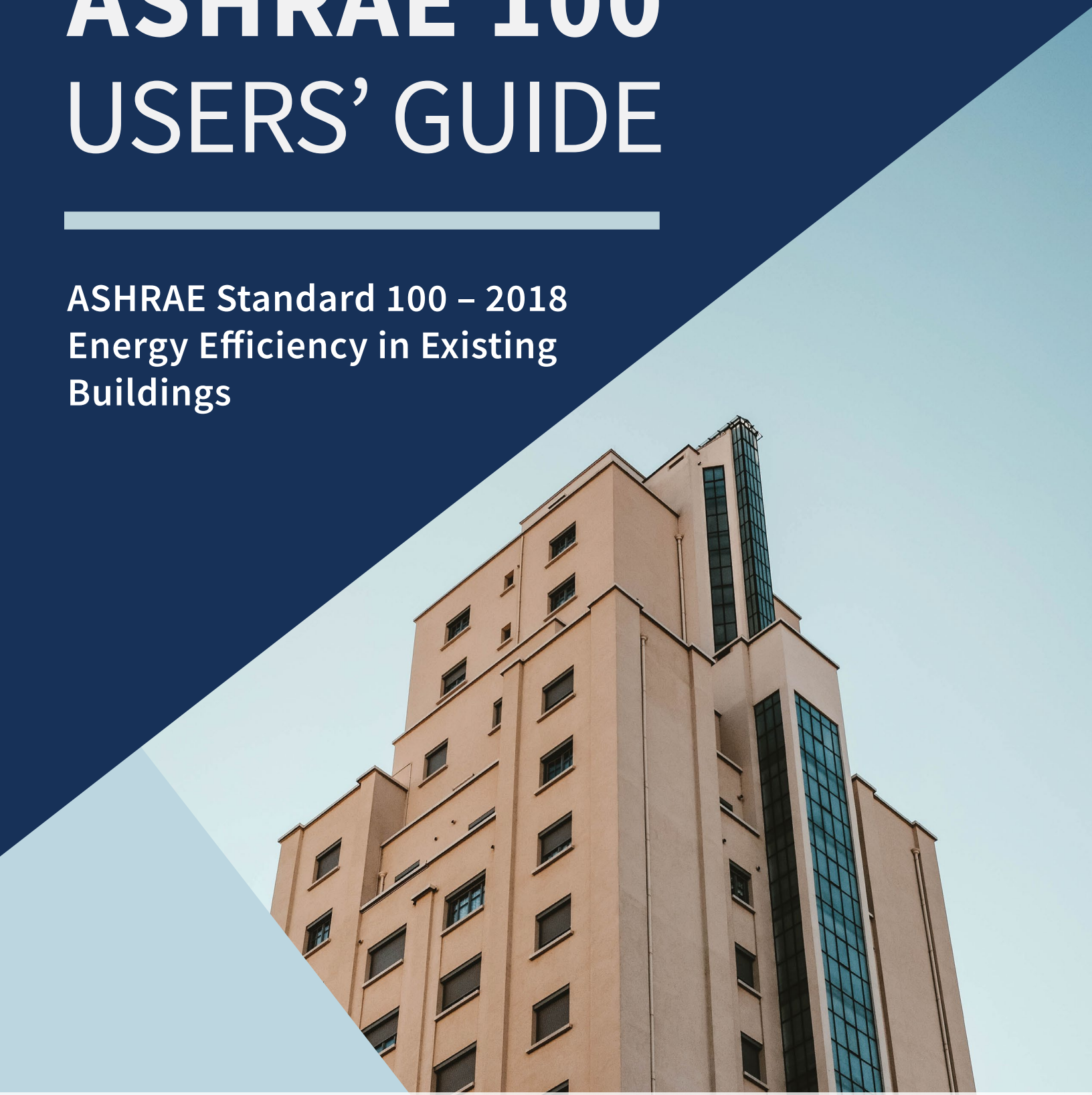
ASHRAE 100 USERS' GUIDE

ASHRAE Standard 100 – 2018 Energy Efficiency in Existing Buildings



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ASHRAE 100
Users' Guide

Users' Guide for ASHRAE Standard 100 – 2018
Energy Efficiency in Existing Buildings

Authored by:

RDH BUILDING SCIENCE

[2021]

Guide Funders

Northwest Energy Efficiency Alliance

BC Hydro

Province of British Columbia

University of British Columbia

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WA State Dept of Commerce Energy Office

Introductory Support Letter

Welcome to the Users' Guide for ASHRAE Std. 100 – 2018 Energy Efficiency in Existing Buildings

As the State of Washington and British Columbia move toward ambitious energy-focused regulations for existing buildings to reduce the environmental impact of existing buildings, they identified a need to develop accessible tools to support building owners, operators, and professionals. Although this Users' Manual is not an ASHRAE published document, a few members of the ASHRAE Std. 100 Standing Standard Project Committee (SSPC) were involved in providing input and comments throughout this Guide's development process.

We gratefully acknowledge the contributions of the Northwest Energy Efficiency Alliance, the Washington State Department of Commerce, the Building and Safety Standard Branch of the Province of British Columbia, the University of British Columbia, BC Hydro, and RDH Building Science for the development of this Guide. We hope you find it a valuable resource toward improving the energy performance of our existing buildings.

– Wayne Stoppelmoor, CEM | chair of SSPC 100

Contributor Letters of Support

The Building and Safety Standards Branch has a mandate to support the Province's CleanBC climate action plan and adopt energy efficiency requirements for existing buildings. Through the B.C. Energy Step Code, the province has seen success with the use of performance metrics for new construction, and ASHRAE 100 performance targets may inform a similar approach for existing buildings. ASHRAE 100 also provides helpful tools for building owners and the building industry to work towards improving the performance of individual buildings.

– Kylie Sandham, PMP, MCIP/RPP, MPA | Policy Analyst, Building and Safety Standards Branch, Office of Housing and Construction Standards, Ministry of Attorney General & Minister Responsible for Housing, Province of British Columbia

The Northwest Energy Efficiency Alliance (NEEA) is a non-profit organization working to cost-effectively deliver energy efficiency in buildings through market transformation. Funded by the regional utilities, NEEA is a collaboration of 140 utilities and efficiency organizations working together to advance energy efficiency in the Northwest on behalf of more than 13 million consumers. This unique partnership has helped make the Northwest region a national leader in energy efficiency. We are thrilled to support the development of the *ASHRAE Standard 100–2018 Users' Guide*. In 2019 Washington State passed a law that requires existing commercial buildings to meet the energy performance standards. The law (HB 1257, 2019) also authorizes Washington State Department of Commerce to develop and implement energy performance standards using ASHRAE Standard 100 – 2018 as the model standard. As a first-of-its-kind regulation for existing building energy consumption at the state level, both Washington's rulemaking experience and detailed technical guidance from this Users' Guide will play a vital role for other states and cities to establish similar policy and assist them to develop their implementation plans. Buildings contribute to 70% electricity demand in the United States. Working together to reduce energy consumption in existing buildings in a cost-effective way will lead to a better built environment and clean building future.

– Bing Liu, P.E., FASHRAE | Sr Manager, Codes, Standards, New Construction, Northwest Energy Efficiency Alliance

Commerce works with local governments, tribes, businesses and civic leaders throughout the state to strengthen communities so all residents may thrive and prosper. The State Energy Office provides a unique mix of energy policy development and implementation programs to support energy technology research, implement grant and demonstration projects and apply state laws that accelerate economic development and enhance environmental quality. Our buildings unit administers the state energy performance standard for commercial buildings, based on ASHRAE Standard 100. https://www.commerce.wa.gov/buildings.

– Chuck Murray | Washington State Department of Commerce, State Energy Office

– Emily Salzber | Managing Director, Building Standards and Performance, Washington State Department of Commerce

BC Hydro is a member of the ASHRAE Std. 100 Technical Committee and we are pleased to be involved and support the development of the *ASHRAE Std. 100 – 2018 Users' Guide*. The Province of BC is planning to adopt new requirements for alterations to existing buildings and energy efficiency is one of the priority areas being considered. ASHRAE Std. 100 and the Users' Guide will be important tools to support building owners and the building industry to enhance energy efficiency in the built environment in the future.

– Toby Lau, M.Sc., P.Eng. | Codes & Standards Principal, Advanced DSM Strategies, Power Smart, BC Hydro

The University of British Columbia has brought performance-based BC Energy Step Code requirements to new residential construction on UBC's Point Grey campus. Performance-based targets are anticipated as part of a new alterations code for existing buildings in BC and ASHRAE Standard 100 provides an excellent framework for applying performance targets for existing buildings. I anticipate the Users' Guide will be a valuable resource for Authorities Having Jurisdiction at the local government level in BC, and for building owners for meeting future requirements, or applying the Standard on a voluntary basis.

– Ralph Wells, M.R.M., M. Eng, Community Energy Manager, University of British Columbia

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Chapter 1 | Introduction and Overview

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ASHRAE Standard 100-2018: Energy Efficiency in Existing Buildings is an international building standard, developed by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), that provides standardized procedures for improving the energy efficiency of existing buildings.

The purpose of this guide is to provide additional explanation, examples, and reference material to supplement ASHRAE Standard 100[1]. It is intended to provide useful material for the primary parties named in ASHRAE Standard 100, including those enforcing the Standard and those required to comply with it (see Figure 1-1).

This introductory section further describes the guide's scope, briefly outlines what ASHRAE Standard 100 is and how it works, and reviews the core concepts needed to understand the Standard.

Scope of this Guide

This guide was developed with support from BC Hydro, the Province of BC, and the Northwest Energy Efficiency Alliance (NEEA), and in partnership with the University of British Columbia (UBC) and the State of Washington Department of Commerce. It is generally applicable anywhere ASHRAE Standard 100 may be implemented, although it provides some supplemental material specific to the regions of British Columbia and Washington State.

ASHRAE Standard 100 also references other standards and industry guidelines, such as *ASHRAE 211 - 2018 Standard for Commercial Building Energy Audits*. Where those documents provide comprehensive guidance on specific functions, such as completing an energy audit, this guide refers the reader to those standards.

ASHRAE Standard 100 is founded on the premise that reducing the energy use of buildings is the starting point for reducing overall environmental impact. As such, the current version of Std. 100 – 2018 focuses on energy use intensity targets and does not include greenhouse gas intensity (GHGI) targets. In general, reduced energy use supports reduced GHGI; however, there is some nuance to this relationship. Changes in fuel type can reduce GHGI without reducing overall energy use, and some energy-saving interventions have minimal impact on GHGI. A full discussion of these interactions and their policy significance is beyond the scope of this guide; however, there is nothing in ASHRAE Standard 100 that would prevent local or regional governments from applying GHGI requirements in conjunction with Std. 100 – 2018.

1 This guide was developed with the permission of ASHRAE; however, it is not an official ASHRAE users' guide, and is intended to serve as a companion document to the Standard.

How to Use this Guide

This guide is intended to be used in conjunction with ASHRAE Standard 100.

Each chapter of this guide is divided into topics that will be relevant for specific roles. Each role has a unique icon to identify its corresponding content as illlustrated by the legend below. Figure 1-1 summarizes which chapters and topics of the guide are relevant to each role.

Note: for clarity and brevity, elements of ASHRAE Standard 100 are referred to in this guide using the format **ASHRAE Std. 100 Table 5-2a**, **ASHRAE Std. 100 Sec. 5.1.2.1**, etc., while elements of this users' guide are referred to by title and page number only.

Legend

Authority Having Jurisdiction (AHJ)

Building Owner

Building Manager

Building Operator

Energy Manager (EM)

Qualified Energy Auditor

Qualified Person Determining Compliance

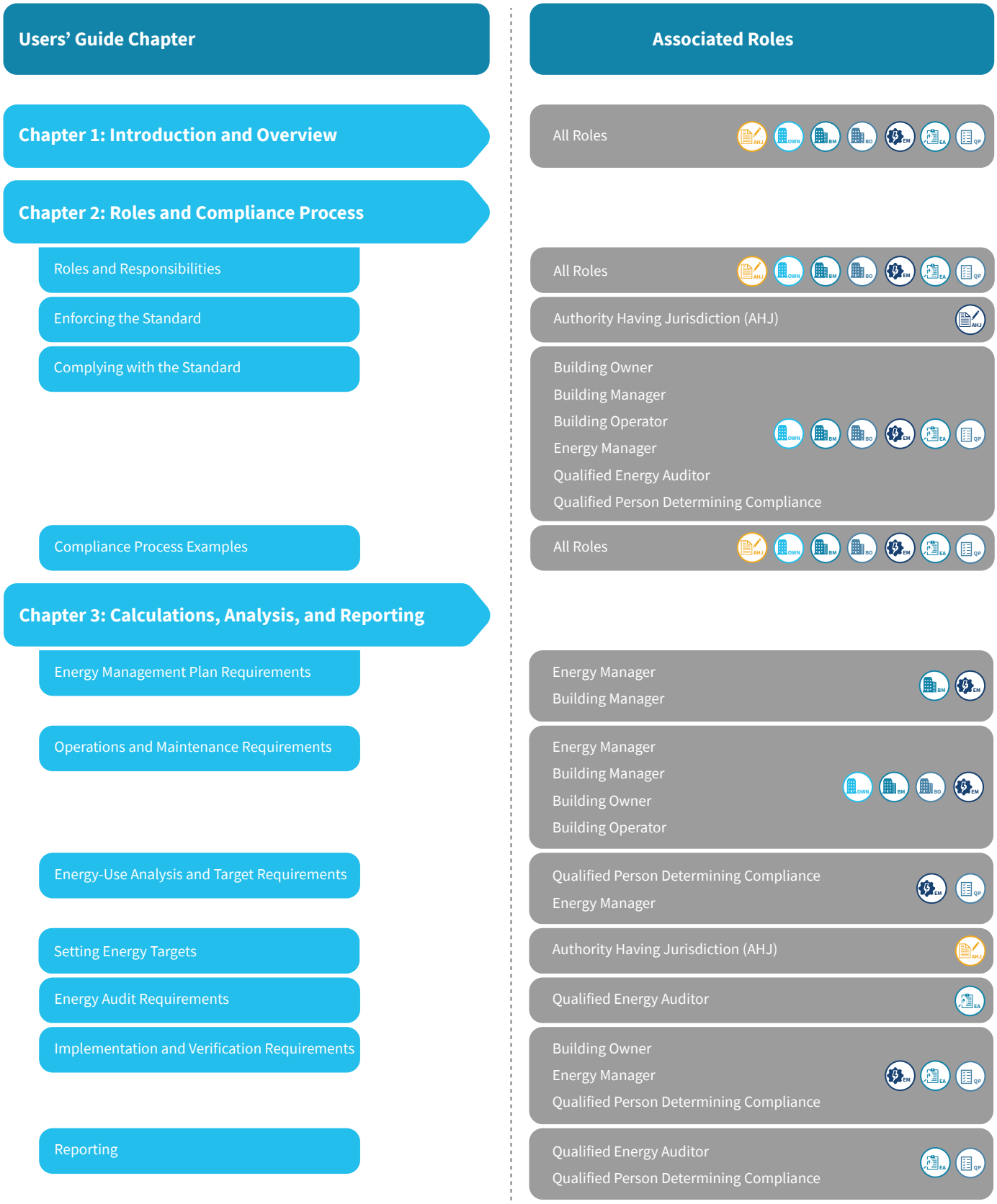

Figure 1-1 Chart summarizing which sections of the guide are relevant to each role

What is ASHRAE Standard 100 and How Does it Work?

ASHRAE Standard 100 is designed to improve the energy efficiency of existing buildings by setting absolute energy performance targets for a range of building types. At a high level, ASHRAE 100 works by following these steps for each building:

- Measure and document energy use of the existing building.
- Compare measured energy use of the existing building to the targeted energy use for that building type and determine if energy efficiency improvements are required.
- Implement and verify energy efficiency improvements, if required.
- Continue to measure and document energy use and compare to the building's energy use target.

One way to understand ASHRAE Standard 100 is in the context of *ASHRAE Standard 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings*, which is another building energy standard developed by ASHRAE. The following are some key differences:

- 90.1 does include some provisions for existing buildings but is typically used for new construction, whereas ASHRAE Standard 100 was specifically developed for existing buildings.
- 90.1 is focused on theoretical component, equipment, and system-level performance, along with energy modelling procedures, whereas ASHRAE Standard 100 is focused on measured whole-building energy use.

Another important point of comparison is ENERGY STAR® Portfolio Manager (ESPM)[2]. Many jurisdictions across North America are using ESPM to support existing building energy performance, including using it to rate performance and track improvements. The rating function of ESPM is relative, such that buildings are ranked against the performance of similar buildings in a nationwide (U.S.) historical database and adjusted for climate and usage patterns.

ESPM is used widely by many cities across North America. It is free, well known, and provides a simple platform for people to report building energy use. A relative rating approach can be challenging, however, for regions or jurisdictions that set policy toward achieving hard targets for energy use and/or greenhouse gas emissions. For this reason, some jurisdictions choose to use the ESPM platform to report energy use without using the ranking functionality.

ASHRAE Standard 100 is not currently used as widely but is preferred by some policymakers because it provides *absolute* targets, and as such, its impact can be more readily quantified. British Columbia and Washington State have taken the targets in ASHRAE Standard 100 a step further by developing their own region-specific targets to reflect their unique circumstances, including a longer history of energy conservation programs for existing buildings (these targets are provided in Appendix A and B).

Core Concepts

Before diving into the specifics of ASHRAE Standard 100, it is useful to review several core concepts that underlie its procedures[3]. These concepts are commonly referenced in the building industry when referring to building energy and sustainability.

All the core concepts behind ASHRAE Standard 100 relate to how buildings use energy. The energy used by buildings is significant: they comprise 20% of secondary energy use[4] in Canada. Improving the energy use of existing buildings is a key part of the energy and greenhouse gas emissions policies of local, regional, and national governments.

Buildings use energy to provide an indoor environment that meets the functions and needs of their occupants; for example by heating or cooling the air to maintain an acceptable space temperature. In addition to heating and cooling, typical building energy end uses include lighting, pumps, fans, domestic hot water, and plug loads. Plug loads—or miscellaneous electrical loads (MELs)—include electrical loads created by equipment and devices placed within the spaces by the building occupants, such as computers, printers, refrigerators, etc.

2 For more information on ENERGY STAR® Portfolio Manager, see https://portfoliomanager.energystar.gov

3 Note that concepts indicated with bolded text are also defined in ASHRAE Standard 100. The discussion in this section of the guide is intended for general information; the definitions in the Standard should also be carefully reviewed for implementation purposes.

4 Secondary energy use is the energy used by final consumers. It is included in primary energy use, which also includes the energy system's own use (for example, to bring energy supplies to the consumer) and the energy to feed industrial processes (Natural Resources Canada 2018, p. 35).

What are the Most Energy-Intensive End Uses in Buildings?

Energy-intensive end uses vary by a number of factors including climate, building type, architectural design, mechanical design, electric design, etc. In Canada, heating is the largest average end use in both residential and commercial buildings[5].

Heating energy use is a function of both the heating load and the mechanical heating, ventilation, and air conditioning (HVAC) systems that meet the load. The heating load is the amount of heat needed to maintain the desired interior environmental conditions, given the building's exterior climate, building enclosure (or envelope), and internal gains. Energy use can therefore be reduced by reducing the load (e.g., through a better enclosure) or by using a more efficient HVAC system to handle the load. In practice, these two strategies go together: a better enclosure will enable different and/or downsized options for HVAC.

What is the Building Enclosure?

From a functional perspective, the **building enclosure** is an environmental separator: it separates the exterior weather from the indoor environment. It is comprised of the various assemblies that make up the exterior of the building, including exterior walls, roofs, exposed floors, windows, and doors.

In terms of energy, the enclosure affects both heating and cooling loads, which in turn impact the heating and cooling energy consumed by the mechanical HVAC systems. Building enclosure properties that affect energy use include the level of insulation, thermal bridging, amount of solar heat gain, and airtightness.

Energy use associated with the building enclosure can be reduced by increasing the insulation value (for example, replacing old non-thermally broken windows with insulated glazing units that have non-conductive frames), reducing thermal bridging (for example, by installing continuous insulation on the exterior of stud walls), and improving airtightness (for example, by identifying and sealing leaks).

What are Mechanical HVAC Systems in Buildings?

Mechanical **HVAC** (heating, ventilation, and air conditioning) systems provide space heating, conditioning of ventilation air, supply and exhaust of ventilation air, and space cooling. They can also provide humidification/dehumidification if designed to do so. In larger buildings, HVAC systems are comprised of three types of components:

- **Plant equipment** can include boilers, furnaces, chillers, centralized air handling and air conditioning units, and centralized heat pumps.
- **Distribution components** can include pipes, ductwork, pumps, fans, grilles, diffusers, and valves.
- **Zone/terminal equipment** can include fan coil units, radiators, convectors, and VAV reheat boxes, as well as self-contained systems that are placed within the space they serve, such as electric baseboards, packaged terminal heat pumps (PTHPs), and air conditioners (PTACs).

Energy use from HVAC systems can be reduced by improving the efficiency of the energy-consuming components (e.g., replacing the boiler with a new, higher-efficiency boiler) or by improving the system efficiency—typically by making changes to the system controls (e.g., changing the boiler supply temperature from constant to reset based on zone demand or the outdoor air temperature).

What are Building Component Life Cycles?

All building components, including the building itself, have designed service lives. **Designed service lives** are the intended duration of use, as determined by the original designer, provided the component is operated and maintained as stipulated by the designer. For example, a roof membrane may be designed to last 30 years before it needs to be replaced.

The **life cycle** of building components refers to the timeline from original production/assembly, through the service life of the equipment, followed by decommissioning, disposal, and replacement.

In the context of ASHRAE Standard 100, maintenance is performed in order to ensure the designed service lives of the components are achieved. Within the energy audit requirements, improvement measures must address impacts over the expected service life of the component.

5 Natural Resources Canada (2018, p. 35).

What is Energy-Use Intensity?

Energy-use intensity (EUI) is typically measured in kWh/m² (kBTU/ft²) or MJ/m² and defines the total annual building energy use per unit of gross floor area (GFA) for a given building. It is a way to compare energy use independent of building size, and as a result is used in many performance-based building metrics, such as the British Columbia Energy Step Code, as well as in building benchmarking and reporting programs such as ENERGY STAR® Portfolio Manager.

What is the Difference between Site and Source Energy?

Site energy is the amount of energy consumed by the building within the boundary of the building perimeter, as measured by the utility meters located at the building. This energy (sometimes referred to as **secondary energy**) represents the energy that building owners and operators have the most direct control over. **Source energy** (sometimes called **primary energy**) is the amount of energy consumed by the building when taking into account upstream energy use associated with the utility grid that supplies energy to the building. Upstream energy use can include energy associated with primary resource extraction, energy losses at the power plant due to inefficiencies in energy conversion, electricity transmission losses, and transportation energy. Figure 1-2 illustrates the main distinctions between site and source energy.

Source energy is typically calculated by multiplying site energy use by a primary energy conversion factor, also referred to as a source-to-site ratio. These factors are energy type and region specific, depending on the local utility grid.

What are Energy Targets?

Energy targets define EUI limits for buildings. In the case of ASHRAE Standard 100, EUI targets are provided by climate zone and building type.

ASHRAE Standard 100 lists two levels of EUI targets: **ASHRAE Std. 100 Sec. 7** (at the 25th percentile of performance) and **Normative Annex A** (at the 40th percentile of performance). Some AHJs may also choose to define their own targets.

What are Energy Efficiency Measures?

Energy efficiency measures (EEMs) are individual upgrades/modifications to an existing building that reduce the annual energy use of the building. For example, an EEM might be replacing the existing 80% efficiency boiler with a new condensing boiler or heat pump.

What are Energy Audits?

Energy audits are studies, carried out by qualified energy auditors, that review the energy-consuming components of the existing building—including the building enclosure, lighting, and mechanical systems—and identify potential EEMs.

Energy audits are required by ASHRAE Standard 100 for buildings that do not have an energy target and for buildings that have an energy target but do not initially meet it.

Site Energy

- Represents energy consumed at the building only
- Useful for comparing similar buildings in similar climates
- Ignores broader energy grid implications
- Favours more specific energy/GHG emission reduction goals (building level, municipal)

VS

Source Energy

- Represents energy consumed at the building, as well as energy consumed by the primary energy grid
- Can make it difficult or even impossible to compare building performance between different regions, even within the same building type and climate
- Favours broader energy/GHG emission reduction goals (global, national)
- Can penalize individual building performance for inefficiencies in their local power grid which are beyond the owner's control.
  - i.e. an inefficient building with a cleaner energy grid may meet a source target, while a building with the same climate and building type that is efficient but has a dirtier grid may not meet the target.

Figure 1-2 Comparison of site vs. source energy

What is the Difference between Weather and Climate?

Weather describes local exterior environmental conditions and varies from moment to moment. **Climate** describes overall trends or patterns in weather.

Within ASHRAE Standard 100, energy targets are defined by climate zones, which are a system for categorizing climate based on historical average weather conditions. Each climate zone has a number ranging from 1 (hottest) to 8 (coldest), as well as a subtype of either A (humid), B (dry), or C (marine). A list of major Canadian, American, and international cities and their associated climate zone can be found in **ASHRAE Standard 90.1-2016 Annex 1**. Figure 1-3 and Figure 1-4 illustrate the ASHRAE climate zones for British Columbia and North America respectively.

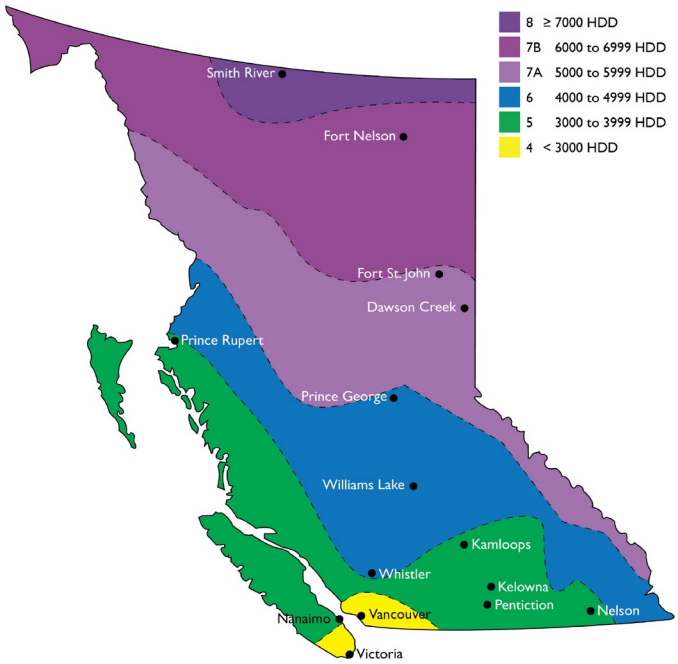

Figure 1-3 ASHRAE Climate Zones British Columbia

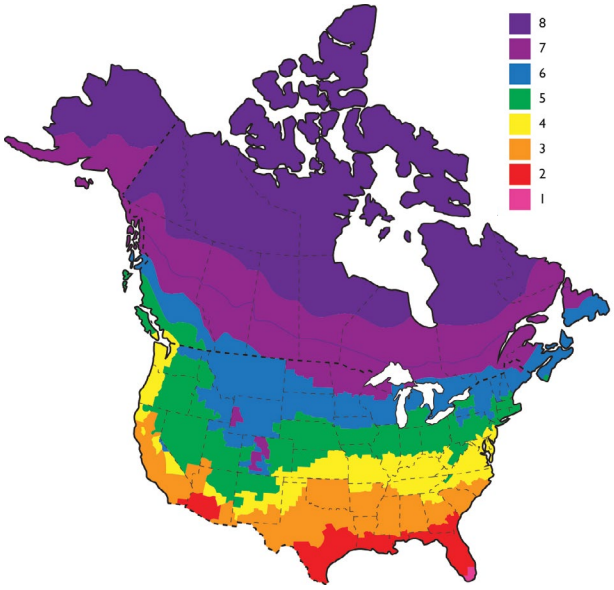

Figure 1-4 ASHRAE Climate Zones North America


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ASHRAE Standard 100 is intended to be used by a range of people with differing roles and responsibilities. This chapter breaks down each role and explains how it fits into the overall process of complying with the Standard.

Roles and Responsibilities

Although different stakeholders may be involved in implementing ASHRAE Standard 100 in varying situations, roles can be broken down into two main categories: those responsible for enforcing the Standard (e.g., the Authority Having Jurisdiction [AHJ]) and those responsible for complying with it. In the compliance category, specific roles can include building owners and staff (building managers, operators, and energy managers) as well as external consultants (energy auditors and contractors/engineers who meet criteria as **qualified individuals determining compliance**. Figure 2-1 summarizes these roles and illustrates how they connect and overlap. For a checklist of activities by role, see Appendix D.

Within these broad roles and responsibilities, stakeholders have assigned tasks to move the overall project through ASHRAE Standard 100 implementation. In some cases, tasks must be completed by a specific person; in other cases, there is flexibility to accommodate different circumstances. For example, calculation of a building's energy-use intensity

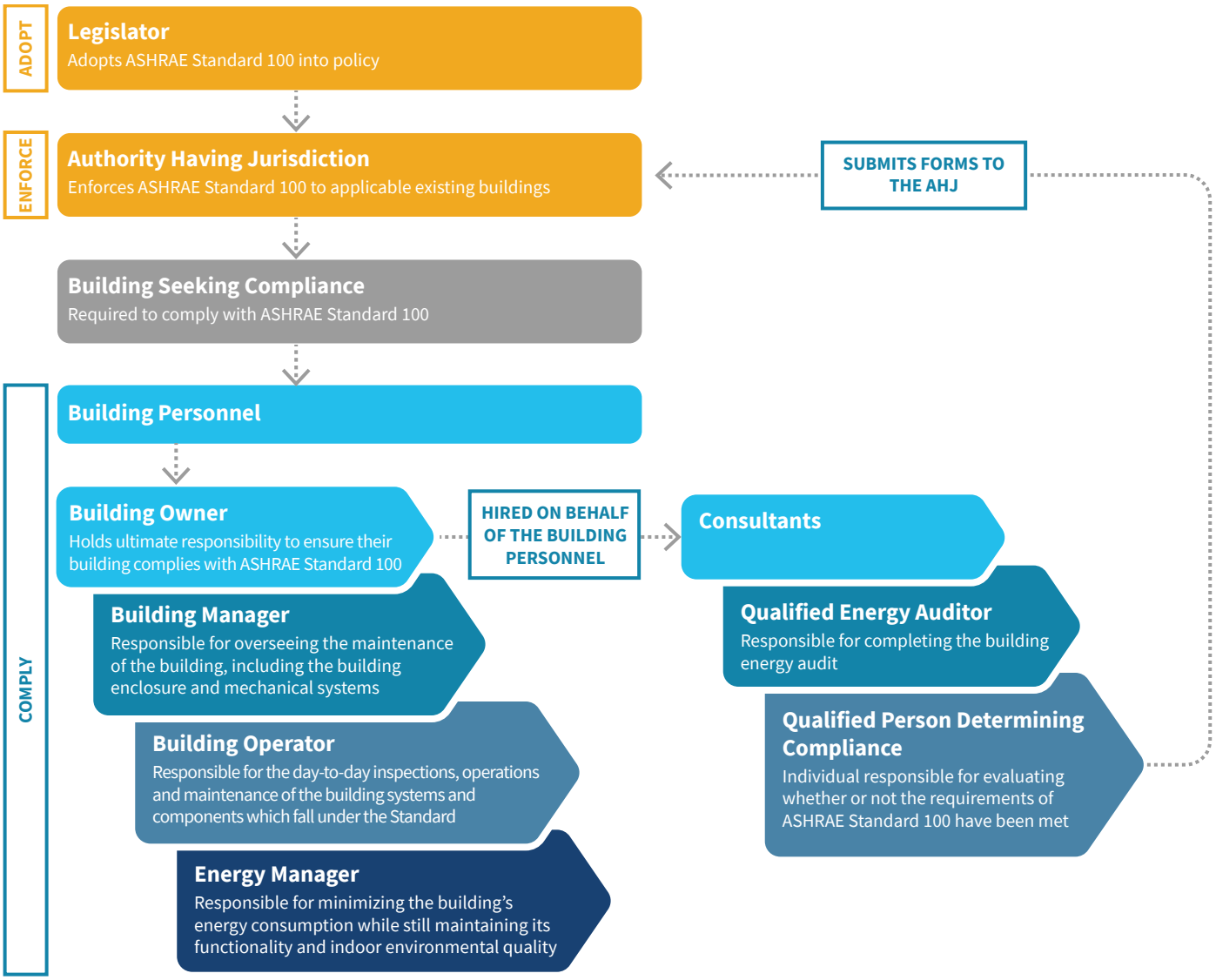


Figure 2-1 Roles and broadly defined responsibilities of those involved in adopting, enforcing and complying with ASHRAE Standard 100

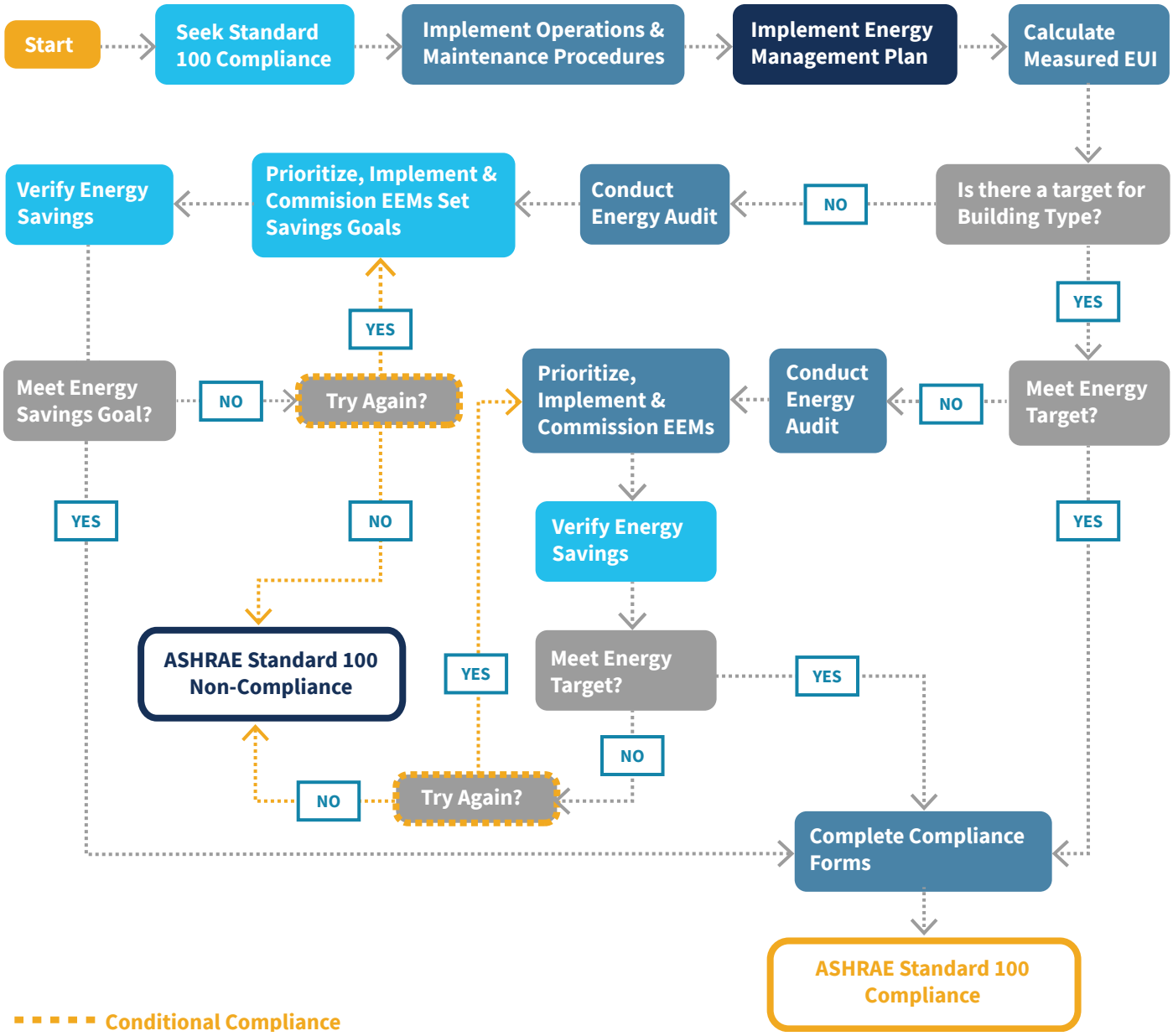


Figure 2-2 Summary of process and specific tasks involved in enforcing and complying with ASHRAE Standard 100

(EUI) may be performed by the energy manager (who may be the building owner, building manager, or building operator) or the qualified person determining compliance. Furthermore, there are additional roles that are not directly addressed by the Standard but are connected to project implementation, such as qualified commissioning agents.

Figure 2-2 illustrates the overall process and key steps for complying with the Standard, from start to finish.

In the following sections, tasks are broken down according to the roles associated with them. This "zoomed in" perspective provides a picture of what the implementation process looks like for each stakeholder.

Enforcing the Standard

Authorities Having Jurisdiction are responsible for enforcing the Standard. As shown in Figure 2-3, this role has four main tasks: setting requirements, communicating requirements, reviewing and evaluating documentation, and taking action based on that review/evaluation.

Setting Requirements

ASHRAE Standard 100 provides criteria and general procedures to support jurisdictions that want to reduce energy use through improved energy performance in existing buildings. Legislators determine many aspects of this regulatory framework, but AHJs will likely establish certain requirements within their jurisdictions, which can range from small municipalities to federal governments. These decisions are a first step in implementation and may be periodically revisited. Table 2-1 summarizes requirements that must be determined by the AHJ as well as those that the AHJ can optionally determine.

As ASHRAE Standard 100 is a relatively new standard and is just beginning to be adopted, it will be useful to learn from early adopters and develop case examples of specific requirements.

Of the optional choices that AHJs can make, one of the most significant is the choice of targets: the core of the Standard revolves around the energy targets buildings must achieve. As noted in Table 2-1, the AHJ may choose source- or site-based targets and/or may choose to specify their own region-specific targets to be applicable within their jurisdiction such as those in **ASHRAE Std. 100 Normative Annex A**. British Columbia (BC Hydro) and Washington State have developed their own EUI targets, provided in Appendix A and Appendix B respectively.

When determining requirements, AHJs may need to consider other energy policies and tools already in place. For example, mandatory disclosure of energy use (energy benchmarking) may already be in place using services such as ENERGY STAR® Portfolio Manager (see Appendix C).

Communicating Requirements

Once the AHJ has set the requirements for its jurisdiction, these requirements must be clearly communicated to industry stakeholders. There are no specific provisions within the Standard regarding this, but this step is nevertheless vital to successful implementation of the Standard.

Important details that must be communicated to industry stakeholders include identifying which buildings are required to comply with the Standard, how the compliance (and conditional compliance) process will work, timelines and frequency of reporting, and consequences for non-conformance.

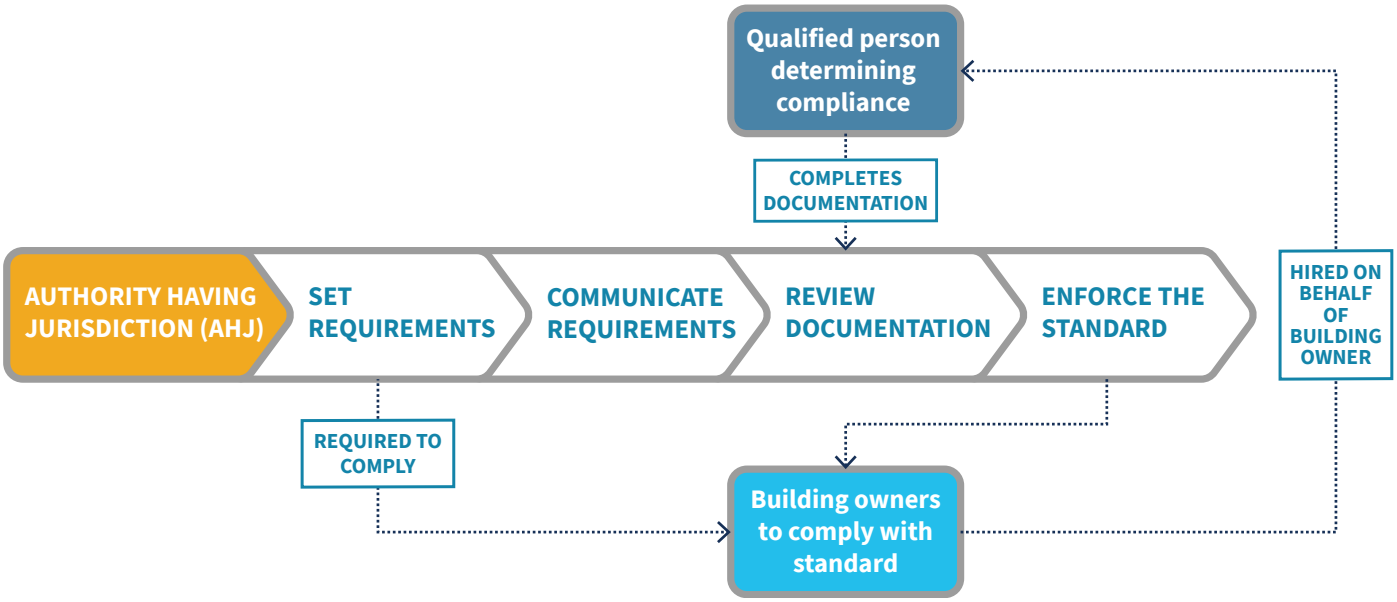


Figure 2-3 Summary of process and specific tasks related to enforcement

Table 2-1 Requirements set by AHJ

MUST SET	MAY SET
Which of the 53 building types listed in **ASHRAE Std. 100 Sec. 7** will have to comply with the Standard and by when. Which building types or scenarios will be exempt from the Standard.	Whether buildings will be required to meet source or site energy targets.
Administrative requirements, including any additional permitting or reporting beyond the Standard (**ASHRAE Std. 100 Sec. 4.4.1**).	Region-specific targets and building-type-specific implementation schedule. → Energy-use intensity (EUI) targets for both site and source energy are specified within **ASHRAE Std. 100 Sec. 7** of the Standard. However, the AHJ may choose to specify their own region-specific targets to be applicable within their jurisdiction such as those in **Normative Annex A**. → Phased implementation of different building types may also be desired.
Reporting protocols, including the format and content of the documentation; who the documentation will be sent to specifically, the timeframe within which the documentation must be submitted, and the frequency at which reporting must be completed.	Alternate criteria for defining roles → The Standard includes typical definitions for what constitutes a "qualified energy auditor" and a "qualified person" in **ASHRAE Std. 100 Sec. 3.1**, but the AHJ may set alternative criteria for defining these roles. The definitions provided are: → A professional architect or engineer licensed within the jurisdiction → An energy auditor/assessor/analyst certified by ASHRAE/AEE (all buildings) or BPI/RESnet (residential buildings)
Protocols for achieving conditional compliance if building EUI targets are not achieved.	Any alternate paths to conditional compliance.
Consequences for failure to comply with the Standard.	
Protocols for scenarios not defined within the Standard, such as establishing an acceptable methodology for estimating exported energy when it cannot be measured (**ASHRAE Std. 100 Sec. 5.2.2**).	

Reviewing Documentation

In addition to setting specific requirements, AHJs receive and review all of the documentation demonstrating that buildings comply with the Standard. This documentation includes the following:

- Forms completed by the qualified person determining compliance
  - Form A – Compliance with Standard 100
  - Form B – Building Activity and Energy Target
  - Form C – Energy Use Intensity Calculations
- If an energy audit is required, energy audit documentation completed by the qualified energy auditor
  - Energy audit reports (**ASHRAE Std. 100 Sec. 4.3.3.3**)
  - Form D – End Use Analysis Requirements Level 1 or
  - Form E – End Use Analysis Requirements Level 2

Enforcing the Standard

Following review of the provided documentation, it is the responsibility of the AHJ to take action regarding each building seeking compliance with the Standard. Possible actions include:

- **AHJs can award compliance** to those buildings that have submitted all necessary documentation and have demonstrated compliance with the Standard.
- **AHJs can award conditional compliance** (**ASHRAE Std. 100 Sec 4.3.2.3**) to buildings that have implemented the necessary energy efficiency measures (EEMs) as identified in their energy audit but have not yet been able to measure energy use for the duration required to confirm compliance.
  - Conditional compliance, as defined within the Standard, lasts for 15 months following the completion of implementation.
  - If, following the conditional compliance period, buildings fail to meet their corresponding energy target, the AHJ can decide whether the building can attempt to implement more EEMs (thereby renewing the 15-month conditional compliance period) or if they are noncompliant.
  - In practice, conditional compliance may take on many forms and it is largely up to the AHJ to determine how to approach it. Additional information can be found in Chapter 3.
- **AHJs can deem a building non-compliant** if required paperwork is not submitted within the established timeframe or if, following a period of conditional compliance, conditions are not met. It is then the responsibility of the AHJ to enforce the established consequences for failing to comply with the Standard.

As with any policy, it is the AHJ's responsibility to evaluate claims of exemption to the policy, along with addressing rights of appeal. The specifics of these processes will vary by jurisdiction.

Complying with the Standard

Complying with ASHRAE Standard 100 involves multiple tasks, which are organized below according to the roles of those completing them. These roles can be divided into two subcategories:

1. Those connected with the building (i.e., the building owner, building manager, building operator, and energy manager).
2. External consultants (the qualified energy auditor and the qualified person determining compliance).

Each role is further detailed below. Note that these roles are flexible: one person could fulfill all of them, but larger buildings may have a team of individuals working together. A building owner is ultimately accountable to the AHJ for fulfilling the requirements of the Standard, and must therefore understand the elements that must be completed and either take on or assign accountabilities accordingly.

Note that those seeking to comply with the Standard can do so as an entire building, or as individual tenants/suites. In practice, however, complying with the Standard as individual tenants/suites may create additional challenges, since many energy-related building systems and components, such as centralized mechanical systems, are not within the control of an individual tenant. As such, this guide focuses on those seeking compliance as an entire building; it is at the discretion of the AHJ to decide how to handle individual tenants within a building who seek to comply with the Standard separately.

Building Owner

The building owner is the legal holder of the property title for the building(s) and/or the land on which the building(s) are located. Building owners have a responsibility to ensure their building(s) conform to the legislation within their jurisdiction and may also voluntarily choose to have their building(s) comply with the Standard. Building owners may authorize other designated parties, such as property or real estate management companies, to fulfill legal obligations on the owner's behalf.

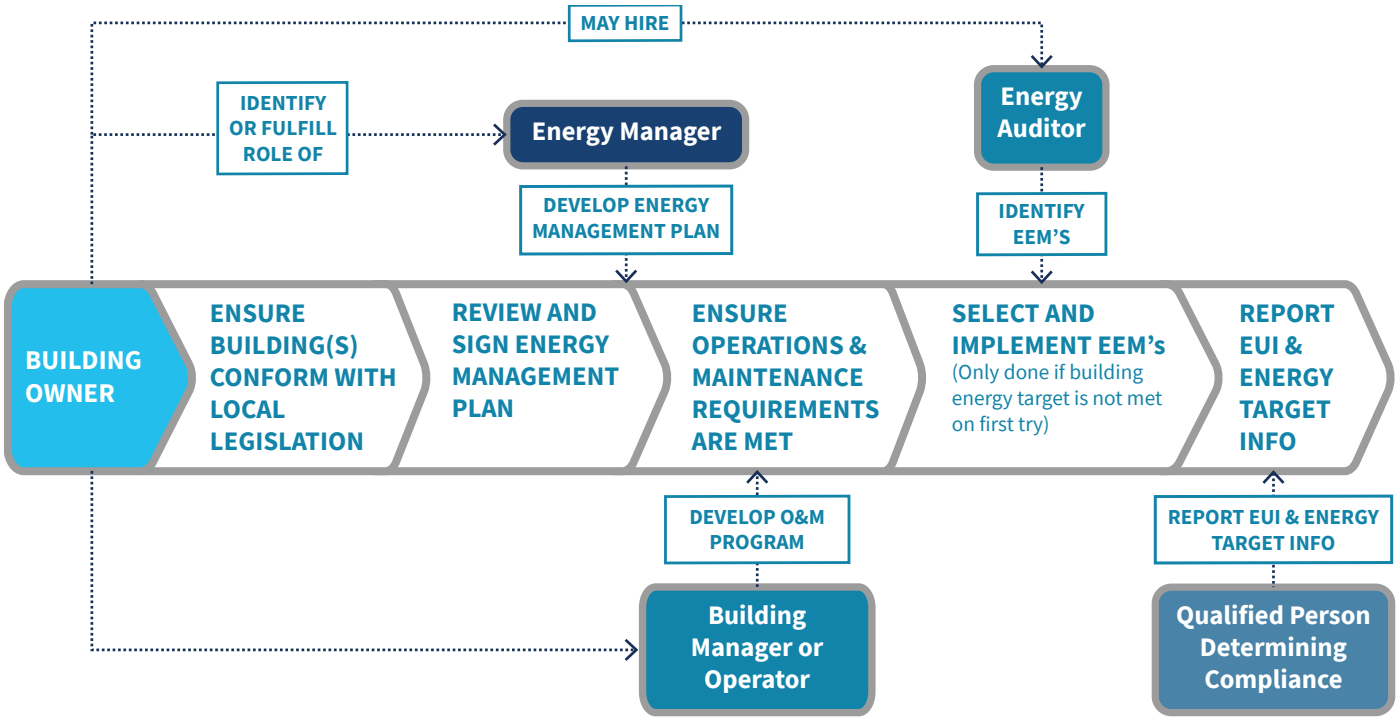


Figure 2-4 Summary of process and specific tasks related to compliance requirements of the building owner

As shown in Figure 2-4, building owner responsibilities primarily relate to the energy management plan, operations and maintenance requirements, implementation of EEMs, and reporting.

Energy Management Plan

Building owners are responsible for several aspects of the energy management plan:

- Identifying the energy manager. Note that building owners themselves may fulfill this role.
- Reviewing and signing the energy management plan on an annual basis.

Operations and Maintenance Requirements

- The building owner is responsible for ensuring that the operations and maintenance requirements of the Standard are met (**ASHRAE Std. 100 Sec. L1**). However, the owner may designate internal staff or an external party to fulfill this responsibility. Examples are not provided in the Standard but might reasonably include personnel such as a building manager or building operator (sometimes called a building engineer).

Operations and maintenance requirements are as follows:

- Develop an operations and maintenance program conforming to **ASHRAE Std. 100 Sec. 6** and **ASHRAE Std. 100 Normative Annex L**, which outline requirements for planning, implementing, and documenting inspections, maintenance, and replacements.
- When replacing mechanical equipment, including HVAC, domestic hot water, or refrigeration equipment, the new equipment must comply with the most stringent of the following:
  1. The national (federal) equipment requirements.
  2. The applicable building code requirements within the jurisdiction.
  3. **ASHRAE Standard 90.1-2013.**
  4. **ASHRAE Standard 90.2-2007**.
- When replacing lighting equipment, including related controls, the new equipment must comply with the most stringent of the following:
  1. The national (federal) equipment requirements.
  2. The applicable building code requirements within the jurisdiction.

Implementation of EEMs

In the event that the building does not meet the required energy target, building owners are responsible for selecting and implementing EEMs, as identified by an energy audit, that will achieve the energy target (**ASHRAE Std. 100 Sec. 8.2.4**).

If the building does not have an energy target, building owners are responsible for selecting and implementing all EEMs identified in the energy audit that comprise the "optimized" EEM bundle (refer to Chapter 3 for more information).

Reporting

Building owners are required to report EUI and energy target information on Form A (**ASHRAE Std. 100 Sec. 10.2.1**), and as calculated on Forms B and C. In many cases, this will be completed on behalf of the owner by the qualified person determining compliance.

Building owners are required to submit updated EUI information within 15 months of implementation of EEMs if they are found to be under conditional compliance (**ASHRAE Std. 100 Sec. 4.3.3.3**). This task may also be completed by the energy manager.

Building Manager

The building manager is the individual responsible for overseeing administrative tasks on behalf of the building owner, and may also be involved in decisions around capital planning and expenditure. The building manager may be the building owner or may be an individual or company hired by the owner.

The building manager's responsibilities as they pertain to ASHRAE Standard 100 are associated with the energy management plan and with operations and maintenance requirements.

Energy Management Plan

The building manager must comply with the energy management requirements of **ASHRAE Std. 100 Sec. 5**. This primarily means complying with the energy management plan, as developed by the building's energy manager. No other action is explicitly required of the building manager, but the energy manager or others may rely upon them for information such as:

- Number of building occupants and any changes to building occupancy.
- Typical operating schedules or working hours and any changes to typical schedules.

Operations and Maintenance Requirements

As with the energy management plan, the building manager is required to comply with the operations and maintenance requirements stated in **ASHRAE Std. 100 Sec. 6**, but no explicit actions are required of the building manager under the Standard.

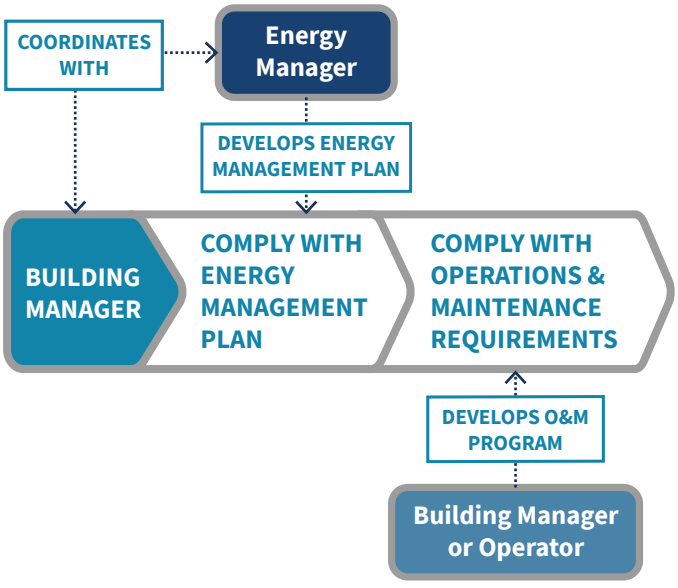


Figure 2-5 Summary of process and specific tasks related to compliance requirements of the building manager

Figure 2-6 Summary of process and specific tasks related to compliance requirements of the building operator

Building Operator (or Building Engineer)

Building operators (sometimes referred to as building engineers) are the individuals responsible for day-to-day technical tasks, i.e., inspections, operations, and maintenance of the building systems and components that are subject to the Standard, including building enclosure components, and electrical and mechanical systems. The building operator may be the building owner, the building manager, or an individual or company hired to complete tasks on behalf of the owner.

The building operator's responsibilities as they pertain to ASHRAE Standard 100 relate specifically to following the operations and maintenance program.

Operations and Maintenance Requirements

The building operator is required to commit to the performance goals described in the operations and maintenance program (**ASHRAE Std. 100 Sec. 6.2**). In terms of specific tasks and duties, the operator must:

- Schedule, verify and record operations and maintenance inspections, taking corrective action when required (**ASHRAE Std. 100 Sec. D3.2.7**). In some cases, this may be completed by the energy manager.
- Schedule and perform inspections of the control systems twice per year (**ASHRAE Std. 100 Sec D6.2.3**), or as frequently as stated in the operations and maintenance plan to meet the needs of the building. This responsibility may be shared with the energy manager.

Energy Manager

Energy managers are the individuals responsible for minimizing the building's energy use while maintaining its functionality and indoor environmental quality. Energy managers are identified by building owners and may be the owner, any member of the building staff (e.g., building manager, building operator), a tenant in the building, or a contractor hired by the building owner.

The energy manager is an important role associated with the energy management plan, operations and maintenance requirements, reporting, and implementation of EEMs.

Energy Management Plan

The energy manager is the primary party responsible for developing, maintaining and updating the energy management plan. A complete explanation of requirements for the energy management plan can be found in Chapter 3. At a high level, tasks include compiling all documentation, communicating with occupants, policy-related planning, and public relations (**ASHRAE Std. 100 Sec. 5.1.1, 5.1.2, 5.3**).

The energy manager is also responsible for establishing formal procedures to ensure that any tenant improvements involving changes to space use or partition location do not increase the building energy use beyond the energy target (**ASHRAE Std. 100 Sec. 6.5**). Examples of tenant improvements that may impact energy use include reallocating space types, moving or altering interior partition walls, making changes to the building enclosure, and installing new interior lighting.

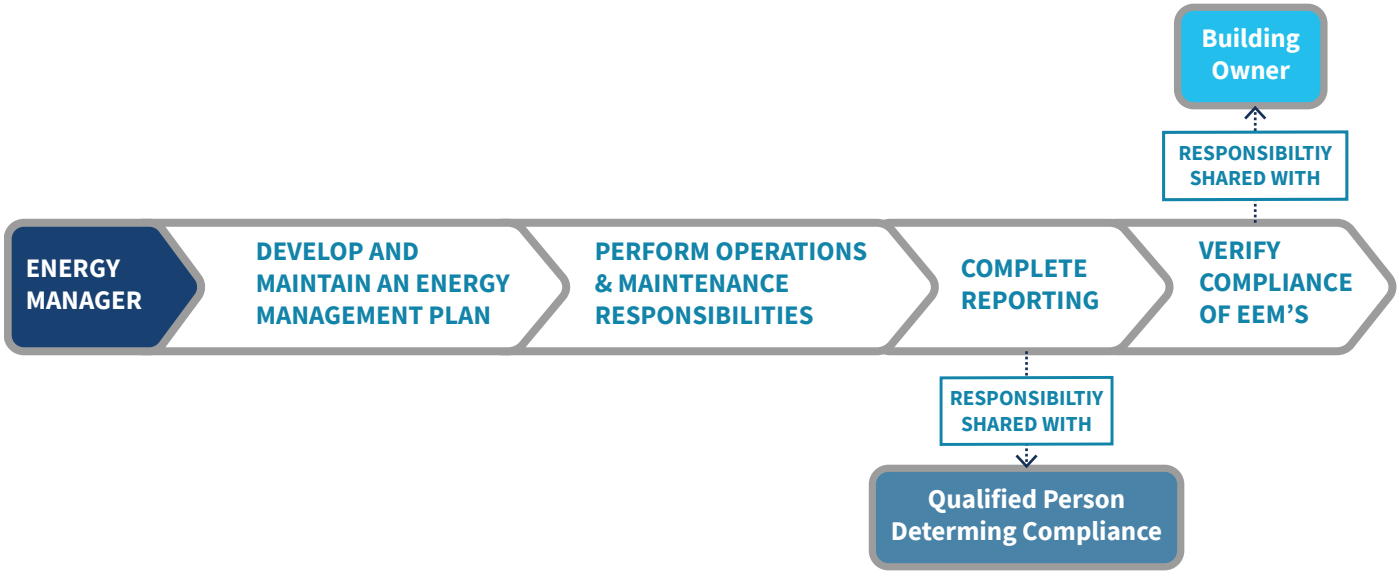


Figure 2-7 Summary of process and specific tasks related to compliance requirements of the energy manager

Operations and Maintenance Requirements

The energy manager has multiple operations and maintenance responsibilities but may share some with the building owner and operator. These responsibilities relate to creating inventories of building systems and equipment and communicating proper operating procedures for energy-related aspects of the building such as building equipment schedules of operation.

Reporting

The energy manager may establish the energy target (EUI) according to A**SHRAE Std. 100 Sec. 7.2.2** for single-type/activity buildings and **ASHRAE Std. 100 Sec. 7.2.3** for mixed-use buildings, and complete Form B. (**ASHRAE Std. 100 Sec. 7.2.1**), if they have been designated as the qualified person determining compliance (see next section).

If the building has multiple activity types and falls into Exception 2 in **ASHRAE Std. 100 Sec. 7.2.3**, in which spaces with less than 10% of the gross floor area have a unique activity type, the energy manager may determine whether these spaces can be combined with other similar activity types. Note that this responsibility is shared with the qualified person determining compliance.

Implementation of EEMs

If EEMs are required, per **ASHRAE Std. 100 Sec. 4.3.2.2/4.3.3.2** the energy manager is responsible for verification of compliance within 15 months of implementation as determined by the AHJ. This responsibility is shared with the building owner.

Qualified Energy Auditor

The qualified energy auditor is the individual tasked with completing the building energy audit, if required. The energy auditor must have established expertise in building energy auditing. As defined under ASHRAE Standard 100, a qualified energy auditor must be one or more of the following:

- A professional architect or engineer licensed within the jurisdiction where the building is located.
- An energy auditor/assessor/analyst certified by ASHRAE the Association of Energy Engineers (AEE), the Building Performance Institute Inc. (BPI) or Residential Energy Services Network (RESnet) (for residential buildings specifically).
- An individual otherwise qualified by the AHJ.

Energy Audit

The energy auditor is responsible for completing the energy audit requirements, as specified in **ASHRAE Std. 100 Sec. 8**.

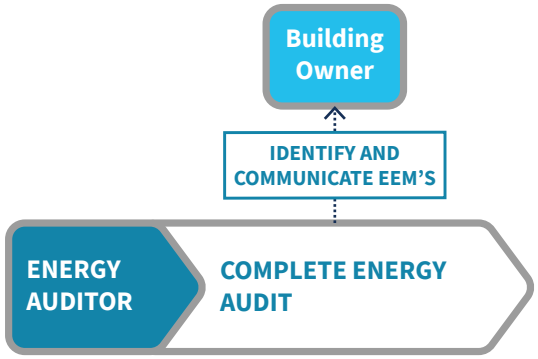


Figure 2-8 Summary of process and specific tasks related to compliance requirements of the qualified energy auditor

Qualified Person Determining Compliance

The qualified person determining compliance is the individual responsible for evaluating whether the requirements of ASHRAE Standard 100 have been met. They are identified by the building owner and may be a member of the building staff or a third party hired to act on behalf of the building owner.

As defined under the Standard, the qualified person determining compliance must be one or more of the following:

- A professional architect or engineer licensed within the jurisdiction where the building is located.
- A licensed contractor recognized within the jurisdiction where the project is located.
- An energy auditor/assessor/analyst certified by ASHRAE/AEE (all buildings) or BPI/RESnet (residential buildings).
- An individual otherwise qualified by the AHJ.

The responsibilities of the qualified person determining compliance, per **ASHRAE Std. 100 Sec. 4.1.1.2**, primarily relate to completing reviews and documentation associated with compliance reporting, confirming if compliance has been achieved, and implementing EEMs if required.

Reporting and Documentation

The qualified person determining compliance is the primary person responsible for reporting and documentation, as required by ASHRAE Standard 100. They must complete the following checks and calculations:

- Determining whether the building seeking compliance falls into the established activity types listed in **ASHRAE Std. 100 Sec. 7** and therefore has an energy target.
- Determining the energy target for the building in accordance with **ASHRAE Std. 100 Sec. 7**.
- Determining the measured EUI of the building according to **ASHRAE Std. 100 Sec. 5.2**.
- If the building has multiple activity types and falls into the exception in **ASHRAE Std. 100 Sec. 7.2.3** in which spaces with less than 10% of the gross floor area have a unique activity type, the qualified person determining compliance may determine if these spaces can be combined with other similar activity types. Note that this responsibility is shared with the energy manager.

In addition, the qualified person determining compliance is responsible for completing the following forms, found in **ASHRAE Std. 100 Normative Annex C**, and submitting them to the AHJ:

- Form A – Compliance with Standard 100
- Form B – Building Activity and Energy Target (EUIt)
- Form C – Energy-Use Intensity Calculations

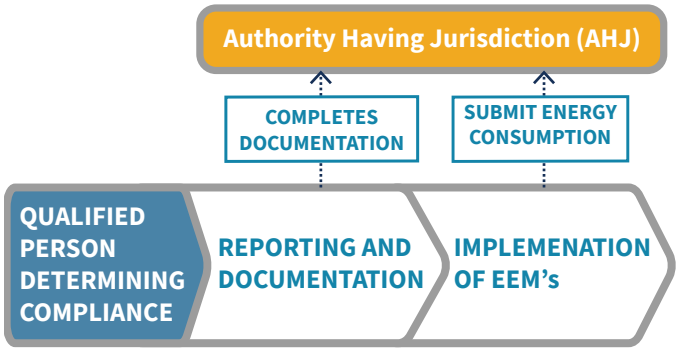


Figure 2-9 Summary of process and specific tasks related to compliance requirements of the qualified person determining compliance

Implementation of EEMs

If the energy target is exceeded, or there is no energy target for the building, implementation of EEMs is required and the qualified person determining compliance may be relied upon for the following tasks.

If the building has an energy target:

- Submitting energy use on behalf of the building owner within 15 months of implementation of the EEMs while under conditional compliance (**ASHRAE Std. 100 Sec. 4.3.3.3**).
- Determining and demonstrating to the AHJ whether the energy targets have been met after implementation of EEMs.

If the building does not have an energy target:

- Submitting energy use on behalf of the building owner within 15 months of implementation of the EEMs while under conditional compliance (**ASHRAE Std. 100 Sec. 4.3.3.3**).
- Determining whether or not the requirements of **ASHRAE Std. 100 Sec. 4.3.3** have been met after implementation of EEMs. This may include the following:
  - Reviewing commissioning reports and certifying that the EEMs are functioning as intended (**ASHRAE Std. 100 Sec. 9.1.2.3**).
  - Reviewing the results of EEM energy monitoring and certifying that the energy savings of the package of EEMs meets or exceeds 75% of the energy savings projected in the energy audit (**ASHRAE Std. 100 Sec. 9.2.2**).

Compliance Process Examples

The examples on the following pages illustrate how a theoretical implementation of ASHRAE Standard 100 might look for two common building types. In practice, details related to the AHJ's local requirements and the circumstances of the building, owner, staff, and consultants will impact the specifics of the implementation process.

Case 1: Office Building (Single-Use) That Complies Immediately

A 10-storey Canadian office building (gross floor area of 50,000 ft²), owned and operated by a commercial property management company (Company X), is required to comply with ASHRAE Standard 100 by its provincial government. The government has elected to require their own regional EUI targets. In this case,

- The provincial government is the AHJ:
- Company X is the building owner. They have a building manager on staff who takes care of administrative logistics, along with a building operator, also on staff, who is responsible for the operation of the systems and equipment.

IMPLEMENTATION STEPS

1. **The provincial government, as the AHJ,**

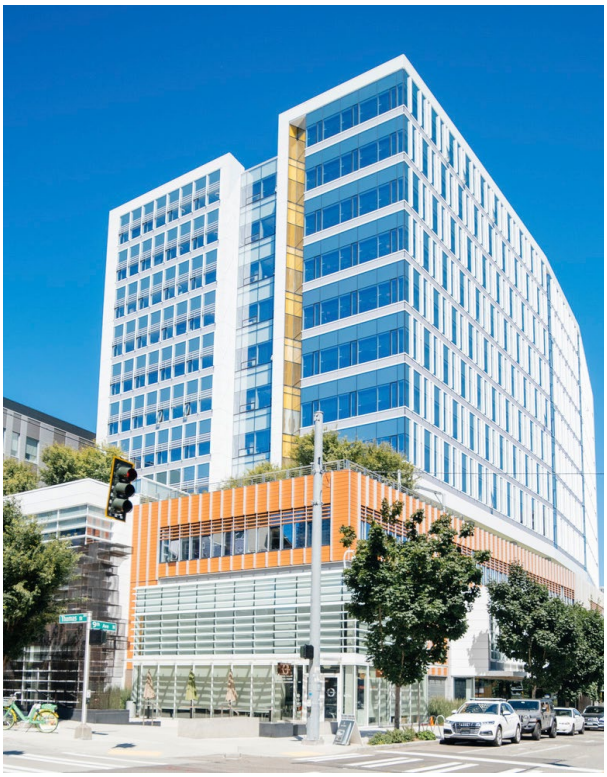
- Adopts ASHRAE Standard 100, establishes local requirements and timelines, and informs building owners within their jurisdiction.

2. **Company X, as the building owner:**

- Informs the building staff (building manager, building operator) that they need to comply with the Standard
  - The building has multiple tenants, but the building owner elects to comply as an entire building rather than submitting for individual tenants.
- Identifies the building manager as the designated energy manager.
- Hires ABC Energy Consulting, a local consulting firm, to be the designated person determining compliance.
- Delegates their operations and maintenance obligations to the building operator.

3. **The building/energy manager:**

- Develops and implements an energy management plan, including establishing policies and communication to the building tenants surrounding energy-efficient operation of the building.



- Hires Enclosure Consulting Inc., a building enclosure consulting firm, to perform a building enclosure condition assessment as required by **ASHRAE Std. 100 Sec. D1.2**.
- Reviews the report and coordinates with building owner to hire contractors to address the building enclosure deficiencies, including fixing broken windows and replacing missing air barrier sealant.
- Performs an inventory of lighting systems per **ASHRAE Std. 100 Sec. D5**.

4. **ABC Energy, as the qualified person determining compliance:**

- Determines the energy target for the building, based on the regional targets specified by the province.
- Calculates the EUI of the building.
  - The EUI is less than the energy target for the building, and so the building therefore complies with the energy requirements of the Standard.

5. **Company X, as the building owner:**

- Reviews and signs the energy management plan.

6. **The building operator, as the designated party responsible for ensuring operations and maintenance requirements are met:**

- Reviews the existing operations and maintenance program and ensures it meets the requirements of the Standard.
- Conducts all inspections and performs required maintenance and documentation on all required building components and systems, including the building enclosure, domestic hot water system, heating system, ventilation system, air conditioning system, refrigeration equipment, lighting systems, controls, electric power distribution, and on-site power generation.

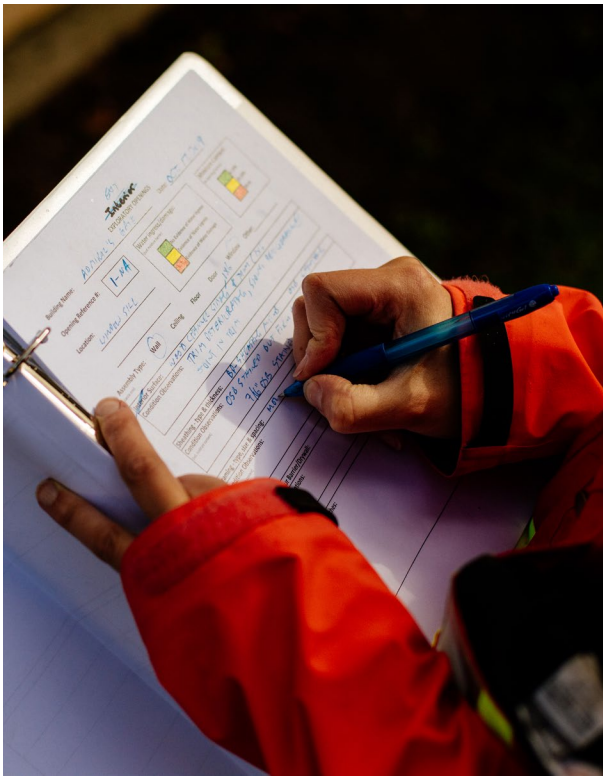
7. **ABC Energy, as the qualified person determining compliance:**

- Verifies/re-calculates the measured EUI, compares it to the target EUI, and determines that the energy target is achieved.
- Confirms that the energy management plan and operational and maintenance requirements of ASHRAE Standard 100 have been met.
- Completes Forms A, B, and C and submits them to the provincial government before the legislated deadline.

8. **The provincial government, as the AHJ:**

- Receives, reviews, and validates Forms A, B, and C.
- Confirms that the requirements of the Standard have been achieved.

9. **Compliance is achieved.**



Case 2: Residential/Commercial Building (Mixed-Use) That Does Not Comply Immediately

A 20-storey multi-unit condominium building, with two levels of at-grade commercial retail space (gross floor area of 100,000 ft²), is required to comply with ASHRAE Standard 100 by the local city government, which has adopted the Standard for all existing buildings over 50,000 ft². The at-grade commercial retail space is owned by Company Y. In this case:

- The city government is the AHJ.
- The collection of individual unit owners, represented through a formal structure (i.e., a condo board or strata council), is the building owner for the residential portion of the building.
- Company Y is the owner of the commercial portion of the building.
- The residential and commercial owners have an ownership agreement surrounding operations and maintenance of the building.
- The mechanical systems are distinct between the residential and commercial portions of the building.

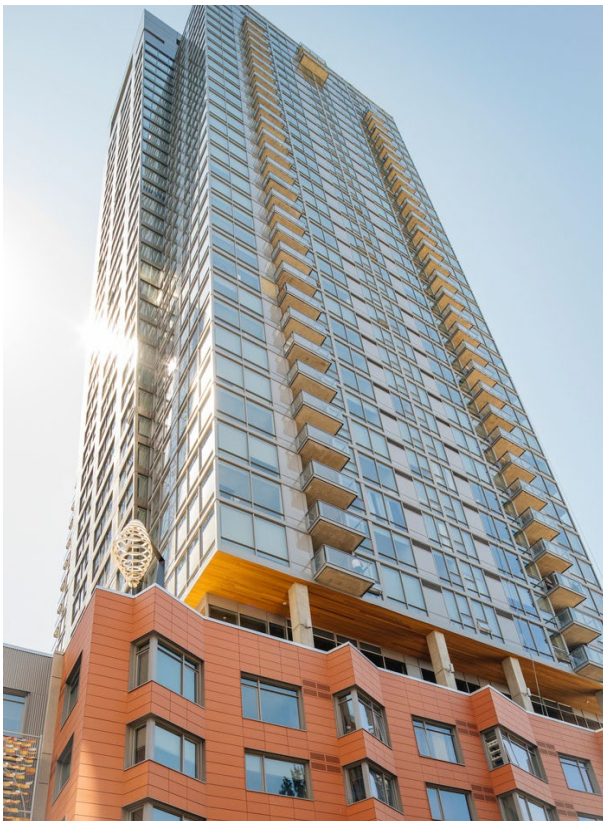
IMPLEMENTATION STEPS

1. **The city government, as the AHJ:**

- Adopts ASHRAE Std. 100, establishes local requirements and timelines, and informs building owners within their jurisdiction.

2. **Company Y and the condo board, as the building owners, jointly:**

- Inform the unit owners, commercial tenants, residential building manager, building operator) that they need to comply with the Standard.
- Elect to comply as a whole building
  - Note that the Standard would allow compliance on an individual tenant/unit basis, but this would not be practical except where all energy-consuming systems and services are distinct and separately metered.



- Identify one of the residential unit owners as the designated energy manager.
- Hire DEF Consulting, a local engineering firm, to be the qualified person determining compliance, and qualified energy auditor if required.
- Hire Type A Maintenance, a maintenance contractor, to fulfill the owners' obligations surrounding operations and maintenance.

3. **The residential unit owner, acting as the energy manager:**

- Develops and implements an energy management plan, including establishing policies and communication to the other owners and tenants surrounding energy-efficient operation of the building.
- Reviews the recent building enclosure condition assessment from BE Architects Inc., to ensure all energy-related building enclosure deficiencies have been corrected.

- Delegates the lighting and systems inventory obligations to DEF Consulting, the qualified energy auditor.

4. **Company Y and the condo board, as the building owners:**

- Review and sign the energy management plan.

5. **Type A Maintenance, as the designated party responsible for operations and maintenance requirements:**

- Develops an operations and maintenance program, delivers it to the building owners, and receives approval to implement (along with approval of related budget).
- Conducts all inspections and performs required maintenance and documentation on building mechanical and lighting systems, including an inspection of the control systems twice per year.

6. **DEF Consulting, as the qualified person determining compliance:**

- Determines the energy target for the building by area weighting the targets for the residential spaces (Activity Type 53) with the commercial retail spaces (Activity Type 40) (**ASHRAE Std. 100 Sec. 7.2.3**).
- Calculates the overall EUI of the building from utility bill data.
- Determines that the measured EUI of the building exceeds the energy target, requiring an energy audit.
- Recommends that the building owners complete an energy audit in order to comply with the Standard.

7. **Company Y and the condo board, as the building owners, jointly:**

- Approve an energy audit based on DEF's recommendation, and retain DEF to carry it out, along with related budget for the audit itself.

8. **DEF Consulting, as the qualified energy auditor:**

- Determines that a Level 2 energy audit is necessary to identify the scope of EEMs required to meet the energy target.
- Performs a Level 2 energy audit in accordance with *ASHRAE 211 - 2018 Standard for Commercial Building Energy Audits*.
- Produces an energy audit report containing the following information:
  - A survey of existing building elements, including (but not limited to) building enclosure assemblies, lighting systems, and mechanical equipment.
  - Estimate of energy use breakdown, highlighting most energy-consuming end uses and associated systems.
  - A list of recommended EEMs that, if implemented, are expected to meet the energy target.
  - A calculation of the estimated measured EUI that will be achieved if the bundle of recommended EEMs are implemented.
  - Estimates for EEM implementation cost, energy cost savings, maintenance cost savings, simple payback, and measure life.

9. **The residential unit owner, acting as the energy manager:**

- Reviews the energy audit report
- Makes a recommendation to the building owners to approve the EEM bundle put forward in the energy audit report by DEF.

10. **Company Y and the condo board, as the building owners:**

- Approves DEF's energy audit report and recommended EEM bundle.
- Retains DEF to carry out needed design work and subsequent contract administration for the recommended EEM bundle, including the budget to do so.
- When bids are received, select contractor(s) and award contract to implement EEMs.

11. **The residential unit owner, acting as the energy manager:**

- Continues to document ongoing energy use

12. **DEF Consulting, as the qualified person determining compliance:**

- Submits Forms A, B, and C to the city government, which include measured energy use and EUI calculation, indicating that compliance has not been achieved but EEMs have been implemented.
- Submits Form E, which summarizes the estimated energy savings that are expected from the bundle of EEMs that have been implemented.

13. **The city government, as the AHJ:**

- Provides confirmation of conditional compliance, including clarification of the date when conditional compliance expires.

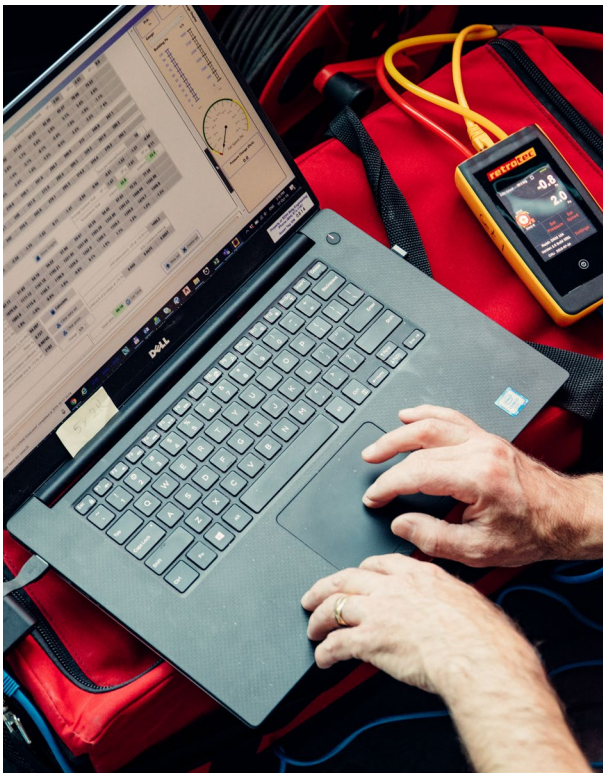
14. **DEF Consulting, as the qualified person determining compliance:**

- At least one year but not more than 15 months after implementation of the EEM bundle, recalculates the measured EUI of the building using the 12 months of post-implementation utility data.
- Determines that the new measured EUI achieves the energy target.
- Resubmits Forms A, B, and C to the city government, indicating that compliance has been achieved.

15. **The city government, as the AHJ:**

- Receives, reviews, and validates Forms A, B, and C.
- Confirms that the building complies with the Standard.

16. **Compliance is achieved.**

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Chapter 3 | Calculations, Analysis and Reporting

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Operations and Maintenance Requirements 32

Energy Use Analysis and Target Requirements 33

Setting Energy Targets 45

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Implementation and Verification Requirements 50

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Summary 53

Calculations, analysis, and reporting procedures comprise the bulk of the compliance work involved in implementing ASHRAE Standard 100. This section of the guide outlines how to complete necessary calculations and satisfy the requirements of the standard. Each subsection is relevant to different roles, which are indicated below the subsection heading.

Energy Management Plan Requirements

RELATED ROLES:

Energy manager role, responsible for developing and implementing the energy management plan.

Building manager role, responsible for complying with the energy management plan.

Every building that is required to comply with ASHRAE Standard 100 must develop an **energy management plan**, with the exception of buildings under 5000 ft^2 (which are not required to have an energy manager or an energy management plan). The **energy management plan** is a living document that describes the building's energy performance. It typically consists of the following 5 subsections, which are further explained in this section:

1. Building energy metering and reporting
2. Energy-Use Intensity (EUI) reporting
3. Energy Efficiency Measure (EEM) implementation
4. Operations and maintenance considerations for Energy Managers
5. Communication responsibilities

The components of the energy management plan have interrelated requirements and are connected to other aspects of ASHRAE Standard 100 implementation, as shown in Figure 3-1.

Detailed energy management plan requirements are described in **ASHRAE Std. 100 Sec. 5**, with specific compliance requirements stated in **ASHRAE Std. 100 Sec. 4.2.2**.

Building Energy Metering and EUI Reporting

As part of the energy management plan, the historical building energy use from energy meters must be collected and reported in the form of a building energy-use intensity (EUI) (on Form C, **ASHRAE Std. 100 Sec 5.2**), along with the building's energy target if available. See "Energy Use Analysis and Target Requirements" (p. 33).

Energy Efficiency Measure (EEM) Implementation

Energy audits are only required when the qualified person determining compliance finds that the energy target EUI has not been met, or when the building does not have a target. For more information on energy audit requirements, see "Setting Energy Targets" (p. 45). When audits are conducted, the report(s) from the energy auditor must then be included in the energy management plan, along with any chosen EEM bundles to achieve the energy target.

TIP: LIGHTING

There is a specific requirement for a list of lighting power densities and schedules throughout the building, the lighting satisfaction survey and lighting checklist, along with any lighting-related EEMs and their associated savings (**ASHRAE Std. 100 Sec. 5.1.2.12** and **5.1.2.13**). However, these items would likely be completed and included within the scope of the energy audit report.

When EEMs are implemented by the building owner, this must be documented in the energy management plan, including the following information:

- List of implemented EEMs, along with the dates of implementation
- Operation and maintenance program updates for each EEM (see "Operations and Maintenance Requirements" p. 32), including but not limited to:
  - Ongoing commissioning plans for each EEM
  - Staff training plan for each EEM

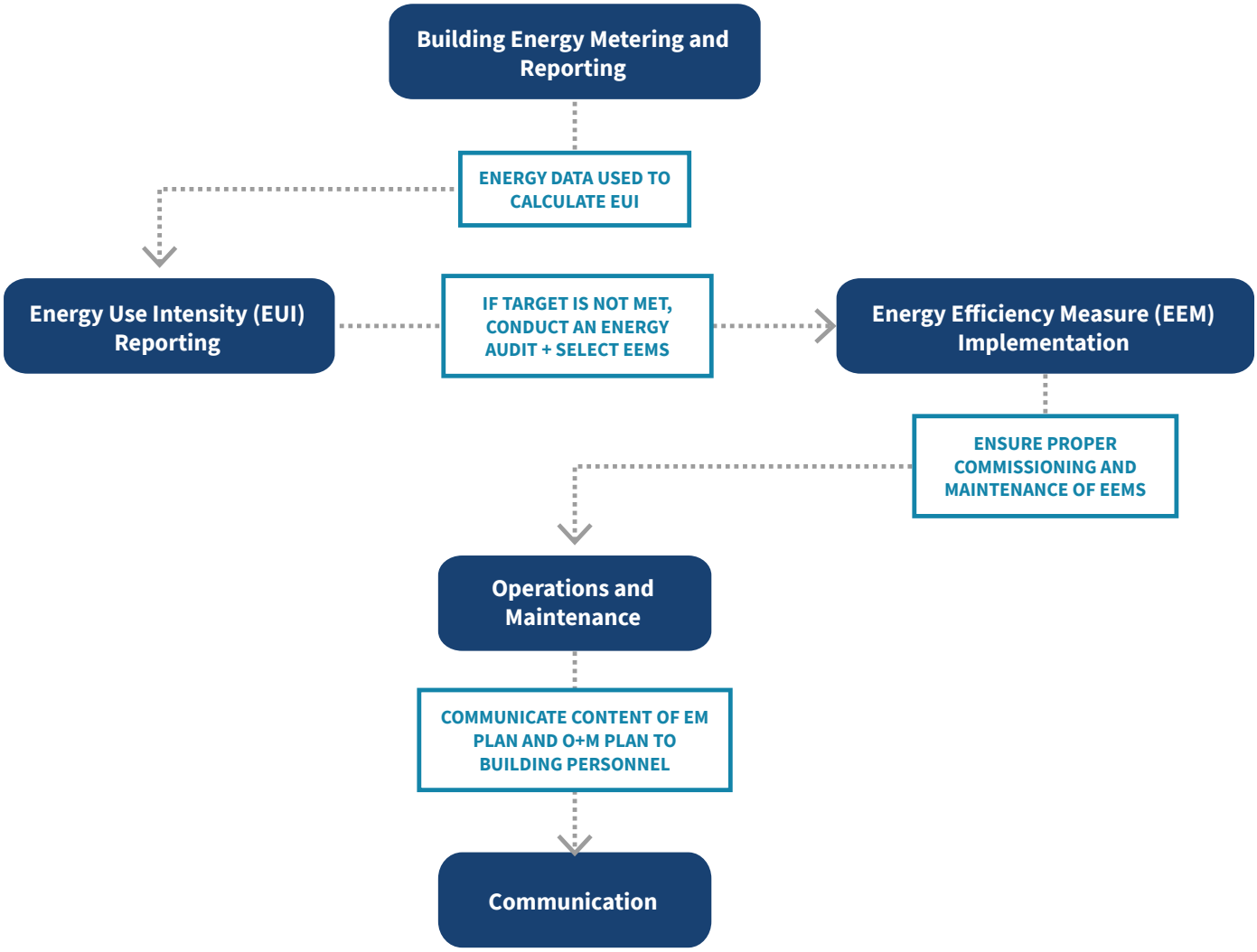


Figure 3-1 Energy management plan requirements

Operations and Maintenance Considerations for Energy Managers

The energy management plan is developed alongside the operations and maintenance plan. Some portions of the operations and maintenance plan pertain specifically to energy use and are developed by the energy manager. Specifically, the energy manager should be aware of the following:

Energy-Related Operations and Maintenance Requirements

The energy management plan has several specific requirements for the operation and maintenance of building systems and components related to energy use:

- A building enclosure inspection must be performed at least every 3 years, with corrective action taken as needed (**ASHRAE Std. 100 Sec. D1.2**).
- An inventory of lighting controls and luminaires must be compiled and included in the energy management plan (**ASHRAE Std. 100 Sec. D5.2**). Note that this task is often completed by the energy auditor as part of the energy audit.
- If applicable, the energy management plan must address proper loading practices for display refrigerators (**ASHRAE Std. 100 Sec. D4.4.2**).
- Documentation of typical operating schedules for building equipment and systems.

Operations Staff Training

An energy-related training plan is required for operations and maintenance staff, including the building operator and maintenance personnel. The training plan focuses on how to operate building systems to optimize energy efficiency without compromising indoor environmental quality or system functionality.

This training plan is the responsibility of the energy manager, although it is integrated into the operations and maintenance plan.

Training must also include developing, documenting, and distributing procedures to building personnel for energy-efficient operation of exterior doors and windows (**ASHRAE Std. 100 Sec. D1.8**).

Capital Planning

Capital planning and asset management carried out by building owners is generally outside the scope of ASHRAE Standard 100. However, with respect to replacement in the event of equipment failure or end-of-life conditions, the energy management plan must include a capital management plan.

The capital management plan consists of a list of energy-consuming equipment to be replaced with new, energy-efficient equipment either at failure or end-of-life. The new equipment must be ENERGY STAR® certified, where applicable, and conform to the most stringent of federal equipment standards, applicable building codes, **ASHRAE Standard 90.1**, and/or **ASHRAE Standard 90.2**.

Contact List

A contact list is required within the energy management plan, including the energy manager, building owner, and qualified energy auditors, as well as suppliers and local representatives of energy-efficient equipment relevant to the given building.

Communication Responsibilities

As part of the energy management plan, there are specific requirements around communication with occupants. The plan must state how occupants will be informed about the benefits of energy-efficient building operation, and how they will be given instructions for efficiently operating windows, HVAC system controls, and lighting system components and controls. The Standard does not specify any particular communication method, but states that it can be electronic or in print form.

As an example, communication could take the form of a memo or short guide, distributed to building occupants and then appended to the energy management plan. The energy management plan itself must also be distributed by the energy manager to the building occupants and stakeholders on an annual basis.

Operations and Maintenance Requirements

RELATED ROLES:

Energy manager role, responsible for developing and implementing the energy management plan, some of which overlaps with operations and maintenance requirements.

Building manager role, responsible for complying with the energy management plan and the operations and maintenance requirements.

Building owner role, responsible for ensuring operations and maintenance requirements are met.

Building operator role, required to execute the operations and maintenance plan and commit to its goals.

Operations and maintenance requirements and procedures are stated in **ASHRAE Std. 100 Sec. 6**, **Informative Annex D**, and **Normative Annex L**. Aside from providing some specific responsibilities for individual roles as discussed earlier, **ASHRAE Std. 100 Sec. 6** generally references **Annex D** regarding operations and maintenance requirements and **Annex L** regarding implementation of the operations and maintenance plan.

The operations and maintenance requirements are intended to standardize energy-related operation and maintenance practices for buildings seeking compliance with ASHRAE Standard 100. The intent is to ensure energy-efficient operation of building systems and components throughout their service lives.

Generally speaking, the requirements set responsibilities for individuals, outline the operation and maintenance plan that must be created for each building, and list the inspection and maintenance requirements for specific systems and equipment.

Like the energy management plan, the operations and maintenance plan is a living document. If an operations and maintenance plan has already been developed for a given building, it can be reviewed and/or updated to meet the requirements of ASHRAE Standard 100. It is expected to contain the following information:

- **Statement of performance objectives** (**ASHRAE Std. 100 Sec. L2.2.1**), including:
  - **Performance objectives** are the functions that the building and associated building systems are designed to perform. They should be specific to the given building; in general, the first objective of any building is to provide a suitable indoor environment based on its function (i.e., an office space vs. warehouse).
  - **Thermal comfort objectives** can relate to indoor temperature, humidity, and air velocity, and may be based on maintaining acceptable agreement with a building standard stipulating thermal comfort criteria such as *ASHRAE Standard 55 Thermal Environmental Conditions for Human Occupancy*.
  - **Indoor air quality objectives** can relate to the amount of outdoor airflow, air filtration, and airborne contaminant concentrations, and may be based on maintaining acceptable agreement to a standard stipulating indoor air quality criteria such as A*SHRAE Standard 62.1 Ventilation for Acceptable Indoor Air Quality* or *ASHRAE Standard 62.2 Ventilation and Acceptable Indoor Air Quality in Residential Buildings*.
  - **Energy efficiency objectives** can relate to mechanical and electrical energy efficiency, and may be based on maintaining acceptable agreement to a standard which stipulates energy performance criteria such as *ASHRAE Standard 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings* or *ASHRAE Standard 90.2 Energy-Efficient Design of Low-Rise Residential Buildings*.
- **Inventory of items** to be inspected and maintained (**ASHRAE Std. 100 Sec. L2.1**). This generally pertains to building assemblies, systems, and equipment that must be maintained in order to ensure energy-efficient operation of the building.
- **Statement of condition indicators** (**ASHRAE Std. 100 Sec. L2.2.2**). The inventory of items identifies what needs to be inspected and maintained, while the condition indicators are what maintenance personnel are checking for. In other words, they set criteria to signal unsatisfactory or out-of-specification performance. Condition indicators may be measurements or observations. If they signal unsatisfactory performance at two successive inspections, the building owner and/or their designated representative are required to further investigate the problem.
- **List of inspection and maintenance tasks** (**ASHRAE Std. 100 Sec. L2.2.3**). Common inspection and maintenance tasks for major building systems and equipment are listed in **ASHRAE Std. 100 Informative Annex D**. For convenience, you can also find a checklist in this guide (Appendix E, p. 73) that can be adapted into the operations and maintenance plan as applicable.
- **Statement of inspection and maintenance frequency** (**ASHRAE Std. 100 Sec. L2.2.4**). Note that although a schedule specifying the frequency of inspection and maintenance activities must be established and adhered to, there is no ASHRAE Standard 100 requirement for how frequent they must be.

- A **log or record** documenting completion of inspection and maintenance activities (**ASHRAE Std. 100 Sec. L2.2.5**).
- **Energy-related content developed as part of the energy management plan**, as described above.

Energy Use Analysis and Target Requirements

RELATED ROLES:

Qualified person determining compliance role, responsible for calculating the building EUI, determining the energy target, and determining compliance to the Standard.

Energy manager role, responsible for gathering the energy data as requested by the qualified person, and may perform part of the energy analysis and energy target determination as part of preparing the energy management plan.

Energy use analysis and target requirements are described in **ASHRAE Std. 100 Sec. 7**. The information provided below describes how to calculate a given building's EUI, how to determine the building's energy target, and how to evaluate compliance. Example calculations are also provided.

Determining a Building's Energy Target

The first step is to determine if the applicant building has an energy target.

1. Make a list of all the unique activity types or uses within the given building, along with their corresponding gross floor area. A given building may have more than one activity type[1].

    a. If there are multiple activity types, but the largest area with a unique activity type represents more than 75% of the total gross floor area, then the applicant building has the option of being considered a single activity building; if applying as a single activity building, the entire gross floor area can be considered as applying to the largest unique activity type.

$$A_{GFA} = \sum_{i=1}^{n} A_{GFA_i}$$

Equation 3-1

$$For\ a\ single\ activity\ building, \frac{A_{GFA,Largest}}{A_{GFA}} \geq 0.75$$

where

A_{GFA} = Gross floor area of the entire building, m² (ft²)

A_{GFA_i} = Gross floor area with a unique activity type i, m² (ft²)

n = number of unique activity types

$A_{GFA,Largest}$ = Gross floor area of the largest unique activity type, m² (ft²)

    b. If there are multiple activity types, but some activity types have a gross floor area of less than 10% of the total building gross floor area, then these areas can be combined with other areas that have a similar activity type at the discretion of the qualified person determining compliance or the energy manager.

$$If\ \frac{A_{GFA_i}}{A_{GFA}} < 0.1, then\ A_{GFA_i}\ can\ be\ combined\ with\ similiar\ activity\ types$$

2. Review **ASHRAE Std. 100 Table 7-1** and **Informative Annex M**, which list 53 different activity types and corresponding sub-types, and cross reference this list against the list of unique activity types for the applicant building.

    a. If all unique activity types listed in Step 1 are found in **ASHRAE Std. 100 Table 7-1**, the building has an energy target.

    b. If one or more unique activity types listed in Step 1 are not found in **ASHRAE Std. 100 Table 7-1**, but the total gross floor area without an energy target is less than 10% of the total building gross floor area, and the area without an energy target is metered separately from the rest of the building, then this area and its corresponding activities can be excluded from energy target and analysis calculations and the building **has an energy target**.

$$To\ be\ excluded, \frac{\sum_{i=1}^{z} A_{GFA,Nontarget}}{A_{GFA}} < 0.10$$

Equation 3-2

1 See Energy Star Portfolio Manager for additional guidance on identifying property types and associated activity types: https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/identify-your-property-type

where

$A_{GFA,Nontarget}$ = Gross floor area with unique activity type i which does not have an energy target listed in **ASHRAE Std. 100 Table 7-1**, m² (ft²)

z = Number of unique activity types without energy targets listed in **ASHRAE Std. 100 Table 7-1**

$$\sum_{i=1}^{z} A_{GFA,Nontarget} \text{ must be metered separately}$$

c. A building **has no energy target** if it cannot satisfy either of the above conditions. A building without an energy target is always required to complete an energy audit and implement EEMs. See "Energy Audit Requirements" (p. 47) and "Implementation and Verification Requirements (Conditional Compliance)" (p. 50) for more information.

3. If all or part of the building is vacant, then the vacant spaces are subject to the following conditions:

   a. If the vacant portion of the building represents 100% of the total building gross floor area, the target shall be set based on the occupancy prior to becoming vacant.

   b. If the vacant portion of the building represents less than 30% of the total building gross floor area, and the vacant area isn't heated, cooled, or illuminated, the vacant area can be excluded from energy target and energy analysis calculations.

   c. If neither a nor b apply, but there is a recent 12-month period for which energy data is available during which the building was occupied, the energy use analysis and targets shall be based on this period and corresponding occupancy.

   d. If neither a nor b apply, and no recent energy data is available during which the building was occupied, the energy analysis and target calculations – and corresponding compliance determination to the Standard – shall be put on hold until relevant data is available.

      The qualified person determining compliance or energy manager must review AHJ requirements for how to notify the AHJ if an exemption or delay applies to the applicant building.

If it is determined that the building has an energy target, then the next step is to confirm local requirements as stated by the AHJ for the jurisdiction in which the building is located.

1. Did the AHJ set its own energy targets? Or are they using the energy targets listed in **ASHRAE Std. 100 Tables 7-2a/b** or in **ASHRAE Std. 100 Annex A Tables A1/2**?
2. Is the AHJ requiring buildings to comply based on site or source energy, or are they using the Standard 100 methodology which allows the qualified person determining compliance to choose site or source EUI?
3. If source energy is being used, confirm whether the AHJ has specified its own primary energy conversion factors, or if it is relying upon the values stated in **ASHRAE Std. 100 Table 5-2b**.

If needed, calculate building energy targets.

Building energy targets are calculated as follows:

$$EUI_t = \sum_{i=1}^{n} \frac{A_{GFA_i}}{A_{GFA}} \times S_i \times EUI_{t_i}$$

Equation 3-3

where

EUI_t = Energy-use intensity target for the entire building, MJ/m² (kBTU/ft²)

S_i = Building operating shift normalization factor from **ASHRAE Std. 100 Table 7-3**

EUI_{t_i} = Energy-use intensity target for activity type i, MJ/m² (kBTU/ft²)

Building operating shift normalization factors are numeric values ranging from 0.4 to 2.1 (and listed in **ASHRAE Std. 100 Table 7-3**) that correct the EUI targets based on the hours of operation during a typical week for the given activity type. For example, 168 weekly hours represents 24/7 operation.

EUI targets for activity types are as specified by the AHJ and will be in the form of either site or source energy targets.

Note that for buildings with a single activity type, the number of unique activity types i=1, and $A_{GFA_i}/A_{GFA} = 1$

$$EUI_t = S_1 \times EUI_{t_1}$$

Equation 3-4

The EUI target is calculated on **ASHRAE Std. 100 Form B – Building Activity and Energy Target (EUI)** and reported on **ASHRAE Std. 100 Form A – Compliance with Standard 100** by the qualified person determining compliance. See "Reporting" (p. 51) for more information.

Building Energy Metering and Reporting

TIP: MULTIPLE BUILDINGS

For campuses and/or multiple buildings on a single meter (ASHRAE Std. 100 Sec. 9.1.2.2):

- The requirements of the Standard can be achieved for multiple buildings on a single utility meter.
- All calculations are to be performed by combining the group of buildings to form a single large building.
- If energy efficiency measures (EEMs) need to be implemented, a multiple-building plan must be drafted that outlines how EEM implementation will be coordinated across the group of buildings.

Building energy monitoring and reporting requirements are outlined in **ASHRAE Std. 100 Sec. 5.2** and referenced in **ASHRAE Std. 100 Sec. 5.1.2.1**. Buildings are required to measure and report their **net annual energy consumption**. Net energy consumption is the amount of energy supplied to the building, less the amount of energy generated at the building site that is exported to other buildings or fed back into the utility grid.[1]

$$E_{Net} = \sum E_{Imported} - \sum E_{Exported}$$

Equation 3-5

where

E_{Net} = Net energy used by the building, MJ/year (kBTU/year)

$E_{Imported}$ = Energy supplied to the building by utility service providers, MJ/year (kBTU/year)

$E_{Exported}$ = Energy generated at the building, which is not used at the building site, and is exported to another building or back into the utility grid, MJ/year (kBTU/year)

The calculation boundary for E_{Net} is defined as the building or group of buildings connected to the utility meter. Energy supplied to the building is determined from utility meters, as measured and billed by the utilities providing services to the building. Additional sub-meters may need to be installed, by the building owner or by the utility, in order to record the quantity of energy exported. In the rare event that exported energy can't be quantified through sub-metering, the AHJ must determine an acceptable alternative method. Figure 3-3 illustrates the concept of net energy and the building boundary.

Note that if all of the building's energy is both generated and consumed on-site, it decreases the amount of energy purchased from utilities, but it will not be included in this net annual energy consumption calculation because it never crosses the building boundary.

The annual net energy consumption reported to the AHJ must be measured over a consecutive 12-month period occurring not more than 2 years prior to the energy audit. If no energy audit is required, the AHJ should establish an acceptable timeframe for the 12-month metering period prior to the submission deadline for compliance documentation.

Annual net energy consumption is reported on **ASHRAE Std. 100 Form C – Energy-Use Intensity Calculations**. See "Implementation and Verification Requirements" (p. 50) for more information on documentation procedures.

If energy consumption, as reported by utilities or energy meters, is not in units of MJ (kBTU) required for submission, **ASHRAE Std. 100 Table 5-2a** can be referenced for energy conversion calculations.

Figure 3-2 Meter set
© Adobe Stock / Robert Keenan

1 Equations in this chapter are derived from the equations and descriptions of calculations provided in the Standard. They are mathematically equivalent but may use a different notation to better fit with the explanations provided in this guide.

TIP: USING OIL OR BIOMASS

If your building uses oil, biomass, or another energy source that is supplied in bulk and consumed over a long period of time, use the following to calculate energy imported:

$$E_{Imported} = E_{Store\ @\ month\ 0} + \sum E_{Supplied} - E_{Store\ @\ month\ 12}$$

Equation 3-6

where

$E_{Store\ @\ month\ 0}$ = The amount of bulk energy stored on-site at the beginning of the metering period (month 0 of 12), MJ (kBTU)

$E_{Supplied}$ = The amount of bulk energy which is supplied to the building during the metering period, MJ (kBTU)

$E_{Store\ @\ month\ 12}$ = The amount of bulk energy stored on-site at the end of the metering period (end of month 12 of 12), MJ (kBTU)

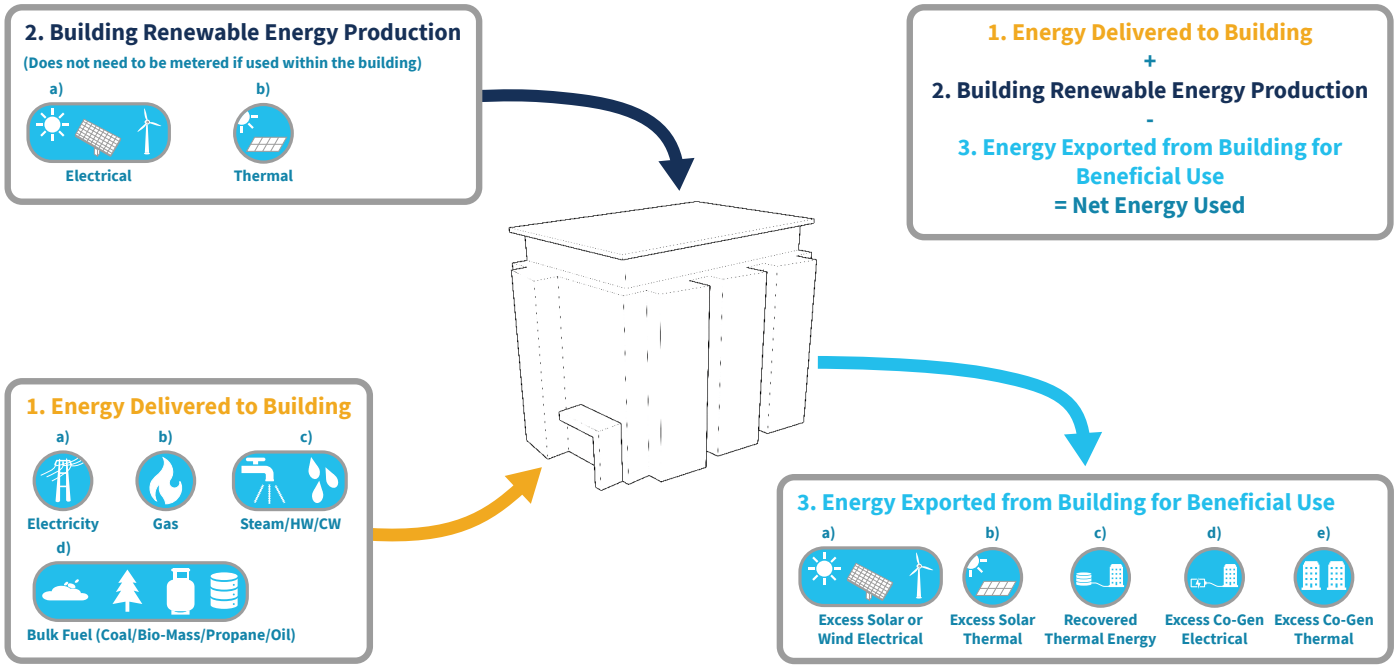


Figure 3-3 Net energy and the building boundary

Example Calculation:

A 6-storey apartment building (50,000 ft²) is located in a rural area. The building is connected to the electrical grid, but also uses a combination of roof-mounted photovoltaic (PV) panels and a fuel oil tank for supplemental energy.

At the beginning of the measurement period (March), the fuel oil tank contains 500 litres (132 U.S. gal) of fuel oil #2 and has a capacity of 1000 litres (264 U.S. gal). A local oil supply company comes to the building site to fill the oil tank every September, with this year's fill totalling 600 litres (158.4 U.S. gal). At the end of the measurement period, the tank contains 400 litres (105.6 U.S. gal).

The annual PV generated is 90,000 kWh, as measured by the PV controller, all of which is consumed on-site.

The electrical utility bills show that 465,000 kWh of electricity was supplied to the building by the electrical utility provider.

CALCULATION

The net energy consumption in metric (SI) base units for the building during this period is calculated as follows, based on Equation 3-5 and Equation 3-6:

$$E_{Net} = \sum E_{Imported} - \sum E_{Exported}$$

where

$$E_{Imported,Fuel} = E_{Store\ @\ month\ 0} + \sum E_{Supplied} - E_{Store\ @\ month\ 12}$$

$$E_{Imported,Fuel} = (500\ L + 600\ L - 400\ L) \times \left(38{,}700\ \frac{kJ}{L}\right) \times \left(\frac{1\ MJ}{1000\ kJ}\right)$$

$$E_{Imported,Fuel} = 27{,}090\ MJ/year$$

$$E_{Imported,Electricity} = 465{,}000\ kWh \times \left(\frac{3.6\ MJ}{1\ kWh}\right) = 1{,}674{,}000\ MJ/year$$

While there is on-site PV, the energy generated is consumed on-site and is therefore not exported.

The exported energy, $\sum E_{Exported}$, is therefore zero.

$$E_{Net} = \sum E_{Imported} - \sum E_{Exported} = (1{,}674{,}000\ MJ + 27{,}090\ MJ)$$
$$= 1{,}701{,}090\ MJ/year$$

The net energy consumption in imperial (IP) base units for the building during this period is calculated as follows, based on Equation 3-5 and Equation 3-6:

$$E_{Net} = \sum E_{Imported} - \sum E_{Exported}$$

where

$$E_{Imported,Fuel} = E_{Store\ @\ month\ 0} + \sum E_{Supplied} - E_{Store\ @\ month\ 12}$$

$$E_{Imported,Fuel} = (132\ U.S.gal + 158.4\ U.S.gal - 105.6\ U.S.gal) \times \left(139{,}000\ \frac{Btu}{U.S.gal}\right) \times \left(\frac{1\ kBtu}{1000\ Btu}\right)$$

$$E_{Imported,Fuel} = 25{,}687\ kBtu/year$$

$$E_{Imported,Electricity} = 465{,}000\ kWh \times \left(\frac{3.412\ kBtu}{1\ kWh}\right) = 1{,}586{,}580\ kBtu/year$$

While there is on-site PV, the energy generated is consumed on-site and is therefore not exported.

The exported energy, $\sum E_{Exported}$, is therefore zero.

$$E_{Net} = \sum E_{Imported} - \sum E_{Exported} = (1{,}586{,}580\ kBtu + 25{,}687\ kBtu) = 1{,}612{,}267\ kBtu/year$$

Energy-Use Intensity (EUI) Reporting

Annual net energy consumption must be converted and reported as an annual **energy-use intensity (EUI)**. Energy-use intensity is the annual net energy consumption, normalized by building gross floor area. It can be reported in site or source energy and is calculated as follows.

$$EUI_{Site} = \frac{E_{Net}}{A_{GFA}}$$

Equation 3-7

where

EUI_{Site} = Annual site energy-use intensity, MJ/m²/year (kBTU/ft²/year)

E_{Net} = Net energy used by the building, MJ/year (kBTU/year)

A_{GFA} = Total building gross floor area, m² (ft²)

$$EUI_{Source} = \frac{\sum_{i=1}^{x} E_{Imported_i} \times PE_i}{A_{GFA}} - \frac{\sum E_{Exported}}{A_{GFA}}$$

Equation 3-8

where

EUI_{Source} = Annual source energy-use intensity, MJ/m²/year (kBTU/ft²/year)

PE_i = Primary energy conversion factor for energy source i, as defined by the AHJ or as listed in **ASHRAE Std. 100 Table 5-2b**.

Gross floor area (GFA, or A_{GFA}) is calculated using exterior dimensions and is measured from the outer surface of the exterior walls of a building[2]. For partition walls between adjacent buildings, GFA is measured from the centre of the partition wall. Note that GFA includes all voids, shafts, and other floor penetrations. For atriums or multi-storey zones, the floor area is only counted once.

Other exclusions not included in the GFA calculations for energy analysis, as identified in ASHRAE Standard 100, include:

- Unconditioned parking garages (conditioned parking garages are included)
- Surface parking
- Crawl spaces
- Covered walkways
- Open roofed-over areas
- Roof overhangs

2 Exterior walls separate conditioned interior space from the outdoors.

- Porches and similar spaces
- Exterior terraces or exterior steps
- Pipe trenches

EUIs are calculated and submitted in the initial year of seeking compliance and are then, if required, updated with any changes, such as if EEMs are implemented. EUIs must also be compared to the energy target. EUIs can be calculated on a site or source energy basis, depending on which method the qualified person determining compliance uses to demonstrate compliance, and/or depending on the targets set by the AHJ. The building EUI is reported on **ASHRAE Std. 100 Form A – Compliance with Standard 100**, based on the energy consumption calculated on **ASHRAE Std. 100 Form C – Energy-Use Intensity Calculations**.

Evaluating Compliance

Once the building EUI has been calculated and the energy target has been determined (where possible), the qualified person determining compliance and/or the energy manager can evaluate whether ASHRAE Standard 100 energy performance criteria have been met.

For buildings with an energy target, this is relatively straightforward:

$$If\ EUI_{Building} \leq EUI_t, compliance\ is\ achieved$$

Equation 3-9

Note that care must be taken to ensure that the building EUI and the energy target are both representing either site energy or source energy.

For buildings without a target, compliance is evaluated based on the amount of savings achieved by the energy efficiency measures (EEMs). Buildings without a target are

required to complete an energy audit and implement the entire optimized bundle of EEMs identified in the energy audit report. Compliance is achieved if the amount of measured energy savings is greater than or equal to 75% of the estimated energy savings, as reported in the energy audit report. As with buildings that have an energy target, evaluation of compliance can be simplified and represented as an equation:

$$If\ \frac{(E_{Net_{Old}} - E_{Net_{New}})}{E_{Savings}} \geq 0.75, compliance\ is\ achieved$$

Equation 3-10

where

$E_{Net_{Old}}$ = Annual net energy consumption of the building, as measured prior to EEM implementation, MJ (kBTU)

$E_{Net_{New}}$= Annual net energy consumption of the building, as measured over 12 months following implementation of EEMs, MJ (kBTU)

$E_{Savings}$ = Annual energy savings, as estimated and reported for the optimized bundle of EEMs in the energy audit report, MJ (kBTU)

If the energy compliance criteria are not achieved, the building can be classified as conditionally compliant or noncompliant depending on a variety of factors at the discretion of the AHJ. See “Implementation and Verification Requirements” (p. 50) for further detail.

Example Calculations

Example 1:

A 12 storey multi-unit residential building located in Seattle, Washington (Climate Zone 4C) has a grocery store on the ground floor (15,000 ft²) and 11 storeys of residential space above (50,000 ft²). The grocery store is open from 8am–10pm, 7 days a week. The building uses natural gas for heating and domestic hot water and uses electricity for all other end uses. From utility bills, the entire building consumed 550,000 kWh of electricity and 60,000 m³ (2,119,000 ft³) of natural gas in the past 12 months. The AHJ has opted to use the site energy targets found within **ASHRAE Std. 100 Sec 7**. Does the building comply with the energy requirements of the Standard?

Determine if the building has an energy target:

Two activity types from **ASHRAE Std. 100 Table 7-1**:

1. Activity Type 53 - Apartment building (5+ units)
2. Activity Type 12 – Grocery/food market

$$\frac{A_1}{A_{GFA}} = \frac{50{,}000\ ft^2}{(50{,}000\ ft^2 + 15{,}000\ ft^2)} = 0.77 > 75\%$$

$$\frac{A_2}{A_{GFA}} = \frac{15{,}000\ ft^2}{(50{,}000\ ft^2 + 15{,}000\ ft^2)} = 0.23$$

This can be considered a single activity type building, with Activity Type 53 – Apartment building (5+ units), as this activity represents greater than 75% of the total building GFA. However, it may be more beneficial to apply as a multi-use building given the large discrepancy in activity types.

Determine whether the energy target would be easier to meet if applying as a single-use building or a mixed-use building:

From **ASHRAE Std. 100 Table 7-2a**, Climate Zone 4C, the site energy targets are:

1. Activity Type 53 is 492 MJ/m²/yr (43 kBTU/ft²/yr)
2. Activity Type 12 is 1486 MJ/m²/yr (131 kBTU/ft²/yr)

From **ASHRAE Std. 100 Table 7-3**, Climate Zone 4C, the building operating shifts normalization factors are:

1. Activity Type 53, S = 1.0 regardless of weekly hours.
2. Activity Type 12, at 7 × 14 = 98 weekly hours, S = 1.0.

(example continued on following spread)

If applying as a single-use building with Activity Type 53

$$EUI_t = S_1 \times EUI_{t_1} = (1.0) \times \left(492 \frac{MJ}{m^2 \cdot yr}\right) = \mathbf{492} \frac{\boldsymbol{MJ}}{\boldsymbol{m^2 \cdot yr}}$$

or

$$EUI_t = S_1 \times EUI_{t_1} = (1.0) \times \left(43 \frac{kBtu}{ft^2 \cdot yr}\right) = \mathbf{43} \frac{\boldsymbol{kBtu}}{\boldsymbol{ft^2 \cdot yr}}$$

If applying as a mixed-use building,

$$EUI_t = \sum_{i=1}^{n} \frac{A_{GFA_i}}{A_{GFA}} \times S_i \times EUI_{t_i}$$

$$EUI_{t_1} = \frac{50{,}000\ ft^2}{50{,}000\ ft^2 + 15{,}000\ ft^2} \times 1.0 \times 492 \frac{MJ}{m^2 \cdot yr} = 378.5\ \frac{MJ}{m^2 \cdot yr}$$

$$EUI_{t_2} = \frac{15{,}000\ ft^2}{50{,}000\ ft^2 + 15{,}000\ ft^2} \times 1.0 \times 1486 \frac{MJ}{m^2 \cdot yr} = 342.9\ \frac{MJ}{m^2 \cdot yr}$$

$$EUI_t = EUI_{t_1} + EUI_{t_2} = 378.46 \frac{MJ}{m^2 \cdot yr} + 342.92 \frac{MJ}{m^2 \cdot yr} = \mathbf{721.4}\ \frac{\boldsymbol{MJ}}{\boldsymbol{m^2 \cdot yr}}$$

or

$$EUI_t = \sum_{i=1}^{n} \frac{A_{GFA_i}}{A_{GFA}} \times S_i \times EUI_{t_i}$$

$$EUI_{t_1} = \frac{50{,}000\ ft^2}{50{,}000\ ft^2 + 15{,}000\ ft^2} \times 1.0 \times 43 \frac{kBtu}{ft^2 \cdot yr} = 33.1\ \frac{kBtu}{ft^2 \cdot yr}$$

$$EUI_{t_2} = \frac{15{,}000\ ft^2}{50{,}000\ ft^2 + 15{,}000\ ft^2} \times 1.0 \times 131 \frac{kBtu}{ft^2 \cdot yr} = 30.2\ \frac{kBtu}{ft^2 \cdot yr}$$

$$EUI_t = EUI_{t_1} + EUI_{t_2} = 33.1 \frac{kBtu}{ft^2 \cdot yr} + 30.2 \frac{kBtu}{ft^2 \cdot yr} = \mathbf{63.3}\ \frac{\boldsymbol{kBtu}}{\boldsymbol{ft^2 \cdot yr}}$$

In this case, it would be easier for this building to comply with the energy requirements as a **mixed-use building**, even though it has the option of applying as a single-use building.

(example continued on following spread)

Determine the building's EUI:

$$EUI_{Site} = \frac{E_{Net}}{A_{GFA}} = \frac{\sum E_{Imported} - \sum E_{Exported}}{A_{GFA}} = \frac{E_{Electricity} + E_{Natural\ Gas}}{A_{GFA}}$$

$$E_{Electricity} = 550{,}000\ kWh \times \frac{3.6\ MJ}{1.0\ kWh} = 1{,}980{,}000\ \frac{MJ}{yr}$$

$$E_{Natural\ Gas} = 60{,}000\ m^3 \times \frac{38{,}400\ kJ}{m^3} \times \frac{1.0\ MJ}{1000\ kJ} = 2{,}304{,}000\ \frac{MJ}{yr}$$

$$EUI_{Site} = \frac{1{,}980{,}000\ \frac{MJ}{yr} + 2{,}304{,}000\ \frac{MJ}{yr}}{(50{,}000\ ft^2 + 15{,}000\ ft^2) \times \frac{1.0\ m^2}{10.76\ ft^2}} = \mathbf{709.2\ \frac{MJ}{m^2 \cdot yr}}$$

or

$$EUI_{Site} = \frac{E_{Net}}{A_{GFA}} = \frac{\sum E_{Imported} - \sum E_{Exported}}{A_{GFA}} = \frac{E_{Electricity} + E_{Natural\ Gas}}{A_{GFA}}$$

$$E_{Electricity} = 550{,}000\ kWh \times \frac{3.412\ kBtu}{1\ kWh} = 1{,}876{,}600\ \frac{kBtu}{yr}$$

$$E_{Natural\ Gas} = 2{,}119{,}000\ ft^3 \times \frac{1{,}030\ Btu}{ft^3} \times \frac{1\ kBtu}{1000\ Btu} = 2{,}182{,}570\ \frac{kBtu}{yr}$$

$$EUI_{Site} = \frac{1{,}876{,}600\ \frac{kBtu}{yr} + 2{,}182{,}570\ \frac{kBtu}{yr}}{(50{,}000\ ft^2 + 15{,}000\ ft^2)} = \mathbf{62.4\ \frac{kBtu}{ft^2 \cdot yr}}$$

Determine if the building complies with the energy requirements:

$$EUI_{Site} = 709.2\ \frac{MJ}{m^2 \cdot yr} \leq EUI_t = 721.4\ \frac{MJ}{m^2 \cdot yr}$$

or

$$EUI_{Site} = 62.4\ \frac{kBtu}{ft^2 \cdot yr} \leq EUI_t = 63.3\ \frac{kBtu}{ft^2 \cdot yr}$$

RESULT: Yes, the building does comply with the energy requirements of the Standard.

Note, however, that if this building had chosen to apply as a single-use building with Activity Type 53 – Apartment building (5+ units), the energy target of 492 MJ/m²/year (43 kBtu/ft²/year) would not have been achieved, and the building would be required to complete an energy audit and implement EEMs.

Example 2:

A data centre (20,000 ft²) located in Kelowna, BC (Climate Zone 5A) operates 24/7. The centre uses electricity for all end uses and consumed 9,300 MWh of electricity in a recent 12-month period. In an effort to save energy (and prior to ASHRAE 100 being required), the building owner hired a qualified energy auditor to complete an energy audit. The energy audit report identified an optimized EEM bundle to upgrade the cooling system and controls with an estimated annual energy savings of 1,500 MWh/year. The building owner proceeded with implementing the entire optimized EEM bundle, and the building consumed 8,100 MWh of electricity in the most recent 12-month period. Does the building comply with the energy requirements of the Standard?

Determine if the building has an energy target:

From **ASHRAE Std. 100 Table 7-1**, no activity type or comparable activity type is listed for data centres.

From **ASHRAE Std. 100 Informative Annex M**, no comparable activity subtype is listed for data centres

The building ***does not*** have an energy target.

Determine the amount of savings achieved by the implemented EEMs:

$$E_{Net} = \sum E_{Imported} - \sum E_{Exported} = E_{Electricity}$$

$$E_{Net_{Old}} = E_{Electricity_{Old}} = 9{,}300\ MWh$$

$$E_{Net_{New}} = E_{Electricity_{New}} = 8{,}100\ MWh$$

$$\frac{\left(E_{Net_{Old}} - E_{Net_{New}}\right)}{E_{Savings}} = \frac{(9{,}300\ MWh - 8{,}100\ MWh)}{1{,}500\ mWh} = 0.80 > 75\%$$

RESULT: Yes, the building does comply with the energy requirements of the Standard.

Setting Energy Targets

RELATED ROLES:

Authority Having Jurisdiction role, responsible for establishing energy targets for their jurisdiction.

While ASHRAE Standard 100 includes energy targets, it is the responsibility of the AHJ and legislator to determine how the Standard will be implemented in their jurisdiction. Energy targets can be set a few different ways:

- Energy targets can be set based on **ASHRAE Std. 100 Table 7-2a/b** (which is based on the top-performing 25th percentile of existing buildings), or alternatively **ASHRAE Std. 100 Annex A Tables A1/2** (which is based on the top-performing 40th percentile).
- Energy targets can be calculated by the AHJ based on the fuel-specific EUIs listed in **ASHRAE Std. 100 Annex A Tables A3/4**, with regionally specific primary energy conversion factors.
- Energy targets can be set based on regionally specific data, at the discretion of the AHJ. For example, see Appendix A and B for the Province of British Columbia and Washington State targets respectively.

AHJs may also wish to coordinate ASHRAE 100 targets with greenhouse gas emission intensity (GHGI) targets and associated policy, to align with climate change goals within their jurisdiction. While this is not within the scope of ASHRAE Standard 100, this guide provides additional guidance in Appendix C.

Using Energy Targets in ASHRAE Standard 100

The most straightforward option for AHJs is to implement energy targets based on the data already provided within ASHRAE Standard 100. The energy use targets presented in the Standard were derived by the Oakridge National Laboratory (ORNL) and the U.S. Department of Energy (DOE). Data was collected by the Energy Information Administration (EIS) as part of two surveys of existing buildings: the Commercial Building Energy Consumption Survey (CBECS) in 2003, and the Residential Energy Consumption Survey (RECS) in 2005.

There are two sets of site and source energy targets listed within the Standard:

1. **ASHRAE Std. 100 Table 7-2a (site) and ASHRAE Std. 100 Table 7-2b (source), which are based on the top-performing 25th (low energy) percentile of buildings within each category.**

   These targets represent buildings that use less energy than 75% of the buildings surveyed in each category.

2. **ASHRAE Std. 100 Table A1 (site) and ASHRAE Std. 100 Table A2 (source), which are based on the top-performing 40th (low energy) percentile of buildings within each category.**

   These targets represent buildings that use less energy than 60% of the buildings surveyed in each category. They represent "better-than-average" performance but are **less stringent** than those listed in **ASHRAE Std. 100 Sec. 7**.

AHJs can choose either set of targets from within the Standard, depending on how stringent they wish the requirements to be.

Site vs. Source Energy Targets

Energy targets can be based on site or source energy. The AHJ has the option of setting energy targets on a site energy or source energy basis. Alternately, the AHJ could choose to leave it up to the qualified person determining compliance and/or the energy manager to decide whether source or site energy targets are used. However, depending on the regional primary energy conversion factors, this may lead to a wide range in the stringency of the targets chosen.

Primary energy conversion factors, or **source-to-site ratios**, are used to convert site energy into source energy and represent the amount of upstream energy use associated with providing a given fuel source at a building level. Primary energy conversion factors are provided in **ASHRAE Std. 100 Table 5-2b**, based on U.S. national averages.

Primary energy conversion factors can vary widely across countries, or even within states/provinces. It is therefore important, if using source-based energy targets, that the AHJ carefully consider which factors to use. The AHJ can use the values from **ASHRAE Std. 100 Table 5-2b** or specify regionally specific primary energy conversion factors that have been determined in accordance with ASHRAE Standard 105 *Standard Methods of Determining, Expressing, and Comparing Building Energy Performance and Greenhouse Gas Emissions*.

Calculating New Source Energy Targets Using ASHRAE Standard 100

ASHRAE Standard 100 provides AHJs the option of calculating their own source energy targets. AHJs may wish to consider this approach if:

- They are choosing to use source energy targets, and

→ They are choosing to use their own primary energy conversion factors rather than using the U.S. national average factors listed in **ASHRAE Std. 100 Table 5-2b** of the Standard.

The Standard provides two sets of electricity and fossil fuel energy use targets, from which AHJs can calculate their own source energy targets. These electricity and fossil fuel-specific targets are site-based but differ from the site energy targets in that they are for specific energy types rather than whole-building energy use. The general idea is for AHJs to take the targets for each energy type and apply the region-specific primary energy conversion factors in order to determine new region-specific source energy targets.

The electricity and fossil fuel energy use targets presented in the Standard are as follows:

1. **ASHRAE Std. 100 Table 7-2c (electricity) and ASHRAE Std. 100 Table 7-2d (fossil fuel), which are based on the top-performing 25th (low energy) percentile of buildings within each category.**

   These targets represent buildings that use less energy than 75% of the buildings surveyed in each category. They are **more stringen**t than the targets listed in **ASHRAE Std. 100 Annex A**.

2. **ASHRAE Std. 100 Table A3 (electricity) and ASHRAE Std. 100 Table A4 (fossil fuel), which are based on the top-performing 40th (low energy) percentile of buildings within each category.**

   These targets represent buildings that use less energy than 60% of the buildings surveyed in each category. They represent "better-than-average" performance, but are **less stringent** than the targets listed in **ASHRAE Std. 100 Sec. 7**.

New energy targets are calculated as follows (**ASHRAE Std. 100 Annex A1.1**):

$$EUI_t = ELUI_t \times PE_{Elec} + FFUI_t \times PE_{FF}$$

Equation 3-11

$ELUI_t$ = Electricity use intensity target, from **ASHRAE Std. 100 Table 7-2c** or **Table A3**.

PE_{Elec} = Local primary energy conversion factor for electricity, as defined by the AHJ within their jurisdiction.

$FFUI_t$ = Fossil fuel use intensity target, from **ASHRAE Std. 100 Table 7-2d** or **Table A4**.

PE_{FF} = Local primary energy conversion factor for fossil fuels, as defined by the AHJ within their jurisdiction.

Example Calculation

A city government in British Columbia (Climate Zone 4C) is adopting ASHRAE Standard 100 for professional office buildings. They are opting to implement source energy targets using the 40th percentile fuel-specific targets listed in **ASHRAE Std. 100 Normative Annex A**. The local electricity primary energy conversion factor is 1.11, and the local fossil fuel primary energy conversion factor is 1.03. Calculate the energy target for offices.

Look up energy targets in **Table A3** and **Table A4 of ASHRAE Std. 100 Normative Annex A**:

Professional office buildings are Activity Type 1 from Table 7-1.

From Table A3, Climate Zone 4C, $ELUI_t$ = 494 MJ/m²/yr (44 kBTU/ft²/yr)

From Table A4, Climate Zone 4C, $ELUI_t$ = 62 MJ/m²/yr (5 kBTU/ft²/yr)

$$EUI_t = ELUI_t \times PE_{Elec} + FFUI_t \times PE_{FF}$$

$$EUI_t = \left(494 \frac{MJ}{m^2 \cdot yr}\right)(1.11) + \left(62 \frac{MJ}{m^2 \cdot yr}\right)(1.03) = \mathbf{612.2}\ \frac{\boldsymbol{MJ}}{\boldsymbol{m^2 \cdot yr}}$$

or

$$EUI_t = ELUI_t \times PE_{Elec} + FFUI_t \times PE_{FF}$$

$$EUI_t = \left(44 \frac{kBtu}{ft^2 \cdot yr}\right)(1.11) + \left(5 \frac{kBtu}{ft^2 \cdot yr}\right)(1.03) = \mathbf{54}\ \frac{\boldsymbol{kBtu}}{\boldsymbol{ft^2 \cdot yr}}$$

Energy Audit Requirements

RELATED ROLES:

Qualified energy auditor role, responsible for completing the energy audit.

An **energy audit** is a detailed study that reviews a given building's systems, equipment, and assemblies that impact energy use, and identifies potential energy efficiency measures (EEMs) to reduce energy use. An energy audit must be performed for an applicant building under ASHRAE Standard 100 if the qualified person determining compliance and/or the energy manager determine that:

- The applicant building has an energy target, and the measured energy use during the recent 12-month measurement period exceeds the energy target, or
- The applicant building does not have an energy target.

If an energy audit is required, it must be completed by a qualified energy auditor retained by the building owner or a person designated on behalf of the owner (such as the energy manager).

Energy Audit Process

Under ASHRAE Standard 100, energy audits must comply with ASHRAE's existing documentation requirements in *ASHRAE Standard 211 - 2018 Standard for Commercial Building Energy Audits*. The level of detail of the energy audits is to be either Level 1 or Level 2, depending on the following criteria:

- **For buildings with energy target**s, the level of detail is selected at the discretion of the energy auditor. The energy audit must provide sufficient detail to fulfill the specific requirements of the Standard discussed in **ASHRAE Std. 100 Section 4.5.2**.
- **For buildings without energy targets**, the level of detail varies depending on the size of the building:
  - For buildings with gross floor area greater than 1,000 m² (10,000 ft²), a Level 2 Audit is to be performed.
  - For buildings with gross floor area less than or equal to 1,000 m² (10,000 ft²), a Level 1 or Level 2 Audit is to be performed.

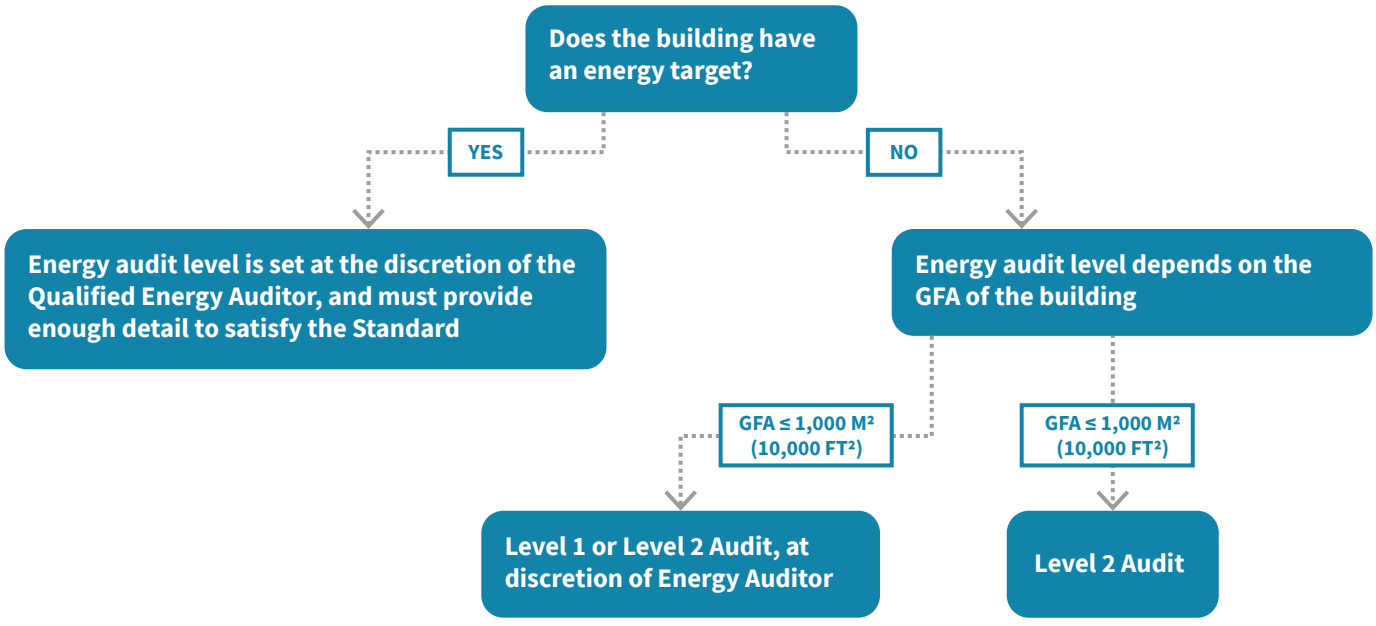


Figure 3-4 Flow chart demonstrating selection of appropriate audit level

Specific Audit Requirements for ASHRAE Standard 100

In addition to the requirements for Level 1 and Level 2 Audits outlined in *ASHRAE Standard 211 - 2018 Standard for Commercial Building Energy Audits*, ASHRAE Standard 100 lists several additional specific requirements to be completed as part of the energy audit process. In many cases, following the basic Level 1 and Level 2 procedures will result in also satisfying specific ASHRAE Standard 100 requirements. However, this may not always be the case.

ASHRAE Std. 100 Sec. 8.2.2 dictates that the scope of the energy audit address all of the items in Figure 3-5. Other requirements specific to the Standard are listed in Table 3-1.

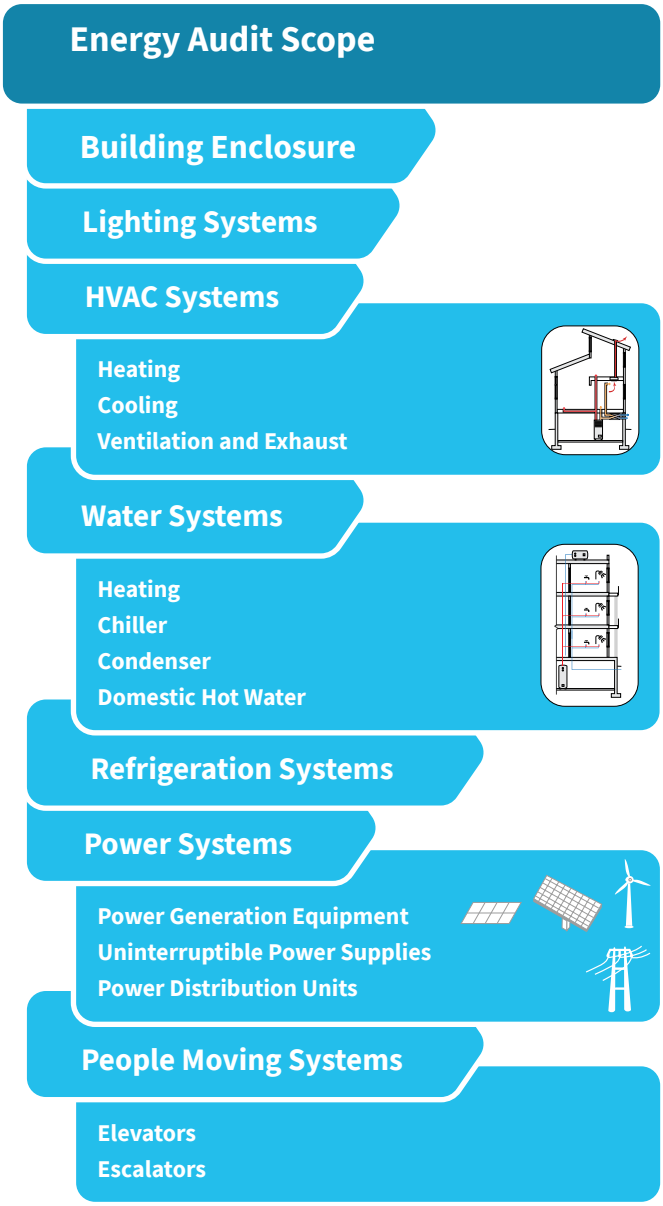


Figure 3-5 Diagram illustrating items included in the scope of the energy audit

Table 3-1 Requirements for Energy Audits Specific to ASHRAE Standard 100

ITEM	DETAILS
A list of recommended EEMs with their estimated service lives.	A list of EEMs, complete with their estimated service lives, is required of all energy audits.
A selected bundle of EEMs that will achieve the energy target OR An optimized bundle of EEMs for buildings without an energy target.	The optimized EEM bundle consists of EEMs with a simple payback of less than 5 years, excluding EEMs with a simple payback greater than their service life. As an alternative to simple payback, the optimized bundle can be based on life-cycle costs using the Building Life-Cycle Cost (BLCC) program BLCC5, a free market tool created by the U.S. National Institute of Standards and Technology (NIST). → Use an internal rate of return of greater than or equal to 20% → Use BLCC5 defaults for all other parameters. For U.S. federal buildings specifically, the optimized bundle is to be based on life-cycle costing using BLCC5 and consist of all EEMs that have a savings-to-investment ratio (SIR) that meets federal requirements.
An energy end use breakdown, required for both the baseline building and the bundle of all selected EEMs as recommended by the energy auditor.	The level of precision required for the end use analysis varies depending on the level of the energy audit. For Level 1 Audits: → End uses must be separated into major groups including lighting, plug loads, heating, cooling, and DHW. → The audit must demonstrate that the sum of end uses is a reasonable representation of the baseline energy use. There are no specific requirements on how to achieve this. End use breakdowns may therefore be based on previous experience with other similar buildings or based on typical performance of reference buildings. For Level 2 Audits: → End uses must be separately broken out for all end uses that represent more than 5% of the historical energy use. → The sum of end uses forms the baseline energy use. The baseline must equal between 90% and 100% of the historical energy use measured during the 12-month period in the energy target calculations. → If the baseline differs from the historical energy use, then all savings estimates must be based on the baseline. For example, if the sum of end uses for the baseline building totals 92% of the historical energy use (from the initial target calculation), this is acceptable; however, all savings estimates are to be based on this baseline energy use.
Energy savings analysis—estimated energy and peak demand savings for each EEM, as well as the optimized EEM bundle (**ASHRAE Std. 100 Sec. 8.5.1-8.5.3**).	Note that energy savings must be presented both in the units used on the building owner's utility bills and the units necessary for comparison to the energy target (MJ or kBTU). For the optimized bundle, savings estimates must account for interactive effects starting with load reduction EEMs (for example, window upgrades), followed by distribution system EEMs (for example, fan or pump upgrades), and lastly plant efficiency EEMs (for example, boiler replacements). $$\begin{aligned}&\textit{Annual Energy Savings } (MJ/Year)\\&\quad = \textit{Baseline Annual Energy Use } (MJ)\\&\quad - \textit{Annual Energy Use With EEMs } (MJ/Year)\end{aligned}$$ $$\begin{aligned}&\textit{Annual Peak Demand Savings } (kW)\\&\quad = \textit{Baseline Maximum Monthly Energy Demand } (kW)\\&\quad - \textit{Maximum Monthly Energy Demand With EEMs } (kW)\end{aligned}$$
Financial analysis (**ASHRAE Std. 100 Sec. 8.5.4**)	Estimated annual operational cost savings, implementation capital cost, and simple payback. $$\textit{Simple Payback } (Years) = \frac{\textit{Implementation Cost } (\$)}{\textit{Annual Opeational Cost Savings } (\$/Year)}$$ $$\begin{aligned}&\textit{Annual Opeational Cost Savings } (\$/Year)\\&\quad = \textit{Baseline Annual Operating Costs } (\$)\\&\quad - \textit{Annual Operating Costs With EEMs } (\$)\end{aligned}$$ Operational cost savings must account for maintenance costs in addition to operational energy costs. Operational energy costs are calculated based on current utility rates at the building location. Operational energy costs must be calculated based on the billing structure of the local utility provider and must account for time-of-use or peak demand charges in addition to energy use charges as applicable.

Implementation and Verification Requirements

RELATED ROLES:

Authority Having Jurisdiction role, responsible for establishing the implementation and verification process.

Building owner role, ultimately responsible for implementing EEMs and ensuring the building complies with the Standard.

Energy manager role, responsible for developing and implementing the energy management plan, which includes implementing EEMs as required.

Qualified person determining compliance role, responsible for determining whether the energy requirements of the Standard have been achieved and submitting documentation to the AHJ.

Implementation and verification, in the context of ASHRAE Standard 100, refers to **implementation** of an energy management plan and **verification** that EEMs have been put in place and their associated energy savings have been observed or measured. Of course, verification of EEMs is only applicable to buildings that are required to conduct an energy audit and implement EEMs. As discussed elsewhere in this guide, buildings in this category are those that don't have an energy target or don't meet their target (in the judgement of the qualified person determining compliance).

Within ASHRAE Standard 100, the implementation and verification procedures are relatively brief, and focus on the perspective of those complying with the Standard. In practice, much of this process needs to be established by the AHJ, particularly decisions surrounding conditional compliance.

ASHRAE Standard 100 describes conditional compliance as lasting for 15 months following the implementation of EEMs. However, the Standard does not specify several aspects of conditional compliance, including how long buildings have to complete an energy audit, how long after the audit they have to implement EEMs, and what happens if the second submission still does not achieve the energy target.

The AHJ must therefore resolve several issues regarding how the implementation and verification process will work within their jurisdiction. Some of the issues that are left open within the Standard to be decided by the AHJ include:

- **Initial adoption deadline**, including timeframe for buildings to complete an initial submission of Forms A, B, and C to the AHJ indicating if they either a) achieve the ASHRAE Standard 100 energy targets, or b) do not achieve the energy targets and/or do not have energy targets and will be completing an energy audit.
- **Timeframe for completion of the energy audit**, if required, including submission of Forms D and/or E.
- **Timeframe for implementation of EEMs**, if required, following the completion of the energy audit. **ASHRAE Std. 100 Sec 9.1.1.2** states this timeframe is 4 years from the application of compliance for buildings without targets, but no timeframe is specified for buildings with targets.
- **Timeframe, criteria, and process for awarding conditional compliance**. This process will likely include some formal documentation, to be submitted to the AHJ, which proves the EEMs identified in the energy audit have been implemented.
- **Deadline for submission of 12 consecutive months of new energy use data** following EEM implementation (and receiving conditional compliance). The timeframe specified in **ASHRAE Std. 100 Sec 4.3.2.3** is 15 months, but this could be modified at the discretion of the AHJ.
- **Procedures surrounding non-compliance**. ASHRAE Standard 100 leaves it to the AHJ to decide what happens if, upon second submission, a given building still does not achieve their energy target or required amount of energy savings. Options include:
  - Requiring the process be repeated, implementing EEMs and resubmitting updated energy use data until the energy requirements are achieved.
  - Revoking conditional compliance and determining that the building is noncompliant.
- **Consequences for non-compliance**, such as financial penalties or restrictions on building operation.

As much of the implementation and verification process is dependant on AHJ-specific decision making, compliance requirements are jurisdiction-specific. However, the general process for those complying with the Standard is as follows:

- All buildings over 5000 ft² are required to develop and implement an energy management plan and an operations and maintenance program.
- At the same time, the qualified person determining compliance and/or the energy manager will perform an energy use analysis, determine whether the building has an energy target, and determine whether the target is achieved.

- The qualified person determining compliance must complete Forms A, B, and C, and submit them to the AHJ.
  - If the target is achieved, then compliance will be achieved.
  - If the target is not achieved, or if there is no target, then an energy audit must be completed by a qualified energy auditor, along with Form D and/or E.
- If applicable, EEMs identified in the energy audit must be implemented.
- Following EEM implementation and AHJ-specific reporting procedures, the building achieves conditional compliance.
- Within 15 months, or another duration specified by the AHJ, 12 consecutive months of post-implementation energy data must be submitted to the AHJ.
  - Buildings with targets are required to resubmit Form A.
  - Buildings without targets are required to verify that at least 75% of the savings identified in the energy audit for the optimized bundle have been achieved.
- The AHJ can then award compliance if the energy requirements are met, require the building to implement more EEMs, or revoke conditional compliance.

Reporting

RELATED ROLES:

Qualified person determining compliance role, responsible for determining if the applicant building has achieved compliance with the Standard, and submitting Forms A, B, and C.

Qualified energy auditor role, responsible for completing the energy audit and submitting Forms D and/or E.

Complying with ASHRAE Standard 100 requires reporting of information to the AHJ acting as the regulator. Although some aspects of the Standard can vary by jurisdiction, reporting procedures require people in specific roles to complete several standardized forms.

Compliance Forms

Compliance forms are to be completed by the qualified person determining compliance. The following forms fall into this category:

- **ASHRAE Std. 100 Form A – Compliance with Standard 100**
- **ASHRAE Std. 100 Form B – Building Activity and Energy Target (EUI)**
- **ASHRAE Std. 100 Form C – Energy-Use Intensity Calculations**

These forms are related in that each has fields or calculations that require information from the others (see Figure 3-6).

Energy Audit Forms

Energy audit forms are completed and submitted directly to the AHJ by the qualified energy auditor (**ASHRAE Std. 100 Sec. 8.1**). However, they require the signature of the qualified person determining compliance. Energy audit forms summarize the end use analysis of the building and consist of the following:

- **ASHRAE Std. 100 Form D – End Use Analysis Requirements Level 1**
- **ASHRAE Std. 100 Form E – End Use Analysis Requirements Level 2**

The qualified energy auditor can fill out either Form D or Form E, depending on the level of audit performed.

Note that the qualified energy auditor may alternatively attach a separate report that provides the same summary of end use breakdown rather than completing the tables in Forms D and E. This may be the case if using hourly energy modeling software, such as DOE-2, to estimate the energy use breakdown.

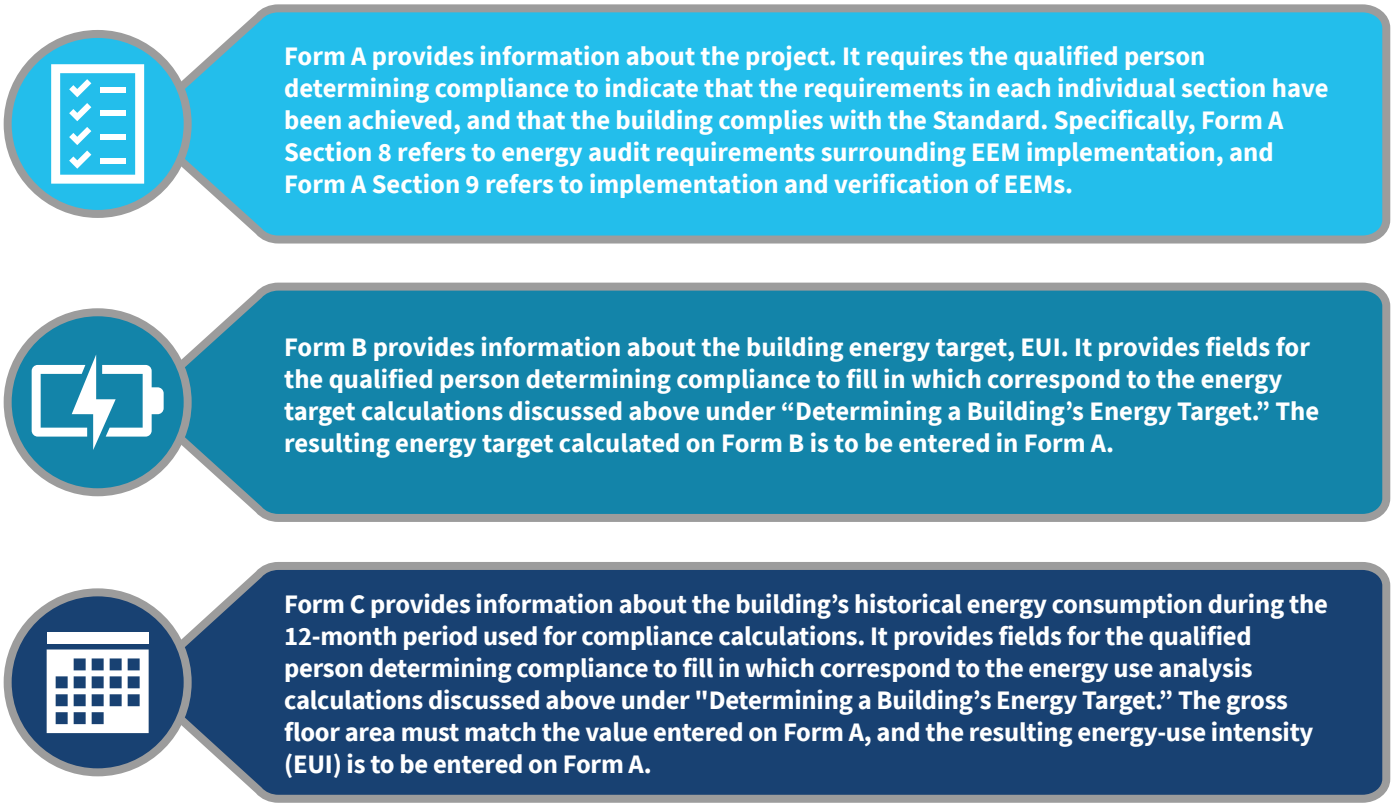


Figure 3-6 Diagram summarizing Forms A, B, and C

Summary

As the building sector moves to reduce energy consumption and greenhouse gas emissions in the built environment, ASHRAE Standard 100 offers a framework within which existing building energy consumption can be evaluated and reduced through well-defined, measurable steps. At a high level, these steps can be summarized as:

- Measure and document energy use of the existing building.
- Compare measured energy use of the existing building to the targeted energy use for that building type and determine if energy efficiency improvements are required.
- Implement and verify energy efficiency improvements, if required.
- Continue to measure and document energy use and compare to the building's energy use target.

This guide is intended to be used in conjunction with ASHRAE Standard 100, to provide context through discussion of core concepts and assist various stakeholder groups in understanding their specific roles and responsibilities. Example calculations and case studies are provided to help readers picture the Standard "in action." As real-world applications continue to lead to further learning, it is expected that this new standard, and the ways in which it is implemented, will continue to evolve.

Further information and tools to support implementation are provided in the appendices that follow. Appendices A and B describe the targets used in BC and Washington State. Appendix C discusses integration of ASHRAE 100 with related policy, using Washington State and New York City as examples of jurisdictions that have implemented related measures. Appendices D and E provide sample checklists that can be used to track compliance with requirements. Finally, Appendix F summarizes the primary energy conversion factors found in **ASHRAE Std. 100 Table 5-2b**, along with US and Canadian national averages developed for ENERGY STAR® Portfolio Manager, to support appropriate use of source energy targets across different regions.

References

ASHRAE. 2018. ANSI/ASHRAE Standard 100-2018, *ASHRAE Standard 100-2018: Energy Efficiency in Existing Buildings* Atlanta: ASHRAE.

Natural Resources Canada. 2018. *Energy Fact Book 2018-2019*. Ottawa: Natural Resources Canada, 35.

Appendix A | British Columbia EUI Targets

The Province of British Columbia, in partnership with the provincial utilities BC Hydro and FortisBC, have developed region specific EUI targets to reflect the building stock within the province. The targets are available for voluntary use by building owners and property managers to enhance building energy performance. In general, the targets are comparable to ASHRAE Std. 100's U.S.-derived values, although there is some variation in the building categories used.

Commercial Buildings

The average energy use intensity (EUI) for each Primary Commercial Building Type in each of the 3 most populous climate zones in British Columbia is shown in Table A-1. These data were determined from the 2016 BC Conservation Potential Review (CPR)[1] prepared for BC Hydro (electricity) and FortisBC (natural gas). The results for Climate Zone 4C are an average of the EUI for buildings in the Lower Mainland and those on Vancouver Island as both regions contain buildings primarily in Climate Zone 4C. These values were compared to ASHRAE Standard 100 EUI data and the Survey of Commercial and Institutional Enegy Use (SCIEU)[2] 2014 EUI data, with results showing generally good alignment in most instances.

Analogous to the Standard proper, targets are determined by multiplying the EUI (Table A-1) by specified multipliers (Table A-2 and Table A-3).

The ASHRAE Std. 100 target multipliers selected for use in BC and are shown in Table A-2. Multipliers were also developed based on BC Hydro and ENERGY STAR® Portfolio Manager from the ratio of EUI in a specified percentile to the average EUI for each building type; however, there were significant inconsistencies between the three datasets, and therefore the ASHRAE Std. 100 values were selected for use. The building area energy target, EUI_t, can be calculated by multiplying the site energy use intensity from Table A-1 by the target multiplier from Table A-2.

Table A-1 Site-Energy-Based Building Total Energy Use Intensity by Climate Zone in British Columbia, MJ/M²

Primary Building Type	Climate Zone 4C	Climate Zone 5	Climate Zone 6
Accommodation	1061	1086	1230
Colleges/Universities	1180	1216	1670
Food Services	2759	2739	3532
Hospitals	2102	2390	3434
Logistics/Warehouses	553	594	835
Long Term Care	1031	1072	1479
Offices	798	847	1017
Other Commercial	700	751	863
Retail - Food	1864	1829	2219
Retail - Non Food	747	789	856
Schools	651	680	982

Table A-2 ASHRAE Standard 100 Target Multipliers Selected for Use

Primary Building Type	ASHRAE Standard 100			
	Building Category	Building Type	40th	25th
Accommodation	Lodging	All in category	0.85	0.70
Colleges/Universities	Education	College/ University	0.85	0.70
Food Services	Food Service	All in category	0.85	0.70
Hospitals	Inpatient Health Care	Hospital/ Inpatient	0.85	0.70
Logistics/Warehouses	Warehouse	All in category	0.85	0.70
Long Term Care	Nursing	Nursing home/ assisted	0.86	0.71
Offices	Offices	All in category	0.85	0.70
Other Commercial	N/A	N/A	0.85	0.70
Retail - Food	Food Sales	All in category	0.85	0.70
Retail - Non Food	Retail (excl. malls)	Retail	0.85	0.70
Schools	Education	All except college/ university	0.85	0.70

1 BC Hydro (Electricity): Navigant. British Columbia Conservation Potential Review. Prepared for BC Hydro. January 18, 2017. FortisBC (Natural Gas): Navigant. British Columbia Conservation Potential Review. Prepared for FortisBC. January 23, 2017.

2 Survey of Commercial and Institutional Energy Use (SCIEU) 2009. Available online: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/scieu/2014/tables.cfm

Example:

What is the 25th percentile target for a Hospital in Climate Zone 5?

- From Table A-1, a hospital in Climate Zone 5 has a site energy use intensity of 2390 MJ/m².
- From Table A-2, a hospital has a 25th percentile multiplier of 0.70.

$$EUI_t = 2390 \frac{MJ}{m^2} \times 0.70 = 1673\ MJ/m^2$$

The schedule multipliers derived for the BC-specific EUI targets are shown in Table A-3. These were developed for each Primary Building Type from data provided in the summary tables of SCIEU and represent national level data in Canada. Schedule multipliers were also developed based on the BC Hydro data; however, the resulting values showed poor alignment with the ASHRAE Standard 100 data, with several values that appeared unreasonable. As a result, the values based on SCIEU were used.

Table A-3 Schedule Multipliers

Primary Building Type	50 hrs or less	51 to 167 hrs	168 hrs
Accommodation	1.0	1.0	1.0
Colleges/Universities	1.0	1.0	1.2
Food Services	0.8	1.0	1.2
Hospitals	1.0	1.0	1.0
Logistics/Warehouses	1.2	1.3	1.3
Long Term Care	1.0	1.0	1.0
Offices	0.9	0.9	1.2
Other Commercial	0.8	1.0	1.2
Retail - Food	1.0	1.0	1.4
Retail - Non Food	0.7	1.1	1.5
Schools	1.0	1.0	1.2

Residential Buildings

Table A-4 shows the EUI values by climate zone for low rise and high rise residential building types derived from RDH study data for low rise and high rise buildings. These values were compared to existing ASHRAE Std. 100 EUI data and various secondary data sources; despite some variation between ASHRAE, 2011 Survey of Household Energy Use (SHEU)[3], and other secondary data sources, the final values selected are expected to be more representative of buildings in BC than the ASHRAE and SHEU data. Single family attached and detached targets have been omitted as it is recommended that additional data sources be analyzed prior to setting targets for these building types.

The target multipliers selected for use in BC are shown in Table A-5. Multipliers were developed from the ratio of EUI in a specified percentile to the average EUI for each building type. These ratios include buildings from all climate zones and therefore the same multipliers are applied to all climate zones. Target multipliers were developed based on various years of data from both BC Housing and BC Hydro. Generally good alignment was found between these datasets and the ASHRAE Standard 100 values. As such, the most recent BC Hydro dataset was used for the final target multipliers as it had better alignment with the ASHRAE Standard 100 values.

Note that unlike commercial buildings, residential building types all have a schedule multiplier of 1.0, and therefore schedule multipliers are not used in the energy target calculations.

Table A-4 Site-Energy-Based Mean Total Building Energy Use Intensity by Climate Zone in British Columbia, MJ/M²

Primary Building Type	Climate Zone 4C	Climate Zone 5	Climate Zone 6
Low Rise Residential	616	591	805
High Rise Residential	767	783	1002

Table A-5 Target Multipliers Selected for Use

Primary Building Type	40th	25th
Low Rise Residential	0.93	0.75
High Rise Residential	0.84	0.60

Appendix B | Washington State Energy Targets

The Washington State Department of Commerce has developed its own energy targets to reflect the building stock within Washington State (WA).

The site-energy-based building energy targets for Climate Zones 4C and 5B are listed below in Table B-1 as certified November 24, 2020.

To ensure the most current targets are being referenced, please visit the Washington State Department of Commerce website at:

https://www.commerce.wa.gov/growing-the-economy/energy/buildings/

Table B-1 Building Activity Site Energy Targets (EUI_t1) (kBtu/sf/yr)

No.	Building Activity Type[1,2]			Notes	Climate Zone 4C	Climate Zone 5B
	Portfolio Manager Types	Portfolio Manager Sub-Types	Sub-Types: Detailed		EUI_t	EUI_t
1	Banking/financial services	Bank Branch			69	71
2	Banking/financial services	Financial Office			69	71
3	Education	Adult Education			49	51
4	Education	College/University			102	102
5	Education	K-12 School	Elementary/middle school		49	50
6	Education	K-12 School	High school		48	49
7	Education	Preschool/Daycare			59	59
8	Education	Vocational School			49	51
9	Education	Other - Education			49	51
10	Entertainment/public assembly	Aquarium			55	59
11	Entertainment/public assembly	Bar/Nightclub			55	59
12	Entertainment/public assembly	Bowling Alley			73	78
13	Entertainment/public assembly	Casino			55	59
14	Entertainment/public assembly	Convention Center			50	52
15	Entertainment/public assembly	Fitness Center/Health Club/Gym			73	78
16	Entertainment/public assembly	Ice/Curling Rink			73	78
17	Entertainment/public assembly	Indoor Arena			67	70
18	Entertainment/public assembly	Movie Theater			67	70
19	Entertainment/public assembly	Museum			67	70
20	Entertainment/public assembly	Performing Arts			55	59
21	Entertainment/public assembly	Race Track			67	70
22	Entertainment/public assembly	Roller Rink			73	78

No.	Building Activity Type[1,2]			Notes	Climate Zone 4C	Climate Zone 5B
	Portfolio Manager Types	Portfolio Manager Sub-Types	Sub-Types: Detailed		EUI_t	EUI_t
23	Entertainment/public assembly	Social/Meeting Hall			50	52
24	Entertainment/public assembly	Stadium (Closed)			67	70
25	Entertainment/public assembly	Stadium (Open)			67	70
26	Entertainment/public assembly	Swimming Pool			73	78
27	Entertainment/public assembly	Zoo			55	59
28	Entertainment/public assembly	Other - Entertainment/ Public Assembly	Entertainment/ culture		67	70
29	Entertainment/public assembly	Other - Entertainment/ Public Assembly	Library		56	59
30	Entertainment/public assembly	Other - Entertainment/ Public Assembly	Other public assembly		55	59
31	Entertainment/public assembly	Other - Entertainment/ Public Assembly	Recreation		73	78
32	Entertainment/public assembly	Other - Entertainment/ Public Assembly	Social/meeting		50	52
33	Entertainment/public assembly	Other - Recreation			73	78
34	Entertainment/public assembly	Other - Stadium			67	70
35	Food sales and service	Bar/Nightclub			361	378
36	Food sales and service	Convenience Store with Gas Station			244	253
37	Food sales and service	Convenience Store without Gas Station			260	269
38	Food sales and service	Fast Food Restaurant			427	454
39	Food sales and service	Food Sales	Grocery/food market		191	198
40	Food sales and service	Food Sales	Convenience store with gas		260	269
41	Food sales and service	Food Sales	Convenience store		244	253
42	Food sales and service	Food Sales	Other food sales		184	189
43	Food sales and service	Food Service	Fast food		427	454
44	Food sales and service	Food Service	Restaurant/cafeteria		361	378
45	Food sales and service	Food Service	Other food service		293	308
46	Food sales and service	Restaurant			361	378
47	Food sales and service	Supermarket/Grocery Store			191	198
48	Food sales and service	Wholesale Club/ Supercenter			68	75
49	Food sales and service	Other - Restaurant/Bar			361	378
50	Healthcare	Ambulatory Surgical Center			90	96
51	Healthcare	Hospital (General Medical & Surgical)*			215	215
52	Healthcare	Medical Office		3		
53	Healthcare	Outpatient Rehabilitation/Physical Therapy			90	96
54	Healthcare	Residential Care Facility			78	82
55	Healthcare	Senior Care Community			78	82
56	Healthcare	Urgent Care/Clinic/ Other Outpatient			90	96

No.	Building Activity Type[1,2]			Notes	Climate Zone 4C	Climate Zone 5B
	Portfolio Manager Types	Portfolio Manager Sub-Types	Sub-Types: Detailed		EUI_t	EUI_t
57	Healthcare	Other - Specialty Hospital			196	196
58	Lodging/residential	Barracks			88	90
59	Lodging/residential	Hotel	Hotel		68	72
60	Lodging/residential	Hotel	Motel or inn		74	77
61	Lodging/residential	Multifamily Housing			32	33
62	Lodging/residential	Prison/Incarceration			101	106
63	Lodging/residential	Residence Hall/ Dormitory			88	90
64	Lodging/residential	Residential Care Facility			78	82
65	Lodging/residential	Senior Care Community			78	82
66	Lodging/residential	Other - Lodging/ Residential			71	74
67	Mixed use	Mixed Use Property		4		
68	Office	Medical Office		3	60	65
69	Office	Office	Admin/professional office		63	66
70	Office	Office	Bank/other financial		69	71
71	Office	Office	Government office		66	69
72	Office	Office	Medical office (diagnostic)	3	60	65
73	Office	Office	Other office		66	68
74	Office	Veterinary Office			90	96
75	Office	Other - Office			66	68
76	Public services	Courthouse			101	106
77	Public services	Fire Station			65	68
78	Public services	Library			56	59
79	Public services	Mailing Center/Post Office			51	54
80	Public services	Police Station			65	68
81	Public services	Prison/Incarceration			101	106
82	Public services	Social/Meeting Hall			50	52
83	Public services	Transportation Terminal/ Station			55	59
84	Public services	Other - Public Service			66	69
85	Religious worship	Worship Facility			39	42
86	Retail	Automobile Dealership			59	66
87	Retail	Convenience Store with Gas Station			260	269
88	Retail	Convenience Store without Gas Station			244	253
89	Retail	Enclosed Mall		5	58	64
90	Retail	Lifestyle Center	Enclosed mall	5	58	64
91	Retail	Lifestyle Center	Other retail		55	62
92	Retail	Lifestyle Center	Retail store		68	75
93	Retail	Lifestyle Center		4		

No.	Building Activity Type[1,2]			Notes	Climate Zone 4C	Climate Zone 5B
	Portfolio Manager Types	Portfolio Manager Sub-Types	Sub-Types: Detailed		EUI_t	EUI_t
94	Retail	Retail Store			68	75
95	Retail	Strip Mall		4		
96	Retail	Supermarket/Grocery Store			191	198
97	Retail	Wholesale Club/ Supercenter			68	75
98	Retail	Other - Retail/Mall	Enclosed mall	5	58	64
99	Retail	Other - Retail/Mall		4		
100	Technology/science	Data Center		6		
101	Technology/science	Laboratory			237	249
102	Technology/science	Other - Technology/ Science	Other service		66	69
103	Services	Personal Services (Health/Beauty, Dry Cleaning, etc.)			66	69
104	Services	Repair Services (Vehicle, Shoe, Locksmith, etc.)	Repair shop		36	39
105	Services	Repair Services (Vehicle, Shoe, Locksmith, etc.)	Vehicle service/repair shop		60	64
106	Services	Repair Services (Vehicle, Shoe, Locksmith, etc.)	Vehicle storage/ maintenance		41	44
107	Services	Other - Services			66	69
108	Utility	Energy/Power Station		7		
109	Utility	Other - Utility		7		
110	Warehouse/storage	Self-Storage Facility			36	44
111	Warehouse/storage	Distribution Center			36	44
112	Warehouse/storage	Nonrefrigerated Warehouse			36	44
113	Warehouse/storage	Refrigerated Warehouse			121	126

Notes:	
1.	Select the most specific building activity type that applies.
2.	For building type definitions see Energy Star portfolio manager definitions except as follows:
	Data center: Is an activity space designed and equipped to meet the needs of high density computing equipment, such as server racks, used for data storage and processing, including dedicated uninterruptible power supplies and cooling systems and require a constant power load of 75 kW or more. Gross floor area shall only include space within the building including raised floor computing space, server rack aisles, storage silos, control console areas, battery rooms and mechanical rooms for dedicated cooling equipment. Gross floor area shall not include a server closet, telecommunications equipment closet, computer training area, office, elevator, corridors, or other auxiliary space.
	Urgent care center/clinic/other outpatient office means the buildings used to diagnose and treat patients, usually on an unscheduled, walk-in basis, who have an injury or illness that requires immediate care but is not serious enough to warrant a visit to an emergency department. Includes facilities that provide same-day surgical, diagnostic and preventive care.
3.	All medical offices considered to be diagnostic type.
4.	Must use of Section 7.2.3 method for mixed use buildings.
5.	Suggest considering use of Section 7.2.3 method for mixed use buildings.
6.	This is a building or activity without an energy target. Included to provide definition only.
7.	This is a building or activity without an energy target. This may be exempt from the standard, see Section Z4.1 2, d.

Washington State also developed their own set of schedule multipliers to replace Table 7-3 within ASHRAE Standard 100, which are presented below in Table B-2.

Table B-2 Building Operating Shifts Normalization Factor

No.	Building Activity Type[1,2]			Notes	Weekly Hours[1,2]		
	Portfolio Manager Types	Portfolio Manager Sub-Types	Sub-Types: Detailed		50 or less	51 to 167	168
1	Banking/financial services	Bank Branch		3	0.8	1.0	1.5
2	Banking/financial services	Financial Office		3	0.8	1.0	1.5
3	Education	Adult Education		4	0.9	1.1	1.9
4	Education	College/University		4	0.9	1.1	1.9
5	Education	K-12 School	Elementary/middle school	4	0.9	1.1	1.9
6	Education	K-12 School	High school	4	0.9	1.1	1.9
7	Education	Preschool/Daycare		4	0.9	1.1	1.9
8	Education	Vocational School		4	0.9	1.1	1.9
9	Education	Other - Education		4	0.9	1.1	1.9
10	Entertainment/public assembly	Aquarium		4	0.6	1.1	1.6
11	Entertainment/public assembly	Bar/Nightclub		4	0.6	1.1	1.6
12	Entertainment/public assembly	Bowling Alley		4	0.6	1.1	1.6
13	Entertainment/public assembly	Casino		4	0.6	1.1	1.6
14	Entertainment/public assembly	Convention Center		4	0.6	1.1	1.6
15	Entertainment/public assembly	Fitness Center/Health Club/Gym		4	0.6	1.1	1.6
16	Entertainment/public assembly	Ice/Curling Rink		4	0.6	1.1	1.6
17	Entertainment/public assembly	Indoor Arena		4	0.6	1.1	1.6
18	Entertainment/public assembly	Movie Theater		4	0.6	1.1	1.6
19	Entertainment/public assembly	Museum		4	0.6	1.1	1.6
20	Entertainment/public assembly	Performing Arts		4	0.6	1.1	1.6
21	Entertainment/public assembly	Race Track		4	0.6	1.1	1.6
22	Entertainment/public assembly	Roller Rink		4	0.6	1.1	1.6
23	Entertainment/public assembly	Social/Meeting Hall		4	0.6	1.1	1.6
24	Entertainment/public assembly	Stadium (Closed)		4	0.6	1.1	1.6
25	Entertainment/public assembly	Stadium (Open)		4	0.6	1.1	1.6
26	Entertainment/public assembly	Swimming Pool		4	0.6	1.1	1.6
27	Entertainment/public assembly	Zoo		4	0.6	1.1	1.6
28	Entertainment/public assembly	Other - Entertainment/ Public Assembly	Entertainment/ culture	4	0.6	1.1	1.6
29	Entertainment/public assembly	Other - Entertainment/ Public Assembly	Library	4	0.6	1.1	1.6
30	Entertainment/public assembly	Other - Entertainment/ Public Assembly	Other public assembly	4	0.6	1.1	1.6
31	Entertainment/public assembly	Other - Entertainment/ Public Assembly	Recreation	4	0.6	1.1	1.6

No.	Building Activity Type[1,2]			Notes	Weekly Hours[1,2]		
	Portfolio Manager Types	Portfolio Manager Sub-Types	Sub-Types: Detailed		50 or less	51 to 167	168
32	Entertainment/public assembly	Other - Entertainment/ Public Assembly	Social/meeting	4	0.6	1.1	1.6
33	Entertainment/public assembly	Other - Recreation		4	0.6	1.1	1.6
34	Entertainment/public assembly	Other - Stadium		4	0.6	1.1	1.6
35	Food sales and service	Bar/Nightclub		4	0.6	1.1	1.5
36	Food sales and service	Convenience Store with Gas Station		4	0.5	0.9	1.3
37	Food sales and service	Convenience Store without Gas Station		4	0.5	0.9	1.3
38	Food sales and service	Fast Food Restaurant		4	0.6	1.1	1.5
39	Food sales and service	Food Sales	Grocery/food market	4	0.5	0.9	1.3
40	Food sales and service	Food Sales	Convenience store with gas	4	0.5	0.9	1.3
41	Food sales and service	Food Sales	Convenience store	4	0.5	0.9	1.3
42	Food sales and service	Food Sales	Other food sales	4	0.5	0.9	1.3
43	Food sales and service	Food Service	Fast food	4	0.6	1.1	1.5
44	Food sales and service	Food Service	Restaurant/ cafeteria	4	0.6	1.1	1.5
45	Food sales and service	Food Service	Other food service	4	0.6	1.1	1.5
46	Food sales and service	Restaurant		4	0.6	1.1	1.5
47	Food sales and service	Supermarket/Grocery Store		4	0.5	0.9	1.3
48	Food sales and service	Wholesale Club/ Supercenter		4	0.6	1.0	1.5
49	Food sales and service	Other - Restaurant/Bar		4	0.6	1.1	1.5
50	Healthcare	Ambulatory Surgical Center		4,7	0.8	1.1	1.3
51	Healthcare	Hospital (General Medical & Surgical)*			1.0	1.0	1.0
52	Healthcare	Medical Office		4,7	0.8	1.0	1.5
53	Healthcare	Outpatient Rehabilitation/ Physical Therapy		4,7	0.8	1.1	1.3
54	Healthcare	Residential Care Facility			1.0	1.0	1.0
55	Healthcare	Senior Care Community			1.0	1.0	1.0
56	Healthcare	Urgent Care/Clinic/ Other Outpatient		4,7	0.8	1.1	1.3
57	Healthcare	Other - Specialty Hospital			1.0	1.0	1.0
58	Lodging/residential	Barracks			1.0	1.0	1.0
59	Lodging/residential	Hotel	Hotel		1.0	1.0	1.0
60	Lodging/residential	Hotel	Motel or inn		1.0	1.0	1.0
61	Lodging/residential	Multifamily Housing			1.0	1.0	1.0
62	Lodging/residential	Prison/Incarceration			1.0	1.0	1.0
63	Lodging/residential	Residence Hall/ Dormitory			1.0	1.0	1.0
64	Lodging/residential	Residential Care Facility			1.0	1.0	1.0
65	Lodging/residential	Senior Care Community			1.0	1.0	1.0

No.	Building Activity Type[1,2]			Notes	Weekly Hours[1,2]		
	Portfolio Manager Types	Portfolio Manager Sub-Types	Sub-Types: Detailed		50 or less	51 to 167	168
66	Lodging/residential	Other - Lodging/ Residential			1.0	1.0	1.0
67	Mixed use	Mixed Use Property		6			
68	Office	Medical Office		4,7	0.8	1.1	1.3
69	Office	Office	Admin/professional office	3	0.8	1.0	1.5
70	Office	Office	Bank/other financial	3	0.8	1.0	1.5
71	Office	Office	Government office	3	0.8	1.0	1.5
72	Office	Office	Medical office (diagnostic)	4	0.8	1.1	1.3
73	Office	Office	Other office	3	0.8	1.0	1.5
74	Office	Veterinary Office		3	0.8	1.1	1.3
75	Office	Other - Office		3	0.8	1.0	1.5
76	Public services	Courthouse		4	0.8	0.8	1.1
77	Public services	Fire Station		3	0.8	0.8	1.1
78	Public services	Library		4	0.6	1.1	1.6
79	Public services	Mailing Center/Post Office		3	0.8	1.2	1.3
80	Public services	Police Station		3	0.8	0.8	1.1
81	Public services	Prison/Incarceration			1.0	1.0	1.0
82	Public services	Social/Meeting Hall		4	0.6	1.1	1.6
83	Public services	Transportation Terminal/Station		4	0.6	1.1	1.6
84	Public services	Other - Public Service		4	0.8	1.2	1.3
85	Religious worship	Worship Facility		5	0.9	1.7	1.7
86	Retail	Automobile Dealership		4	0.6	1.0	1.5
87	Retail	Convenience Store with Gas Station		4	0.5	0.9	1.3
88	Retail	Convenience Store without Gas Station		4	0.5	0.9	1.3
89	Retail	Enclosed Mall		4	0.6	1.0	1.5
90	Retail	Lifestyle Center	Enclosed mall	4	0.6	1.0	1.5
91	Retail	Lifestyle Center	Other retail	4	0.6	1.0	1.5
92	Retail	Lifestyle Center	Retail store	4	0.6	1.0	1.5
93	Retail	Lifestyle Center					
94	Retail	Retail Store		4	0.6	1.0	1.5
95	Retail	Strip Mall					
96	Retail	Supermarket/Grocery Store		4	0.5	0.9	1.3
97	Retail	Wholesale Club/ Supercenter		4	0.6	1.0	1.5
98	Retail	Other - Retail/Mall	Enclosed mall	4	0.6	1.0	1.5
99	Retail	Other - Retail/Mall					

No.	Building Activity Type[1,2]			Notes	Weekly Hours[1,2]		
	Portfolio Manager Types	Portfolio Manager Sub-Types	Sub-Types: Detailed		50 or less	51 to 167	168
100	Technology/science	Data Center					
101	Technology/science	Laboratory		3	1.0	1.0	1.0
102	Technology/science	Other - Technology/ Science	Other service	3	0.8	1.2	1.3
103	Services	Personal Services (Health/ Beauty, Dry Cleaning, etc.)		4	0.8	1.2	1.3
104	Services	Repair Services (Vehicle, Shoe, Locksmith, etc.)	Repair shop	4	0.8	1.2	1.3
105	Services	Repair Services (Vehicle, Shoe, Locksmith, etc.)	Vehicle service/ repair shop	4	0.8	1.2	1.3
106	Services	Repair Services (Vehicle, Shoe, Locksmith, etc.)	Vehicle storage/ maintenance	4	0.8	1.2	1.3
107	Services	Other - Services		4	0.8	1.2	1.3
108	Utility	Energy/Power Station					
109	Utility	Other - Utility					
110	Warehouse/storage	Self-Storage Facility		4	0.8	1.0	1.4
111	Warehouse/storage	Distribution Center		3	0.8	1.0	1.4
112	Warehouse/storage	Nonrefrigerated Warehouse		3	0.8	1.0	1.4
113	Warehouse/storage	Refrigerated Warehouse		3,8	1.0	1.0	1.4

Notes:	
1.	Do not count the hours when the property is occupied only by maintenance, security, the cleaning crew, or other support personnel. Do not count the hours when the property is occupied only by maintenance staff.
2.	Working hours are based on the average use over the twelve month period selected to document energy use in form C.
3.	The weekly hours are the total number of hours per week where the majority of workers are present. If there are two or more shifts of workers, add the hours. When developing targets using Section 7.2.3 for mixed use buildings, use the hours each separate activity, the hours per week the majority of workers are present.
4.	The weekly hours are the hours that be majority of the building is open to serve the public. When developing targets using Section 7.2.3 for mixed use buildings, the hours each separate activity is open to the public.
5.	The weekly hours the facility is open for operation, which may include worship services, choir practice, administrative use, committee meetings, classes, or other activities.
6.	Must use of Section 7.2.3 method for mixed use buildings.
7.	Health care buildings may use other weekly hours if they are required to operate building systems additional hours to protect patient and staff safety. Provide documentation of the requirement in the energy management plan.
8.	Refrigerated warehouse greater than 167 hours assumes the workers on shift are loading and/or unloading vehicles.

Appendix C | Discussion of Integration of ASHRAE 100 with Related Policy

Several jurisdictions in North America are considering or have implemented policy and programs to achieve energy and greenhouse gas emission reductions in existing building. Two examples are included here to provide insight into how ASHRAE Std. 100 can be either directly referenced or support existing building policy.

1.1 Washington State

In Washington State, rule WAC 194-50 was filed in October 2020. The new Commercial Clean Buildings Performance Standard directly references ASHRAE Standard 100, with amendments, to regulate and improve the energy performance of existing buildings over time.

Prior to adopting ASHRAE Standard 100, Washington State already had building energy benchmarking requirements in place for select building types using ENERGY STAR® Portfolio Manager. Implementing ASHRAE Standard 100 is considered the next step in improving the energy efficiency of the existing building stock.

While much of the rule language is derived from ASHRAE Standard 100, the following are key additions and modifications implemented by the Washington State Department of Commerce to suit the context of their specific jurisdiction, and align with policy already in place:

- ENERGY STAR® Portfolio Manager serves as the reporting and benchmarking tool for calculation of building energy use intensities, as well as calculating the building energy rating as compared to other comparable buildings.
- State-specific energy targets were developed to reflect the building stock within Washington State (See Appendix B).
- Energy targets for more recently built buildings, with construction permit application dates of July 1, 2016 or later, are 15% lower than the targets otherwise set for the given building type.
- Two new Annexes were added to supplement the Standard: Normative Annex X and Normative Annex Z.
  - Normative Annex X provides an alternative compliance pathway based on financial investment criteria, mainly focused on Life Cycle Cost Analysis (LCCA). This serves as an alternative way to determine which Energy Conservation Measures (ECMs) to implement, as opposed to the traditional compliance pathway, which focuses solely on energy savings.
  - Normative Annex Z provides implementation procedures specific to Washington State. These include timelines for the AHJ to establish requirements and inform building owners, as well as timelines and reporting requirements for building owners required to comply with the Standard. Annex Z also outlines penalties and procedures for buildings that fail to comply with the Standard.

Please reference https://www.commerce.wa.gov/growing-the-economy/energy/buildings/clean-buildings-standards/ for full details of the regulation and implementation timeline.

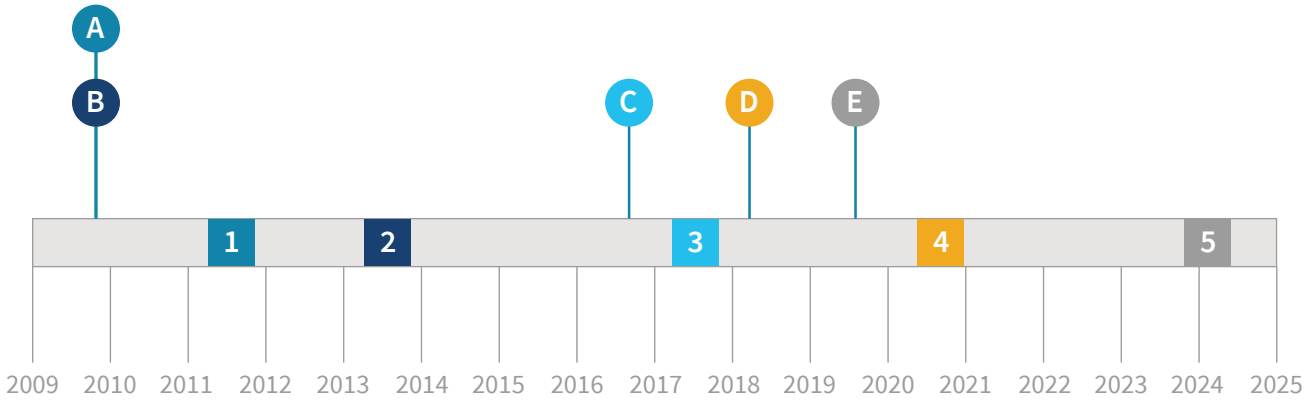
1.2 New York City

In 2009, New York City (NYC) released their Greener Greater Building Plan (GGBP), which set ambitious sustainability goals for new construction and existing buildings. Part of the GGBP was energy and water benchmarking for large buildings. New York now uses ENERGY STAR® Portfolio Manager (ESPM) to gather annual benchmarking data, and a Department of Energy (DOE) Audit Template customized by the Pacific Northwest National Laboratory (PNNL) to document completion of ASHRAE Level 2-type audits every 10 years (with some modifications to data fields from the Level 2 audits outlined in ASHRAE's *Procedures for Commercial Building Energy Audits*). Energy and GHG emission reporting, carried out through ESPM, along with completion of ASHRAE Level 2-type audits, are both analogous to the first steps of compliance with ASHRAE Standard 100.

NYC has elected to set their own building emission limits, which is a similar concept to ASHRAE Standard 100, but with a focus on GHG emissions instead of building energy consumption. ASHRAE Std. 100 EUI averages and targets were reportedly used to inform the development of GHG targets.

The 2009 version of the GGBP required that buildings larger than 50,000 ft^2 report energy and water usage[1]. Gradually, additional building types were required to benchmark; auditing was introduced, and retro-commissioning was added to the plan. The implementation timeline is shown in Figure C-1.

1 Local Law No. 84; available at https://www1.nyc.gov/assets/buildings/local_laws/ll84of2009.pdf



Legislation Passed Into Law:

- **A** December 2009: Annual benchmarking for buildings ≥ 50,000 ft²
- **B** December 2009: Audits every 10 years for buildings ≥ 50,000 ft²
- **C** October 2016: Annual benchmarking for buildings ≥ 25,000 ft²
- **D** January 2018: Annual energy labeling for buildings ≥ 25,000 ft²
- **E** May 2019: Annual building emission limits for buildings ≥ 25,000 ft²

Building Owner Compliance Date:

- **1** May 2011: First benchmarking deadline for buildings over ≥ 50,000 ft²
- **2** December 2013: Audits submission deadline for buildings ≥ 50,000 ft²
- **3** May 2017: First benchmarking deadline for buildings ≥ 25,000 ft²
- **4** October 2020: Building owners must post labels within 30 days of receiving them from the city
- **5** January 2024: Building owners must meet the emission limits for their building type

Figure C-1 Timeline showing stepped implementation of New York City's Greener Greater Building Plan.

Appendix D | Task Checklist

The following checklist accompanies Chapter 2 – Roles and Compliance Process (pg 10) and includes each task that must be completed either by or on behalf of the building owner to comply with ASHRAE Std. 100. Each major task is listed by category. Yellow blocks indicate which roles may complete each task.

The building owner – or party designated on behalf of the building owner – can review this list and assign the member of their team who will be responsible for completing each task, within the limitations described in Chapter 2 of this guide. Note that the titles used here to identify roles (building manager, building operator, etc.) are as laid out in ASHRAE Standard 100, and may not align with day-to-day job titles. Ultimately it is up to the building owner to ensure the building complies and to assign responsibilities to appropriate individuals.

References to ASHRAE Standard 100 sections are identified wherever relevant. Tasks designated to be completed by the Authority Having Jurisdiction (AHJ) are not presented in this checklist, as they are outside the scope of responsibility of the building owner and their team.

Task Checklist

	OWN	BM	BO	EM	EA	QP	Team Member Identified (Name and Contact Info)	✓ COMPLETE
General								
Identify roles for each team member, including the Energy Manager (EM) (**ASHRAE Std.100 p.3 + Sec 5.1.1**).	■							☐
If required, arrange to have sub-meters installed (**ASHRAE Std.100 Sec 5.2.2**). This may be necessary if: → Complying with the standard as individual suites/tenants → Site utility meters include adjacent buildings/facilities that are not within the scope → Energy auditor requires more resolution of data to determine building end-uses	■							☐
Determine the building's energy target								
Determine whether the building seeking compliance has an energy target according to **ASHRAE Std.100 Sec 7** and establish the energy target (EUI_t) if possible. Targets are determined in accordance with ASHRAE Std.100 Sec 7.2.2 for single-type/ activity buildings and **ASHRAE Std.100 Sec 7.2.3** for mixed-use buildings.				■		■		☐
Determine if spaces with unique activity types that make up less than 10% of the gross floor area are similar enough to be combined with other spaces (**ASHRAE Std.100 Sec 7.2.3**).				■	■	■		☐
Calculate energy-use intensity (EUI)								
Calculate the building's measured EUI by completing **Form C** (**ASHRAE Std.100 Sec 5.2., 4.3.1**).				■		■		☐
Demonstrate to the AHJ that the building has met the required energy targets per the AHJ's definition (site or source energy, using the set of targets specified by the AHJ) in accordance with **ASHRAE Std.100 Sec 7**, or have met the requirements in **ASHRAE Std.100 Sec 4.3.3** for buildings without energy targets.						■		☐

OWN **Building Owner**

BM **Building Manager**

BO **Building Operator**

EM **Energy Manager (EM)**

EA **Qualified Energy Auditor**

QP **Qualified Person Determining Compliance**

Task Checklist

	OWN	BM	BO	EM	EA	QP	Team Member Identified (Name and Contact Info)	
Develop an energy management plan								
Develop and maintain an energy management plan for the building in accordance with **ASHRAE Std.100 Sec 5**.				■				☐
Put in place a formal process to ensure that any tenant improvements involving a change in space use or the relocation of partitions (including partial height partitions) do not change the annual net energy consumption except to the extent that the change (increase or decrease) is consistent with any change in the building's energy target. (**ASHRAE Std.100 Sec 6.5**).				■				☐
Provide a copy of the energy management plan to all building occupants and other stakeholders annually (**ASHRAE Std.100 Sec 5.1.3**).				■				☐
Comply with the energy management requirements of **ASHRAE Std.100 Sec 5** (**ASHRAE Std.100 Sec 4.2.2**).		■						☐
Review and sign the energy management plan annually. (**ASHRAE Std.100 Sec 5.1.4**).	■							☐
Establish operations and maintenance requirements								
Schedule, verify, and record O&M evaluations of the HVAC systems, taking corrective action where indicated (to be recorded in the Energy Management Plan) (**ASHRAE Std.100 Annex D3.2.7**).			■	■				☐
For refrigeration systems, work with users so that refrigerant products are located to permit air circulation, particularly near walls and ceilings (**ASHRAE Std.100 Annex D4.7.2**).				■				☐
Inventory and verify correct operation, programming, and placement of all lighting controls. (**ASHRAE Std.100 Annex D5.2**).				■				☐
Complete a survey of all existing luminaires and create an as-built lighting schedule, complete with calculation of the lighting power density. Any changes to lighting must be documented and compared to previous lighting schedules, and the lighting power density must decrease over time unless there is a change to the space activity type (**ASHRAE Std.100 Annex D5.3**).				■				☐

OWN **Building Owner**

BM **Building Manager**

BO **Building Operator**

EM **Energy Manager (EM)**

EA **Qualified Energy Auditor**

QP **Qualified Person Determining Compliance**

Task Checklist	OWN	BM	BO	EM	EA	QP	Team Member Identified (Name and Contact Info)	
Schedule and perform evaluations of the control systems twice per year (**ASHRAE Std.100 D6.2.3**).			■	■				☐
Comply with the operations and maintenance requirements of **ASHRAE Std.100 Sec 6** (**ASHRAE Std.100 Sec 4.2.1**).		■						☐
Complete energy audit								
If required, complete an energy audit of the building in accordance with **ASHRAE Std.100 Sec 8**.					■			☐
Implementation and verification								
Select and implement EEMs per the requirements of **ASHRAE Std.100 Sec 9** following completion of the energy audit (**ASHRAE Std.100 Sec 8.2.4**).	■							☐
If EEMs are implemented that require commissioning, review commissioning report and certify that the EEMs are functioning as intended (**ASHRAE Std.100 Sec 9.1.2.3**).					■	■		☐
For buildings with energy targets, within 15 months of EEM implementation, recalculate the building EUI and resubmit **Form A** in order to demonstrate that the energy target, EUI_t, has been met (**ASHRAE Std.100 Sec 4.3.2.3**).				■				☐
For buildings without energy targets, review the results of the EEM energy monitoring and certify that the energy savings of the package of EEMs meets or exceeds 75% of the energy savings projected in the energy audit (**ASHRAE Std.100 Sec 9.2.2**).					■	■		☐
Submit verification of measured post-implementation energy savings for buildings without energy targets (**ASHRAE Std.100 Sec 4.3.3.3**).	■					■		☐
Reporting								
Indicate on **Form A** if this compliance is for the whole building or for individual tenant spaces /dwelling units in a multi-tenant building/multi-unit residential building (**ASHRAE Std.100 Sec 4.1.1.2**).						■		☐
Complete energy target calculations on **Form B** (**ASHRAE Std.100 Annex C**)				■		■		☐

Building Owner

Building Manager

Building Operator

Energy Manager (EM)

Qualified Energy Auditor

Qualified Person Determining Compliance

Task Checklist	OWN	BM	BO	EM	EA	QP	Team Member Identified (Name and Contact Info)	
Complete energy use intensity (EUI) calculations on **Form C** (**ASHRAE Std.100 Annex C**).								☐
Complete **Form A**, including reporting the building energy target and EUI from **Forms B** and **C** respectively (**ASHRAE Std.100 Annex C, 10.2.1**).								☐
Submit **ASHRAE Std.100 Forms A, B**, and **C** to the AHJ.								☐
If an energy audit is required, complete **Forms D** and/or **E** documenting the building end-use analysis (**ASHRAE Std.100 Sec 8.5.5**, **Annex C**).								☐
If an energy audit is required, submit **Forms D** and/or **E** to the AHJ (**ASHRAE Std.100 Sec 8.1**). A copy of the energy audit summary results must be included in this submission.								☐

OWN **Building Owner**

BM **Building Manager**

BO **Building Operator**

EM **Energy Manager (EM)**

EA **Qualified Energy Auditor**

QP **Qualified Person Determining Compliance**

Appendix E | Operations and Maintenance Checklist

The following generally contains the Operations and Maintenance requirements listed in ASHRAE Standard 100 Informative Annex D, organized as a trackable checklist.

For this checklist, items fall into three categories:

- **General**: general requirements that cover a variety of different actions, including replacing parts, repairing broken components, analyzing data, etc.
- **Maintain**: requirements related to keeping equipment and components operating or functioning in accordance with manufacturers' recommendations and industry standards over their service lives.
- **Inspect**: requirements related to performing a visual review to assess the condition of a given system or component.

Operations and Maintenance Checklist		Date
#	Task	✓ COMPLETE
Sec 6	**General Requirements**	
6.2	Establish and implement a formal operations and maintenance (O&M) program	☐
6.3	Implement the O&M program in accordance with ASHRAE Std. 100 Normative Annex L.	☐
6.4.1	Maintain all equipment, components, and systems in accordance with applicable manufacturers' requirements, and include tasks that minimize failures and maintain energy consumption efficiency.	☐
6.4.2	Provide safe and reasonable access to all equipment covered by the O&M program.	☐
6.4.3	Re-evaluate the O&M requirements when building use changes or renovations/alterations are made that affect the facility's operations.	☐
6.5	Ensure that any tenant improvements involving a change in space use or the relocation of partitions do not change the annual net energy consumption except to the extent that the annual net energy use change is consistent with any change in the building's energy target.	☐
6.6.1	Ensure that when HVAC, domestic hot-water heating, or refrigeration equipment or appliances are replaced, the replacement equipment meets the most stringent energy efficiency requirements in the federal equipment standards, in the applicable building code, in ASHRAE/IES Standard 90.1, or in ASHRAE Standard 90.2. Exception: Equipment intended for standby or emergency use only.	☐
6.6.2.1	Ensure that when lighting equipment is replaced, the replacement equipment meets the most stringent energy efficiency requirements in both the federal equipment standards and in the applicable building code.	☐
6.6.2.2	Ensure that the replacement of any lighting equipment does not increase the existing installed lighting power demand. Exception: The existing installed lighting power may proportionally increase when the current light levels are below those recommended in the IES Lighting Handbook.	☐
D1	**Building Envelope**	
D1.1 (Sec 6)	Ensure the operations and maintenance (O&M) requirements for the building envelope include all applicable items in Section 6.	☐
D1.2	Verify that a building envelope inspection is performed at least once every three years.	☐
D1.3	Seal all exterior joints in the building envelope, and all around penetrations of the building envelope by utility services.	☐
D1.4	Replace broken or missing windows.	☐
D1.5	Repair or replace exterior door weather stripping, threshold, and door sweeps as needed.	☐
D1.6	Seal or cap obsolete shafts, chimneys, and other air chases.	☐
D1.7	Repair or replace existing door closers on exterior doors.	☐
D1.8	Develop, document, and distribute procedures to building personnel for energy-efficient operation of exterior doors, loading docks, and operable windows.	☐
D2	**Domestic Hot-Water Systems**	
D2.1	**General Requirements**	
D2.1.1 (Sec 6)	Ensure the O&M requirements for domestic hot-water (DHW) systems include all applicable items in Section 6.	☐
D2.1.2	Securely and visibly locate a list of operating parameters.	☐

Operations and Maintenance Checklist		Date
#	Task	
D2.2	Hot-Water Heaters	
D2.2.1	Maintain proper combustion efficiency—carry out a combustion analysis and carbon monoxide testing at least annually. Exception: The input capacity of the heater is less than 100,000 Btu/h (29,310 W).	☐
D2.2.2	Deenergize booster heaters when the serviced equipment is not in use or is in standby mode. Make allowance for warmup time in heater schedule	☐
D2.2.3	Control the domestic hot water (DHW) heater so that DHW temperature is maintained between 120°F (49°C) and 125°F (52°C). Exceptions: 1. Systems dedicated to serving equipment requiring higher water temperatures. 2. Systems that use a water heater to meet both domestic hot water needs and space heating load.	☐
D3	Heating, Ventilation, and Air-Conditioning (HVAC) Systems	
D3.2	General Requirements	
D3.2.1 (Sec 6)	Ensure O&M requirements for HVAC systems include all applicable items in Section 6.	☐
D3.2.2	Ensure that each O&M task is performed in a safe and professional manner by qualified personnel. Tasks that require specialized expertise should be performed by personnel with the requisite expertise who are certified where required by code or regulation.	☐
D3.2.3	Perform O&M tasks twice per year Exception: If otherwise noted elsewhere in the Standard.	☐
D3.2.4	Securely and visibly display a list of operating parameters.	☐
D3.2.5	For systems using refrigerant, maintain the refrigerant charge per the manufacturer's requirements.	☐
D3.2.6	Display and maintain a service log on each piece of equipment.	☐
D3.2.7	Schedule, verify, and record O&M evaluations of the HVAC systems, taking corrective action where indicated. Such evaluations should include the following:	☐
.1	Poll occupants and users of the HVAC systems for any observations or operational issues that have occurred.	☐
.2	Physically inspect the maintained systems and components.	☐
.3	Analyze occupant complaints and how these relate to system operation.	☐
.4	Maintain indoor environmental quality parameters that have been established for the building, including temperature, humidity, and ventilation.	☐
.5	Maintain HVAC system rooms and spaces for proper and safe service access. Relocate any material or debris impeding access to the HVAC equipment. Maintain service lighting.	☐
.6	Maintain HVAC system schedules to meet current requirements, including the following: a. Occupied mode b. Unoccupied mode c. Start mode	☐
.7	Maintain HVAC system electrical connections.	☐
.8	Maintain equipment to avoid excessive mechanical noise and vibration.	☐
.9	Maintain HVAC heat exchange surfaces for effective heat transfer.	☐

Operations and Maintenance Checklist		Date
#	Task	
.10	Maintain serviceable points of lubrication.	☐
.11	Replace or clean filters in accordance with the manufacturer's recommended schedule or design pressure drop.	☐
.12	Maintain HVAC system piping and duct systems against leakage.	☐
.13	Maintain insulation on HVAC system piping and duct systems.	☐
.14	Maintain the steam water heating, hot-water heating, and chilled-water cooling control valves against leakage a minimum of once every three years.	☐
D3.2.8	Document periodic maintenance work and service work on service logs.	☐
D3.3	**Boiler Systems**	
D3.3.1 (Sec 6)	O&M requirements for boiler systems include all applicable items in Section 6.	☐
.1	**Boiler Burners**	
a.	Maintain proper combustion efficiency—carry out a combustion analysis and carbon monoxide testing at least annually and make necessary corrections to achieve rated efficiency and safety.	☐
b.	For boilers ≥400,000 Btu/h (117,240 W), design input, perform combustion analysis, and make adjustments to optimize boiler efficiency at least once annually.	☐
c.	For boilers <400,000 Btu/h (117,240 W), design input, perform combustion analysis, and make adjustments to optimize boiler efficiency at least once every three years.	☐
d.	Maintain burners.	☐
e.	Maintain combustion chamber to avoid incomplete combustion.	☐
f.	Inspect combustion chamber against cracks or deterioration.	☐
g.	Maintain pilot and flame controls, flues, combustion air openings, and safeties.	☐
h.	Maintain boiler blowdown to ensure it is functional and not excessive.	☐
D3.3.2	**Boiler Controls**	
.1	Adjust controls to cycle the boiler system through an entire heating cycle and maintain proper operation.	☐
.2	Maintain reset controls.	☐
.3	Maintain heating operations so they do not result in short or rapid cycling of the burners.	☐
D3.3.3	**Venting**	
.1	Maintain combustion and ventilation air openings.	☐
.2	Maintain boiler vent discharge and intakes.	☐
D3.3.4	**Steam and Condensate Return Loop**	
.1	Maintain condensate return systems.	☐
.2	Maintain feed water systems.	☐
.3	Maintain pressure relief and venting.	☐

Operations and Maintenance Checklist		Date
#	Task	
.4	Maintain steam traps.	☐
.5	Maintain water treatment.	☐
D3.3.5	**Hot-Water Hydronic Loop**	
.1	Maintain pump operation and sequencing.	☐
.2	Maintain water systems makeup and relief.	☐
.3	Maintain system water pressure.	☐
.4	Maintain system free of leaks and entrained air.	☐
.5	Maintain water treatment and antifreeze additives.	☐
D3.4	**Chilled-Water Systems**	
D3.4.1	**Chillers**	
.1	Maintain refrigeration system for proper temperatures and pressures.	☐
D3.4.2	**Chilled-Water System Controls**	
.1	Maintain controls to cycle the chilled-water system through an entire cooling cycle and verify proper operation.	☐
.2	Maintain flow controls, operating controls, and safeties for proper operation.	☐
.3	Maintain reset and head pressure controls for proper operation.	☐
.4	Where cooling is provided by multiple units, maintain proper sequencing to achieve maximum efficiency while meeting required load.	☐
D3.4.3	**Chilled-Water Hydronic Loop**	
.1	Maintain proper water temperatures during operation.	☐
.2	Maintain proper pump operation and sequencing.	☐
.3	Maintain proper system water pressure.	☐
.4	Maintain the entire system and ensure the distribution system is free of leaks and entrained air.	☐
.5	Maintain water treatment.	☐
D3.4.4	**Cooling Towers and Condenser Water Loop**	
.1	Maintain proper water temperatures during operation.	☐
.2	Maintain proper pump operation and sequencing.	☐
.3	Maintain the entire system and ensure the distribution system is free of leaks and entrained air.	☐
.4	Maintain water treatment, bleed control, and cycles of concentration.	☐
.5	Maintain corrosion coupon consumption.	☐
.6	Maintain cooling tower sump.	☐
.7	Maintain proper fan operation.	☐

Operations and Maintenance Checklist		Date
#	Task	
D3.5	Air-Side Heating, Cooling, and Ventilating Systems	
D3.5.1	Air-Handling Systems	
.1	Maintain all airflow components, including motors, fans, variable-frequency drives, inlet vanes, drain pans, piping, ductwork, dampers, louvres, coils, energy recovery devices, and cabinets.	☐
.2	Maintain controls, including sensors and actuators, and proper sequence of operation.	☐
.3	Maintain heat exchange devices, including coils.	☐
.4	Maintain damper systems.	☐
D3.5.2	Heat Recovery Systems Including Energy Recovery Ventilation (ERV) and Heat Recovery Ventilation (HRV)	
.1 (D3.5.1)	See items listed above under D3.5.1 as applicable.	☐
.2	Maintain correct physical operation.	☐
D3.5.3	Humidification	
.1	Maintain fill and drain systems.	☐
.2	Maintain water compartment for proper operation.	☐
.3	Maintain sprayers and nozzles.	☐
.4	Maintain sumps.	☐
.5	Maintain control valve and steam traps.	☐
D3.6	Heat Exchanger Testing	
	Perform heat exchanger testing on furnace heat exchangers at a minimum of once every three years per AHRI Guideline X, Induced Draft Furnace Heat Exchanger Inspection.	☐
D3.7	Review Complaints and Observations	
	Review occupant hot/cold complaints and operator hot/cold observations. If the complaint is validated, do the following:	☐
.1	Check the HVAC system equipment operation.	☐
.2	Review draft problems.	☐
.3	Review zoning conflicts.	☐
.4	Test the zone for good and stable temperature control.	☐
.5	Measure the humidity level to verify it is below the ASHRAE Standard 55 upper dew-point limit of 62.2°F (16.8°C).	☐
.6	Adjust diffusers and other parts of heating and cooling distribution systems to minimize overheating and over-cooling of rooms and zones.	☐
D3.8	Maintain Economizer Systems	
.1	Check that dampers move freely through their entire operating range. Clean, lubricate, adjust, and repair as necessary.	☐
.2	Maintain damper blades and side seals.	☐

Operations and Maintenance Checklist		Date
#	Task	
.3	Maintain wiring.	☐
.4	Maintain controls, including sensors, wiring, pneumatic tubing and their connections, damper actuators, damper linkages, and damper sequencing for proper operation.	☐
D3.9	**Unitary Systems and Air-Handling Systems**	
.1 (D3.5.1)	See items listed above under D3.5.1 as applicable.	☐
.2	Maintain system heating and cooling operation.	☐
.3	Maintain controls for proper sequence of operations.	☐
.4	Maintain condensate drain pan and piping.	☐
.5	Maintain direct-expansion cooling or heating.	☐
.6	Refer to Section D4 below for direct-expansion refrigerant-based systems.	☐
D3.10	**Evaporative Cooling Systems**	
.1 (D3.5.1)	See items listed above under D3.5.1 as applicable.	☐
.2	Maintain proper fill and drain operation.	☐
.3	Maintain water compartment moisture and air containment.	☐
.4	Maintain sprayers, nozzles, evaporative media, and water distribution components for proper operation.	☐
.5	Maintain drains and clean sumps.	☐
.6	Maintain proper system heating, heat recovery, and cooling operation.	☐
.7	Maintain controls for proper sequence of operations.	☐
D3.11	**Geothermal Systems**	
.1 (D3.5.1) (D3.9)	See items listed above under D3.5.1 and D3.9 as applicable.	☐
.2	Maintain system heating and cooling operation.	☐
D3.12	**Terminal Systems**	
.1 (D3.5.1)	See items listed above under D3.5.1 as applicable.	☐
.2	Maintain system heating and cooling operation.	☐
D3.13	**Thermal Energy Storage Systems**	
.1	Maintain all equipment in accordance with requirements for each type of equipment elsewhere in this section.	☐
.2	Operate the thermal energy storage system through its entire cooling and/or heating cycle and verify proper operation of all controls. Perform adjustments and repairs as necessary.	☐
D4	**Refrigeration Systems**	
D4.2	**Operations and Maintenance**	

Operations and Maintenance Checklist		Date
#	Task	
.1	Monitor refrigerating systems at regular intervals, determined by the type of system and historic leakage rates, to ensure that systems are well sealed, have the correct refrigerant charge, and are operating properly.	☐
.2	Securely and visibly locate a list of operating parameters.	☐
.3	Check for refrigerant leaks using industry standard procedures.	☐
.4	Monitor and record all additions of refrigerant to, or removals from, the system, along with the reason for the action.	☐
.5	Maintain the refrigerant charge within the manufacturer's specified range.	☐
D4.3	**Maintain Evaporator Defrost System for Proper Operation**	
D4.4	**Retail Store Product Display Refrigeration Systems**	
.1	Maintain refrigeration systems.	☐
.2	The EM should work with staff to ensure they know correct product loading practices for display refrigerators. Avoid uneven loading, overloading, blocked air curtains, or blocked return air paths.	☐
.3	In stores that are not open 24 hours a day, maintain the use of night covers for display cases and refrigerators to minimize ambient air infiltration.	☐
D4.5	**Walk-In Coolers and Freezers**	
.1	Maintain refrigeration system.	☐
.2	Maintain doors, including hinges, gaskets, and closures.	☐
.3	Maintain evaporator and condenser coils.	☐
.4	Maintain evaporator drains lines. In freezers, maintain the drain line heat tape to operate properly, and maintain the drain line insulation in good condition.	☐
.5	Maintain the defrost operation, including frequency. Schedule defrost to avoid activation during peak demand periods.	☐
.6	Maintain the interior of refrigerated enclosures for punctured or broken panels and breaches around pipe or wiring penetrations; maintain vapour barrier integrity.	☐
.7	Encourage users to turn lights off when the room is vacant.	☐
D4.6	**Ice-Making Machines**	
.1	Maintain refrigeration systems.	☐
.2	Maintain water system, reservoir, and evaporator coil for scale or mineral buildup and proper operation.	☐
.3	Maintain strainer, inlet water valve screen, and float valve for proper operation.	☐
.4	Maintain air filter, condenser coil, and condenser fan.	☐
.5	Maintain the bin ice control for proper operation, including drain and water overflow.	☐
D4.7	**Refrigerated Warehouses**	
.1	Maintain refrigeration systems.	☐
.2	The EM should work with users so that product is located to permit air circulation, particularly near walls and ceiling.	☐
.3	Examine walls and ceiling monthly for evidence of frost buildup. Locate the source and make corrective repairs.	☐

Operations and Maintenance Checklist		Date
#	**Task**	
.4	Maintain doors, rollers, door travel, and threshold as needed to minimize door leakage.	☐
.5	Maintain the interior of refrigerated enclosures for punctured or broken panels and breaches around ducts, pipe, or wiring penetrations; maintain vapour barrier integrity.	☐
D	**Lighting Systems**	
5.1 (Sec 6)	O&M requirements for lighting systems include all applicable items in Section 6.6.2.	☐
D5.2	**Lighting Controls**	
D5.2	Inventory and verify correct operation, programming, and placement of all lighting controls.	☐
D5.2	Repair and make functional all lighting controls that have been disabled.	☐
D5.2	Perform functional testing on dimmers, multiscene controls, occupancy sensors, time switches, or photosensors, if present, in accordance with the requirements of Section 9.4.4 of ASHRAE/IES Standard 90.1.	☐
D5.3	**Luminaire Integrity**	
D5.3	Survey all existing luminaires and create an as-built lighting schedule. This lighting schedule may be developed using a lighting survey tool.	☐
D5.3	Calculate and document the lighting power density and compare with any previous lighting power density calculation, such as those from original design documents or from previous lighting schedules. Continued compliance with this section requires that the lighting power density does not increase with time unless there is a corresponding, documented change in use of the space.	☐
D5.4	**Lighting Schedule**	
D5.4	Evaluate the current lighting schedule for opportunities for energy savings through implementation of energy efficiency measures (EEMs), such as those listed in **ASHRAE Std. 100 Informative Annex E, Sec. 6** (nonresidential), or **ASHRAE Std. 100 Informative Annex E, Sec. 7** (residential), and prepare an estimate of the energy savings. Include this estimate in the energy management plan (see **ASHRAE Std. 100 Informative Annex E, Sec. 5.1.2.12** if an energy management plan is required).	☐
D5.6	**Lighting Maintenance**	
a.	Replacement of failed lamps and ballasts.	☐
b.	Replacement of failed luminaires.	☐
c.	Periodic cleaning of all optical surfaces, including lenses, reflectors, louvres, and shielding mechanisms, as well as lamps. Individual luminaires should be cleaned whenever lamps or ballasts are replaced, and all luminaires as a group should be cleaned at least once every three years. All such cleaning should be performed in accordance with manufacturer's instructions if available.	☐
d.	Any lamp or ballast replacement within the existing luminaires in a space should not increase the installed interior lighting power density of the space unless the previous light levels were less than the IES recommended levels as specified in the IES Lighting Handbook 4 or in the IES Recommended Practices title for that space type. If the exact space type cannot be found, then the space type with the closest functional activities should be used.	☐
e.	For exterior residential lighting, all replacement lamps should be high-efficacy lamps unless controlled to automatically limit power use to less than 2200 total hours of full-power operation per year.	☐
f.	For nonresidential exterior lighting, turn off all exterior lighting during daylight hours. Exceptions to D5.6(f): 1. Signage. 2. Lighting needed for safety. 3. Lighting needed for operational necessity.	☐
D5.7	**Interior Lighting in Nonresidential Buildings**	

Operations and Maintenance Checklist		Date
#	Task	
D5.7	Conduct a lighting satisfaction survey at least every three years	☐
D5.7	Identify and correct key issues as necessary.	☐
D6	**Control Systems**	
D6.2	Maintain all equipment according to the manufacturer's instructions.	☐
D6.2.1	Perform each O&M task safely and in accordance with good trade practice by qualified personnel. Tasks that require specialized expertise should be performed by personnel with the requisite expertise and who are appropriately certified where required by code or regulation.	☐
D6.2.2	Perform O&M tasks twice per year, unless otherwise noted in this standard, or as recommended by the manufacturer.	☐
D6.2.3	Schedule and perform evaluations of the control systems twice per year. System evaluations shall include the following:	☐
a.	Review recorded trouble calls and occupant complaints and analyzing how these relate to control operation.	☐
b.	Physically inspect maintained systems and components.	☐
c.	Check that all set points are correct per efficiency requirements, design, or the owner's needs.	☐
d.	Check to ensure seasonal control changes are adjusted.	☐
e.	Check that time of day and holiday schedules are optimized to meet current occupied hours.	☐
f.	Make calibration checks of all system-level sensors, including hot-water, chilled-water, and multiple-zone air-handling units, at least every three years.	☐
g.	Make calibration checks of all space sensors showing small drift or offset over time at least once every five years.	☐
h.	Check whether controls are overridden or in manual operation and making corrections as necessary.	☐
i.	Check the control of minimum outdoor air ventilation and make adjustments where necessary to avoid either excessive or inadequate minimum outdoor airflows.	☐
D6.2.4	Correct all issues found during the control system evaluations.	☐
D6.3	**Pneumatic Controls (including Pneumatic Sensors and Actuators)**	
D6.3.1	Check for properly operating receivers, controllers, and transducers and calibrate as required.	☐
D6.3.2	Check for oil in the air lines. Clean lines and any affected components as required.	☐
D6.3.3	Check filters on air dryer and clean or replace as necessary.	☐
D6.3.4	Check condenser coil on the air dryer and clean as necessary.	☐
D6.3.5	Check pressure-reducing valves (PRV or regulator) operation and calibrate as required.	☐
D6.3.6	Check for leaks in air storage tank.	☐
D6.3.7	Check tank condensate drain operation.	☐
D6.3.8	Check thermostat for proper operation and calibrate as required.	☐
D6.3.9	Check system for leaks in the high pressure lines.	☐
D6.3.10	Check compressor run time; it should run less than 50% of the time. If runtime is excessive, check for leaks or other causes of high demand for control air and take corrective action as needed.	☐

Operations and Maintenance Checklist		Date
#	Task	
D6.3.11	Correct all issues found during the pneumatic control system evaluations.	☐
D6.4	**Analog Controls**	
D6.4.1	Check differential pressure gauges operation.	☐
D6.4.2	Check differential pressure switches operation.	☐
D6.4.3	Check air pressure switches operations.	☐
D6.4.4	Check thermostat operation.	☐
D6.4.5	Check transformer input and output voltages.	☐
D6.4.6	Check system's back-up batteries.	☐
D6.4.7	Correct all issues found during the analog control system evaluations.	☐
D6.5	**Direct Digital Controls (DDC) (including Electronic Sensors and Actuators)**	
D6.5.1	Review DDC system applications programs and verify the system is working in accordance with the design sequence of operation.	☐
D6.5.2	Confirm component readings are in range through audits, calibration, or comparison to performance standards.	☐
D6.5.3	If the DDC system has back-up batteries, check system's back-up batteries.	☐
D6.5.4	Inspect, clean, and maintain all sensors and meters in conformance with the manufacturer's recommendations.	☐
D6.5.5	Verify the most recent calibration report of CO2 sensors and recalibrate as recommended by the manufacturer.	☐
D6.5.6	Check whether outdoor devices have adequate enclosures and whether the enclosures are in good conditions.	☐
D6.5.7	Verify input and output transformer voltages.	☐
D6.5.8	Verify control actuation, linkage attachment, stroke timing, and torque required for motor actuators.	☐
D6.5.9	Correct all issues found during the DDC system evaluations.	☐
D7	**Electric Power Distribution and On-Site Generation Systems**	
D7.2 (D6.1)	Ensure all applicable items in Section D6.1 pertaining to O&M requirements for electric power distribution and on-site generation systems are met.	☐
D7.3	Maintain each piece of on-site electrical generation equipment or built-up systemin accordance with the manufacturer's instructions.	☐
D7.4	**Metering and Submetering**	
D7.4	Calibrate meters and submeters owned by the facility at least once every five years per the manufacturer's instructions.	☐
D7.5	**On-Site Electricity Generation**	
D7.5.1	**Fuel-Fired Cogeneration.**	
D7.5.1	Maintain and report a monthly record of cogeneration operating hours and heat recovery annually. Annual energy generated and useful heat recovered should be compared to the design estimates for these values.	☐
D7.5.2	**Photovoltaic (PV) Systems.**	
D7.5.2	Report PV system performance on an annual basis. The annual output should be compared to the system's designed output or output during previous operating periods.	☐

Operations and Maintenance Checklist		Date
#	Task	
D7.5.2	Analyze shortfalls in annual system performance for cause and possible system defects.	☐
D7.5.2	Troubleshoot and perform corrective work as necessary.	☐
D7.5.3	**Fuel Cells**	☐
D7.5.3	Report fuel cell performance on a monthly basis.	☐
D7.5.3	Analyse shortfalls in monthly system performance for cause and possible system defects.	☐
D7.5.3	Troubleshoot and perform corrective work as necessary.	☐

Appendix F | Primary Energy Conversion Factors

Primary energy conversion factors, or source-to-site ratios, are multipliers that can be applied to *site energy* consumption in order to calculate *source/primary* energy consumption, including generation losses (e.g., related to material extraction or power plant inefficiencies) and transmission losses (e.g., transformer inefficiencies).

Within ASHRAE Standard 100, primary energy conversion factors are used when calculating source energy use intensities and source energy targets.

A table of conversion factors is provided in **ASHRAE Std. 100 Sec. 5**, **Table 5-2b**. However, these values are based on US national averages and may not be applicable for a given geographic region, including regions within the US that have more efficient energy grids, such as Washington State, or less efficient energy grids, such as Hawaii. For this reason, if AHJs permit applicants to use source energy targets for compliance, it is recommended that consideration be given to selecting appropriate primary energy conversion factors for their region.

Table F-1 below summarizes the primary energy conversion factors found in **ASHRAE Std. 100 Table 5-2b**, along with US and Canadian national averages developed for ENERGY STAR® Portfolio Manager[1].

Table F-1 Primary Energy Conversion Factors

Energy Type	ASHRAE Std. 100	PortfolioManager U.S. Average	PortfolioManager Canadian Average
Electricity (Grid Purchase)	3.15	2.8	1.96
Electricity (On-site Generation)	(Assumed 1.0)	1.0	1.0
Natural Gas	1.09	1.05	1.01
Fuel Oil (No 1,2,4,5,6, Diesel, Kerosene)	1.19	1.01	1.01
Propane & Liquid Propane	1.15	1.01	1.04
Steam	1.45	1.20	1.33
Hot Water	1.35	1.20	1.33
Chilled Water	1.04	0.91	0.57
Wood	1.1	1.0	1.0
Coal/Coke	1.1	1.0	1.0
Other	1.1	1.0	1.0

1 For more information on ENERGY STAR® Portfolio Manager, see https://portfoliomanager.energystar.gov/pdf/reference/Source%20Energy.pdf

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