-2007 Appendix G. This Balkanization creates problems and confusion in practice. For instance, it is not clear how buildings certified under different versions of LEED compare to one another. Another problem is the extreme load on software development, the resultant lack of availability of compliance and rating software, and the ultimate impact this has on compliance rates and building energy efficiency. Because of the care and tedium involved, automation of performance procedures is critical to their widespread and effective use. However, because performance procedures are based on continually moving prescriptive baselines, the software that implements them must be continually updated.

A. Single rule set

All codes and beyond-code programs should use a single rule set, i.e., 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.

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.

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

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

[55] COMNET, "Buildings Energy Modeling Guidelines & Procedures (MGP),accessed November 2013, http://www.comnet.org/mgp/?purpose=0.

Some of these recommendations are already being pursued. The proposed ASHRAE 90.1 Addendum bm would create a unified code compliance/beyond-code path. This path would be based on ASHRAE 90.1-2004 Appendix G and require 45 percent performance improvements for compliance. The implication is that subsequent code updates would take a more top-down approach where the performance goal is developed first and prescriptive requirements – possibly in the form of building-specific packages – are created to match the performance goals. Eventually, prescriptive options may disappear entirely, making simulation-driven, performance-based compliance mandatory.

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

3.2.1.1.2 Residential buildings

Unlike the commercial space, the use of energy modeling tools for demonstrating code compliance, calculating asset ratings, and awarding certificates within the residential space is characterized by a plurality of methods implicitly embodied in tools. Many of these methods are software program and end-use specific, and do not build on, reference, or reuse one another.

Some residential rating systems provide a method for accreditation of simulation tools for generating their specific ratings. The software tool accreditation process usually involves submitting formal documentation demonstrating the proposed software's effectiveness. In the case of a HERS rating, approved software tools must generate a code-compliant reference home, pass HERS BESTEST[56] Tier 1 tests, produce acceptable outputs for HVAC, duct distribution efficiency, and DHW (domestic hot water) predictions, and calculate a HERS rating within some acceptable margin of error.

The software accreditation process does not address minimum standards defining the complexity of the underlying physics engines that generate energy usage predictions. Other residential rating systems require a single physics engine be used, eliminating the need for software accreditation entirely. Multiple end-user applications can be used to access the same rating engine. For example, the DOE Home Energy Score requires use of their centralized rating engine, but allows multiple software systems to access it.

Existing residential ratings systems also have naturally evolved to serve the different transactions that occur within a building's lifetime; for example, time of construction, time of retrofit, and time of sale.

Gap Analysis and Recommendations

Given the variety of rating systems in the marketplace, a standard or standards may be needed to ensure minimum technical rigor for software tools used to develop ratings for specific uses. For example, minimum software tool feature requirements for generating a rating for a newly constructed highly efficient home could include the ability to model hourly thermal mass effects and/or external shading devices using the rigor defined above, while minimum software tool feature requirements for time of retrofit ratings of existing homes may be relaxed with respect to thermal mass but include the

[56] Developed by the National Renewable Energy Laboratory (NREL), the Home Energy Rating System (HERS) Building Energy Simulation Test (BESTEST) are standard methods of test for building energy analysis computer software.

ability to correctly model the part load operation of existing HVAC systems or have the capability to model a specific range of retrofit options.

Furthermore, testing and administrative procedures may be useful in ensuring that software tools that produce certain types of ratings are tested using defined procedures whenever a new version of the software is released.

A. **Working Group to identify standards for different rating purposes**
   It is recommended that a working group be developed, with public involvement, to identify what standards are required and cost effective given different rating purposes (e.g., real estate transaction, posting on 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.

3.2.1.1.3 Multi-family buildings

Both ASHRAE and ICC consider multifamily buildings having three or fewer stories (above grade) to be low-rise and they are mostly covered under residential standards. Those having greater than three stories (above grade) are considered high-rise residential and are covered under commercial standards. As such, the reader can refer to descriptions of existing standards, gaps, and recommendations in the commercial and residential sections above to describe multifamily buildings appropriately.

3.2.1.1.4 Data Centers

While mostly handled in the past by commercial building energy codes and labels, data centers are now splitting off into a separate category. In part because of their extreme internal load characteristics and thermal comfort requirements, data centers need to keep computers – rather than human occupants – "comfortable."

Gap Analysis and Recommendations

ASHRAE Standard 90.1 currently covers all computer rooms, but a new standard which is currently under development, ASHRAE Standard 90.4, will cover larger data centers. When Standard 90.4 is complete, those data centers will likely be removed from the scope of Standard 90.1. Informed by ASHRAE Technical Committee 9.9, Standard 90.4 is still in its early formation stages, and the Standard Project Committee (SPC) is still debating foundational decisions regarding both efficiency standards and a path to those standards. For instance, SPC has not decided whether 90.4 will set absolute Power Use Efficiency (PUE)[57] targets – or if it will pursue a path similar to that of 90.1 with minimum PUEs determined by prescriptive requirements. In the case of the latter, simulation will be a critical element. TC 9.9 is looking to answer some of these questions using ASHRAE-sponsored research projects.

[57] PUE, the ratio of total data-center energy consumption to computer equipment energy consumption, is the de facto standard efficiency metric for data-centers.

A. Standard for data centers

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.

3.2.1.2 Energy Simulation for Whole-Building Energy Efficiency Incentives

Energy simulation is often used to generate predictions for awarding performance-based incentives. Incentives can be grouped into two broad categories: 1) funding provided by utility-sponsored energy efficiency programs in the form of rebates, and 2) subsidies provided by federal, state or local governments in the form of tax credits or deductions.

3.2.1.2.1 Commercial Buildings

Model-based energy efficiency incentives for commercial buildings consist of the $179D federal tax deduction, utility Energy Design Assistance (EDA) for new construction programs, and a single pilot program for deep retrofits.

The $179D federal deduction, enacted by the 2005 Energy Policy Act, offers monetary incentives for new and retrofitted buildings achieving 50 percent savings beyond code. The statute specifies simulation as the savings calculation method and ASHRAE 90.1-2004 PRM (i.e., Appendix G) as the calculation protocol, with additional modeling requirements for occupancy, infiltration, and lighting power borrowed from California's Title 24-2005 ACM. The Internal Revenue Service has certified a number of simulation engines for use, a list that is sometimes referenced by other programs. $179D requires only a professional engineering certificate of the modeler. With the help of NREL, DOE has developed a screening tool for $179D that uses regression-based estimates derived from EnergyPlus simulations for DOE/NREL reference buildings.

Many utilities operate Energy Design Assistance (EDA) programs either directly or indirectly, using in-house modeling staff or contractors. Program details vary, but a representative program is the one run by Xcel Energy in Colorado. Baseline performance is established by ASHRAE 90.1-2007, although sub-jurisdictions can adopt more stringent standards. Xcel EDA targets new commercial buildings over 50,000 square feet in size, and sets a performance target of 15 percent above code. The modeling protocol is ASHRAE 90.1-2007 Appendix G, modified to reflect Colorado-specific conditions, as well as the early stage design nature of the program. On a case-by-case basis, projects can apply for exemptions from various aspects of the modeling protocol including, and most frequently, allowances for plug and process loads. Xcel mandates the use of hourly simulation software. Participating consultants must have a Building Energy Modeling Professional (BEMP)[58] or a Building Energy Simulation Analyst (BESA™)[59] credentialed modeler on the team and meet additional project and software experience requirements.

[58] Information on ASHRAE's Building Energy Modeling Professional (BEMP) certification is available at: https://www.ashrae.org/education--certification/certification/building-energy-modeling-professional-certification.

[59] Information on the Association of Energy Engineers' Building Energy Simulation Analyst (BESA™) certification is available at http://www.aeecenter.org/i4a/pages/index.cfm?pageid=3479.

Gap Analysis and Recommendations

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, *Standard method of test for the evaluation of building energy simulation programs*, is not sufficiently comprehensive for this purpose at this time.

A. Simulation methodologies and protocols

ASHRAE standard 209 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 be highly data-driven, and therefore may evolve slowly. Pushing the fast-forward button on 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.

3.2.1.2.2 Residential Buildings

Utility sponsored whole-house energy efficiency programs often adopt the EPA/DOE Home Performance with ENERGY STAR® (HPwES) or a similar "whole house" program model. While energy simulation is not a specific program requirement of HPwES compliance, when a program offers a whole-house incentive pathway, energy simulation – both building-specific and more generally using prototype buildings – is sometimes used to generate the incentive. An existing standard, ANSI/BPI Standard 2400, *Standard Practice for Standardized Qualification of Whole-House Energy Savings Predictions by Calibration to Energy Use History*, was developed as a methodology for determining a qualifying baseline for determining energy savings. The standard has completed public review and has been published. Efforts (led primarily by Efficiency First) to educate and promote the standard to influential stakeholders continue. RESNET has developed a variation of their energy rating tool accreditation process for use in existing home retrofits. This test procedure uses all the rating test requirements except the rating score test, and adds a requirement to test the interaction of proposed improvements to the baseline model.

DOE's Building Energy Descriptor Exchange Standard (BEDES) includes standard descriptors for energy conservation measures (ECMs); the precise definition of each measure will be set by a technical working group. Although BEDES is not a simulation-specific schema, simulation guidance can be developed for these descriptors. Recent work by Rocky Mountain Institute (RMI) is developing such guidance in the form of measure simulation cutsheets that specify simulation methodologies, required inputs, and related benchmarking and analysis. NREL's Building Component Library (BCL) – an online repository of simulation model data objects (including scripts for transforming simulation input models) – includes public, auditable, citable implementations of common ECMs for the OpenStudio platform. OpenStudio is currently specific to the EnergyPlus simulation engine, but can be generalized to other engines.

Gap Analysis and Recommendations

Several standard gaps hamper adoption of whole-house performance based rebates. BEDES, RMI's ECM cutsheets, and NREL's BCL are recent efforts that do not coordinate with one another. For example, the cutsheets and BCL measure implementations are not standardized. In addition, these programs largely target commercial buildings. In the residential arena, there is a lack of standard definitions and protocols for simulating energy conservation measures. Currently, different simulation programs implement these differently. For example, some simulation tools model the addition of an attic fan using empirically-derived equations that calculate annual electrical load and an associated change in thermostat set-point to represent the thermal load changes. Other tools model this measure by increasing infiltration/ventilation rates during summer nighttime periods. Even within a single tool, there are often multiple ways to model the same measure. Where there are different approaches, there is no basis for choosing among them based on accuracy. This is addressed more specifically in Section 3.2.2.1, Energy Simulation Software Capabilities and Accuracy.

A related gap is a lack of well-defined, accepted uncertainty ranges in savings calculations. Uncertainty can be due to the simulation method approximations or the simulation model inputs. Additionally, service providers lack software tools that can easily generate uncertainty estimates. In residential whole house projects, different homeowners often choose to make different investments based on different risk tolerances. When risk tolerances are not exposed, investments are often not made.

A standardized procedure for simulation model review is also missing. Currently, models are reviewed by individuals of varying competence using ad-hoc procedures often associated with specific simulation tools. The lack of standardized model review protocols creates inconsistent results and degrades confidence in the modeling enterprise. The RMI measure cutsheets include model review protocols, including benchmarking, for individual measures. The BCL can be used as a proactive model review tool. Models created using pre-approved BCL content and measures are in some sense "good by construction." Xcel Energy's Energy Design Assistance Program uses OpenStudio and the BCL in this precise way to reduce model review costs; it should be noted that this is a pilot application.

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

The recommendation is to align and cascade the BEDES, measure cutsheet, and BCL projects, potentially using ASHRAE Standard 209P as a standards vehicle for the simulation protocols. HERS BESTEST, BPI 2400 standard for establishing a baseline in an existing home, 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 priority and should be completed in 5+years.

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. As this is not within the scope of ASHRAE 209P, it should be picked up elsewhere. An initial framework can likely be put together in about 2 years.

Recommended Timeline: This is a near-term priority and should be conducted in 0-2 years.

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. This could be picked up jointly by the RESNET calibration standard, and ASHRAE standard 209P.

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.

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

3.2.1.3.1 Commercial Buildings

Building energy simulation is a commonly used tool for the evaluation of energy efficiency programs and for the measurement and verification of projects (EM&V). It is identified as Option D in the International Performance Measurement and Verification Protocols[60] (IPMVP). Calibrated energy simulation can be used for both retrofits and new construction. Energy use is typically simulated for components or the whole facility. The simulations may be of either specific or representative buildings.

Simulation is most useful for estimating savings from commercial or industrial measures affecting HVAC usage. This includes HVAC efficiency and envelope improvement measures. Applications for industrial facilities tend to be more like commercial applications. Simulation is also commonly used to estimate the effects of HVAC interaction with lighting efficiency measures. It may also be used to estimate equivalent full load hours for HVAC equipment. It is useful where:

- pre-retrofit energy data do not exist or are unavailable
- post-retrofit energy use data are unavailable or obscured by factors whose influence will be difficult to quantify
- the expected energy savings are not large enough to be separated from the facility's utility meter using IPMVP Option C

[60] Efficiency Valuation Organization. "International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings Volume 1," last modified 2012, http://www.evo-world.org/index.php?option=com_content&view=article&id=272&lang=en.

- the savings associated with individual ECMs need to be determined, but IPMVP Options A or B isolation and measurements are too difficult or costly[61]

The DOE Uniform Method Project protocols call for simulation for commercial and industrial lighting interactive effects, small commercial and residential unitary and split system HVAC cooling equipment-efficiency upgrade, peak demand, and time-differentiated energy savings.[62] These protocols are currently referenced by public utility commissions responsible for revising evaluations of utility programs.

Reference buildings are frequently used in commercial modeling. This application is most common with prescriptive rather than custom measures. Standard commercial reference building models are available from the National Renewable Energy Laboratory (NREL)[63] and Pacific Northwest National Laboratory (PNNL).[64]

Calibration is a critical element of accurate simulation. Models must be calibrated to utility billing data and/or end-use metered data so that the model reasonably matches actual consumption and demand from either pre- or post-retrofit conditions. ASHRAE Guideline 14, *Measuring Energy and Demand Savings*, addresses calibration of building simulation models, as does the Building Performance Institute's BPI 2400-S-2011, *Standardized Qualification of Whole-House Energy Savings Estimate* and the California Evaluation Framework and Protocols.[65,66]

Gap Analysis and Recommendations

There is a similar need in the residential space as described in the commercial buildings discussion above:

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, BPI 2400-S-2011, and the California Evaluation Framework and Protocols.

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

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[61] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). "ASHRAE Guideline 14, Measuring Energy and Demand Savings," last modified 2002, https://www.ashrae.org/standards-research--technology/standards--guidelines/titles-purposes-and-scopes#Gdl14.

[62] Jayaweera, T., Haeri, H., Bruchs, D., Keeling, J., Khawaja, S., Rushton, J., et al. (2013). *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. National Renewable Energy Laboratory.

[63] Deru, M., Field, K., Studer, D., Benne, K., Griffith, B., Torcellini, P., et al. (2011). *U.S. Department of Energy Commercial Reference Building Models of the National Building Stock.* Golden, CO: National Renewable Energy Laboratory.

[64] Thornton, B., Rosenberg, M., Richman, E., Wang, W., Xie, Y., Zhang, J., et al. (2011). *Achieving the 30% Goal: Energy and Cost Savings Analysis of ASHRAE Standard 90.1-2010.* Pacific Northwest National Laboratory.

[65] TecMarket Works. (2004). *The California Evaluation Framework.* Oregon, WI: TecMarket Works.

[66] TecMarket Works. (2006). *California Energy Efficiency Program Evaluation Protocols: Technical, Methodological, and Reporting Requiremnts for Evaluation Professionals.* Oregon, WI: TecMarket Works.

3.2.1.3.2 Residential Buildings

Simulation is most useful for estimating savings from residential measures affecting HVAC usage. This includes HVAC efficiency and envelope improvement measures. Simulation is also commonly used to estimate the effects of HVAC interaction with lighting efficiency measures. It may also be used to estimate equivalent full load hours for HVAC equipment. It is useful where:

- pre-retrofit energy data do not exist or are unavailable
- post-retrofit energy use data are unavailable or obscured by factors whose influence will be difficult to quantify
- the expected energy savings are not large enough to be separated from the facility's utility meter using IPMVP Option C
- the savings associated with individual ECMs are needed, but IPMVP Options A or B isolation and measurements are too difficult or costly[67]

The California Evaluation Framework identifies building simulation as robustly applicable for residential air leakage sealing, cool roofs, duct leakage, exterior shading, natural ventilation, passive solar heat, radiant barriers, refrigerant charge and airflow, sunspaces/atria, thermal mass, and zonal HVAC systems.[68]

Building simulation is not currently identified in the Uniform Methods Project protocols for residential buildings. The next edition, due in 2014, may specify building simulation. Simulation models may be used to calculate parameters for use in default energy savings values in technical reference manuals (TRMs) issued by public utility commissions. For example, the Pennsylvania TRM[69] uses per-unit energy and demand savings estimates based on prior building simulations of windows.

Reference buildings are typically used in residential modeling, as the populations of participants tends to be in the thousands and individual building modeling is not cost-effective.

Calibration is a critical element of accurate simulation. Models must be calibrated to utility billing data and/or end-use metered data, so that the model reasonably matches actual consumption and demand from either pre- or post-retrofit conditions. ASHRAE Guideline 14 addresses calibration of building simulation models, as does BPI 2400-S-2011, and the California Evaluation Framework and Protocols.

Gap Analysis and Recommendations

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,

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[67] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). (2002). *ASHRAE Guideline 14, Measuring Energy and Demand Savings*. Atlanta, Georgia: ASHRAE.

[68] TecMarket Works. (2004). *The California Evaluation Framework*. Oregon, WI: TecMarket Works.

[69] Public Utilities Commission. 2012. *Technical Reference Manual: State of Pennsylvania Act 129 Energy Efficiency and Conservation Program & Act 213 Alternative Energy Portfolio Standards.*

including ASHRAE Guideline 14, BPI 2400-S-2011, and the California Evaluation Framework and Protocols.[70,71]

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

3.2.2 Energy Simulation Standards

3.2.2.1 Energy Simulation Software Capabilities and Accuracy

Software is certified for specific purposes on the basis of its scope of simulation capabilities and its "accuracy" within that scope.

3.2.2.1.1 Commercial Buildings

There is no single "acceptance" standard for energy simulation software. There is a standard method of test, ASHRAE Standard 140 and sets of reference results. A number of simulation engines including EnergyPlus and DOE2.2 have been tested using this method.[72] The intent is that individual programs set use-specific acceptance criteria based on deviation from the reference results. The Internal Revenue Service uses ASHRAE Standard 140 to certify software for calculating commercial building energy efficiency tax deductions. ASHRAE 90.1 requires software to be tested to Standard 140, but includes no acceptance criteria. It is not clear how many other programs require certified software and how many of those simply reference the IRS certification process. Some rating programs – DOE's Commercial Building Asset Rating, for example – are single-engine by virtue of their implementation. The state of California is moving in the direction of specifically certified software on a context-sensitive basis. For example, software would be certified based on a cross-match of its capabilities and elements of the building.

Gap Analysis and Recommendations

ASHRAE Standard 140 itself has growing test coverage, although some of the tests are outdated and need refurbishing. An important goal for ASHRAE Standard 140 is increasing the number of tests that have reference results obtained from test facility measurement. Most of the current tests are either simple enough to have known analytical solutions or are consensus results generated by multiple simulation engines that have each "passed" the analytical tests. A related meta-gap is the absence of a roadmap for energy simulation validation. This gap is exacerbated by the high cost of obtaining high-quality validation-grade measured data and by the circular dependence between the validation and the measurement processes. A standard set of acceptance thresholds for different energy simulation end-use cases is also missing.

A. Develop an energy simulation validation roadmap

This 2-5 year activity would use test the growing collection of test facility data to characterize and benchmark the simulated accuracy of major building-physics phenomena and common

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[70] TecMarket Works. (2004). *The California Evaluation Framework*. Oregon, WI: TecMarket Works.

[71] TecMarket Works. (2006). *California Energy Efficiency Program Evaluation Protocols: Technical, Methodological, and Reporting Requiremnts for Evaluation Professionals*. Oregon, WI: TecMarket Works.

[72] Henninger, R., & Witte, M. (2003). *EnergyPlus Testing with ANSI/ASHRAE Standard 140-2001 (BESTEST*). U.S. Department of Energy.

HVAC system types, and create a prioritized list of simulation hot-spots combined with measurement experiments needed to resolve or upgrade them.

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

B. Develop standard energy-simulation engine acceptance criteria for various end-uses

This 2-5 year activity would follow closely behind the simulation accuracy benchmarking activity described above. It could be led by a standards organization whose published scope covers this type of activity, such as ASHRAE, RESNET, or COMNET.

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

3.2.2.1.2 Residential Buildings

RESNET has published procedures for accrediting simulation programs for various purposes. These include RESNET Publication 06-002, *Procedures for Verification of RESNET Accredited HERS Software Tools*, RESNET Publication 2006-001, *Procedures for Certifying Residential Energy Efficiency Tax Credits*, and RESNET Publication 07-003, *Procedures for Verification of International Energy Conservation Code Performance Path Calculation Tools*. Publication 06-002 is referenced in the Mortgage Industry National Home Energy Rating Standards as well. HERS BESTEST, developed by the National Renewable Energy Laboratory (NREL), is a method of test that assesses calculation capabilities for residential simulation software.

Gap Analysis and Recommendations

A. Create a companion to the RESNET test to increase the usability and standardization of other rating approaches

In regulated contexts, credentials for the accuracy of calculations are extremely valuable. Therefore, the development of a third-party test that could be used as a companion to the RESNET test (but adapted to other use cases) would be helping in increasing the usability and standardization of other rating approaches. Utility programs rely on state-level technical reference manuals (TRMs) to approve calculation methodologies. The manuals seek to include references to standards as opposed to specific tools.

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

3.2.3 Energy Simulation Professionals

Appropriate use of simulation tools may require understanding of engineering principles and specific training in the use of the tools. Some simulation end-use instances – including instances of code compliance and asset rating – require credentialed simulation professionals.

3.2.3.1 Commercial Buildings

There are two energy simulator certificates: ASHRAE's Building Energy Modeling Professional (BEMP) and AEE's Building Energy Simulation Analyst (BESA™). The number of professionals holding each certificate is small (under 300). It is also not clear which programs require these certificates.

ASHRAE specifies in Standard 14 that five years of simulation experience is required for use of calibrated simulation for measurement and verification. Standards addressing simulation do not always address this issue.[73,74]

Gap Analysis and Recommendations

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

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 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 priority and should be completed in 5+years.

3.2.3.2 Residential Buildings

A standardized process for credentialing qualified users of residential energy simulation software currently does not exist. RESNET offers a HERS rater credentialing system. The Home Energy Score – DOE's residential asset rating program – certifies users for use of the Home Energy Scoring Tool, but this is a program/rating-specific credential. BPI has a software-agnostic residential modeling credential in development.

Gap Analysis and Recommendations

A. Standardized methods of credentialing qualified users of residential energy simulation software should be created

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

[73] Jayaweera, T., Haeri, H., Bruchs, D., Keeling, J., Khawaja, S., Rushton, J., et al. (2013). *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* National Renewable Energy Laboratory.

[74] Efficiency Valuation Organization. (2012). *International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings Volume 1.* . Efficiency Valuation Organization.

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

4.0 Introduction

Evaluation, measurement, and verification (EM&V) within energy efficiency (EE) covers a wide range of practices that are undertaken to quantify the effects of EE measures, projects, and program activities, as well as methods to assess EE's potential effects and assess the performance of retrofits or programs.[75] The quantification of energy savings for a particular measure or project is known as Measurement and Verification (M&V). From this broad landscape, the EESCC working group on EM&V chose to focus on energy efficiency savings, specifically in buildings, and issues closely associated with those savings (e.g. reporting). Energy savings are the fundamental connection between energy efficiency activity and understanding what that activity accomplished to inform business, economic, and policy analysis or decisions. Some approaches are applicable to industrial processes as well, though these are not the focus of the described issues and gaps.

The "Evaluation" component in EM&V captures implementation and programmatic impacts such as measure saving's persistence and market transformation. Further, an important aspect of evaluation captures the cost benefit aspects of programmatic EE, identifying net savings by assessing "free rider[76]" and "spillover[77]" rates. Lastly, the methods to quantify EE program savings through evaluation inform the development, deployment, and improvement of programs. This chapter captures several levels of EM&V, while focusing on M&V as the technical basis for determining energy reduction values resulting from EE investment.

EM&V savings calculations are used to support electrical industry resource planning by utilities and electrical system operators. Their use also applies to natural gas resource planning, though to a lesser extent. This chapter focuses on the use of EM&V methods to determine energy savings as essential information in its own right and as a critical component that underlies many of the other EM&V activities. This includes the assessment of value of EE, particularly of EE programs, in comparison to other energy resources or approaches to satisfying energy demand. The EM&V working group of the EESCC identified a broad array of issues in the determination of electricity savings and selected those deemed most ready for road mapping in the direction of refined guidelines, identification of best practices, and ultimately, standards.

The field of EM&V evolved from the original EE programs in the mid-to-late 1970's and has built up a wide array of tools and methods to determine savings in many contexts. This chapter builds on that extensive body of work to identify standardization activities that would help the industry move towards

[75] "Programmatic activity" covers activities conducted by utility and non-utility program administrators, often funded by electric or natural gas utility rates (third-party sources), and overseen by public authorities such as Public Utility Commissions, municipal or independent boards.

[76] Free riders are EE program participants that utilize rebate or incentives offered in cases where they would have made the investment without these economic stimulate.

[77] Spillover accounts for EE investment that occurs as a result of the presence of programmatic stimuli, but where participant does not utilize a rebate or incentive in order to make the EE investment.

more consistent and rigorous savings determination. There are more than 250 entries in the EESCC Inventory Database tagged for EM&V. Among those most commonly used in the EM&V field are:[78]

- International Performance Measurement and Verification Protocol (IPMVP)
- North American Energy Standards Board (NAESB) Model Business Practice Standards
- State and regional protocols such as California, Pacific Northwest, and Independent System Operators (ISOs) in the Northeast
- U.S. Department of Energy (DOE) efforts, including the State and Local Energy Efficiency Action Network (SEE Action) and the Uniform Methods Project (UMP)

Review of these references reveals the almost universal practice of considering savings as the difference between what occurred and what *would have* occurred had no energy efficiency action been taken. This perspective underlies most, if not all, of the development of methods up to this point, and frequently guided the EM&V working group in its prioritization of various topics. Over time, modifications of existing protocols or development of new EM&V methods may be needed to capture other potential uses of EM&V results, for example (private) EE finance and the closely related area of metrics for energy management.

Even with this history, continued expansion of EE and its potential use in new areas (e.g. air quality improvement) has given rise to a need to increase the level of transparency and rigor, and at the same time quicken the availability of results at lower costs. Underscoring this are several studies that indicate that there is progress to be made in increasing consistency and comparability as savings from similar activities are assessed in different venues. These provided a major impetus for this working group's efforts. The other impetus is the perception of the increasing availability of rich data in the form of higher resolution usage information for the buildings and individual pieces of equipment, and for the additional program information that plays a critical role in EM&V.

4.1 Measurement and Verification Methodological Approaches

As discussed in the Introduction, significant elements of EM&V are the measurements and calculations used to determine the reductions in energy use due to energy efficiency measures. The combination of methodological approaches, engineering calculations, and adjustments factors are captured in EM&V activities, to which this section is dedicated. Many of these monitoring and verification approaches also apply to specific sites.

The general approach to measuring reductions from EE measures and projects are presented in the IPMVP description of M&V approaches. The activities that ensue, once an approach is selected, may include direct measurements before and after, indirect measurements using proxy variables or statistical methods on sample populations of measures or billing data, engineering analysis, or simulation models. Numerous resources have been developed over the past three decades that capture and standardize a broad range of engineering details for the express purpose of simplifying and

[78] A comprehensive listing of relevant EM&V documents can be found in the EESCC Inventory Database: http://toolswiki.ansi.org/tiki-index.php?page=EESCCTabs.

standardizing the process of Measurement and Verification. This section addresses methodological approaches that capture savings at the project level and those methods that allow for estimation of savings at the program level. These include baseline criteria, statistical methods, whole building meter, and complex large retrofit analysis. In addition to measurement approaches, methods for assessing variability in gross savings are addressed through measure life and persistence studies, which help to reflect the lifecycle impacts of EE.

The use of Technical Resource Manuals (TRMs) is often viewed as a means to standardize approaches, and to conserve evaluation resources by providing data and information on specific EE measures and program types that can be applied in appropriate similar settings without incurring the additional cost of specific site measurement when not needed to achieve a desired level of accuracy. A number of efforts underway to standardize processes for EM&V, including the Department of Energy (DOE) Uniform Methods program (UMP), also seek to consider how increased standardization of methods will not only produce comparable results, but will also conserve resources. Depending on how the EE savings data will be used (i.e., energy services company (ESCO) settlement purposes, system planning, or ISO markets) there may be different value placed on specific aspects of the data. The governing conditions will impact decisions made by those overseeing evaluation activities regarding the value of specific information versus the cost of gathering and analyzing data to provide the most appropriate information.

It should be noted that M&V is a tool used in many program impact evaluations. M&V is also used in other arenas including evaluating compliance with guaranteed savings claims in performance contracts between energy consumers and ESCOs. Much of the early work in standardization of M&V methods and terminology was driven by the ESCO community's needs. Today, a primary driver for standardization and increased rigor springs from ratepayer-funded state utility programs and the 25 or more states with EE Portfolio Standards or EE policy goals. M&V is also used to estimate the savings from projects undertaken by organizations so that they can determine the achieved financial impact of projects or progress toward internal sustainability goals. The ISO 50001 energy management system standard currently supports such activities. Throughout the rest of this chapter, the focus is on EM&V of programmatic energy efficiency and on M&V as a tool used within EM&V.

4.1.1 Baselines

Determining the impact of energy efficiency measures, projects, or programs requires a comparison of the amount of energy used after the energy efficiency action was taken to the energy use that *would have* occurred in the absence of the measure, project, or program. In describing what would have occurred in the absence of the intervention, the term "baseline" can refer to the equipment that would have existed, the set of conditions that define the operation of the systems, or to the estimated energy use or demand of the systems. Baselines can be defined at a program level, project level, measure level, or individual measure level.

A key evaluation responsibility is to determine the proper baseline for a project, measure, or program. Improper baseline definition in the *ex ante* (pre-project or program implementation) calculations is a common cause for differences between verified and *ex ante* savings. Differences in baseline definition can result in significant differences in savings reductions estimates for the same EE implementation activity. This can result from correct use of algorithms and variables in savings calculations, but the underlying logic is incorrectly applied to the location, facility, or measure. State jurisdictions defining different baselines for a the same measure type result in different net savings may in some cases be justified due to differences in building stocks and more or less mature markets for specific products.

Increasing consistency and comparability in the practice of EM&V will raise confidence in EM&V results. The various evaluation guidelines are consistent in describing baseline development for the main project categories. Several evaluation guidelines and standards define baselines at a high level:

- NAPEE (National Action Plan for Energy Efficiency) Model Impact Evaluation Guide
- SEE Action Energy Efficiency Program Impact Evaluation Guide
- PA Evaluation Framework
- The CPUC Decision 11.07.030 Attachment B (provides more detailed instruction related to the provisional energy savings determination of site-specific retrofit projects)
- ISO-New England and PJM M&V Manuals
- NAESB Model Business Practice Standards

The SEE Action Energy Efficiency Program Impact Evaluation Guide includes extensive material on selecting baselines. This guidance may be sufficient to meet the needs for many if not most programs and measures. While the theoretical constructs for baseline estimation are fairly straightforward and are commonly defined in the literature, there are several areas in which more structured guidance could be used:

1. Selecting between in-situ and standard practice baselines;
2. Use of “dual” or two-part baselines and baseline categories; and,
3. Creating baselines in industrial settings (production-related or using an energy use index).

Gap Analysis and Recommendations

A. Selecting between in-situ and standard practice

While the documents above 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 standard practice (ISP) could be used to determine a baseline, or a baseline could be determined using the specific circumstances at the retrofit site (in-situ baseline).

Determining if a project or measure triggers a Code/ISP baseline or an in-situ 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.

Recommended Timeline: This should be conducted in the long-term: 5+ years.

B. Treatment of dual baselines

When an EE program induces the replacement of equipment before it would otherwise have been replaced, an issue arises whether the applicable baseline should be based on the efficiency of the replaced equipment or based on 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 been standard practice in impact evaluation to determine the first year energy savings from energy efficiency measures and then 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 in-situ baseline for the remaining years of useful life and then using a code or industry standard 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.

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

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.

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

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.

A number of documents provide guidance on developing baselines for industrial facilities, including the Northwest Energy Efficiency Alliance's (NEEA) *Energy Baselines Methodologies for Industrial Facilities*,[79] the *Superior Energy Performance Measurement and Verification Protocol for Industry*,[80] and DOE's *Steps to Developing a Baseline: A Guide to Developing an Energy Use and Energy Intensity Baseline and the Reporting Requirements for the Save Energy Now LEADER Pledge.*[81]

Practice in this area should be examined and, to the extent possible, standardized. Or if that proves infeasible, standards should be developed to describe the method or procedure used, so there is transparency.

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

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 usage and being programmed to estimate equations describing building energy usage. The advantages are that then 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

[79] Northwest Energy Efficiency Alliance, "Energy Baselines Methodologies for Industrial Facilities," October 17, 2013: http://neea.org/docs/default-source/reports/energy-baseline-methodologies-for-industrial-facilities.pdf?sfvrsn=7.

[80] Regents of the University of California, "Superior Energy Performance Measurement and Verification Protocol for Industry," November 19, 2012, http://www.superiorenergyperformance.net/pdfs/SEP_MV_Protocol.pdf.

[81] U.S. Department of Energy, "Steps to Develop a Baseline: A Guide to Developing an Energy Use and Energy Intensity Baseline and the Reporting Requirements for the Save Energy Now LEADER Pledge," http://www1.eere.energy.gov/manufacturing/resources/pdfs/leaderbaselinestepsguideline.pdf.

buildings) but at potentially different accuracy at each individual building. While this is an interesting possibility for developing faster, much less costly EM&V, it relies on the quality of the benchmark the building's EMS's 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,[82] but more must be done for self-benchmarking buildings to provide a reliable basis for EM&V.

Research 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 as to the purpose and use of the self-benchmarking capability.

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

4.1.2 Methods for Determining First-Year Savings

The previous section described the starting point for determination of energy savings for any piece of equipment, building, or complex – defining and measuring the baseline energy consumption. Once a baseline is established, a variety of methods to analyze the impacts of energy savings actions taken to reduce consumption may be used. Energy savings activities may include equipment replacement, maintenance, commissioning, or retro commissioning. It could also include operational changes affected by end-user behavior. The following sections describe the most commonly used approaches for developing sound estimates of energy savings for these various energy-savings activities and identifies gaps in moving towards standardization.

4.1.2.1 Verification, IPMVP Option A, IPMVP Option B

One of the most common methods for evaluating projects within a program is to conduct onsite verification of the installation in combination with collection of site-specific data in order to implement IPMVP Option A or B. These methods can be applied to fully custom projects or can be used in conjunction with partially deemed values from a TRM. These methods are generally well understood, yet different implementations of Option B may result in different calculated results. With growing data availability, it may soon be possible to undertake a comparative analysis of how great the resulting differences in results are. This could point the way to refinements, more standard practice, and more confidence in results.

Gap Analysis and Recommendations

A. Range of calculated savings

On one or more EE projects, determine the range of calculated savings from different applications of Option B performed under a range of typical budgets, availability of data, or

[82] 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.

other potential sources of variation in the calculated savings; assess the resulting “spread” in calculated savings as a “go/no-go” for additional analysis.

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

4.1.2.2 Statistical Methodologies

There are currently a number of nationwide and regional documents providing guidelines on M&V that include sections on the use of statistical techniques. These include detailed guidelines such as those from DOE and ASHRAE, as well as brief sections on the subject in M&V requirements from various regional forward capacity markets. The bulk of these documents address sample design and analysis, as many regulating bodies have requirements for the precision of savings estimates given a stipulated confidence level.

EM&V of savings from energy efficiency involves a number of sources of uncertainty in the estimation of energy savings. In the case of EM&V of utility or government-sponsored programs, it is often impractical to collect data on every project in the participant population. This leads to the introduction of sampling error to energy savings estimates. EM&V projects often require either direct measurement of changes in energy consumption or of some intermediate parameters used in engineering algorithms. These parameters may be subject to some degree of measurement error from metering equipment or survey instruments. Additionally, statistical and simulation models are a common part of many EM&V efforts. This can introduce specification error as omitted variables, improper functional form, or prediction outside the range of observed values, resulting in inaccurate estimates.

Many jurisdictions have requirements on the maximum confidence intervals for reported results, typically expressed in terms of relative precision given a stipulated confidence interval. Reported precision requirements vary by parameter, measure, project, program, or portfolio.

Statistical methods can also be used to help direct EM&V funding. Increasingly, jurisdictions managing large EM&V budgets, such as the California Public Utilities Commission, are using uncertainty analysis to help plan and manage their EM&V activities.[83] The goal of this work area would be to draft standard methods of quantifying uncertainty at the project and portfolio level.

Current State of Standards for Statistical Methodologies

The following table provides an account of the major EM&V guidelines, which provide explicit guidance on the use of statistical methodologies and reporting of uncertainty. The federal and international documents[84] on this provide general guidelines on the application of techniques, without explicit mention of regulatory requirements, and are meant to apply to a wide audience. These documents describe methods for calculating uncertainty, but not explicit requirements for levels of reported uncertainty. Meanwhile, documents from ISOs forward capacity markets typically include a clear

[83] California Public Utilities Commission, “2013-2014 Energy Division-Investor Owned Utility Energy Efficiency Evaluation, Measurement and Verification Plan Version 2,”August 2013, page 247, http://www.cpuc.ca.gov/NR/rdonlyres/B6D32B87-249E-44BB-8083-7139EC4D3B3A/0/20132014_EnergyDivisionEMV_Workplan_v2.pdf.

[84] This includes the California Evaluation Framework, which has been applied widely outside of California.

requirement for the degree of uncertainty in EM&V results, given a level of confidence (typically one-tailed 90%).

EESCC Inventory Database Record #[85]	Title of Document	Year	Developer/ Organization	Topics Covered
SD-32	California Evaluation Framework	2004	CPUC	Sample design, combining uncertainty, types of error, regression modeling, survival analysis, power analysis
SD-60 through SD-71	Uniform Methods Protocol	2013	DOE NREL	Sample design, combining uncertainty, types of error, measure-specific regression modeling
SD-54	IPMVP (Appendix B)	2012	EVO	Types of error, combining uncertainty, general regression analysis
SD-50	FEMP M&V Guidelines	2008	DOE EERE	Sample design, combining uncertainty, types of error, regression modeling
SD-53	ASHRAE Guideline 14	2002	ASHRAE	Types of error, sampling (brief), combining uncertainty (brief), modeling and prediction error
SD-540	SEE Action Guide	2012	DOE/EPA	Sample design, combining uncertainty, types of error, regression modeling
SD-75	WEQ-021 Measurement and Verification Of Energy Efficiency Programs Model Business Practices	2012	NAESB	Sample design, types of error, meter accuracy requirements, VEE

[85] The record numbers link to entries in the EESCC Inventory Database: http://toolswiki.ansi.org/tiki-index.php?page=EESCCTabs.

EESCC Inventory Database Record #[85]	Title of Document	Year	Developer/ Organization	Topics Covered
SD-76	REQ.19 Model Business Practices for the Measurement and Verification of electrical energy and demand impacts of Energy Efficiency Programs	2012	NAESB	Sample design, allowed savings determination approaches, meter accuracy requirements.
SD-14	ISO-NE Manual	2012	ISO New England	Sample design, types of error, meter accuracy requirements, VEE
SD-46	PJM Manual	2013	PJM	Sample design, types of error, meter accuracy requirements, VEE

Best practices for the use of regression models is covered in most documents along with techniques for the minimization of bias in the data collection process and approaches to assess sampling, modeling, or other sources of error. Few documents discuss research design (particularly the use of RCTs) in much detail.

Gap Analysis and Recommendations

The areas where current guidance for statistical calculations and reporting are either inconsistent or absent entirely are:

A. Quantifying uncertainty in regression models, for all time periods. (e.g. monthly, daily, hourly)
Leveraging the CA Evaluation Framework requirements on presenting uncertainty, a voluntary standard should be developed that would apply to regression models.

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 usage; and, 2) what is the sensitivity of the model outputs to changes in the model inputs? For example, if hours of occupancy change, what is the energy use change in a fully specified building energy model?

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 CA Evaluation Framework.

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

4.1.2.3 Whole Building Metered Analysis

Whole building metered data analysis entails the estimation of retrofit savings using data from utility meters or whole building sub-meters. It is most effective when savings are relatively large so as to be discernible from random or unexplained energy variations, typically 10 percent or more of baseline energy usage.[86] It is important to control for changes that are unrelated to the energy saving retrofit, such as weather and usage patterns. This can be done through regression analysis.

Whole building metered data analysis can be performed for single sites or for aggregations of buildings. The latter is typically done for analysis of residential or small commercial and industrial (C&I) programs. The former is typically done for analysis of C&I measures such as the following:

- HVAC controls in commercial facilities
- Efficient boilers and furnaces at sites without large process gas loads
- Production efficiency (continuous improvement) programs
- Lighting in parking garages or warehouses
- Variable Frequency Drives (VFDs) on irrigation pumps (dedicated utility meter)

Guidance on this use of whole building analysis can be found in the IPMVP, ASHRAE Guideline 14, the California Evaluation Framework,[87] the Bonneville Power Administration Reference Guide,[88] the Superior Energy Performance Measurement and Verification Protocol,[89] and the Uniform Methods Project Protocols.[90]

Historically, models have been established for statistical fit and validated against datasets of extensive building data. There are many indices of validity, including r-squared, degrees of freedom, t-statistics, and autocorrelation. The Bonneville Power Administration provides a good guide to validation.[91]

Standard analyses using monthly electricity usage information augmented by information obtained from on-site survey is relatively mature. To ensure reliable analysis using these information sources, the key

[86] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). (2002). *ASHRAE Guideline 14, Measuring Energy and Demand Savings.* Atlanta, Georgia: ASHRAE.

[87] TecMarket Works. (2004). *The California Evaluation Framework.* Oregon, WI: TecMarket Works.

[88] Bonneville Power Administration, "Regression for M&V: Reference Guide," September 2011, http://www.bpa.gov/energy/n/pdf/BPARegression_forMV_ReferenceGuide.pdf.

[89] U.S. Department of Energy, "Superior Energy Performance Measurement and Verification Protocol for Industry," November 2012, http://www.superiorenergyperformance.net/pdfs/SEP_MV_Protocol.pdf.

[90] Jayaweera, T., Haeri, H., Bruchs, D., Keeling, J., Khawaja, S., Rushton, J., et al. (2013). *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* National Renewable Energy Laboratory.

[91] Bonneville Power Administration, "Regression for M&V: Reference Guide," September 2011, http://www.bpa.gov/energy/n/pdf/BPARegression_forMV_ReferenceGuide.pdf.

requirements are based on quality of the data and analytics. Large data set availability gives rise to the opportunity for new analysis techniques to be deployed.

One application that uses large data sets is "inverse" modeling that act as predictive models for post-construction operations. Unlike forward models, these simplified models are developed using operational data (often generated from a representative forward model) and can be "trained" to represent building energy use as a function of input variables. Many techniques can be used to develop inverse models.

Recently, utility sponsored "demonstration" projects by the California utilities Emerging Technology Program have begun to test several modeling products that use inverse modeling techniques. These projects aim to replicate procedures used in ASHRAE Standard 140, *Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs*. The goal of these demonstration projects is to develop performance criteria (accuracy and reliability), and to produce test protocols for determining efficiency measure effectiveness while using readily available interval meter data and other key data feeds. This is a new area that raises two questions: *When is one model superior to another? Are there standard forms that produce satisfactory results?*

Gap Analysis and Recommendations

A. Standards for data collection and the appropriate forms of the statistical analyses to be used on these data

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 Method's Project for residential whole building may provide a starting point for formal standards development.

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

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 development of actual standards.

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

C. Standardization of methods for automated analysis approaches

If suitable data sets and testing procedures can be developed in the mid-term, the standardization of methods for automated analysis approaches that provide performance metrics could be developed.

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

4.1.2.4 Methodologies Used for Large, Complex Retrofits

Verification of savings for projects involving the installation of multiple efficiency measures at large single or multiple facilities on a campus, for example, is a challenging technical process and may incur large EM&V investment. Some EE programs provide incentives for multiple measures installed at a single site or multiple sites, if they are controlled by the same customer. Further, as EE investment goes deeper, multiple EE investments at a single facility are encouraged as they reduce transaction costs overall. For example, a common, high-impact project might be retrofitting a school under a performance contract or utility program. This type of project may include installation of the following measures for a single site: an energy management system, high-efficiency lighting, variable speed drives, a PC Power management system, etc. The interactive effects and unique characteristics of the individual measures, including savings and measure life, make it challenging to assess the near term and long term impacts.

The number of these types of projects tends to be small relative to the total number of projects implemented by a utility. However, the savings from these projects may be 50% or more of the total annual savings achieved by a large utility serving commercial/industrial, residential, and low-income sectors. As discussed in the chapter Introduction, there is a significant benefit to increasing consistency and comparability in the practice of EM&V, especially in large, complex savings opportunities.

Existing technical reference manuals typically do not address methods for evaluating multiple heterogeneous measures having significant interactive effects, though several documents offer guidance on sampling within a project of any size. They typically offer methods for evaluating multiple similar measures, including the installation of lighting or energy efficient motors, but not complex systems. The "M&V Guidelines: Measurement and Verification for Federal Energy Projects"[92] includes an appendix on sampling.

The Uniform Methods Project Metering Protocol includes guidance on sampling within a project that includes multiple measures. The BPA Sampling Protocol includes guidance on sampling within a project that includes multiple measures. Most evaluation guides recommend use of IPMVP for custom projects.

Gap Analysis and Recommendations

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, however, there is little guidance 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, then each measure may need to be evaluated. If only the project level savings

[92] U.S. Department of Energy, "M&V Guidelines: Measurement and Verification for Federal Energy Projects, Version 3.0 ," April 2008, http://www1.eere.energy.gov/femp/pdfs/mv_guidelines.pdf.

are required, then measures that 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 and 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?

Recommended Timeline: Guidance should be developed over the long-term (5+ years) on the evaluation of projects that include multiple heterogeneous measures.

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 analyses may involve manual uncontrolled processes. While existing EM&V resources generally do not address transparency, the IPMVP includes 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 on Reporting).

Recommended Timeline: This work should be conducted in the long-term: 5-7 years.

4.1.3 Duration of Savings: Effective Useful Life

The determination of savings over time requires the estimation of how long those savings will last. Historically this has been termed the analysis of the useful life or effective useful life (EUL) of a measure.

The determination of the cost-effectiveness of energy efficiency activities and their use in energy (especially electrical) resource planning relies on the estimated duration of energy efficiency savings. Virtually every existing comprehensive compilation of energy efficiency savings determination methodologies discusses this issue. However, there is a significant lack of consistency and transparency in the development of EULs because similar measures are given different useful lives, often without analysis of why a particular EUL was chosen. This is primarily because a direct determination of EUL would involve the observation of many specific measures in multiple locations over extended periods of time (years and even decades). Such long-term studies are usually impractical and could produce accurate distributions of EULs for measures that were more than likely technologically obsolete. In the absence of such studies, there seem to be three general approaches to estimating EULs because measurement has proven impractical:

1. Use a manufacturer's rated life.
2. When there is replacement of a measure prior to its failure, a two-part EUL is used in some venues to reflect different baselines: the period up to the predicted EUL, and the period after (see Section 4.1.1, Baselines).
3. For specific issues (e.g. early burn-out of lighting fixtures of lower than average quality), a special study of the problem.

Gap Analysis and Recommendations

Overall, the area of EULs has lacked terminology to specify which and why a particular EUL is being used. There is a presumption that EUL can be estimated using survival analysis methods. These methods include non-parametric methods (Kaplan-Meier) and fit different parametric survival functions to observed data. Survival analysis has already been widely used in EM&V, especially for estimating EULs. However, there are no national standards for which methods are appropriate in different applications or how uncertainty about the estimates should be conveyed. This can be especially critical when dealing with data quality issues such as censored data, very small sample sizes, short study time frames, or extrapolation far beyond the span of the collected data.

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 RTMs.

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

B. Assessing feasibility and usefulness of single national study using survival analysis

In addition, the 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.

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

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 can be standardized and lead to protocols on how such studies can be undertaken in the future. As the EUL of a measure depends on the application of that measure, this is particularly complex.

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

4.1.4 Technical Reference Manuals (TRMs)

Several states or regions have established processes through which energy efficiency savings for a specific list of measures or activities are established and publically available. The information in the resulting “document” – the technical reference manual (TRM) – is usually used for specific activities in electrical or natural gas industry implementation, public planning, or regulatory processes. TRMs fall under the broad class of M&V supporting documents and, as described below, are numerous and widely used. Further, TRMs as a valid reference tool in conducting M&V is accepted nationally as standard business practice in wholesale and retail electricity markets.[93]

Implementation of Measurement and Verification (M&V) practices commonly involves direct measurement of energy consumption before and after installation of energy efficient devices or practices. This practice of measure or project-level measurement can be time consuming and expensive for mass-market efficiency programs, such as lighting, motors, and HVAC. As an alternative to direct measurement, using prescriptive or deemed savings estimates can provide accurate quantification of savings, provided the inputs and use of the deemed savings are rigorously applied. Over the past decade, numerous volumes have been developed primarily by regulated electric utilities that catalogue deemed savings in TRMs. These documents are also sometimes called program savings documents (PSDs). As many as twenty-five TRMs have been developed or are in the process of being developed by states, federal agencies, or technical organizations across the United States.

Measure-level information in the TRMs include, but are not limited to, methodologies, calculations for annual and lifetime energy and demand savings, default assumptions not based on site specific parameters, measure life, baseline criteria, persistence and coincidence factors, gross to net calculations, and interactive measure effects. TRMS undergo periodic updates to reflect changes in engineering analysis or use characteristics such as persistence and coincidence rates. Additionally, TRMs used as part of state sponsored efficiency programs are subject to regulatory review and approval by state level utility commissions to ensure third party independence.

Current State of TRMSs

The following summary and analysis draws from a 2011 study looking at the feasibility of national databases for EM&V documents and measure savings.[94] The table below represents the TRMs or related guides for TRMs identified in the study and elsewhere. There are 21 states that maintain TRMs to support their ratepayer-funded efficiency programs, two regional systems, and the EPA ENERGY STAR® Products Guide. The table below illustrates the TRMs captured in the Database. A complete list of these TRMs and website information is located in Appendix 4A.

[93] NAESB EE M&V standards were adopted by FERC in February 2013 under order 676-G and are applicable to wholesale electricity markets administered by ISO/RTOs. A similar set of model business practices standards were adopted by NAESB in a final action for Measurement & Verification of Energy Efficiency Programs in October of 2012 applicable to retail markets and are voluntary. These current set of standards allow for use of TRMs provided they are appropriate and current.

[94] Jayaweera et al., *SEE Action Network - Scoping Study to Evaluate Feasibility of National Databases for EM&V Documents and Measure Savings*. Cadmus Group: June 2011.

EESCC Inventory Database Record #	Title of Document	Developer/Organization
SD-227	State of Illinois Energy Efficiency Technical Reference Manual	Illinois Commerce Commission
SD-226	Business Programs: Deemed Savings Manual V1.0	Public Service Commission of Wisconsin
SD-225	Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions	Efficiency Vermont, VT Department of Public Service
SD-224	Deemed Savings, Installation & Efficiency Standards	Public Utilities Commission of Texas
SD-223	Pennsylvania Technical Reference Manual	Pennsylvania Public Utility Commission
SD-222	State of Ohio Energy Efficiency Technical Manual	Public Utilities Commission of Ohio
SD-221	New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs	New York Department of Public Service
SD-220	New Jersey Clean Energy Program Protocols to Measure Resource Savings	New Jersey Board of Public Utilities
SD-219	MI Energy Measures Database	Michigan Public Service Commission
SD-218	Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures	MA DPU, TRM Coordinating Committee, Program Administrators, Department of Energy Resources
SD-217	Efficiency Maine Residential Technical Reference Manual No. 2009-1	Efficiency Maine
SD-216	Efficiency Maine Commercial Technical Reference Manual No. 2006-1	Efficiency Maine
SD-215	Hawaii Energy Efficiency Program TRM	Hawaii Public Utility Commission

EESCC Inventory Database Record #	Title of Document	Developer/Organization
SD-214	Connecticut Light & Power and United Illuminating Company Program Savings Documentation	CT Department Public Utility Control
SD-213	Database for Energy Efficient Resources (DEER)	California Energy Commission
SD-212	Arkansas Technical Reference Manual TRM Volume 1/Version 2.0: EM&V Protocols	Arkansas Public Service Commission
SD-211	Mid-Atlantic TRM_V1.2	Northeast Energy Efficiency Partnership - Regional M&V Forum
SD-210	Regional Technical Forum (RTF) Deemed Measures	Northwest Power & Conservation Council - Bonneville Power Administration
SD-209	ENERGY STAR® Products - TRM	U.S. Environmental Protection Agency (EPA)

The following characteristics are common among all the identified documents:

- TRMs provide either *ex ante* savings values or algorithms.
  - For the resources that have *ex ante* savings estimates, a stipulated (deemed) value is given for the savings.
  - For the resources primarily composed of algorithms, a formula is given where input parameters are stipulated or determined based on specific conditions (e.g. a lookup table for hours-of-use based on building type).
  - For the resources that include both algorithms and *ex ante* savings values, the primary format for measure savings is algorithms in nearly all cases.
- These resources primarily contained energy savings and measure costs.
- Few resources included non-energy benefits or market transformation metrics.

As can be seen in the table above, TRMs are used to document prescriptive savings from energy efficiency measures, typically for the purpose of compliance with state or federal regulatory requirements. States with regulated energy efficiency programs may elect to develop a set of prescriptive savings calculations for market based efficiency measures. These are commonly assembled into a TRM (also known as a Program Savings Document). TRMs may also exist for federal facilities or may be utilized for efficiency standards, such as ENERGY STAR.®

Gap Analysis and Recommendations

The current set of TRM documents does not provide a consistent format or treatment of data useful for broader adoption of deemed savings analysis. Regional differences in treatment of non-energy calculations and impact factors add to the difficulty of creating a singular source for deemed savings.

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 assuming that the fundamental engineering analysis is not applicable across sectors or regions.

   Recommended Timeline: This effort is on several stakeholders' work plans that are 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.

4.2 Reporting and Tracking Systems

Energy efficiency projects performed as part of any large scale program, or set of programs, have associated data which must be maintained for the purpose of project management and reporting. Generally speaking, each jurisdiction will specify a combination of tools and methods to accomplish its data management and reporting needs. These tools and methods fall broadly into categories like Tracking Data and Reporting Data. Supporting tools such as TRMs (see Section 4.1.4) in managed data systems may also be used to support tracking and reporting needs.

The following sections address the status of industry standardization on these topics. Some of the sections below are informed by recent experience in implementing large EE activities/programs. This experience has revealed that the first step in establishing standard energy efficiency tracking and reporting tools is to consider the general business model under which the programs are deployed and assure that all participants in a particular activity, e.g. implementers, analysts, and regulators share the same underlying principles.

Energy efficiency savings are always defined with a specific business context. In the case of ratepayer funded IOU programs, the savings may be evaluated in terms of a program's success in influencing the market for a specific technology. In an energy savings performance contract (ESPC), there is usually no consideration for savings attribution. While the energy savings project in both situations may be the same, the types of data that are tracked and reported depend on the business context.

Keeping in mind that understanding the business context is critical to defining the tracking, reporting, and specific technical data needs. Further, these issues can be categorized as those pertaining to the tracking system, data inputs, and reporting.

4.2.1 Tracking Systems

Collecting and reporting energy efficiency technical data is a critical task in every energy efficiency project or program. Increasingly, a wide range of stakeholders, including Air Resources Boards, Public Utility Commissions, financiers, and software/platform providers, are seeking energy efficiency project and program data that can be shared and compared across and between regional and programmatic boundaries. Currently, most regions and projects have adopted naming conventions and taxonomies that apply only to their own programs or jurisdictions. This limits the exchange of data that would allow comparisons and enhance the efficacy of a national marketplace for energy efficiency.

Several states or regions, including California, the Northeast Energy Efficiency Partnership (NEEP), and the Regional Technical Forum (RTF), have established standards for data required to track program effectiveness in utility programs. Additionally, regional entities such as ISO New England and PJM collect standardized data across multiple state and local boundaries as part of administering wholesale markets and system planning studies. Standard Program Tracking (SPT) data typically consists of project and measure-level data that supports the accounting of program savings, costs, and cost effectiveness. A limited set of data systems collect significantly more detailed information including billing meter, location, installation, EUL dates, and reference to methodological basis for measured savings, primarily for audit purposes. Such record in a set of SPT data may contain measure data (unit energy savings, cost), implementation data (building type, building vintage, climate zone), customer, and contractor (address, meter id).

The Building Energy Data Exchange Specification (BEDES)[95] is just beginning to assemble stakeholders across a wide range of energy data standardization needs. The SEE Action Network[96] has begun to work on protocols for sharing program results across regions.

Gaps and Recommendations

There is not currently a common standard for program tracking data between states or regions. There is no current program that is addressing the data standards needs on a national level.

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

[95] U.S. Department of Energy, "Building Energy Data Exchange Specification," last modified November 2013, http://www1.eere.energy.gov/buildings/commercial/bedes.html?utm_source=BEDES%2Bredirect&utm_medium=redirect&utm_campaign=BEDES%2Bredirect.

[96] SEE Action, "Evaluation, Measurement, and Verification Working Group," accessed November 2013, http://www1.eere.energy.gov/seeaction/evaluation.html.

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.

4.2.2 Standardized Data Collection

There is generally commonality in the kinds of data collected and the format in which it is collected. But to date, there has not been any examination or standardization of the data underlying the calculation of savings. For example, a program to accomplish whole-house retrofits will track the number of homes affected. But to calculate savings, additional data is gathered including the number of homes, the number of floors in each home, square footage, number of occupants, etc. There is no standardization as to whether the square footage is for the total interior space, the portion of the interior that is air conditioned, or whether garages and patios (enclosed or open) are included. Specifications on what these data represent are material to the specific method used to calculate savings and to the meaning and use of those savings results. This issue addresses the lack of common data standards.

In addition, the absence of a standard makes it difficult if not impossible to compare or combine data from different sources. For example, two analyses of the savings from residential whole-house retrofits may produce different results. To use the example above, it matters if one study used air-conditioned square footage and the other used total square footage (which might include an attached garage). In order to permit the pooling of data and research that could be built upon larger data sets, a single data taxonomy or specification is essential.

There have been efforts to standardize building data. Recently DOE has begun an effort to standardize building data. It has established a data taxonomy and XML specification. This draft Building Energy Data Specification (BEDES) has 200+ data fields. DOE has begun one effort in this area: the Building Energy Data Exchange Specification.[97] DOE has begun a process of circulating its specification for review. Another activity in the residential area includes efforts by the Building Performance Institute (BPI),[98] which has worked to standardize data used in residential building descriptions underlying residential energy efficiency and weatherization retrofit work. Their focus is more on the qualifications of personnel and the practice of home energy calculations. The BPI effort covers more topics than described here (e.g. installation and worker qualifications) but overlaps in the data used for home energy audit calculations.

Gap Analysis and Recommendations

A single standard taxonomy (and XML specification) does not exist that covers central data needs for calculating savings.

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[97] U.S. Department of Energy, "Building Energy Data Exchange Specification," last modified November 2013, http://www1.eere.energy.gov/buildings/commercial/bedes.html.

[98] Additional information on BPI can be found at http://www.bpi.org/home.aspx.

A. **Collaborative effort to address 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 which can be included in the data specification, and establish a continuous update process to manage evolving changes.

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

4.2.3 Reporting

"Reporting" covers the data, process, and formats used to communicate EE EM&V outcomes for use by business, governments, or other stakeholders in EE activity. The issues around useful reporting have been central in a number of forums where EE results are used to assess accomplishment of utility, state or regional energy goals, energy resource planning, and air quality trends.[99] Many states currently require EE program administrators to report EE savings, expenditures, and other impacts to their state commissions concerned with energy use, federal agencies, and other regional entities.

Reporting requirements are known to vary from state to state. This makes it difficult to compare and/or aggregate state-level data to inform energy and environmental decision-makers concerned with energy markets and policies, or even to understand the success of EE as a policy tool.

The following table lists several significant examples of state, regional, and national reporting standards or practices. These illustrate that the definitions of what is reported including EE program types, costs, and results (e.g. savings) differ to various degrees. These reporting practices inform the identification of gaps and opportunities for developing guidance/standards to support greater consistency in EE reporting.

[99] While the scope of this section could apply more broadly to all EE reporting, including state efficiency investments in state buildings, and municipal/community EE programs, this section focuses on ratepayer-funded EE programs administered by electric and natural gas utilities, and in some cases designated state EE program administrators.

Title of Reporting Document	Developer/Organization *Description (if active)*
NATIONAL REPORTING	
Annual EE Industry Report Annual report of EE impacts at sector level by state for CEE members. (http://www.cee1.org/annual-industry-reports)	**Consortium for Energy Efficiency (CEE)** Includes aggregate current year budgets and prior year expenditures and savings by program type and customer sector levels; also includes net-to-gross factors by region.
EIA Form 861 Schedule D Basic EE/DSM data reporting required of utilities. (http://www.eia.gov/survey/form/eia_861/form.pdf)	**Energy Information Administration (EIA)** Includes annual EE program savings at the sector level for energy and demand, as well as cost data by general cost categories.
REGIONAL REPORTING	
Regional EE Database (REED) Annual data reported by 10 jurisdictions (New England states, NY, MD, DE, DC). Launched in March 2013. (www.neep-reed.org)	**Northeast Energy Efficiency Partnerships (NEEP), via the Regional EM&V Forum** Includes annual and lifetime energy and demand savings and associated expenditures by region, state, sector, and/or program type levels.
ISO-New England electric utility program administrator reporting of EE savings and expenditures. Data collected feeds directly into NEEP Regional EE Database (REED). (http://www.iso-ne.com/eefwg)	**ISO New England** Collects largely the same data as REED but with additional detail including measure-level savings data.
NW Regional Technical Forum/NWPCC Formerly tracked EE program impacts from across the region, but has not for past several years. In process of scoping new reporting system. (http://rtf.nwcouncil.org)	**Northwest Power Planning Conservation Council (NWPCC)**
STATE REPORTING	
CA Energy Efficiency Groupware Application (EEGA) Utility (IOU) reporting of EE impacts. Currently being re-branded and updated. Data reported by CA IOUs including annual, quarterly, and monthly data at	**California Public Utilities Commission (CPUC)** Monthly data is reported for energy and demand savings, by program category, with information on budget and expenditures (year to date, and since inception). It also includes benefit/cost ratios by program, savings by end use (measure level),

different levels of detail. (http://eega.cpuc.ca.gov/Savings.aspx.)	number of program participants, and other details.
NY EE Portfolio Standard (EEPS) Scorecard New on-line database launched fall 2013. Feeds into REED, and is also used by NYISO for system planning. (http://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=07-M-0548)	**New York Department of Public Service (NY DPS)** Includes data feed to REED and additional information by program type.

Gap Analysis and Recommendations for Standardized and Consistent EE Reporting

Important differences exist in reporting practices that make it difficult to compare program impacts, including:

- **Definitions of Savings and Program Typology:** State, regional, and national reporting entities often use different definitions of savings (e.g. the same term can refer to annual incremental savings, cumulative savings up to the current year, or to the expected future cumulative savings of a program offered in a given year). These entities also use different program type categories. Program typology differs both in the number of program types used and their definitions.

- **Expenditure Categories:** States often utilize different expenditure categories. For example, some states report administration and marketing costs separately while others combine these costs.

- **Cost of Saved Energy Calculations:** Where this information is reported, definitions often differ across states, in particular, where a levelized value may be used instead of a lifetime value; and discount rate assumptions range (utility discount rate vs. other lower long-term discount rate).

- **Net vs. Gross Savings:** States often have different definitions of net savings in terms of e.g. free-ridership and spillover (participant and non-participant effects), rebound effect, and/or longer term market effects.

The basis for differences in reporting savings between similar programs may arise from several causes. First, users of energy efficiency results may have different needs. For example, energy use forecasters may need cumulative savings up to the point of forecasting, but separately need predictions of savings going forward based on different scenarios of EE program continuation. State commissions may only care about EE savings accomplished by the programs in a given year, both in that year and over the life of the measures installed in that year, to track progress towards statewide energy goals. Depending on the needs of those participating in the development of a reporting specification, these different needs may cause differences in the reporting specifications that may not be apparent to the user of the reported information.

A. A series of analyses and discussions should be undertaken to assess:

1. What are the needs of each of the general types of users of EE reported information and what are the parameters 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. The next step would be to 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 some of the data collection tools/databases in place to support broader coordination across the country. Also, consideration should be given throughout for opportunities that take advantage of new technologies for data gathering and sharing.

Recommended Timelines: Activities 1 and 2 (near-term) should be completed in the next two years through formal, collaborative efforts. Several organizations with wide reach in the programmatic energy efficiency industry are pursuing this issue.[100] Activity 3 (long-term) should be completed after the first two are complete and within 5 years, also through formal, collaborative efforts.

4.3 Other Evaluation Methodological Approaches

The expansion of energy efficiency as a resource tool in broader policy goals, such as climate change and air emissions, requires that the valuation of EE consider broader-based metrics and determinants. Other approaches to EM&V covered in this chapter expand the lens of measurement to include top-down macro-economic approaches, value risk, and finance considerations. These broader issue areas complement the measure-level approaches and warrant consideration.

Investments in energy efficiency, as managed by utilities and third-party program implementers, often face a variety of additional scrutiny by regulators and a variety of market actors and interveners. Attribution of reduced energy consumption to the program activities, and not some other influence, is important to the analysis of investments of public funds. In addition, these programs often influence

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

end-users and supply chain actors to make additional EE choices beyond those directly incented by the programs. To evaluate attribution and potential market effects, a net-to-gross (NTG) study is often conducted. While the measured savings for a particular piece of equipment or activity is considered the gross savings, participant and non-participant spillover to other EE purchases and activities are measured via surveys and through the use of supplier data and control groups. Likewise, surveys can help determine what action a particular program participant might have taken in the absence of the program. Several references exist for NTG analysis, including those from the SEE Action Network, and a current effort underway by DOE to develop appropriate NTG protocols within the UMP context.

4.3.1 Top-Down and Bottom-Up Methodological Approaches

"Top-down" methods analyze aggregate energy use to assess changes resulting from energy efficiency, typically for a geographic region, entire industry, or economic sector. They often incorporate methods using energy use metrics or energy intensity indicators, along with a structural or economic analysis to isolate drivers of energy use changes at an aggregate level. A common approach is to develop statistical or macro-economic equations to model or predict energy use, including among the energy use determinants, one or more variables that reflect energy efficiency activity. By analyzing energy use at an aggregate level, either for a geographic region, an industry, or customer sector, the overall, combined trends or impacts of policy or a combination of policies can be captured and quantified.

The importance of top-down methods is in their use as overall indicators of progress towards energy usage reductions goals at a large scale. Such goals are common at state, regional, or national levels, including those established for greenhouse gas reductions, climate change, or energy independence. A high-level view of savings reductions allows for the attribution of a combination of multiple (policy) activities without the difficulties of looking at each, and the potential interaction of each (policy) activity with other activities.

"Top-down and bottom-up" methods are those that combine a top-down analysis with a bottom-up analysis, reconciling the differences with the goal of providing a decomposition of the overall changes in energy use into its constituent factors. For example, a top-down and bottom-up analysis of energy use in the state of California might identify the overall change in energy use and decompose it into changes from the specific energy efficiency programs operated by the electric and natural gas utilities (from adding the individual program effects – the "bottom-up" component) and the remaining change assigned to changes in economic activity, population, or demographic changes, and interactions between these factors.

These methods are common in Europe[101] and are under consideration for use by some states (e.g. California[102]) or organizations. These methods are a direct approach to indicating the overall success of policies designed to impact energy use. Unlike top-down, bottom-up methods focused on a specific policy encounter mounting difficulties in assessing overall impacts. With multiple policies over time, the interactions between individual programs grow and become more complex, especially as these programs are pursued over extended time.

Since each top-down model is usually built to solve a particular problem, there are variations in the approaches. While each application may have been sufficient for solving problem the problem for which it was designed, this approach poses challenges when the need is to compare policy effects between two different entities (geographic regions, industries, etc.). One example is when the need is to compare the success of one region in reducing energy with the success of another region. Another example is when several regions are separately obliged to work towards a common goal. An example in the U.S. might be if the Regional Greenhouse Gas Initiative states chose to make overall comparisons of energy efficiency effects.

Gap Analysis and Recommendations

For "top-down" analysis to be used with confidence in the U.S., several gaps need to be overcome. First, there is no systematic, objectively based method to assess the accuracy of top-down analysis. Second, there is insufficient experience with top-down analysis to proscribe for particular use cases a current best practice or sufficient detail to guide a new implementation of top-down analyses including:

- Data to gather
- Form (equations) to estimate (the "top-down" model)
- Guidance on how to use the equations to answer questions about energy use
- Guidance on how to assess the usefulness or accuracy of the resulting analysis

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 usage, including whether the use case is for purely historical analysis or 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.

[101] Typical European summaries are Vreuls, Harry, Wim De Groote, Peter Bach, Richard Schalburg, et al., "Evaluating energy efficiency policy measures & DSM programs - volume I: evaluation guidebook," October 2005. Accessed 3 November 2013 at http://www.ieadsm.org/Files/EXCO%20File%20Library/Key%20Publications/Volume1Total.pdf, or Boonekamp, P.G.M. and S. Thomas, "Evaluation and Monitoring of the EU Directive of Energy End-Use Efficiency and Energy Savings,"WP6.1 Integration of Bottom-Up and top-down methods, ECN, EIE_06_128_EMEEES, 30 April 2009. Accessed 3 November 2013 at http://www.evaluate-energy-savings.eu/emeees/en/publications/reports/EMEEES_WP61_report_090430.pdf.

[102] A recent summary of work in California is provided by: "Macro Consumption Metrics Pilot Study Technical Memorandum Preliminary Findings," prepared by *Demand Research, LLC,* for the California public Utility Commission, Energy Division. August 21, 2012. Accessed on 3 November, 2013 at http://www.energydataweb.com/cpucFiles/pdaDocs/866/HOROWITZ-MCM Technical Memo August 21 2012.pdf.

2. For each use case the essential explanatory variables that need to be included 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 usage questions.

5. Develop criteria for assessing the accuracy of the resulting analysis and guidelines on their presentation.

Recommended Timeline: This is a long-term priority and should be accomplished in 5-7 years.

4.3.2 Use of Evaluation in Financial Risk Analysis

There has been an interest in private finance of energy efficiency activities, but to date private finance has been limited to a few specialized, or even publically supported program activities. The perception in the financial community is that EE provides low and uncertain energy cost reductions. This perception seems to lead potential sources of finance to the conclusion that large-scale lending would have uncertain returns or carries risk in excess of return, either making private finance very difficult. To improve the prospects of private finance, a couple of avenues have been explored that would clarify the riskiness of EE savings (and also energy cost reductions).

Complex energy retrofit projects and energy efficiency portfolios can involve dozens or hundreds of separate input variables (i.e. hours of use, occupant behavior, estimated savings from different measures or programs, etc.). Because many of the input variables are inherently uncertain, estimating the project savings or financial impacts from these complex projects can be difficult and uncertain. The risk associated with different estimates can be quantified using a variety of techniques, including Monte Carlo sampling and Bayesian methods. Both of these methods use distributions to quantify the uncertainty associated with input variables and provide probability distributions that can be used to compute intervals and descriptive statistics for the quantity of interest. Similar techniques are discussed in the California Evaluation Framework and are being used to plan upcoming evaluations in California. However, the benefits of improved energy efficiency savings estimates remain unquantified. Financiers and parties holding the risk of energy efficiency program performance can help establish this target by providing input on the value of reduced risk/uncertainty.

Monte Carlo methods are but one technique for assessing risk in energy efficiency projects. There are no nationwide standards on how these methods are used to quantify uncertainty and translate that uncertainty into an estimate of financial risk. Furthermore, there are currently no nationwide standards dictating under what conditions risk or financial gain should be assessed for prospective portfolios or projects. Finally, there is no quantitative guidance on determining the optimum budgeting (as defined by the value of reduced risk to all parties) of evaluation activities for various program/project activities.

Another approach that DOE is attempting to pursue is to develop large-scale databases of actual building characteristics and energy use. This project is called the Building Performance Database (BPD). The variety of buildings can be used to generate distributions of energy use reductions based on the efficiency of equipment in the buildings. These distributions can be translated into energy cost reduction distributions providing the input for financial risk analysis. This project is on-going. If successful in generating distributions of EE's financial benefits, it may spark further interest in developing these capabilities.[103]

Yet another approach has been the Investor Confidence Project[104] (ICP) which seeks to establish rigorous audit, project management, and M&V for particular types of projects. By establishing these rigorous guidelines, potential investors in a given project could be expected to have higher confidence in the resulting savings and be more willing to invest.

Gap Analysis and Recommendations

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 program and project uncertainties based uncertainty in underlying parameters. This process would leverage work on Monte Carlo analysis, the BPD, and the ICP.

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

B. Systematic framework for translating engineering uncertainties to financial instrument ratings

The development of a systematic framework for translating engineering uncertainties to 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 with input from the potential users of the information: the financial community.

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

C. Stakeholder process to assess needs

Based on A and B, a stakeholder process could 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.

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

[103] More information on the Building Performance Database can be found at http://www1.eere.energy.gov/buildings/commercial/bpd.html.

[104] Additional information can be found at http://www.eeperformance.org.

4.4 Emerging Issue Areas

The EM&V working group considered a number of important areas that could have been included, but they were either being developed elsewhere or represent potential for future work.

4.4.1 Role of Conformity Assessment/Accreditation

The successful implementation of EM&V practice requires the use of assessment techniques, software, measurement equipment, and personnel. These elements must conform to minimum requirements for producing accurate measurements for any standard established for EM&V. Accreditation and certification of these elements ensure that entities relying on results from the EM&V practice have actionable assurance that the underlying components utilized in the development of product specifications, engineering practices, and analytical assessments meet minimum criteria for conformance with standard requirements.

While conformity assessment practices in general have been established for more than a decade, it is discussed in the emerging issue areas section of this chapter as it is a growing area that impacts the world of the EM&V practice.

Gap Analysis and Recommendations

Conformity assessment standards provide a necessary foundation to the base assumption that EM&V practices produce accurate and consistent results.[105] The use of conformity assessment standards may provide the basis for establishing certificate authorities. While there are products such as metering and measurement devices that have been certified by certification bodies, presently there are no certifications for methodological practices or approaches used in the EM&V process.

Accreditation and its roles in risk and financial management

To create the proper conditions to foster continued investment, countries need to institute comprehensive investment systems that are supported by a legislative framework that includes a solid system of standards and conformity assessment. Accredited conformity assessment bodies allow consumers, sellers, regulators, and other interested parties to have confidence in the results of conformity assessment while avoiding the creation of unnecessary barriers to trade. These principles are based on the conformity assessment language in the Agreement on Technical Barriers to Trade, one of the agreements within the World Trade Organization (WTO). Accreditation is an important part of the conformity assessment system, representing a third party attestation of the management and technical competence of conformity assessment bodies such as laboratories and product certification organizations. Internationally recognized accreditation such as that governed by ILAC/IAF, opens more international market possibilities for those products that receive an accredited test report, inspection, or certification. ILAC/IAF promotes the principle of “test, inspected, or certified once – accepted everywhere,” building market and investment confidence by minimizing barriers to trade.

[105] The ISO/IEC 17025:2005, Conformity assessment – General requirements for the competence of testing and calibration laboratories, supports such accuracy and consistency in results.

Accreditation reduces risk for businesses and their customers by assuring them that accredited Conformity Assessment Bodies are competent to carry out the work they undertake within their scope of accreditation. AB signatories of both the ILAC MRA and IAF MLA undergo regular evaluations of each other to assure the equivalence of their accreditation programs.

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 these conformity assessment standards are equally related to applications in the compliance and enforcement of standards and workforce credentialing, and will be 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 mid-term: 2-5 years.

4.4.2 Technology-Specific Areas

The topics above are generally of wider scope or applicability to the field of EM&V and the determination of energy efficiency savings for buildings in particular. The sections below take up specific areas in which development is important, where there is a close connection to work covered elsewhere, and are considered higher priority than other topics.

4.4.2.1 Behavior-Based (BB) Programs

Behavior-based (BB) programs are those programmatic activities that seek to reduce energy consumption by influencing the behavior of energy users and supply chain actors, as opposed to reducing consumption by providing direct financial incentives for the replacement of equipment.[106]

Behavior-based programs are among the newer EE program concepts to be implemented on a large scale in recent years. The understanding of customer behavior implied by these programs is that even customers attempting to improve their welfare (broadly speaking) often make decisions with an incomplete understanding about energy use causing them to use more energy that if they had had fuller information. Even customers who understand the decisions needed to use less energy, often do not take action due to other priorities, or because of accepted social norms among their social network. The motivating principle of behavior based programs is that providing customers with targeted information and education can result in reduced energy use. Keeping in mind that customers vary widely in their motivations, baseline behaviors ability to capture and understand new information through social networks, tweets, texts, and emails, there is no "one size fits all" approach for evaluating behavioral programs.

[106] The SEE Action network definition is slightly different, but similar in scope: "Behavior-based energy efficiency programs are those that utilize strategies intended to affect consumer energy use behaviors in order to achieve energy and/or peak demand savings. Programs typically include outreach, education, competition, rewards, benchmarking and/or feedback elements."

Behavior-based energy efficiency programs may be one of the most challenging types of EE and demand response (DR) programs to evaluate:

- Programs sometimes do not have *ex ante* or utility/program administrator developed savings estimates. In these cases, the evaluator has to develop the first program savings estimates.
- BB programs usually are *not* designed to motivate customers to take one or two predefined actions or install one or two predefined measures such as CFLs. As the programs encourage a variety of energy use behaviors, savings are typically estimated with whole-building energy use data.
- Savings from BB programs may be a small percentage of whole-building energy use and hard to detect statistically in small program populations.
- Because BB programs are typically such a small percentage of whole-building energy use, any bias in the savings estimate can overwhelm the savings itself.
- Persistence or longevity of BB programs' savings is more uncertain than for traditional rebate programs that promote a small number of well-defined EE measures such as CFLs or T5 lighting systems.
- Estimating net to gross ratios for some BB programs can be challenging.
- BB programs may cause customers to participate in other utility energy efficiency programs, creating the potential for double-counting of savings and complicating attribution of savings to different programs. For all BB programs, the double counting of energy savings is a potentially significant issue. The difficulty of addressing this issue ranges from low in the case of an EE program with tracked savings, where the BB programs are determined using a randomized controlled trial (RCT)[107] design; to extremely high for netting out the savings from an upstream/midstream EE program,[108] regardless of the program design.[109]

Current State of Behavior-Based Programs

BB programs achieve savings by educating customers about the benefits of efficiency and encouraging them to change their energy-use behaviors. Utilities have implemented BB programs in the residential, commercial, and industrial sectors. The total potential for energy savings through behavior change is not well understood empirically, though these programs represent a relatively untapped area for investors in EE resources.

Scope of programs include training efforts (including building operator certification), feedback mechanisms (such as home energy reports and in-home monitors), gamification, community based social marketing, goal setting programs, mass media efforts, contests, competitions, and continuous

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[107] The RCT for the BB program should identify the savings that occur in the other program's tracking system.

[108] Upstream/Midstream Programs are financial incentives that involve payments to parties that are "up the supply chain" from the individual customer purchase transaction. Upstream incentives reach relatively far up the supply chain, typically to manufacturers; midstream incentives are targeted closer to the customer end of the market, typically to retailers or installation contractors. National Action Plan for Energy Efficiency, "Customer Incentives for Energy Efficiency Through Program Offerings," last modified February 2010, http://www.epa.gov/cleanenergy/documents/suca/program_incentives.pdf.

[109] For example, the BB program may induce the purchases of efficient light rebated with savings tracked in a separate system. Because such "upstream" programs track only equipment and not the purchaser, the purchaser's motivations can't be uncovered and the double counting assessed.

energy improvement programs for industry. Programs that are tied to the purchase of specific, pre-defined equipment and rely only on monetary incentives, such as rebate programs, are *outside the scope* of "behavior" programs. While those that motivate people to make purchases of equipment, but don't include financial incentives, are in scope.

The table in the chapter appendix highlights categories of programs (that have distinct evaluation approaches), the methods for which it is possible to obtain an estimate of savings (the spreadsheet uses the phrase "correctly estimating net savings," to encompass both low bias and high precision), and the methods lower confidence and precision in the estimates of savings.

The table in Appendix 4B categorizes programs by design features, focusing on features with implications for the appropriate evaluation approach. This can help utilities and other stakeholders design programs that increase the likelihood of obtaining reliable (unbiased, high precision) estimates of program savings.[110]

Gap Analysis and Recommendations

Two gaps in current practices deserve attention now. First, programs are often designed with little consideration for how the program is to be evaluated. Utilities and other program implementers should be strongly encouraged to contract with third-party evaluators to work with implementers in the early stages of program design. Quite often minor, low-cost changes in program design generate significant improvements for accurately estimating program effects.

Second, many implementers and even some third-party evaluators do not have sufficient understanding of recent methodological developments in program evaluation. The SEE Action report is an example of attempts to remediate this gap in knowledge, with particular attention on the advantages of RCTs. There may be significant benefits from continued efforts to close the gap between the available state-of-the-art methods in impact evaluation and current standard practice.

A. Randomized controlled trials

Randomized controlled trials (RCTs) are the preferred design for behavioral programs. To the extent that an RCT is not feasible, quasi-experimental designs as outlined in the SEE Action report are the preferred alternative.

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

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).

[110] A significant focus of on-going work in BB programs is the SEE Action Workgroup on Customer Information and Behavior. More information can be found at http://www1.eere.energy.gov/seeaction/customer_info.html.

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

There are several references in the EESCC Inventory Database that provide methodologies for evaluation of feedback programs, specifically those that involve experimental design with large samples of customers and control groups that receive comparative information and billing data are available.

A shortage of EM&V references that analyze the impacts of other types of behavior programs is apparent. While many evaluations of training programs have been completed, a plethora of approaches have been used to determine the impacts and persistence of these efforts. The same is true for mass media campaigns and game-based programs. The table in Appendix 4B indicates program types with limited consensus or available literature on evaluation methods. For example, the benefits of home energy monitors (a technology that provides feedback, but in and of itself does not save energy) and the persistence of savings that may be attributed to their use are not well documented beyond limited pilot programs in some regions.

In the commercial building and industrial facility sectors, there is a growing body of literature on the impacts of continuous energy improvement (CEI) or Strategic Energy Management programs that do not involve the installation of new equipment, but rather rely on operational changes at the facility. Methods used in evaluating these programs generally utilize site-specific methods that deploy one or more of the IPMVP protocols described earlier in this chapter.

A. 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.

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

4.4.2.2 Evaluating Emerging EE Technologies

There is constant evolution in energy efficiency technology. The process of evaluation and M&V must also keep pace with the influx of technology and technology applications. Without reliable and documented savings results, attribution of savings and levels of incentive are difficult to apply. The evaluation of emerging technologies in energy efficiency can be thought split into three objectives: evaluating actual installations, evaluating "Emerging Technology" programs, and predicting the contribution of emerging technologies into forecasts or plans for energy efficiency programs.

Several program implementers operate "Emerging Technology" programs that attempt to increase the market penetration of promising energy saving technologies. The effectiveness of such programs tends to be evaluated based on the technology's impact on the market, rather than the direct energy savings impacts of the programs. Measure-level savings therefore tend to be unreliable and the optimization of the M&V process, for example, incorporation in TRMs is limited. Some emerging technologies in building energy efficiency include:

- Advanced power strips
- LED/solid state lighting
- Ductless mini-split AC and heat pumps
- Set top boxes
- Heat pump water heaters
- Smart (web-integrated) thermostats for small commercial applications

As explained in the chapter Introduction, there is a perceived benefit to increasing consistency and comparability in the practice of EM&V. The IPMVP methods can be applied to all of the technologies listed above to determine savings at the project or measure level. Guidance on how to evaluate emerging technologies programs can be found in the following resources (note: this is not intended to be a comprehensive listing):

- *Establishing Savings Algorithms and Evaluation Procedures for Emerging Technologies and Innovative Program Approaches*[111]
- The "Emerging Technologies Protocol" chapter of the California 2006 Energy Efficiency Evaluation Protocols
- NEEP Regional Initiative on emerging technologies has so far addressed heat pump water heaters
- NAPEE (National Action Plan for Energy Efficiency) Model Impact Evaluation Guide, Appendix C
- NAPEE Guide for Conducting Energy Efficiency Potential Studies
- FEMP New and Emerging Technology Evaluation Process[112]

Issues that have been identified in evaluating such programs include:

- Estimating measure lives
- Estimating measure persistence
- Recommending reasonable *ex ante* savings algorithms
- Small sample sizes where there is a small number of installations
- Assessing the knowledge created and knowledge disseminated
- Estimating adoption rates

Planning processes that accommodate for forecasted energy efficiency are challenged by capturing the dynamic nature of emerging technology. Estimating the impacts of future programs on energy and demand as with attribution of delivered EE, must be reliable and robust. This is a challenging process, requiring an assessment of the market place, rates of penetration, and reliability of data. There are existing guidance documents on how to perform potential studies, including one prepared by NAPEE. A few ISO/RTOs forecast EE and incorporate their long range planning studies. They typically use a stakeholder processes to inform uncertainty attributes due to changing program makeup and emerging technology.[113]

Gap Analysis and Recommendations

[111] McCowan, Brian et al" Establishing Savings Algorithms and Evaluation Procedures for Emerging Technologies and Innovative Program Approaches*,"* Paper presented at the 2012 ACEEE Summer Study on Energy Efficiency in Buildings, August 12, 2012 - August 17, 2012, Pacific Grove, California: http://www.aceee.org/files/proceedings/2012/data/papers/0193-000119.pdf.

[112] U.S. Department of Energy, "New and Emerging Technology Evaluation Process," last modified August 2012, http://www1.eere.energy.gov/femp/technologies/newtechnologies_process.html.

[113] ISO-New England, "Energy-Efficiency Forecast Working Group," accessed November 2013, http://www.iso-ne.com/eefwg.

Project-level M&V methods to evaluate emerging technologies are adequately addressed by the IPMVP. There is no gap when it comes to evaluating "Emerging Technologies" for which incentives are likely to be provided. The current program evaluation guidance on "Emerging Technology" programs is adequate.

(No gap): No gaps in evaluating the impacts of installed emerging technologies are seen at this time.

4.4.2.3 Energy Performance Indicators (EnPIs)

Energy performance indicators (EnPIs) have become key elements of energy management performance systems such as the Superior Energy Performance (SEP) certification programs fostered by the U.S. Council for Energy Efficient Manufacturing (U.S. CEEM) and the International Standards Organization's (ISO) standard on energy management (ISO 50001). Central to rigorous energy management has been guidance or specifications on how to calculate the energy performance indicators used to measure changes in energy performance. The U.S. CEEM has produced guidance for SEP in the form of the "Superior Energy Performance M&V Protocol for Industry."[114] ISO is developing a comparable standard to support ISO 50001. These protocols incorporate many of the elements described above for whole premise statistical analysis, even though they were developed for industrial applications. These include development of a baseline, allowable approaches to compare energy use in two time frames (focused on the issue of baseline), specification of the types of variables to include, and sufficient statistical rigor.

To date, the development of protocols for developing EnPI's has been focused and performed in a manner that generally comports well with typical EM&V practice. But there are already some notable differences. These differences will become material for organizations that want to practice energy management and participate in state/utility customer funded energy efficiency programs. The difficulty will be in satisfying multiple measurement requirements raising the cost of energy efficiency and potentially producing conflicting results as to how much energy was saved. For example, the discussion of industrial baselines in Section 4.1.1 indicates that in California and New York there is a specified treatment of baselines when the installed efficiency measure itself raises potential production levels. This treatment may limit or conflict with the guidance that exists in the SEP (draft) protocol.

The specific issue is not insurmountable but illustrates that the same methods in EM&V support multiple "clients" each with potentially different needs or objectives to be obtained by having a measurement of energy efficiency savings.

A. SEP protocols as a subset of current practice

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 seek 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.

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

[114] Lawrence Berkeley National Laboratory, "Superior Energy Performance: Measurement and Verification Protocol for Industry," accessed November, 2013, http://www.superiorenergyperformance.net/pdfs/SEP_MV_Protocol.pdf.

Appendix 4A: Listing of Technical Reference Manuals

Scope of TRM	Resource Name	Web Site	Format	Information Included	Administrator	Update Status (checked October 4, 2013)
National	ENERGY STAR®	http://www.energystar.gov/index.cfm?c=products.pr_find_es_products	Online Calculators	*Ex ante* savings based on algorithms	Agency	Individual calculators updated periodically
Regional – Northwest	Regional Technical Forum (RTF) Deemed Measures	http://www.nwcouncil.org/energy/rtf/measures/Default.asp	Online Database	*Ex ante* savings based on algorithms	Advisory Committee	Individual savings estimates updated periodically
Regional– Mid-Atlantic	Mid-Atlantic TRM	http://www.neep.org/Assets/uploads/files/emv/emv-products/TRM_March2013Version.pdf	PDF	Algorithms and *ex ante* savings	Non-Profit Organization	Updated March 2013; Version 3
Arkansas	Arkansas Deemed Savings Quick Start Programs	http://www.apscservices.info/EEInfo/TRM.pdf	PDF	Algorithms	Public Utility	Updated September 2013; Version 2, Volume 2
California	DEER Database for Energy-Efficient Resources	http://www.deeresources.com/	Software Program	*Ex ante* savings	State Commission	Updated May 2012. For Use in the California IOU 2013-14 Energy Efficiency Planning. Software is downloaded here: \\cadmusgroup.org\Energy\Library$\Technical Reference Manual (TRM)\California\DEER READI Database
Colorado	2012/2013 Demand-Side Management Plan	http://www.xcelenergy.com/staticfiles/xe/Regulatory/2012-2013%20Biennial%20DSM%20Plan.pdf	PDF	Algorithms and *ex ante* savings	State Commission	Updated August 2013
Connecticut	Connecticut Light & Power and United Illuminating Company Program Savings Documentation	http://www.ctenergyinfo.com/2012%20CT%20Program%20Savings%20Documentation%20FINAL.pdf	PDF	Algorithms and *ex ante* savings	Public Utility	Updated for 2012 Program Year
Delaware	Delaware Technical Reference Manual	http://www.dnrec.delaware.gov/energy/information/otherinfo/Documents/EM-and-V-guidance-documents/DELAWARE_TRM_August%202012.pdf	PDF	Algorithms	Agency	Updated April 2012

Scope of TRM	Resource Name	Web Site	Format	Information Included	Administrator	Update Status (checked October 4, 2013)
Hawaii	Hawaii Energy Efficiency Program TRM	http://www.hawaiienergy.com/media/W1siZiIsIjIwMTMvMDUvMTcvMTlfNTNfMTZfOTk1X1BZMTFfSGF3YWlpRW5lcmd5VFJNLnBkZiJdXQ/PY11-HawaiiEnergyTRM.pdf?sha=c230e920	PDF	Algorithms and *ex ante* savings	State Commission	Updated 2011
Illinois	Illinois Statewide TRM for Energy Efficiency	http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Illinois_Statewide_TRM_Version_2.0.pdf	PDF	Algorithms	Advisory Committee	Updated June 2013; Version 2
Indiana	Indiana Technical Resource Manual	\\cadmusgroup.org\Energy\Library$\Technical Reference Manual (TRM)\Indiana	PDF	Algorithms and *ex ante* savings	Agency	Updated January 2013; Version 1
Maine	Efficiency Maine TRM – Commercial	http://www.efficiencymaine.com/docs/EMT-Commercial-TRM.pdf	PDF	Algorithms and *ex ante* savings	Trust	Commercial: Updated August 2013. Version 2014-1.
	Efficiency Maine TRM – Residential	http://www.efficiencymaine.com/docs/EMT-TRM_Residential_v2014-1.pdf				Residential: Updated August 2013. Version 2014-1.
Massachusetts	Massachusetts Statewide TRM for Estimating Savings from Energy Efficiency Measures	http://www.ma-eeac.org/Docs/8.3_TRMs/1MATRM_2013-15%20PLAN_FINAL.pdf	PDF	Algorithms and *ex ante* savings	Agency	Updated October 2010 for the 2013-2015 Program Years
Michigan	Michigan Energy Measures Database	http://www.michigan.gov/mpsc/0,1607,7-159-52495_55129---,00.html	Excel Database	*Ex ante* savings	State Commission	Updated 2014 Excel Databases (see dropdown menu at bottom of page)
Minnesota	Minnesota TRM	http://mn.gov/commerce/energy/topics/conservation/Design-Resources/Technical-Reference-Manual%20.jsp	Excel Database	Algorithms and *ex ante* savings	Agency	Updated 2012
New Jersey	New Jersey Clean Energy Program Protocols to Measure Resource Savings	http://www.njcleanenergy.com/files/file/NJ%20Protocols%20Revisions%208-14-12_Clean%281%29.pdf	PDF	Algorithms and *ex ante* savings	Agency	Updated August 2012
New York	New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs	http://efile.mpsc.state.mi.us/efile/docs/16671/0026.pdf	PDF	Algorithms and *ex ante* savings	Agency	Updated Oct 2010

Scope of TRM	Resource Name	Web Site	Format	Information Included	Administrator	Update Status (checked October 4, 2013)
Ohio	Ohio TRM	http://amppartners.org/pdf/TRM_Appendix_E_2011.pdf	PDF	Algorithms and *ex ante* savings	State Commission	Updated August 2010
Pennsylvania	Pennsylvania TRM	http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx	DOC	Algorithms and *ex ante* savings	State Commission	Updated for 2013
Rhode Island	Rhode Island TRM for Estimated Savings from Energy Efficiency Measures	http://www.nationalgridus.com/non_html/eer/ri/Rhode%20Island%20TRM_PY2013_final.pdf	PDF	Algorithms	State Commission	Updated for 2013 Program Year
Texas	Deemed Savings, Installation, and Efficiency Standards	http://www.entergy-texas.com/content/Energy_Efficiency/documents/Deemed_Savings_Measures_List.pdf	PDF	Algorithms and *ex ante* savings	State Commission	Updated January 2013
Vermont	Efficiency Vermont Technical Reference User Manual	\\cadmusgroup.org\Energy\Library$\Technical Reference Manual (TRM)\Vermont	PDF	Algorithms and *ex ante* savings	Non-Profit Organization	Updated March 2013; Number 2013-81
Washington	Washington State Energy Code	http://www.energy.wsu.edu/BuildingEfficiency/EnergyCode.aspx#TEXT	PDF	*Ex ante* savings	Agency	Updated 2012
Wisconsin	Focus on Energy Evaluation Business Programs: Deemed Savings Manual	http://www.focusonenergy.com/sites/default/files/bpdeemedsavingsmanuav10_evaluationreport.pdf	PDF	Algorithms and *ex ante* savings	State Commission	Updated March 2010; Version 1

Appendix 4B: Categories of Behavior-Based Programs

Behavior-Based Program Descriptor	Information Target	Means of recruitment/ exposure	Location of savings	Expected significant cross-customer spill over?	Typical difficulty of correctly estimating net energy savings	Examples of programs	Notes
Randomized Controlled Trial (RCT)	End user	RCT design with opt-out or opt-in	End user premises	No	Low, assuming sufficient number of treatment customers, and a very low rate of opt-out	Any program in which treatment results from random assignment from a pool of customers; currently, energy report programs are the common form	
Opt-in with quasi-experimental evaluation method	End user	Opt-in by end user	End user premises	No	Medium-Low in best-case scenario in which there are sufficient number of treatment customers and there exists the opportunity to use best available methods for addressing various sources of bias, especially selection bias	Web-based information programs, Opt-in home energy display programs; opt in programs at the organization level when program goal is on-site savings; opt-in programs involving building operator certification/training	
Random Encouragement Design (RED)	End user	Opt-in by end user, but with a randomly-selected subset of customers targeted for encouragement	End user premises	No	Low; the design addresses selection bias, though the method requires assumptions that may not be met in some cases, and the method also requires data collection for a relatively large number of customers	Any opt-in program can be designed as an RED program	

Behavior-Based Program Descriptor	Information Target	Means of recruitment/ exposure	Location of savings	Expected significant cross-customer spill over?	Typical difficulty of correctly estimating net energy savings	Examples of programs	Notes
Organization-Focused, Off-site Savings	Organizations of end users, e.g. employees of a business, children of a classroom or school, members of a religious group	Opt-in at the organization level with contained chained exposure	Organization member premises (homes of employees, homes of schoolchildren, etc.)	No	Medium-Low when energy use data of member premises is available (note in particular that selection at the organization level implies a weaker case for selection bias at the member level); High when this data is not available and deemed savings for claimed behaviors is necessary	Programs at businesses or schools that organize "teams" (e.g. by business department, by classroom) that compete with one another to save energy at the residences of team members	"**chained exposure**" refers to a design feature in which some customers receive information from a primary source and are explicitly tasked with passing it on to other customers; "**contained chained exposure**" is chained exposure that stays within a population known to the analyst (e.g. within employees of a business)
Uncontained Social Networking	Social network	Opt-in by member of the social network, with subsequent uncontained chained exposure	Premises of social network members	Yes	High due to difficulty of tracking networks	BGE program designed by Opower (focused on demand savings only)	

Behavior-Based Program Descriptor	Information Target	Means of recruitment/ exposure	Location of savings	Expected significant cross-customer spill over?	Typical difficulty of correctly estimating net energy savings	Examples of programs	Notes
Umbrella marketing	Customers within the umbrella	Exposure without recruitment; these programs provide exposure via radio announcements, advertising buys, etc.	Premises of customers exposed to messaging	Yes (e.g. media messaging that reaches beyond the target audience)	High; requires knowledge/data of where the "edges" of the umbrella lie, geographically and demographically; requires the development of a comparison group from outside the marketing boundary		

Chapter Five: Workforce Credentialing

5.0 Introduction

Verifiable and standards-based workforce credentials serve as an anchor for growing energy efficiency industries. A strong and competent workforce – one that is agile enough to meet changing market demands – provides the underpinning for growth and consumer acceptance resulting in reduced energy consumption and the creation of market-valued jobs. However, unsubstantiated claims of competency and inconsistent assessment practices have given rise to a confusing and rather chaotic assortment of workforce credentials. The good news is that a core of quality standards and credentialing schemes are in place and provide a strong launching pad from which to build a competent workforce. The challenge is sorting through the various credentials offered, finding the credential that meets the needs of employers and consumers, and making sure that both consumers and workers select industry-developed and recognized standards. This chapter is intended to guide stakeholders in understanding, identifying, and selecting quality credentials.

At the heart of the issue is understanding credentialing in the first place. In reviewing standards and conformance assessment schemes to identify those appropriate to workforce credentialing in energy efficiency, the EESCC workforce credentialing working group requested and received almost 90 submittals from 28 organizations. Not all of the entries met the definition of energy efficiency credentials; others did not provide enough information to support their energy efficiency content. But for those that did, members of the committee looked for evidence that the credentials were industry-aligned, developed according to best practices, current, and relevant for today's workforce. During its review, the working group reached a number of conclusions.

In workforce credentialing, **standards** and **conformity assessment** are the two guiding elements in selecting credentials.

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Voluntary consensus standards establish valid requirements that assure appropriate stakeholder involvement.

Conformity assessment schemes assure compliance with the standards.

Currently, there is confusion in the marketplace about the various types of credentialing programs offered – including certificate, training, and certification – and what these credentials are intended to achieve for the worker. Often, terminology is used incorrectly. For example, some "certificate" programs describe their scope as "certification." While seemingly a minor inaccuracy, credentials can carry varying degrees of rigor; some demonstrate learning outcomes, while others assess occupational competencies. There is also a lack of understanding of the components that describe quality credentialing programs, and measures to differentiate "market-valued" credentials from those that are not. The end result is confusion among various industry stakeholders, including the worker seeking a credential, and end users such as employers and regulators who rely on the credential as a means of qualifying the workforce. This chapter of the roadmap is intended to address these issues in an effort to guide stakeholders in the selection of quality credentials.

What stands behind a credential – how it is developed and maintained – is as important as the end product itself. Rigor and adherence to best credentialing practices lay a solid foundation for well-developed credentialing programs. Ongoing maintenance and review are also critical components of well-designed and managed credentialing programs. These elements help to ensure the integrity of a program, and in turn, the value of the credential. Not only should the public, government officials, utility companies, employers, and other consumers support credentialed workers and services, they should expect and ask for evidence that the credentials are meaningful and follow accepted measures of conformance to industry-driven standards. Credentials play a pivotal role in assuring safety and in preparing a workforce. When developed correctly, credentials bring value to *all* stakeholders, whether they are directly using services of credentialed individuals, or indirectly benefiting from higher industry standards that focus on quality and safe practices.

While not all standards and credentials are alike in terms of quality and industry relevance, this chapter should enable stakeholders to better understand the type of credential most suitable for their purposes. Several references are provided in the chapter appendix to guide stakeholders in the selection of credentials that qualify a workforce. Stakeholders are encouraged to review the references in their entirety, and to compare standards and conformance assessments.

5.1 Terminology: Defining Workforce Credentialing

As noted above, much confusion surrounding workforce credentialing stems from the incorrect use of terminology. The select definitions that follow are intended to guide stakeholders in understanding key terms, and to establish consistency in and correct usage of these terms. In selecting the definitions for this section, several sources were referenced and are noted in Appendix 5A, and users of this roadmap are encouraged to refer to those documents in their entirety.

- **Accreditation**—third-party attestation related to a conformity assessment body conveying formal demonstration of its competence to carry out specific conformity assessment tasks (Reference ISO/IEC 17000 *Conformity assessment—Vocabulary and general principles*).

- **Programmatic accreditation**—third-party conformity assessment of an academic program's conformance with standards specifically developed in an area of study (as defined by Workgroup 5).

- **Certificate**—document issued by a certification body under the provisions of this International Standard [ISO/IEC 17024:2012 *Conformity Assessment—General requirements of bodies operating certification of persons*] indicating that the named person has fulfilled the certification requirements; document (letter, card, or other medium) awarded to the certificate holders that designates the successful completion of a certificate program's requisites (Reference ASTM E 2659—09 *Standard Practice for Certificate Programs*).

- **Certification**—third-party attestation related to products, processes, systems, or persons (Reference ISO/IEC 17000 *Conformity assessment—Vocabulary and general principles*).

- **Personnel Certification**—A process of verifying that an individual meets the competency requirements of an established standard to perform in a job or occupation. Personnel certifications include an assessment and maintenance requirements.

- **Educational/Training Certificate program**—non-degree granting education or training program consisting of (1) a learning event or series of events designated to educate or train individuals to achieve specified learning outcomes within a defined scope; and, (2) a system designed to ensure individuals receive a certificate only after verification of successful completion of all program requisites including but not limited to an evaluation of learner attainment of intended learning outcomes (Reference ASTM E 266595—09 *Standard Practice for Certificate Programs*).

- **Credentialing**—the process by which a body or organization recognizes or records the recognition status of persons, that meet predetermined criteria (Reference ISO/IEC TC/SC N81, *Conformity Assessment—Common terminology related to competency of persons*, DRAFT).

- **License, licensure**—the recognition of competence to practice a given occupation or profession conveyed to a person or entity by a regulatory body; approval process, carried out by an authorized body granting permission to a person or organization to engage in a given occupation after verifying that he/she/they have met predetermined requirements. This is usually demonstrated by a document or care (a license). (Reference ISO/IEC TC/SC N81, *Conformity Assessment—Common terminology related to competency of persons*, DRAFT).

While not considered workforce credentialing terminology, the following are used in this roadmap and considered important to quality workforce credentials:

- **Industry Recognized**—acceptance of the credential by industry as a valid job, skill set, or knowledge area (as defined by Workgroup 5).

- **Market-Valued Certificate**—certificate issued has value in the market by teaching skills that are in demand by employers, and/or by achieving recognition by industry, government, and/or the public that training outcomes result in marketable and job-related skills (Reference IREC Standard 14732:2013 *General Requirements for Renewable Energy & Energy Efficiency Certificate Programs*).

- **Registered Apprenticeship Program**—government (state or federal) approved program of learn-and-earn training programs in a particular trade or occupation. Required features include approval by the government accrediting agency of minimum training standards, a standardized curriculum approved by industry partners in labor and management; fair and impartial selection processes; work site supervision by journey-level workers of the same trade, and an approved public education institution partner. Includes increases in pay as skills are acquired, and upon graduation, award of journey-level status by certifying government agency.

- **Stakeholder**—any materially affected or interested party (as defined by Workgroup 5).

Recommendation

Standard and industry-accepted credentialing and workforce terminology should be used to avoid confusion and promote understanding for stakeholders searching for and utilizing conformance programs.

5.2 Indicators of Quality Credentialing Programs

In addition to understanding the correct use of terminology in selecting standards and conformance assessment schemes for workforce credentials, knowing the indicators of quality of credentialing programs will assist stakeholders in differentiating programs of integrity from those of lesser quality.

One of the first indicators of quality to look for is accreditation. Accreditation is typically a voluntary process, although it can be mandated by industry and/or professions associated with workforce credentialing or by federal or state government. There are numerous organizations that administer accreditation programs for personnel certification and certificate programs that take the guesswork out of finding quality credentialing programs, including but not limited to the American National Standards Institute (ANSI) and the Institute for Credentialing Excellence (ICE).[115] Accreditation is most applicable to personnel certification, certificate programs, and programmatic accreditation, which applies to programs in institutions of higher education and/or vocation and technical training institutes. Programmatic accreditation is discussed in Section 5.6.

[115] For **personnel certification**, ANSI administers ISO/IEC 17024:2012 *Conformity assessment—general requirements for bodies operating certification of persons*; the National Commission for Certifying Agencies (NCCA), a branch of ICE, administers *Standards for the Accreditation of Certification Programs*, 2004; IREC administers 01024:2013 *General Requirements for Renewable Energy, Energy Efficiency and Distributed Generation Instructors and Master Trainers*. For **certificate programs**, ANSI administers ASTM E 2659-09 *Standard Practice for Certificate Programs*; ANSI/IREC administers Standard 14732:2013 *General Requirements for Renewable Energy & Energy Efficiency Certificate Programs*; and IREC administers Standard 10123:2013 *General Requirements for Renewable Energy, Energy Efficiency and Distributed Generation Training*.

While accreditation is a highly valued indicator of quality credentialing programs, few credentialing programs seek accreditation; and yet, these programs can be of high quality. This section details indicators of quality credentialing programs to help guide stakeholders in selecting standards and conformance assessment schemes:[116]

Indicators of Quality Personnel Certification Programs:

- Third-party, independent governing body that demonstrates impartiality
- Scope of certification available to the public without request
- Current job task analysis
- Process for examination development, maintenance, and administration (psychometric review)
- Eligibility requirements (prerequisites)
- Recertification requirements
- Code of ethics
- Disciplinary procedures
- Certificate awarded includes expiration date
- Publication of certified individuals (website, directory)
- Policies that guide all certification decisions, including due process
- Protection of Intellectual Property, including examination, logos, marks, and certificates
- Balanced stakeholders that provide on-going systematic input
- Separation of training from testing
- Complaints and appeals process
- On-going professional development/recertification

Indicators of Quality Certificate Programs:

- Balanced stakeholders that provide on-going systematic input
- Job task analysis or other content standard on which the program is based
- Validation study
- Published scope of certificate
- Program prerequisites
- Alignment of learning objectives with assessments
- Certificate and training is industry recognized
- Criterion-referenced assessments of the learner
- Qualified faculty
- Environments conducive to learning
- Available resources to support learning
- Program evaluation (summative and formative)
- Policies that guide program decisions, including due process

Indicators of Quality Accreditation Programs:

- Third-party independent governing board

[116] For the purposes of this roadmap, indicators are limited to personnel certification, certificate programs, and accreditation.

- Scope of accreditation available to the public without request
- Balanced stakeholder input on accreditation requirements representing the market being served
- Policies that guide the accreditation programs
- Due process
- Publication of accreditation requirements
- Desk review and site-visit
- Separation of assessors from an accreditation body that make the accreditation decision
- Qualified and trained assessors
- Continual training of assessors to facilitate consistent decisions
- Inter-rater reliability studies for assessors
- Appeals and complaints process

Stakeholders selecting workforce credentials may encounter several credentials for the same job or skill set. In credentialing, competition exists. Assessing available credentials for the same skills will invariably lead to comparisons and judgment based on a variety of criteria, so differentiating between credentials may require careful review of standards to identify indicators of quality.

Recommendations

Indicators of quality credentialing programs should be drawn on to guide stakeholders in selecting standards and conformance assessment schemes.

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Both certifications and certificates should include assessment of attainment of competencies and skills.

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State and federal agencies should recognize accredited credentialing programs

5.3 Role of Registered Apprenticeships in Workforce Credentialing

Registered apprenticeship programs play a role in training and qualifying a skilled energy efficiency workforce and should be considered part of the workforce credentialing framework. The U.S. Department of Labor (DOL) and/or state labor agencies provide registration[117] of apprenticeship training

[117] According to the U.S. Department of Labor (DOL), Registered Apprenticeship combines on-the-job training with theoretical and practical classroom instruction to prepare workers for American industry. The process of apprenticeship program registration with federal and state government agencies is standards-based, and is designed to ensure that working apprentices, program sponsors, and the general public can gain a clear understanding of the training content and the measures that are in place to ensure ongoing quality. Additional information on Registered Apprenticeship is available on DOL's website: http://www.doleta.gov/OA/apprenticeship.cfm.

programs, and graduates of federal- or state-approved programs receive a federal- or state-issued, nationally-recognized credential. This credential indicates occupational proficiency and is portable, conveying significant value in the market. Apprenticeship is an “earn-while-you-learn” model that provides employment with on-the-job training and technical classroom instruction provided by a community college or other educational partner. Programs are funded through employer and employee contributions and employers sit on curricula committees and thus ensure training is directly linked to industry needs.

Apprenticeship programs may offer energy efficiency-specific training and credentials embedded in broader occupational training programs. These credentials are embedded in apprenticeship training as one component of the broad and comprehensive foundational training learned over the three to five years of an apprenticeship for each particular construction trade. The market value of apprentice programs is linked to the availability of the apprenticeship based on the demand for jobs, which avoids training workers for non-existent jobs. Additional details on the role of apprenticeship in workforce credentialing are provided in Appendix 5D.

Recommendations

Energy efficiency skills and knowledge should be incorporated into training and credentialing programs for traditional occupations in both the construction trades and other relevant professions, such as engineering and architecture. In instances in which this approach is not feasible, training may focus on a specific skill area.

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A clear, formal process beginning with a job task analysis should be used to delineate the knowledge, skills, and abilities (KSAs) required for major occupations related to energy efficiency.

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Technical specifications for installation, maintenance, and operations of energy efficiency equipment and systems should be formalized and then mapped to occupations, job task analyses, KSAs, training programs, and certifications.

5.4 Determining Market Value of Workforce Credentialing Programs

Credentials play a key role in identifying a qualified workforce. Frequently, credentials are used as a means of selecting workers for jobs, and in enabling workers to demonstrate the currency and job-relatedness of their skills, advance in their field, and increase compensation. For both employers and workers, credentials can have a high market value. In fact, the more employers and workers demand a credential, the greater its market value can become, and the wider its value can reach to the organization that administers it, the industry that supports it, and the consumer who relies on it. The market value of a credential can be assessed by one or several of these variables, and at any given time, one indicator of market value may trump others.

There is broad recognition of workforce credentials in the field of energy efficiency, from government and trade associations to standards developing organizations, educational institutions, manufacturers, distributors, utilities, and the consumer: each has a stake in the efficient use of energy and the workforce that installs, services, and maintains the systems using the energy. The support of a workforce credential by any of these sectors can also define the market value of a credential.

Stakeholders can define the market value of the credential by considering the following factors relative to industry and/or its workforce:

- *What would happen if the credential did not exist—would errors and accidents occur?*
- *Is the credential linked to industry, and is it job and/or skills related?*
- *Are the skills and knowledge current and relevant, and can the student begin working immediately without further training?*
- *How does the credential qualify a workforce?*
- *Who are the end-users of the credential—workers, employers, consumers?*
- *Will there be an ongoing need for the credential?*

Recommendation

Credentials should hold demonstrated market value for workers, employers, and consumers.

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The energy efficiency industry and credentialing bodies should jointly market the quality assurances built into credentialing the workforce.

5.5 The Role of Conformity Assessment in Building Confidence in Credentialing Programs

The practices and procedures involved in the daily operation and maintenance of buildings have significant impact on energy performance. Where energy use is monitored based on sustainability and cost savings factors, credibility and confidence in the professionals charged with safeguarding the value of building stock, complying with evolving energy codes, and carrying out mission critical directives to drive down energy usage and costs are essential.

A building-trades professional who holds a credential is said to possess distinct qualifications. Personnel certification confirms the competence of individuals to perform specified services or duties. A personnel certification program develops criteria against which an individual needs to demonstrate competencies and ensures these criteria are held by applicants before certifying them. Just as credential holders are held to standards with regard to skills and ethics, credentialing bodies are held to standards of practice. By placing confidence in the standards and practices of a third-party accredited personnel certification body, stakeholders can save the cost of independently assessing the qualifications of a candidate or the time-intensive work of comparing those qualifications to others. For example, ANSI's accreditation program for personnel certification bodies is based on the international standard ANSI/ISO/IEC 17024, *Conformity assessment—General requirements for bodies operating certification of persons*. An impartial assessor evaluates the certification process, determining if the examination is evaluating the identified competencies and enhancing consumer and public confidence in a certification program and the person who holds the certification.

The accreditation process is designed to provide assurance that accredited personnel certifiers are accurately assessing the knowledge and skills possessed by professionals, bolstering the mobility of these professionals and industry confidence in the legitimacy and accuracy of these certifications. Third-party accreditation is valuable to consumers, employers, governments, and the industry because it ensures the certification program and its credential have been vetted to meet all established benchmarks for operating a competent and impartial certification program.

Recommendation

Third-party accreditation of energy efficiency credentialing programs by an independent party should be encouraged to ensure that the program has met established benchmarks for operating a competent and impartial credentialing program.

5.6 Programmatic Accreditation for Training

While the accreditation of institutions of higher education and vocational/technical programs is an accepted and critical indicator of quality education in the United States, institutional accreditation does not provide an indicator of the quality of energy efficiency programs. To support the growth and maturity of the energy efficient workforce, and to assure that the technical content delivered meets industry standards and the program prepares energy efficiency workers to perform discrete jobs safely and effectively, the next step in credentialing is programmatic accreditation.

A key component of programmatic accreditation is the development of the accreditation standards, including the curricular content, by industry stakeholders. The involvement of industry stakeholders – educators, manufacturers, distributors, contractors, and technicians – results in an industry-supported program and curriculum that covers the knowledge, skills, abilities, attitudes, and tasks each accredited program must deliver, thereby assuring greater consistency in the performance of the graduate and future worker. Additionally, industry sets criteria for the educators, program funding, and the equipment needed to produce the workforce.

One industry accreditation may not fit all workforce career programs in a given discipline. Therefore, industry partners, even in small groups, may develop more than one accreditation program with the intent of raising the educational bar. Criteria for recognizing any accrediting body shall include evidence that the accrediting body follows an open, transparent, and inclusive process for awarding accreditation.

Recommendations

Energy efficiency training programs should be accredited to technical and programmatic content to assure workers perform jobs safely and effectively. In some cases, the most appropriate accreditation body may exist outside of the current scope of higher education accreditation.

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Energy efficiency training should result in an industry-supported program and curriculum that covers the knowledge, skills, abilities, attitudes, and tasks each accredited program must deliver, thereby assuring greater consistency in the performance of the graduate and future worker.

5.7 Defining the Energy Efficiency Content of Occupations

Energy efficiency is frequently an *aspect* of a job or trade, but not necessarily an occupation in and of itself. Therefore, stakeholders seeking workforce credentials in energy efficiency may not find credentials exclusive to energy efficiency. Stakeholders reviewing workforce credentials for individuals qualified in energy efficiency should review the job task analysis upon which certification and certificate programs are based in order to determine if competencies and skills include energy efficiency. Appendix 5E contains a methodology to assist stakeholders in calculating the energy efficiency content of a credential, and also some sample rankings of different occupations. The goal is to encourage inclusion of relevant energy efficiency content in occupational training or testing, and also allow students or candidates and their sponsors a way to evaluate energy efficiency content in courses or tests. Furthermore, the methodology should allow clients of courses or tests to evaluate the extent to which appropriate energy efficiency content is included, and how much a career could impact the efficiency of a given building type.

Job Task Analyses (JTAs) from two programs (Facility Manager and Energy/Sustainability Manager) were analyzed to determine the percentage of the JTA that is energy-related, and how much they could impact the efficiency of a building. In addition, two other programs (Retrofit Installer Technician and Energy Auditor) were analyzed to determine their energy content. As shown in Appendix 5E, the Energy/Sustainability Manager has both greater energy content and greater potential to impact the efficiency of a commercial building compared to a Facility Manager. In the second example, Energy Auditor is shown to have much greater energy content than Retrofit Installer Technician. The methodology proposed can be used to rank occupations by both energy content (EC) of the JTA, and also the potential energy impact (PEI) the career can have on the energy efficiency of the building types the occupation serves. This information can be used by various stakeholders to determine which careers to focus on when trying to improve the energy efficiency of an organization.

Recommendations

Stakeholders reviewing workforce credentials should review the job task analysis on which the certification or certificate program is based in order to determine if energy efficiency competencies and skills are included.

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To better quantify an occupation's actual impact on energy efficiency, a two-step methodology is recommended. Occupations should first be measured and ranked on how much of the job task analysis is related to energy using a comprehensive review of the existing job task analysis. A second measure is an estimation of how much an occupation can impact the overall energy efficiency of the building types the occupation serves. Combined, these two metrics give good indication if an occupation can impact the energy marketplace.

5.8 Measuring Outcomes on the Performance of the Credentialed Workforce

The assurance that an individual has the needed competencies is a key goal of credentialing, and the attainment of credentials enables workers to demonstrate their skill set, knowledge, and/or competencies. While this demonstration of competence adds value to the worker, the employer, and the consumer, and benefits industry, the measure of outcomes of credentialing in terms of job-performance and actual energy savings is not always available or calculated. Validation and impact studies with a well-developed methodology, sampling plan, data collection tools, and protocols could help to resolve these issues.

In determining variables of market value, validation and impact studies that calculate energy savings gained by a credentialed workforce performing a job correctly would strengthen the relationship between credentialing and a qualified, effective workforce. There are two key areas of interest for performance outcomes: **validation of the credential** and **energy savings impact** of credential holders.

From a practical standpoint, it is worthwhile to note that these studies are research-intensive and could be costly. Organizations committed to this level of rigor should be prepared to devote the necessary resources to produce meaningful results for assessment of the credential program. Methodologies for conducting an impact study and a credential validation study are provided in Appendix 5F.

1. **Credential Validation Study**
   A validation can help to address the measure of actual performance of an exam.

2. **Impact Study**
   Impact studies aim to quantify the energy and demand impacts attributed to credentialing. Existing methodologies include credential holder surveys and site visits to determine energy impacts through engineering analysis. An evaluation can provide annual energy and demand savings per participant, per square foot, per site address (and/or company), and other aggregate levels.

Recommendations

Outcomes on credentialing should be tied to job performance. Validation studies with a well-developed methodology, sampling plan, data collection tools, and protocols should show the link between the credentialed individual and job performance.

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Validation and impact studies are needed to promote models for credentialing organizations to implement in order to consistently gather and interpret data regarding the effectiveness of the credentialing programs in reducing energy use.

5.9 Conclusion: The Importance of Workforce Credentialing

A qualified workforce, in addition to the implementation of practices and procedures involved in the daily operation and maintenance of buildings, has a significant impact on energy performance. Where energy use is monitored based on sustainability and cost savings factors, credibility and confidence in the workers charged with safeguarding the value of building stock, complying with evolving energy codes, and carrying out mission critical directives to drive down energy usage and costs, is critical. Standards and conformity assessments are one means to guide stakeholders in determining energy efficiency practices and the requirements of workforce to implement them. It is hoped that the issues discussed in this chapter on workforce credentialing will provide stakeholders with the necessary tools to increase energy performance in their jobs, businesses, and daily lives.

5.10 Summary of Recommendations to Advance and Improve Credentialing for the Energy Efficiency Workforce

In an effort to advance and improve credentialing for the energy efficiency workforce, the EESCC working group on workforce credentialing puts forth the following overarching recommendations:

Recommendation: Standard and industry-accepted credentialing and workforce terminology should be used to avoid confusion and promote understanding for stakeholders searching for and utilizing conformance programs. *(Section 5.1)*

Recommendation: Indicators of quality credentialing programs should be drawn on to guide stakeholders in selecting standards and conformance assessment schemes. (*Section 5.2*)

Recommendation: Both certifications and certificates should include assessment of attainment of competencies and skills. *(Section 5.2)*

Recommendation: State and federal agencies should recognize accredited credentialing programs. *(Section 5.2)*

Recommendation: Energy efficiency skills and knowledge should be incorporated into training and credentialing programs for traditional occupations in both the construction trades and other relevant professions, such as engineering and architecture. In instances in which this approach is not feasible, training may focus on a specific skill area. *(Section 5.3)*

Recommendation: A clear, formal process beginning with a job task analysis should be used to delineate the knowledge, skills, and abilities (KSAs) required for major occupations related to energy efficiency. *(Section 5.3)*

Recommendation: Technical specifications for installation, maintenance, and operations of energy efficiency equipment and systems should be formalized and then mapped to occupations, job task analyses, KSAs, training programs, and certifications. *(Section 5.3)*

Recommendation: Credentials should hold demonstrated market value for workers, employers, and consumers. *(Section 5.4)*

Recommendation: The energy efficiency industry and credentialing bodies should jointly market the quality assurances built into credentialing the workforce. *(Section 5.4)*

Recommendation: Third-party accreditation of energy efficiency credentialing programs by an independent party should be encouraged to ensure that the program has met established benchmarks for operating a competent and impartial credentialing program. *(Section 5.5)*

Recommendation: Energy efficiency training programs should be accredited to technical and programmatic content to assure workers perform jobs safely and effectively. In some cases, the most appropriate accreditation body may exist outside of the current scope of higher education accreditation. *(Section 5.6)*

Recommendation: Energy efficiency training should result in an industry-supported program and curriculum that covers the knowledge, skills, abilities, attitudes, and tasks each accredited program must deliver, thereby assuring greater consistency in the performance of the graduate and future worker. *(Section 5.6)*

Recommendation: Stakeholders reviewing workforce credentials should review the job task analysis on which the certification or certificate program is based in order to determine if energy efficiency competencies and skills are included. *(Section 5.7)*

Recommendation: To better quantify an occupation's actual impact on energy efficiency, a two-step methodology is recommended. Occupations should first be measured and ranked on how much of the job task analysis is related to energy using a comprehensive review of the existing job task analysis. A second measure is an estimation of how much an occupation can impact the overall energy efficiency of the building types the occupation serves. Combined, these two metrics give good indication if an occupation can impact the energy marketplace. *(Section 5.7)*

Recommendation: Outcomes on credentialing should be tied to job performance. Validation studies with a well-developed methodology, sampling plan, data collection tools, and protocols should show the link between the credentialed individual and job performance. *(Section 5.8)*

Recommendation: Validation and impact studies are needed to promote models for credentialing organizations to implement in order to consistently gather and interpret data regarding the effectiveness of the credentialing programs in reducing energy use. *(Section 5.8)*

Appendix 5A: Reference Documents for Terminology[118]

Reference Document	Scope/Description
ASTM E2708-10, *Standard Terminology for Personnel Credentialing*	This terminology defines terms related to the credentialing of persons. These terms are offered to enable the development of future ASTM documents relating to personnel certificate and certification programs. The source document for each definition is cited when an appropriate document is available. Many definitions are the product of the committee that compiled this terminology, and as such, are the result of the collected knowledge and experience of the committee members. Since credentialing of persons is being carried out by many different bodies in many career fields, usage of descriptive terms can vary. There is no attempt to include all credentialing terms in this terminology. Rather, this terminology contains those terms most commonly encountered in the credentialing process.
ASTM E2659-09, *Standard Practice for Certificate Programs*	ASTM E2659-09 specifies general terms and definitions relating to the accreditation of certificate issuers to develop and administer quality certificate programs and to stakeholders for determining the quality of certificate programs, including certificate. The standard includes the requirements for both the entity issuing the certificate and requirements for the specific certificate programs for which it issues certificates and provides the foundation for the recognition or accreditation or both of a specific entity to issue a specific certificate or certificates to individuals after successful completion of a certificate program.
ISO/IEC 17000, *Conformity assessment - Vocabulary and general principles*	ISO/IEC 17000:2004 specifies general terms and definitions relating to conformity assessment, including the accreditation of conformity assessment bodies, and to the use of conformity assessment to facilitate trade. A description of the functional approach to conformity assessment is included as a further aid to understanding among users of conformity assessment, conformity assessment bodies and their accreditation bodies, in both voluntary and regulatory environments. ISO/IEC 17000:2004 does not set out to provide a vocabulary for all of the concepts that may need to be used in describing particular conformity assessment activities. Terms and definitions are given only where the concept defined would not be understandable from the general language use of the term or where an existing standard definition is not applicable.
ISO/IEC TC /SC N81 ISO/IEC WD 17024-2, *Conformity Assessment - Common terminology related to competency of persons**	This standard is currently under development.
ISO/IEC 17024:2012, *Conformity Assessment - General requirements for bodies operating certification of persons*	ISO/IEC 17024:2012 specifies general terms and definitions relating to certification of persons, as well as the requirements for a body certifying persons against specific requirements, and includes the development and maintenance requirements of the certification scheme for persons. Terminology includes certification process, certification scheme, certification requirements, and certificate.

[118] Unless noted with an asterisk*, information on these documents is also available in the EESCC Inventory Database: http://toolswiki.ansi.org/tiki-index.php?page=EESCCTabs.

Appendix 5B: Reference Documents for Guidance on Credentialing Programs[119]

Document	Scope/Description
ISO/IEC 17024, *Conformity assessment - General requirements for bodies operating certification of persons*	ISO/IEC 17024:2012 contains principles and requirements for a body certifying persons against specific requirements, and includes the development and maintenance of a certification scheme for persons.
ST10 ICE 1100 2010 (E), *Standard for Assessment-Based Certificate Programs*	The standard specifies essential requirements for certificate programs and provides guidance to program providers, consumers, and others on what defines a high-quality program.
ASTM E2833, *Standard Practice for Certification Bodies that Certify Personnel Engaged in Inspection and Testing of Construction Activities and Materials Used in Construction, Including Special Inspection*	This practice provides supplemental requirements to those of ANSI/ISO/IEC 17024 for bodies that certify personnel engaged in inspection and testing of construction activities and materials used in construction, including Special Inspection. ANSI/ISO/IEC 17024 provides generic requirements that can be adapted to any discipline where assurance that certified individual meets the requirements of the certification scheme. Therefore, certification bodies certifying personnel engaged in inspection and testing of construction activities and materials used in construction, including Special Inspection, must meet the requirements of this practice and ANSI/ISO/IEC 17024.
ASTM E2659-09, *Standard Practice for Certificate Programs*	This practice provides guidance to certificate issuers for developing and administering quality certificate programs and to stakeholders for determining the quality of certificate programs. This practice includes requirements for both the entity issuing the certificate and requirements for the specific certificate programs for which it issues certificates. This practice provides the foundation for the recognition or accreditation or both of a specific entity to issue a specific certificate or certificates to individuals after successful completion of a certificate program. This practice does not address guidance pertaining to certification of individuals nor does it address guidance pertaining to education or training programs in general, including those that issue certificates of participation or certificates of attendance.
IAS - International Accreditation Service, Inc. AC371, *Accreditation Criteria for Training Agencies for Work Force Qualification Programs*	These criteria set forth requirements for obtaining and maintaining International Accreditation Service, Inc. (IAS), accreditation for non-degree-granting training agencies for adult education for work force qualification programs, and to certificates which may be issued by these agencies to successful participants.
IAS - International Accreditation Service, Inc. AC372, *Accreditation Criteria for Curriculum Development for Work Force Qualification Programs*	These criteria set forth requirements for obtaining and maintaining International Accreditation Service, Inc. (IAS), accreditation for curriculum development for work force qualification programs. The scope of these criteria does not extend to users of approved curricula (training schools).
IREC Standard 01023:2013, *General Requirements for the Accreditation of Clean Energy Technology Training*	This standard identifies requirements for the quality systems, resources, personnel, and curriculum by which job-related training in clean energy technologies and practices may be accredited. For the purposes of this standard, clean energy technologies and practices include renewable energy, energy efficiency, distributed renewable energy generation, and other sustainability practices.

[119] Unless noted with an asterisk*, information on these documents is also available in the EESCC Inventory Database: http://toolswiki.ansi.org/tiki-index.php?page=EESCCTabs.

Document	Scope/Description
IREC Standard 01024:2013, *General Requirements for the Certification of Clean Energy Technology Instructors and Master Trainers*	This standard establishes requirements for the instructional and professional field experience, subject-matter expertise, and instructional quality by which instructors and master trainers in clean energy technologies and practices may become certified. For the purposes of this standard, clean energy technologies and practices include renewable energy, energy efficiency, distributed renewable energy generation, and other sustainability practices.
IREC (Interstate Renewable Energy Council, Inc.) Standard 14732:2013, *General Requirements for Renewable Energy & Energy Efficiency Certificate Programs*	This standard forms the foundation for the accreditation of certificate-awarding entities that develop and administer credit or non-credit energy efficiency and renewable energy-related programs offered in formal educational institutions and other legal entities. For the purposes of this standard, energy efficiency is defined as the result of efforts to reduce the amount of energy consumed in producing a service, product, or condition. Renewable energy constitutes wind, solar, geothermal, bioenergy, hydrogen, non-conventional hydro, and renewable fuels. 1.2 This standard provides the accreditation requirements that energy efficiency and renewable energy programs must meet and document to earn and maintain accreditation. The purpose of accreditation is to determine whether the program meets the requirements for issuing a market-valued certificate. 1.3 This standard does not address requirements for the certification of individual practitioners, educators, or trainers in energy efficiency and renewable energy programs. 1.4 Organizations shall abide by local, state, and federal regulatory requirements. This standard is not intended to supersede any codes, requirements, or regulation.
ANSI/IACET Standard for Continuing Education and Training	The ANSI/IACET Standard for Continuing Education and Training defines a proven model for developing effective and valuable continuing education and training (CE/T) programs. Because the Standard focuses on *how* learning programs are developed, not *what* they cover, it provides a framework of best practices that can be applied across disciplines and industries.
Distance Education and Training Council - DETC Publications*	The Distance Education and Training Council offers a number of publications on its website. (http://www.detc.org/publications/index.html)
Registered Apprenticeships Requirements*	The Registered Apprenticeship system provides an opportunity for workers seeking high-skilled, high-paying jobs and for employers seeking to build a qualified workforce. The U.S. Department of Labor regulates apprenticeship programs at the national level according to federal regulations that set standards for establishing and registering apprenticeship programs.[120] State laws also regulate apprenticeship and these standards are fairly similar among states with such laws. In California, for example, the Division of Apprenticeship Standards (DAS) administers California apprenticeship law and enforces apprenticeship standards for wages, hours, working conditions, and the specific skills required for state certification as a journeyperson in an apprenticeable occupation.[121] (http://www.doleta.gov/oa/)

[120] Federal Register, Vol. 73, No. 210, "29 CFR Part 29 Apprenticeship Programs, Labor Standards for Registration, Amendment of Regulations; Final Rule" October 29, 2008, http://www.doleta.gov/OA/pdf/FinalRule29CFRPart29.pdf, and U.S. Department of Labor, Employment and Training Administration, "Labor Standards for the Registration of Apprenticeship Programs (Title 29, CFR Part 29)," October 29, 2008, http://www.doleta.gov/OA/regulations.cfm.

Appendix 5C: Additional Reference Documents[122]

Document	Scope/Description
***Job Task Analysis Guidance Document* For use with: IREC Standard 14732:2013. April 2013.**	This document is intended to provide guidance for conformity with IREC Standard 14732:2013 General Requirements for Renewable Energy & Energy Efficiency Certificate Programs (Standard 14732), in particular, to assist certificate-awarding entities in developing and/or selecting a job task analysis (JTA) from which to form the basis of their curriculum or syllabus. This guidance document does not prescribe specific methodologies for conducting job task analysis studies. Rather, it provides guidance on key elements applicant organizations should consider, whether they use an existing JTA upon which to base their education/training curricula, or choose to develop a JTA themselves upon which to base their education/training curricula. Therefore, an overview of key elements considered "acceptable" JTA practices have been outlined below to help applicant organizations determine if the JTA being utilized or developed as the foundation for their curricula in energy efficiency or renewable energy meets the requirements of Standard 14732.
ANSI Public Guidance PCAC-GI-502, *Guidance on Psychometric Requirements for ANSI Accreditation*	This document has been developed to provide guidance about compliance with psychometric requirements of ANSI/ISO/IEC 17024, Conformity Assessment - General Requirements for Bodies Operating Certification of Persons, to certification bodies interested in ANSI accreditation. It does not prescribe specific statistics that should be computed and displayed or specific procedures/methods to be used. Rather, it emphasizes classes of methods and procedures, types of analyses, and how they are applied, as a basis for the accreditation standards in ANSI/ISO/IEC 17024 (Section 4.3.6).
U.S. Department of Labor, *Credential Resource Guide*, December 2010*	The purpose of this Credential Resource Guide is to provide information on the types of credentials available to workforce program participants and explain how they can acquire and leverage these credentials to build lasting careers. (http://wdr.doleta.gov/directives/attach/TEGL15-10a2.pdf)

[121] State of California Department of Industrial Relations, "Overview of DAS," accessed November 2013, http://www.dir.ca.gov/das/DAS_overview.html.

[122] Unless noted with an asterisk,* information on these documents can also be found in the EESCC Inventory Database: http://toolswiki.ansi.org/tiki-index.php?page=EESCCTabs.

Appendix 5D: Apprenticeships

The most common type of apprenticeship program is the Joint Apprenticeship Committee (JAC) or Joint Apprenticeship and Training Committee (JATC), sponsored by a collaborative arrangement between an employer association (or single large employer) and a labor union. The Plant Standard or Unilateral Apprenticeship Committee (UAC), sponsored by a single employer or trade association, is a less common type of program and unilateral programs generally graduate fewer apprentices.

Federal and state standards help to ensure the quality and consistency of apprenticeship programs, which can vary widely without regulation. The U.S. Department of Labor (DOL) regulates apprenticeship programs at the national level according to federal regulations that set standards for establishing and registering apprenticeship programs.[123] DOL or a State Apprenticeship Agency provides assistance identifying training needs, developing apprenticeship standards, and developing apprentice recordkeeping systems, among other services. State laws also regulate apprenticeship and these standards are fairly similar among states with such laws. In California, for example, the Division of Apprenticeship Standards (DAS) administers California apprenticeship law and enforces apprenticeship standards for wages, hours, working conditions, and the specific skills required for state certification as a journeyperson in an apprenticeable occupation.[124]

There are roughly 9,000 DOL Registered Apprenticeship programs training and credentialing construction trades workers across the U.S. for the occupations most closely related to energy efficiency in major building systems including electrical, mechanical, and building envelope systems. We derive this estimate by analyzing DOL Registered Apprenticeships[125] (as of the end of FY 2012) that correspond to selected occupations for the energy efficiency and green construction sectors as listed in the O-NET online database.[126] This is a rough estimate intended to provide a snapshot of the national landscape for apprenticeship and does not include, or compare, apprenticeship programs approved at the state-level, where applicable.[127] Apprenticeship programs provide solid outcomes and returns on investment for both employers and workers. From the workers' perspective, indicators of quality apprenticeship programs include high graduation/completion rates, high job placement rates, and career pathway development (such as wage progressions and credentials). It is more difficult to measure the productivity gains or market advantage that employers receive from investments in training, but some indicators include lower turnover, market recognition of worker credentials, employers' willingness to continue to invest in training, and quality work that delivers the full potential of energy efficiency savings.

[123] Federal Register, Vol. 73, No. 210, "29 CFR Part 29 Apprenticeship Programs, Labor Standards for Registration, Amendment of Regulations; Final Rule," (October 29, 2008): http://www.doleta.gov/OA/pdf/FinalRule29CFRPart29.pdf and U.S. Department of Labor, Employment and Training Administration, "Labor Standards for the Registration of Apprenticeship Programs (Title 29, CFR Part 29)," (October 29, 2008):http://www.doleta.gov/OA/regulations.cfm.

[124] State of California Department of Industrial Relations, "Overview of DAS," accessed November 2013, http://www.dir.ca.gov/das/DAS_overview.html.

[125] U.S. Department of Labor, Employment and Training Administration, "Available Occupations": http://www.doleta.gov/OA/occupations.cfm.

[126] O-NET Online is available at http://www.onetonline.org/find/green.

[127] U.S. Department of Labor, Employment and Training Administration, "State Apprenticeship Information": http://www.doleta.gov/oa/sainformation.cfm.

Appendix 5E: Defining the Occupation of Energy Efficiency

The goal of the methodology described herein is to develop metrics to determine the impact of an occupation on the building efficiency marketplace, as well as to:

1. Encourage inclusion of appropriate energy efficiency content in occupational training or testing
2. Allow students or candidates and their sponsors to evaluate energy efficiency content in courses or tests
3. Allow clients of courses or tests to evaluate the extent to which appropriate energy efficiency content is included
4. Gauge the impact of a profession on how much it could impact the energy efficiency of a given type of building

Proposal and Methodology:

1. The EE occupations should be ranked/rated by Energy Content (EC)
2. Occupations should also be measured by how much an occupation impacts energy efficiency Potential Energy Impact (PEI)
3. PEI may be differential in residential/commercial/industrial/public buildings
4. **Potential methodology**
   a. Rate (qualitatively) how much a given domain in a JTA is related to energy efficiency (percentage wise), and multiply this by the already established weighting percentage of that domain, then sum these numbers to determine how much the JTA is energy-related (EC from 0-100%).

   b. This may have to be done separately for the different building sector types, depending on the occupation (residential/commercial/industrial/public buildings).

   c. Rate (quantitatively) how much this career could impact the building types the occupation serves (PEI with scale of 1-10). This rating would depend on how much the occupation can affect the energy efficiency of a given building type. As an example, a janitor would have less impact than an energy manager on the efficiency of a commercial office building. Again, different rating might apply to different building types.

   d. Report a dual score of: 1) How much the career is energy-related; and, 2) how much the career can impact the efficiency of buildings.

Two EE Role Reviews

Following are reviews of two roles in the commercial building sector: Facility Manager and Energy/Sustainability Manager. A comprehensive JTA was developed for each by DOE. These evaluations were done solely to demonstrate the feasibility of this methodology. They are not to be considered authoritative.

1) Facility Manager

A Facility Manager is a building maintenance specialist and property administrator who conducts building operations and maintenance activities, coordinates facility programs and projects, and supervises building personnel; by inspecting the facility, analyzing building data, forecasting future needs, solving problems, and communicating with others; to ensure the efficient and sustainable operations of the facility and the satisfaction of the facility occupants. Energy efficiency/management skills/topics are a somewhat important part of a Facility Manager's career, but represent a somewhat small fraction of the overall skills/topics needed (estimated at 15-25 percent). This person is responsible for managing the facility as a whole, and is responsible for a diverse range of issues, from safety to janitorial/grounds maintenance to developing budgets. The following are the major domains:

- Managing Facility O&M Programs
- Managing People/Personnel
- Managing Other Internal/External Facility Programs
- Managing Facility Projects
- Managing Facility Finances
- Conducting Strategic Planning Activities
- Managing Facility Assets
- Managing Facility Resources

Parts of each of these topics relate to energy efficiency/management, but it is not a major focus of any of them. However, this career does have a fairly large potential to impact the energy efficiency of a commercial office building (estimated 5 on a scale of 1-10, especially if the organization does not have a regional/corporate energy/sustainability manager). A certification program could be developed just for the energy efficiency/management skills/topics for a facility manager. It would be much smaller in scope compared to a full program for a facilities manager. In the table below, En % is the percent of the task that is estimated to be energy related. The EC is the Energy Content, and is the task weighting times the En %.

Facility Manager Example

Duties and Tasks		Weighting	En %	EC
A	**Managing Facility O&M Programs**	**32%**	25%	8%
B	**Managing People/Personnel**	**15%**	5%	1%
C	**Managing Other Internal/External Facility Programs**	**15%**	20%	3%
D	**Managing Facility Projects**	**10%**	25%	3%
E	**Managing Facility Finances**	**11%**	20%	2%
F	**Conducting Strategic Planning Activities**	**5%**	20%	1%
G	**Managing Facility Assets**	**7%**	20%	1%
H	**Managing Facility Resources**	**5%**	15%	1%
		100%	Total	20%

2) Energy/Sustainability Manager

An Energy/Sustainability Manager monitors energy and material consumption in facilities by performing site audits and conducting energy and sustainability analyses, to identify opportunities to increase building efficiencies, promote renewable resources, and minimize the social, environmental, and financial impacts of an organization's operation. For an Energy/Sustainability Manager, almost every skill/topic associated with the career relates to energy efficiency/management (estimated at 90 percent). The following are the major domains:

- Developing Strategic Plans (related to energy efficiency/management)
- Performing Site Audits (related to energy efficiency/management)
- Performing Energy and Sustainability Accounting and Analysis
- Improving Energy Efficiency and Sustainability
- Communicating with Others (about energy efficiency/management)

Each of these focuses almost exclusively on energy efficiency/management. This career does have a large potential to impact the energy efficiency of a commercial building (PEI is estimated 8 on a scale of 1-10). In the table below, En % is the percent of the task that is estimated to be energy related. The EC is the Energy Content, and is the task weighting times the En %.

ENERGY MANAGER EXAMPLE

Duties and Tasks		Weighting	En %	EC
A	**Developing Strategic Plans**	**26%**	85%	22%
B	**Performing Site Audits**	**18%**	90%	16%
C	**Performing Energy and Sustainability Accounting and Analysis**	**22%**	95%	21%
D	**Improving Energy Efficiency and Sustainability**	**22%**	95%	21%
E	**Communicating with Others**	**12%**	80%	10%
		100%	Total	90%

Appendix 5F: Measuring Outcomes on the Performance of the Credentialed Workforce

METHODOLOGY FOR CREDENTIAL VALIDATION STUDY

A methodology for conducting a credential validation study is provided below:

1. Create two versions of EE credentials for high PEI jobs (see Issue #7: *Potential Energy Impact = PEI)*. Some jobs, like building architect, purchasing agent, or energy architect, have a high impact on the energy efficiency of the building they're constructing (= high PEI). Other credentialed workers, like roofers, window installers, and cement layers, have less direct impact on the building energy efficiency – even though what they do actually impacts the building tremendously.
2. Create criterion measures of the energy measures these credentials impact.
3. Evaluate 200 people employed with this credential.
4. Select the 100 with the highest contrast between their performance and written test scores.
5. Evaluate the 100 select in terms of their energy performance on the job.
6. See which test (written or performance) better predicts energy efficiency on the job.
7. Use the results of several of these studies to predict energy performance resulting from the 2 test types.
8. Create incentives to use the most effective test type.

METHODOLOGY FOR IMPACT STUDY

Annual gross energy and demand impacts can be estimated through the following data collection efforts via an engineering analysis:

1. **Participant Survey via Internet**: Field an Internet survey to a census of credential holder population. The survey will gather data to identify and collect detailed inputs needed for engineering analysis.

2. **Secondary Data Review**: To support the engineering analysis, draw upon existing data sources such as those noted above.

3. **Site Visits**: To enhance the rigor of estimates and reduce respondent burden, conduct site visits on the population of survey respondents to verify actions taken and collect additional data required for selected measures.

NEXT STEPS FOR THE EESCC ROADMAP

Energy efficiency is a complex, cross-cutting issue that impacts all industry sectors, government policy, and consumers alike. Given the complexity of the energy efficiency space and the sheer number of stakeholders involved, V1.0 of the EESCC Roadmap will be issued for public comment to provide an opportunity for broad review and feedback on the EESCC's findings and recommendations before its final publication in mid-2014.

Following publication, V1.0 of the roadmap will be widely promoted, and its recommendations are expected to see broad adoption and implementation. The EESCC will actively monitor implementation of the roadmap's recommendations and follow updates on status of work to close identified gaps. As appropriate, the EESCC will work with relevant groups to ensure gaps are addressed, and facilitate coordination and collaboration among domestic, regional, and international standardization activities.

While this roadmap represents a specific snapshot in time, it is envisioned as an ongoing effort that will evolve in tandem with market and standardization needs. The aim is to provide a living document that will help guide, coordinate, and enhance the standardization landscape to support energy efficiency in the United States. It is envisioned that a V2.0 of the roadmap will track progress to implement recommendations made in V1.0 and highlight new developments and updates.

Organizations interested in carrying out standardization work to close a gap identified in this roadmap are asked to notify the EESCC[128] so that the collaborative can monitor the roadmap's implementation and assist with coordination of standardization activities, as appropriate.

[128] Contact eescc@ansi.org.

Roadmap Appendix A: Summary Of Gap Analysis/Recommendations

RECOMMENDED TIMELINES: NEAR-TERM (0-2 YEARS); MID-TERM (2-5 YEARS); LONG-TERM (5+ YEARS).

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter One: Building Energy and Water Assessment and Performance Standards	The Water-Energy Nexus	1.1		There is currently no recognized consistent methodology for the way building systems, products, and services are evaluated as to 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 serve several purposes: 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 sector where the combined water and energy savings potential is very high.	While work should begin as soon as possible, this is a complex issue and should therefore be conducted in the long-term: 5+ years.
Chapter One: Building Energy and Water Assessment and Performance Standards	The Water-Energy Nexus	1.1		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.	While work should begin as soon as possible, this is a complex issue and therefore should be considered in the long-term: 5+ years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Building Envelope	1.2		There is a need to address detailing and integration of the building envelope at interface conditions - quite literally the 'gaps' between materials, components, and systems in a building enclosure. Improper detailing and installation at these conditions is, perhaps more than any other single aspect of design and construction, the most common source of improperly managed heat/air/moisture transfer and corresponding increase in energy use, operation, and maintenance costs over the lifecycle of a building.	This work should be conducted in the near-term: 0-2 years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter One: Building Energy and Water Assessment and Performance Standards	Air Conditioning/Cooling Systems	1.4		The codes and standards related to the energy performance of individual air-conditioning and cooling systems is 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 will serve to only enhance the basis in which architects, designers, engineers, and builders incorporate these systems in residential, commercial, and industrial applications. Some standards developers are beginning to look at this issue.	This work should be conducted in the mid-term: 2-5 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Air Conditioning/Cooling Systems	1.4		Control standards for integrated air-conditioning and cooling systems are needed so that the performance and usage of the systems can be optimally controlled. Some standards developers are beginning to look at this issue.	This work should be conducted in the mid-term: 2-5 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Heating Systems	1.5		The codes and standards related to the energy performance of individual heating systems is well defined. Establishing independently developed performance metrics that specify the cost and efficiency benefits of the overall performance of integrated heating systems will serve to only enhance the basis in which architects, designers, engineers, and builders incorporate these systems in residential, commercial, and industrial applications. Some standards developers are beginning to look at this issue.	This work should be conducted in the mid-term: 2- 5 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Heating Systems	1.5		Control standards for integrated heating systems are needed so that the performance and usage of the systems can be optimally controlled. Some standards developers are beginning to look at this issue.	This work should be conducted in the midterm: 2- 5 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Mechanical Systems	1.6		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 in efficiencies in both residential and commercial applications. Standards that provide independently developed cost / benefit metrics are required to help designers, engineers and home builders better understand the long term benefits of employing these technologies in buildings.	This work should be conducted in the mid-term: 2-5 years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter One: Building Energy and Water Assessment and Performance Standards	Mechanical Systems	1.6		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 to guide standards developers determine cost effective provisions while avoiding unnecessary cost.	This work should be conducted in the mid-term: 2-5 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Mechanical Systems	1.6		To improve energy efficiency even more there is a need to develop testing protocols for whole HVAC duct system components. There is a high need for this as codes move towards requiring system testing prior to certificate of occupancy. There is also a need to standardize various techniques for measuring leakage in non-residential and multifamily air distribution and exhaust systems. Several standards developers are starting development on this topic.	This work should be conducted in the mid-term: 2-5 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Mechanical Systems	1.6		There is a need to develop research on the cost effectiveness of conducting leakage tests on HVAC systems operating in the field. Although a process for evaluating the energy impacts of single-family ducts leaks is well documented in ASHRAE Standard 152, there is no commonly accepted yardstick for determining the energy impacts of leaks in non-residential and multifamily buildings, and therefore no good way to evaluate the cost effectiveness of testing. This research would eventually add to the existing standards on duct leakage testing, and in the future, HVAC total system leakage testing.	This work should be conducted in the mid-term: 2-5 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Mechanical Systems	1.6		The potential to use non-traditional 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 (i.e., open desiccant cooling, passive solar, photovoltaic (PV) solar cooling, and solar closed loop absorption systems) – transcritical CO_2 systems, and employing heat from energy generating microturbines, are technologies where additional information is required to determine the cost effectiveness of use in various applications.	This work should be conducted in the long-term: 5+ years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Mechanical Systems	1.6		Research has shown that component faults in HVAC systems that significantly diminish efficiencies are common and go mostly undetected. Standards developers should consider the cost and benefits of requiring the installation of fault detection technologies on mechanical systems that can alert building owners of malfunctioning components.	This work should be conducted in the mid-term: 2-5 years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter One: Building Energy and Water Assessment and Performance Standards	Energy Storage	1.7		Safety is a crucial element for the success of energy storage standards in the wake of recent fires and accidents. Issues including ratings, markings, personnel barriers/set backs, system entry and exit points, physical abuse, and temperature ratings come immediately to mind. These may be addressed by SDOs like UL, IEC, and others. The standards should make use of previously identified standards in SAE and UL for battery components, should the system use batteries as the storage medium.	This should be done in the near-term: 0-2 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Energy Storage	1.7		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 systems are functioning as specified, standards need to be developed to determine: ▪ **Availability** – optimal times and levels of charge and discharge based on physical location, historical patterns, and other factors. ▪ **Reliability** – what is the mean uptime and mean time to failure; what is the mean lifetime and cycle life of the system and/or storage medium component therein. ▪ **Maintenance** – what maintenance routines should be performed and when.	This should be done in the mid-term: 2-5 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Energy Storage	1.7		As information technology becomes layered over electrical components, it is essential that each smart grid component is interoperable and that each component is appropriately shielded, insulated, or otherwise designed to reduce or prevent electromagnetic interference.	This should be done in the long term: 5+ years. There are significant barriers to testing EMC in many instances currently.
Chapter One: Building Energy and Water Assessment and Performance Standards	Energy Storage	1.7		The need exists to limit or prevent electrical damage to the energy storage system through the development of standards for load flow, protection coordination, automatic gain control.	This should be done in the mid-term: 2-5 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Energy Storage	1.7		Prior to 2012, there was no methodology for comparing the performance attributes of energy storage systems. The Pacific Northwest National Laboratory (PNNL) Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems lays out a convenient framework for accomplishing this. Notably, it can be applied across systems that employ different types of storage mediums by establishing representative duty cycles by application. A starting point developing such a list of applications and/or use cases is the California Public Utility Commission (CPUC) Energy Storage Staff Proposal. Figure 4 from that report which is freely available on the internet, is reproduced below. A series or family of standards specifying representative duty cycles and performance metrics applicable by representative duty cycle should be written. This family 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.	This should be done in the near-term: 0-2 years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter One: Building Energy and Water Assessment and Performance Standards	Energy Storage	1.7		Standards are needed to evaluate the energy efficiency of an energy storage system to enable a larger system (e.g. the public electricity grid or an industrial facility grid) to use the system as an energy efficiency enhancement means.	This should be done in the mid-term: 2-5 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Water Heating	1.8		Consensus standards for heat metering and hot water solar thermal systems need to be completed to advance the utilization of thermal technologies for water heating applications. This represents a significant and very achievable advancement in energy efficiency.	This work should be conducted in the mid-term: 2-5 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Water Heating	1.8		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.	This work should be conducted in the mid-term: 2-5 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Water Heating	1.8		Standards are needed for water heating and delivery systems that address the location of the heating source and the end-of-use point to ensure that the most efficient system is installed to save energy while meeting the 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 to provide guidance on how to design the most efficient systems.	This work should be conducted in the near-term: 0-2 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Indoor Plumbing	1.9		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 evaluates the impact of those designs on the plumbing system's overall performance due to reduced flows in the system, especially 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.	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.
Chapter One: Building Energy and Water Assessment and Performance Standards	Indoor Plumbing	1.9		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 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.	This work constitutes a long-term project: 5+ years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter One: Building Energy and Water Assessment and Performance Standards	Indoor Plumbing	1.9		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.	This work should be done in the near-term: 0-2 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Indoor Plumbing	1.9		Reducing hot water temperatures in plumbing systems has been proven to 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. The publication of these guidance documents will assist facility managers with techniques that can be employed to mitigate Legionellosis outbreaks, as well as a set of best practices for when outbreaks occur.	This work should be conducted in the near-term: 0-2 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Alternate Water Sources	1.10		The biggest challenge facing the expanded use of water from alternate water sources is the need to develop 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 – 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 and therefore require different treatment measures than rainwater in other areas. Standards developers need to continue to expand their knowledge base and consider provisions that will foster increased use of alternate water sources.	Improvements to Alternate Water Use standards should be an ongoing process with advancements made as consensus, achieved in the short-, mid-, and long- terms.
Chapter One: Building Energy and Water Assessment and Performance Standards	Alternate Water Sources	1.10		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 and ARCSA are currently developing a stormwater harvesting design standard which may address this gap.	Development of these standards will necessitate collaboration between water use experts, civil engineers, and other stakeholders. This is a long-term effort: 5+ years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter One: Building Energy and Water Assessment and Performance Standards	Landscape Irrigation	1.11		While the green codes have provisions to address some aspects of landscape irrigation, each has some unique criteria for the same issue (such as the maximum application rate for sloped areas). The model codes related to energy or water-use efficiency do not reference any standards for landscape irrigation because they do not exist. The irrigation industry has relied upon the competitive forces within the marketplace for product development. The products have been innovative and the quality and performance of the products have had to meet market demands.	These standards are in progress with committees actively working and are near-term priorities: 0-2 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Landscape Irrigation	1.11		Additional standards for landscape irrigation products 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. 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 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.	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		Other potential gaps in standards for landscape irrigation are interrelated, but currently not enough information or research has been done to provide guidance for standards development. 3) 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. 4) A standard 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.	If standards are developed they should address the process to follow in making the evaluation. This work is for the long-term: 5+years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Swimming Pools, Hot Tubs, Spas, Aquatic Features	1.12		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.	This should be done in the near-term: 0-2 years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter One: Building Energy and Water Assessment and Performance Standards	Swimming Pools, Hot Tubs, Spas, Aquatic Features	1.12		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.	This should be done in the near-term: 0-2 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Swimming Pools, Hot Tubs, Spas, Aquatic Features	1.12		Standards are needed to test the energy efficiency of these disinfection systems to determine the energy consumption at integral power levels of chemical output.	This should be done in the near-term: 0-2 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Swimming Pools, Hot Tubs, Spas, Aquatic Features	1.12		While primary design consideration of these devices is appropriately focused on safety performance aspects, these products can contribute to the total pumping loss or TDH (total dynamic head) of circulation systems in all aquatic facilities. These products can be redesigned to reduce the pumping loss. NSF 50 includes validation of the head loss and work can be done to help classify products with preferred performance characteristics. These products can also be life cycle tested along with requiring best practice maintenance guidelines to minimize leakage and reduce water consumption.	This should be done in mid-term: 2-5 years
Chapter One: Building Energy and Water Assessment and Performance Standards	Swimming Pools, Hot Tubs, Spas, Aquatic Features	1.12		Pool covers and liquid barriers represent a significant opportunity to minimize pool energy use by reducing heat loss and evaporation. Standards are needed to evaluate the efficiency of pool covers and liquid barriers through ongoing testing for evaporation rates and heat loss. In addition, these standards should offer best practice maintenance guidelines to reduce energy loss due to damaged or misused pool covers and liquid barriers.	This should be done in the near-term: 0-2 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Commissioning	1.13		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.	These activities should be conducted in the near-term: 0-2 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Commissioning	1.13		There is a lack of understanding of the commissioning process and how to utilize it among many commissioning users, such as building owners, facility managers, and personnel. There needs to be education, documentation and training developed for the commissioning users on the commissioning process, deliverables and expected results. Having educated consumers is equally important to a quality process and providers.	These activities should be conducted in the near-term: 0-2 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Commissioning	1.13		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.	This work should be conducted in the mid-term: 2-5 years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter One: Building Energy and Water Assessment and Performance Standards	Commissioning	1.13		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.	These activities should be conducted in the mid-term: 2-5 years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Commissioning	1.13		Over the long-term, commissioning will increasingly become a regular part of building and project completion as well as operations and maintenance. Ongoing commissioning will depend on monitoring of all building systems in order to assure that the systems are operating 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. 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.	These activities should be completed in the long-term: 5+ years.
Chapter One: Building Energy and Water Assessment and Performance Standards	Conformity Assessment in Building Energy and Water Assessment and Performance Standards	1.14		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.	This depends on the 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.
Chapter One: Building Energy and Water Assessment and Performance Standards	Conformity Assessment in Building Energy and Water Assessment and Performance Standards	1.14		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. **See section 1.14 for more information on this recommendation.**	This should be conducted in the mid-term: 2-5 years.
Chapter Two: Systems Integration and Systems Communications	Systems Integration and Systems Communications: Gap Analysis and Recommendations	2.3		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.	This work should be conducted in the near-term: 0-2 years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter Two: Systems Integration and Systems Communications	Systems Integration and Systems Communications: Gap Analysis and Recommendations	2.3		As standards are implemented to support communication between building energy management systems and the grid, there will be an ongoing need for standards to evolve to support communication.	This work should be conducted in the mid-term: 2-5 years, with ongoing attention to evolving needs.
Chapter Two: Systems Integration and Systems Communications	Systems Integration and Systems Communications: Gap Analysis and Recommendations	2.3		Standards are needed to support more consistent data communication back to the utility.	This work should be conducted in the near-term: 0-2 years.
Chapter Two: Systems Integration and Systems Communications	Systems Integration and Systems Communications: Gap Analysis and Recommendations	2.3		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.	This work should be conducted in the near-term: 0-2 years.
Chapter Two: Systems Integration and Systems Communications	Systems Integration and Systems Communications: Gap Analysis and Recommendations	2.3		There is a need for standards to establish measurement and monitoring protocols to support energy data.	This work should be conducted in the near-term: 0-2 years.
Chapter Two: Systems Integration and Systems Communications	Systems Integration and Systems Communications: Gap Analysis and Recommendations	2.3		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. Note: "Building" in this usage refers to the structure of building envelope.	This work should be conducted in the mid-term: 2-5 years.
Chapter Two: Systems Integration and Systems Communications	Systems Integration and Systems Communications: Gap Analysis and Recommendations	2.3		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.	This should be conducted in the near-term: 0-2 years.
Chapter Two: Systems Integration and Systems Communications	Systems Integration and Systems Communications: Gap Analysis and Recommendations	2.3		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 as a test to be sure the content of the standard provides for all of the information needed to optimize the energy performances of the building.	This should be conducted in the near-term: 0-2 years.
Chapter Two: Systems Integration and Systems Communications	Systems Integration and Systems Communications: Gap Analysis and Recommendations	2.3		A better integration of automation and controls into the skills standards underlying workforce training and certification programs is needed.	This should be conducted in the mid-term: 2-5 years

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter Three: Building Energy Rating, Labeling, and Simulation	Rating and Labeling Programs: Gap Analysis and Recommendations	3.1.5		Operational ratings and labeling programs rely on data that is representative of the existing building and industrial plant stock. As noted before, data sources such as 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. 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. One of the critical issues 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.	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 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: Gap Analysis and Recommendations	3.1.5		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.[129]	This should be conducted in the near-term: 0-2 years.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Rating and Labeling Programs: Gap Analysis and Recommendations	3.1.5		Through the process of inventorying operational rating and labeling systems, it became clear that there is no central resource or catalogue that outlines which programs exist and what their focus is. There is an opportunity for the establishment of a consistently updated "rating & labeling directory" that catalogues different programs and discusses each program's design and focus in a systematic format.	This should be conducted in the near-term:0-2 years, however it will require update over time.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Code Compliance and Asset Rating: Commercial Buildings	3.2.1.2		All codes and beyond-code programs should use a single rule set, i.e., performance-path modeling.	This process should be initiated in the near-term: 0-2 years, but may not be fully implemented for 2-5 years.

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

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Code Compliance and Asset Rating: Commercial Buildings	3.2.1.2		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.	This should be conducted in the near-term: 0-2 years
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Code Compliance and Asset Rating: Commercial Buildings	3.2.1.1.1		Rule sets need to be better defined, more comprehensive, and more robust.	This should be conducted in the near-term: 0-2 years
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Code Compliance and Asset Rating: Residential Buildings	3.2.1.1.2		Develop a working group, with public involvement, to identify what standards are required and cost effective given different rating purposes (e.g., real estate transaction, posting on MLS or commercial listing service, energy audit, new home, financial incentive applications).	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.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Code Compliance and Asset Rating: Data Centers	3.2.1.1.4		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.	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		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 The current ASHRAE Standard 140 is not sufficiently comprehensive for this purpose at this time. ASHRAE standard 209 is designed to fill the modeling protocol gap described in this section. 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. Pushing the fast-forward button on the standard – specifically on the data gathering and model reconciliation activities that underlie the standard – will require substantial resources.	This should be conducted in the mid-term: 2-5 years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Whole-Building Energy Efficiency Incentives: Residential Buildings	3.2.1.2.2		Develop standardized definitions for energy conservation measures, standard protocols for simulation, and standard implementations of those protocols: The recommendation is to align and cascade the BEDES, measure cutsheet, and BCL projects, potentially using ASHRAE Standard 209P as a standards vehicle for the simulation protocols. HERS BESTEST, BPI 2400 standard for establishing a baseline in an existing home, and the RESNET extensions to HERS BESTEST for heating plant, distribution system, DHW 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.	This is a long-term priority and should be completed in 5+years.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Whole-Building Energy Efficiency Incentives: Residential Buildings	3.2.1.2.2		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. As this is not within the scope of ASHRAE 209P, it should be picked up elsewhere. An initial framework can likely be put together in about 2 years.	This is a near-term priority and should be conducted in 0-2 years.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation for Whole-Building Energy Efficiency Incentives: Residential Buildings	3.2.1.2.2		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. This could be picked up jointly by the RESNET calibration standard, and ASHRAE standard 209P.	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.
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		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, BPI 2400-S-2011, and the California Evaluation Framework and Protocols.	This should be conducted in the near-term: 0-2 years.
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		There is a similar need in the residential space as described in the commercial buildings discussion above: 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, BPI 2400-S-2011, and the California Evaluation Framework and Protocols.[130,131]	This should be conducted in the near-term: 0-2 years.

[130] TecMarket Works. (2004). *The California Evaluation Framework*. Oregon, WI: TecMarket Works.

[131] TecMarket Works. (2006). *California Energy Efficiency Program Evaluation Protocols: Technical, Methodological, and Reporting Requiremnts for Evaluation Professionals*. Oregon, WI: TecMarket Works.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation Software Capabilities and Accuracy: Commercial Buildings	3.2.2.1.1		Develop an energy simulation validation roadmap. This 2-5 year activity would use test 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 simulation hot-spots combined with measurement experiments needed to resolve or upgrade them.	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 Buildings	3.2.2.1.1		Develop standard energy-simulation engine acceptance criteria for various end-uses. This 2-5 year activity would follow closely behind the simulation accuracy benchmarking activity described above. It could be led by a standards organization whose published scope covers this type of activity, such as ASHRAE, RESNET, or COMNET.	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: Residential Buildings	3.2.2.1.2		Create a companion to the RESNET test to increase the usability and standardization of other rating approaches.	This work should be conducted in the near-term: 0-2 years.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation Professionals: Commercial Buildings	3.2.3.1		Harmonize – or at least differentiate – the BESA™ and BEMP certificates	Differentiation is a near-term goal: 0-2 years. Harmonization is a long-term goal: 5+ years
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation Professionals: Commercial Buildings	3.2.3.1		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.	This is a long-term priority and should be completed in 5+years.
Chapter Three: Building Energy Rating, Labeling, and Simulation	Energy Simulation Professionals: Residential Buildings	3.2.3.2		Standardized methods of credentialing qualified users of residential energy simulation software should be created.	This should be conducted in the near-term: 0-2 years.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Measurement and Verification Methodological Approaches: Baselines	4.1.1		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 standard practice (ISP) could be used to determine a baseline, or a baseline could be determined using the specific circumstances at the retrofit site (*in situ* baseline). 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.	This is a long-term priority: 5+ years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Measurement and Verification Methodological Approaches: Baselines	4.1.1		When an EE program induces the replacement of equipment before it would otherwise have been replaced; an issue arises 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. 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.	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		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.	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		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, or if that proves infeasible, standards should be developed to describe the method or procedure used, so there is transparency.	This should be conducted in the mid-term: 2-5 years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Measurement and Verification Methodological Approaches: Baselines	4.1.1		Research 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 as to the purpose and use of the self-benchmarking capability.	This should be conducted in the near-term: 0-2 years.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining First-Year Savings: Verification, IPMVP Option A, IPMVP Option B	4.1.2.1		On one or more EE projects, determine the range of calculated savings from different applications of Option B performed under a range of typical budgets, availability of data, or other potential sources of variation in the calculated savings; assess the resulting “spread” in calculated savings as a “go/no-go” for additional analysis.	This should be conducted in the near-term: 0-2 years.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining First-Year Savings: Statistical Methodologies	4.1.2.2		Quantifying uncertainty in regression models, for all time periods. (e.g. monthly, daily, hourly). Leveraging the CA Evaluation Framework requirements on presenting uncertainty, a voluntary standard should be developed that would apply to regression models.	This should be addressed in the mid-term: 2-5 years.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining First-Year Savings: Statistical Methodologies	4.1.2.2		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 usage, 2) what is the sensitivity of the model outputs to changes in the model inputs. For example, if hours of occupancy change, what is the energy use change in a fully specified building energy model?	This should be addressed in the mid-term: 2-5 years.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining First-Year Savings: Statistical Methodologies	4.1.2.2		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 CA Evaluation Framework.	This should be addressed in the mid-term: 2-5 years.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining First-Year Savings: Whole Building Metered Analysis	4.1.2.3		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 Method’s Project for residential whole building may provide a starting point for formal standards development.	This work should be conducted in the mid-term: 2-5 years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining First-Year Savings: Whole Building Metered Analysis	4.1.2.3		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 development of actual standards.	This should be done in the near-term: 0-2 years.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining First-Year Savings: Whole Building Metered Analysis	4.1.2.3		If suitable data sets and testing procedures can be developed in the mid-term, the standardization of methods for automated analysis approaches that provide performance metrics could be developed.	This should be done in the mid-term: 2-5 years.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Methods for Determining First-Year Savings: Methodologies Used for Large, Complex Retrofits	4.1.2.4		There is sufficient guidance on sampling within similar sets of measures for a given project; however, there is little guidance on how to treat projects that include multiple unique measures.	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 First-Year Savings: Methodologies Used for Large, Complex Retrofits	4.1.2.4		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 analyses may involve manual uncontrolled processes. While existing EM&V resources generally do not address transparency, the IPMVP includes 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 on Reporting).	This work should be conducted in the long-term: 5-7 years.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Duration of Savings: Effective Useful Life	4.1.3		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 RTMs.	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		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.	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		Several studies of EUL should be undertaken to determine if survival studies could add accuracy to the determination of EULs in a manner that can be standardized and lead to protocols on how such studies can be undertaken in the future. As the EUL of a measure depends on the application of that measure, this is particularly complex.	This should be done in the mid-term: 2-5 years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Technical Reference Manuals (TRMs)	4.1.4		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 assuming that the fundamental engineering analysis is not applicable across sectors or regions.	This effort is on several stakeholders' work plans that are 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.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Reporting and Tracking Systems: Tracking Systems	4.2.1		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.	This should be accomplished in the mid-term: 2-5 years.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Reporting and Tracking Systems: Standardized Data Collection	4.2.2		In the near term, a collaborative effort should be begun to: 6. Examine and consolidate the existing (BPI, BEDES, others) taxonomies of data used in energy efficiency savings calculations. 7. Work with stakeholders to refine these definitions to those which are material for different analytic methods. 8. Publish a data dictionary and XML specification for use in describing and communicating data. 9. Consider "locking down" the agreed-upon data standard through an ANSI-approved standards process under an ANSI-accredited organization. 10. Track the development of new EM&V methods to determine whether a new data type is being used which can be included in the data specification and establish a continuous update process to manage evolving changes.	This should be done in the near-term: 0-2 years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Reporting and Tracking Systems: Reporting	4.2.3		A series of analyses and discussions should be undertaken to assess: 1. What are the needs of each of the general types of users of EE reported information and what are the parameters 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. The next step would be to 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. Also, consideration should be given throughout to opportunities to take advantage of new technologies for data gathering and sharing.	**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.[132] **Activity 3** (long-term) should be completed after the first two are complete, and within 5 years, also through formal, collaborative efforts.

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

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Other Evaluation Methodological Approaches: Top-Down and Bottom-Up Methodological Approaches	4.3.1		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 usage, including whether the use case is for purely historical analysis or 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 that need to be included 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 usage questions. 5. Develop criteria for assessing the accuracy of the resulting analysis and guidelines on their presentation.	This is a long-term priority and should be accomplished in 5-7 years.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Other Evaluation Methodological Approaches: Use of Evaluation in Financial Risk Analysis	4.3.2		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 program and project uncertainties based uncertainty in underlying parameters. This process would leverage work on monte carlo analysis, the BPD, and the ICP.	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		The development of a systematic framework for translating engineering uncertainties to 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.	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		Based on A and B, a stakeholder process could 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.	This should be accomplished in the mid-term: 2-5 years.

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Emerging Issue Areas: Role of Conformity Assessment/Accreditation	4.4.1		While conformity assessment standards are equally related to applications in the compliance and enforcement of standards and workforce credentialing and will be 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.	This should be done in the mid-term: 2-5 years.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Technology-Specific Areas: Behavior-Based (BB) Programs	4.4.2.1		Randomized controlled trials (RCTs) are the preferred design for behavioral programs. To the extent that an RCT is not feasible, quasi-experimental designs as outlined in the SEE Action report are the preferred alternative.	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		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.	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		Methods are needed that would allow for assessing the impacts of these programs more broadly without the significant expense of extensive site-specific analysis.	This should be done in the near-term: 0-2 years.
Chapter Four: Evaluation, Measurement, and Verification (EM&V)	Technology-Specific Areas: Energy Performance Indicators (EnPIs)	4.4.2.3		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 seek 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.	This should be done in the near-term: 0-2 years.
Chapter Five: Workforce Credentialing	Terminology	5.1		Standard and industry-accepted credentialing and workforce terminology should be used to avoid confusion and promote understanding for stakeholders searching for and utilizing conformance programs.	Overarching recommendation
Chapter Five: Workforce Credentialing	Indicators of Quality Credentialing Programs	5.2		Indicators of quality credentialing programs should be drawn on to guide stakeholders in selecting standards and conformance assessment schemes.	Overarching recommendation
Chapter Five: Workforce Credentialing	Indicators of Quality Credentialing Programs	5.2		Both certifications and certificates should include assessment of attainment of competencies and skills.	Overarching recommendation
Chapter Five: Workforce Credentialing	Indicators of Quality Credentialing Programs	5.2		State and federal agencies should recognize accredited credentialing programs	Overarching recommendation
Chapter Five: Workforce Credentialing	Role of Registered Apprenticeships in Workforce Credentialing	5.3		Energy efficiency skills and knowledge should be incorporated into training and credentialing programs for traditional occupations in both the construction trades and other relevant professions, such as engineering and architecture. In instances in which this approach is not feasible, training may focus on a specific skill area.	Overarching recommendation
Chapter Five: Workforce Credentialing	Role of Registered Apprenticeships in Workforce Credentialing	5.3		A clear, formal process beginning with a job task analysis should be used to delineate the knowledge, skills, and abilities (KSAs) required for major occupations related to energy efficiency.	Overarching recommendation

Chapter	Issue Area	Section	Page	Gap Analysis/Recommendations	Recommended Timeline
Chapter Five: Workforce Credentialing	Role of Registered Apprenticeships in Workforce Credentialing	5.3		Technical specifications for installation, maintenance and operations of energy efficiency equipment and systems should be formalized and then mapped to occupations, job task analyses, KSAs, training programs, and certifications.	Overarching recommendation
Chapter Five: Workforce Credentialing	Determining Market Value of Workforce Credentialing Programs	5.4		Credentials should hold demonstrated market value for workers, employers, and consumers.	Overarching recommendation
Chapter Five: Workforce Credentialing	Determining Market Value of Workforce Credentialing Programs	5.4		The energy efficiency industry and credentialing bodies should jointly market the quality assurances built into credentialing the workforce.	Overarching recommendation
Chapter Five: Workforce Credentialing	The Role of Conformity Assessment in Building Confidence in Credentialing Programs	5.5		Third-party accreditation of energy efficiency credentialing programs by an independent party should be encouraged to ensure that the program has met established benchmarks for operating a competent and impartial credentialing program.	Overarching recommendation
Chapter Five: Workforce Credentialing	Programmatic Accreditation for Training	5.6		Energy efficiency training programs should be accredited to technical and programmatic content to assure workers perform jobs safely and effectively. In some cases, the most appropriate accreditation body may exist outside of the current scope of higher education accreditation.	Overarching recommendation
Chapter Five: Workforce Credentialing	Programmatic Accreditation for Training	5.6		Energy efficiency training should result in an industry-supported program and curriculum that covers the knowledge, skills, abilities, attitudes, and tasks each accredited program must deliver, thereby assuring greater consistency in the performance of the graduate and future worker.	Overarching recommendation
Chapter Five: Workforce Credentialing	Defining the Energy Efficiency Content of Occupations	5.7		Stakeholders reviewing workforce credentials should review the job task analysis on which the certification or certificate program is based in order to determine if energy efficiency competencies and skills are included.	Overarching recommendation
Chapter Five: Workforce Credentialing	Defining the Energy Efficiency Content of Occupations	5.7		To better quantify an occupation's actual impact on energy efficiency, a two-step methodology is recommended. Occupations should first be measured and ranked on how much of the job task analysis is related to energy using a comprehensive review of the existing job task analysis. A second measure is an estimation of how much an occupation can impact the overall energy efficiency of the building types the occupation serves. Combined, these two metrics give good indication if an occupation can impact the energy marketplace.	Overarching recommendation
Chapter Five: Workforce Credentialing	Measuring Outcomes on the Performance of the Credentialed Workforce	5.8		Outcomes on credentialing should be tied to job performance. Validation studies with a well-developed methodology, sampling plan, data collection tools, and protocols should show the link between the credentialed individual and job performance.	Overarching recommendation
Chapter Five: Workforce Credentialing	Measuring Outcomes on the Performance of the Credentialed Workforce	5.8		Validation and impact studies are needed to promote models for credentialing organizations to implement in order to consistently gather and interpret data regarding the effectiveness of the credentialing programs in reducing energy use.	Overarching recommendation

ROADMAP APPENDIX B: ADDITIONAL RELATED ACTIVITIES OF INTEREST

The U.S. standards system acknowledges that there are multiple paths to achieving globally relevant standards. Many SDOs and consortia operate on an international scale; what matters is that the standards are developed according to the principles of the World Trade Organization's Technical Barriers to Trade Agreement, which are also consistent with ANSI's *Essential Requirements: Due process requirements for American National Standards*. The process must be consensus-based, open, with balanced participation – and include all the other elements that are the hallmarks of the U.S. standards system.

Energy efficiency in the United States is being shaped by the standards activities of a number of SDOs – both U.S.-based and non-U.S. based – as well as codes, regulations, conformance and training programs, and related activities of many stakeholders, including U.S. federal government agencies, and other cross-sector initiatives.

Listed in this appendix are some of the international and regional standardization activities, U.S. federal agency programs, and other standards-related cross-sector initiatives that are influencing energy efficiency in the United States. For a comprehensive listing of the range and breadth of standardization activities developed by U.S.-based and non-U.S. based organizations, the reader is directed to the EESCC Inventory Database.[133] The following is meant to be broadly representative and is not necessarily exhaustive.

INTERNATIONAL (ISO, IEC) AND REGIONAL STANDARDIZATION ACTIVITIES

International Electrotechnical Commission (IEC)

Within the IEC, a number of technical committees (TC) are actively engaged in energy efficiency-related standardization, including IEC TC 13, *Electrical energy measurement and control*, IEC TC 57, *Power systems management and associated information exchange*, IEC TC 65, *Industrial-process measurement, control and automation*, and IEC TC 85, *Measuring equipment for electrical and electromagnetic quantities*.

The recently formed **IEC Advisory Committee on Energy Efficiency** (ACEE) deals with energy efficiency matters that are not specific to one single IEC technical committee, and is responsible for the assignment of horizontal energy efficiency requirements. The **U.S. Coordinating Committee on Energy Efficiency (USCCEE) Virtual Technical Advisory Group** (V-TAG) to the IEC coordinates U.S. positions in the various IEC technical committees, subcommittees, and working groups dealing with energy efficiency, and reviews positions taken by the ACEE.

On the conformity assessment front, the **IEC Working Group 12 Conformity Assessment Board** was formed to identify all sectors of electrotechnology where current and future energy efficiency developments may give rise to a market need for conformity assessment, and to develop a roadmap to guide IEC's response to these needs.

[133] The EESCC Inventory Database is available at http://toolswiki.ansi.org/tiki-index.php?page=EESCCTabs.

International Organization for Standardization (ISO)

The **ISO Strategic Advisory Group on Energy Efficiency and Renewable Resources** (SAG E) is engaged in a roadmapping initiative to identify short-, medium-, and long-term requirements for energy efficiency and renewable energy, with the goal of publishing the roadmap in September 2014. The **ANSI V-TAG to ISO SAG E** provides an opportunity for U.S. stakeholders to be involved in this process, and is responsible for bringing U.S. positions forward.

Among the ISO TCs working on energy efficiency-related standardization are: ISO TC 205, *Building environment design*, ISO TC 163, *Thermal performance and energy use in the built environment,* ISO TC 257, *General technical rules for determination of energy savings in renovation projects, industrial enterprises and regions,* and ISO TC 242, *Energy Management*, which developed the energy management system standard ISO 50001.

A joint effort of the ISO and IEC, **ISO/IEC Joint Project Committee (JPC) 2,** *Energy Terminology*, is currently working on a standard, ISO/IEC 13273, which will specify terms and definitions used in the field of energy efficiency and renewable energy sources.

CEN CENELEC

The European Standards Organizations (ESOs) **CEN** – the European Committee for Standardization, and **CENELEC** – the European Committee for Electrotechnical Standardization formed the **Sector Forum Energy Management** (SFEM)[134] in 2006 to define and monitor the European standardization strategy on energy management, energy efficiency, renewable, and alternative energy sources.

European directives covering energy efficiency include: European Directive 2010/31/EU on the energy performance of buildings; European Directive 2009/125/EC, which establishes a framework for the setting of ecodesign requirements for energy-related products; and European Directive 2010/30/EU, which covers the indication by labeling and standard product information of the consumption of energy and other resources by energy-related products.

U.S. Federal Government Agency Programs

U.S. Department of Energy (DOE)

DOE is supporting the development of this standardization roadmap and the growth of the energy efficiency market on a number of fronts. The long-term goal of DOE's Building Technologies Office is to reduce energy use by 50 percent as compared to a 2010 baseline. DOE's **Better Buildings Initiative** is a broad, multi-strategy initiative to make commercial and industrial buildings 20 percent more energy efficient over the next 10 years and accelerate private sector investment in energy efficiency. In support of the Better Buildings Initiative, in September 2013, DOE launched the **Better Buildings Workforce Guidelines Project** in partnership with the National Institute of Building Sciences (NIBS) to develop voluntary national guidelines that will improve the quality and consistency of commercial building workforce credentials for five key energy-related jobs. Information on DOE's many energy efficiency-related programs is available at http://energy.gov/eere.

[134] Information on the SFEM is available at: http://www.cen.eu/cen/Sectors/Sectors/UtilitiesAndEnergy/Energy/Forum/Pages/default.aspx.

U.S. Environmental Protection Agency (EPA)

Among the EPA initiatives that support U.S. energy efficiency is **ENERGY STAR®** – a voluntary program that promotes energy efficiency in consumer products, homes, commercial buildings, and industrial sectors. Since the program began in 1992, ENERGY STAR® has helped Americans save nearly $230 billion on utility bills and prevented more than 1.7 billion metric tons of greenhouse gas emissions.

U.S. Department of Commerce (DOC)

In support of U.S. renewable energy and energy efficiency manufacturers and services providers, DOC established the **Renewable Energy and Energy Efficiency Advisory Committee** (RE&EEAC). The RE&EEAC provides input on trade issues that will support the international competitiveness of U.S. companies in this expanding sector.

National Institute of Standards and Technology (NIST)

NIST's **Net-Zero Energy, High-Performance Buildings Program** develops and deploys advances in measurement science to move the nation toward net-zero energy, high-performance buildings while maintaining a healthy indoor environment. Under this program, NIST convened stakeholders to develop the 2010 report, *Measurement Science Roadmap for Net-Zero Energy Buildings*,[135] which outlines goals for achieving improvements in building performance and sustainability through measurement science. Currently, researchers at NIST's Engineering Laboratory are testing various high-efficiency and alternative energy systems, materials, and designs at the **Net-Zero Energy Residential Test Facility** (NZERTF) with the goal of demonstrating that a net-zero energy house—one that produces as much energy as it consumes over the course of a year—can become a reality in any neighborhood.

U.S. Department of Housing and Urban Development (HUD)

HUD leads several energy initiatives that promote energy efficiency in HUD Homes. The Partnership for Advancing Technology in Housing (PATH) aims to accelerate the creation and widespread use of advanced technologies in order to improve the affordability, quality, durability, environmental and energy-efficiency of homes. PATH's TOOLBASE provides a housing industry resource for technical information on building products, materials, new technologies, business management, and housing systems.

OTHER STANDARDS-RELATED CROSS-SECTOR INITIATIVES

National Energy Efficiency Technology Roadmap Portfolio

The *National Energy Efficiency Technology Roadmap Portfolio*[136] exists to define and refine a technology research agenda for the medium and long-term (five to twenty years) to guide institutional and regional investment strategies. It does so by identifying the landscape of energy efficiency R&D programs linked directly to desired technology characteristics and by tracking research needs that are already being addressed. Coordinated by the **Bonneville Power Administration** (BPA) in partnership with the **Electric Power Research Institute** (EPRI), it seeks to identify and prioritize R&D gaps to allow for a more rational

[135] National Institute of Standards and Technology, *Measurement Science Roadmap for Net-Zero Energy Buildings,* 2010: http://www.energetics.com/news/Documents/NetZeroEnergyBuildings.pdf.

[136] The *National Energy Efficiency Technology Roadmap Portfolio* is available at http://www.bpa.gov/Energy/N/pdf/EE_Tech_RM%20Portfolio_Jan_2013.pdf.

allocation of limited funding and resources by organizations such as the BPA, national labs, research universities, private businesses, and venture capitalists.

High-Performance Building Council (HPBC)

Under a directive of the Energy Policy Act of 2005, the National Institute of Building Sciences (NIBS) established the HPBC to assess the existence of guidance and technology for achieving high performance, identify research needs, and make recommendations to accelerate development of high performance building processes. In 2008, the Council released its report, *Assessment to the U.S. Congress and U.S. Department of Energy on High Performance Buildings*.[137] The Council is presently in the process of identifying high-performance building attributes, high-performance goals, primary indicators, performance metrics, high-performance benchmarks, standards and guidelines for establishing, verifying or validating these benchmarks.

Smart Grid Interoperability Panel (SGIP)

The SGIP was established to support NIST in its fulfillment of its responsibilities pursuant to the *Energy Independence and Security Act of 2007* (EISA). SGIP's mission is to provide a framework for coordinating all Smart Grid stakeholders in an effort to accelerate standards harmonization and advance the Interoperability of Smart Grid devices and systems. SGIP fulfills this mission by facilitating standards development for Smart Grid interoperability; identifying necessary testing and certification requirements; overseeing the performance of these activities; and conducting outreach to establish global interoperability alignment.

U.S. Council for Energy-Efficiency Manufacturing (U.S. CEEM)

U.S. CEEM is a voluntary, industry-led partnership engaging industry, government, and other stakeholders to help U.S. industry improve energy efficiency and competitiveness. Its mission is to enable U.S. industry to achieve global leadership in energy efficiency while maintaining competitiveness and reducing greenhouse gas emissions. U.S. CEEM works in collaboration with DOE to guide **Superior Energy Performance**[138] a certification program that provides industrial facilities with a system for verifying energy performance improvements and management practices. A central element of SEP is implementation of ISO 50001, with additional requirements to achieve and document energy performance improvements. Facilities that achieve Superior Energy Performance certification obtain ANSI-ANAB accredited third-party verification for meeting program requirements. It is anticipated that Superior Energy Performance will launch nationally in 2013.

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[137] *Assessment to the U.S. Congress and U.S. Department of Energy on High Performance Buildings, 2008:* http://c.ymcdn.com/sites/www.nibs.org/resource/resmgr/HPBC/NIBS_HighPerformanceBuilding.pdf.

[138] See http://www.superiorenergyperformance.net.

Clean Energy Ministerial

The Clean Energy Ministerial is a high-level, global forum to promote policies and programs that advance clean energy technology, to share lessons learned and best practices, and to encourage the transition to a global clean energy economy. Initiatives are based on areas of common interest among participating governments and other stakeholders. The U.S. serves as a lead on several CEM projects, including the **Global Superior Energy Performance Partnership** (GSEP)[139] to accelerate energy efficiency improvements throughout industrial facilities and large buildings. The purpose of this initiative is to significantly cut global energy use by encouraging industrial facilities and commercial buildings to pursue continuous improvements in energy efficiency and promoting public-private partnerships for cooperation on specific technologies or in individual energy-intensive sectors. GSEP is also a task group under the **International Partnership for Energy Efficiency Cooperation** (IPEEC)[140] an international forum that provides global leadership on energy efficiency by identifying and facilitating government implementation of policies and programs that yield high energy-efficiency gains.

[139] See http://www.cleanenergyministerial.org/our_work/buildings_and_industry/index.html.

[140] See http://www.ipeec.org/.

Roadmap Appendix C: Index of Acronyms and Abbreviations

A2LA – American Association for Laboratory Accreditation

ACCA – Air Conditioning Contractors of America

ACM – Alternative Calculation Method

AEA – American Evaluation Association

AEO – Annual Energy Outlook

AFD – Automated Fault Diagnostics

AHRI – Air-Conditioning, Heating, and Refrigeration Institute

AI – Analog Inputs

ANSI – American National Standards Institute

AO – Analog Output

APIs – Application Programming Interfaces

ASABE – American Society of Agricultural and Biological Engineers (ASABE)

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

ASME – American Society of Mechanical Engineering

ASPE – American Society of Plumbing Engineers

ATIS – Alliance for Telecommunications Industry Solutions

AWS – American Welding Society

BAR – Building Asset Rating

BAS – Building Automation System

BB – Behavior Based

BCL – Building Component Library

BEDES – Building Energy Descriptor Exchange Standard

BEI – Business Enterprise Integration

BEMP – Building Energy Modeling Professional

BEQ – Building Energy Quotient

BESA – Building Energy Simulation Analyst

BESTEST – Building Energy Simulation Test

BI – Binary Inputs

BO – Binary Outputs

Btu – British Thermal Unit

C&I – Commercial and Industry

CAB – Conformity Assessment Bodies

CARB – California Air Resources Board

CASCO - Conformity Assessment Committee

CBECS – Commercial Building Energy Consumption Survey

CEC – California Energy Commission

CEE – Consortium for Energy Efficiency

CEI – Continuous Energy Improvement

CFLs – Compact Fluorescent Lighting

CIEB – Continual Improvement of Existing Buildings

CPUC – California Public Utility Commission

DAS – Division of Apprenticeship Standards

DER – Distributed Energy Resource

DEER – Database for Energy Efficient Resources

DHW – Domestic Hot Water

DLC – Direct Load Control

DOL – U.S. Department of Labor

DUSD – Deputy Under Secretary of Defense

ECB – Energy Cost Budget

EC – Energy Content

ECMs – Energy Conservation Measures

EDA – Energy Design Assistance

EE – Energy Efficiency

EEGA – Energy Efficiency Groupware Application

EEPS – Energy Efficiency Portfolio Standard

EIA – 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

EPIs – Energy Performance Indicators

ESCOs – Energy Consumers and Energy Services Companies

ESI – Energy Services Interface

EUI – Energy Use Intensity

EUL – Effective Useful Life

EVO – Efficiency Valuation Organization

FEM – Federal Energy Management

FEMP – Federal Energy Management Program

FSGIM – Facility Smart Grid Information Model

GBI – Green Building Initiative's

HPwES – Home Performance with ENERGY STAR®

HVAC – Heating, Ventilation, and Air Conditioning

HVACR – Heating, Ventilation, Air Conditioning, and Refrigeration

I & E – Installations and Environment

IA – Irrigation Association

IAPMO – International Association of Plumbing and Mechanical Officials (IAPMO)

IAS – International Accreditation Service, Inc.

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

IMC – International Mechanical Code

IOU – Investor Owned Utilities

IPMVP – International Performance Measurement and Verification Protocols

IREC – Interstate Renewable Energy Council, Inc.

IRS – Internal Revenue Service

ISO – International Organization for Standardization

ISOs – Independent System Operators

ISP – Industry Standard Practice

JAC – Joint Apprenticeship Committee

JATC – Joint Apprenticeship and Training Committee

JTAs – Job Task Analyses

KSAs – Knowledge, Skills, and Abilities

LBNL – Lawrence Berkeley National Lab

LEDs – Light Emitting Diodes

LEED – Leadership in Energy Efficient Design

M&V – Measurement and Verification

MECS – Manufacturing Energy Consumption Survey

MGP – Modeling Guidelines and Procedures

NAESB – North American Energy Standards Board

NAICS – North American Industry Classification System

NAPEE – National Action Plan for Energy Efficiency

NEC® – National Electric Code

NECA – National Electrical Contractors Association

NEEP – Northeast Energy Efficiency Partnerships

NFPA – National Fire Protection Association

NIBS – National Institute of Building Sciences

NIST – National Institute of Standards and Technology

NREL – National Renewable Energy Laboratory

NVLAP – National Voluntary Laboratory Accreditation Program

NWPCC – Northwest Power Planning Conservation Council

PEI – Potential Energy Impact

PNNL – Pacific Northwest National Laboratory

PRM – Performance Rating Method

PSDs – Program Savings Documents

PUE – Power Use Efficiency

PV – Photovoltaic

QA – Quality Assurance

RCTs – Randomized Controlled Trials

RECS – Residential Energy Consumption Survey

RED – Random Encouragement Design

REED – Regional EE Database

RESNET – Residential Energy Services Network

RTF – Regional Technical Forum

SCTE – Society of Cable Telecommunications Engineers

SDOs – Standards Developing Organizations

SEE Action – State Energy Efficiency Action

SGIP – Smart Grid Interoperability Panel

SMACNA – Sheet Metal and Air Conditioning Contractors' National Association

SPC – Standard Project Committee

SPT – Standard Program Tracking

STEP – Sustainable Technology Environment Program

TDH – Total Dynamic Head

TIA – Telecommunications Industry Association (TIA)

TRMs – Technical Reference Manuals

UAC – Unilateral Apprenticeship Committee

UMC – Uniform Mechanical Code

UPC – Uniform Plumbing Code

USC – United States Code

USEIA – U.S. Energy Information Administration

VFD – Variable Frequency Drive

WBDG – Whole Building Design Guide

WTO – World Trade Organization