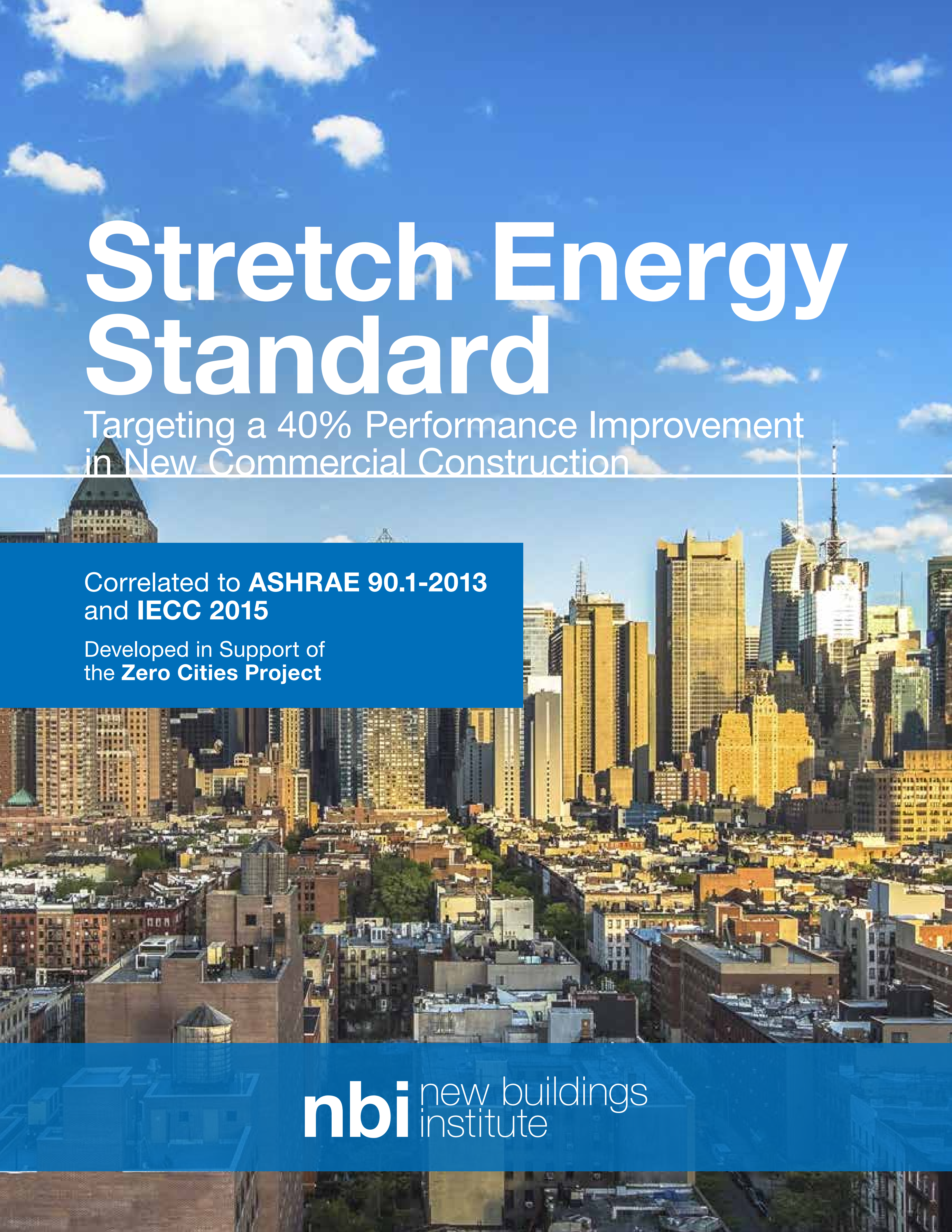
Stretch Energy Standard

Targeting a 40% Performance Improvement in New Commercial Construction

Correlated to **ASHRAE 90.1-2013** and **IECC 2015**

Developed in Support of the **Zero Cities Project**



nbi new buildings institute

TABLE OF CONTENTS

INTRODUCTION

Many U.S. cities and states have adopted meaningful goals to reduce carbon impacts and energy use, often aligned with the international Paris Climate Agreement[1]. Recognizing that buildings are responsible for 40% of the total carbon emissions and 70% of the electricity consumption in the United States, local governments are seeking tools and strategies to guide improvements in the energy performance of local building stock.

Energy codes are a critical tool for driving energy efficiency improvements in the building sector. However, for jurisdictions with established energy and climate action goals, current base energy codes do not deliver the necessary level of building energy performance. Cities and states working aggressively to achieve energy and carbon reduction goals may choose to adopt more stringent codes and/or other policies that drive higher levels of energy improvement in the commercial building sector. Stretch codes, also called reach codes, provide an opportunity to introduce advanced practices in a local market ahead of full adoption of the base energy code. Even those cities unable to adopt a stretch code can tie these advanced standards to incentives or other policies that create energy improvements in the building sector.

The *40% Stretch Energy Standard* is a set of stretch code strategies that target 40% better efficiency than current national model energy codes. The guide is a follow-up to the 20% Model Stretch Code Provisions, which was released in 2017. Both guides are part of a larger project focused on the technical development of advanced energy codes and policies, and on support for jurisdictions to adopt and implement these approaches. Ultimately, this series of provisions with increasing stringency for commercial construction could be considered and adopted by cities as advanced local code amendments, stretch codes, policies and/or incentive program standards. The advanced codes and standards outlined in these

1 By signing The Agreement, Nations pledge to take action to fight climate change and adapt to its effects. https://bigpicture.unfccc.int/#content-the-paris-agreemen

Table 1: Two Paths for Achieving Significant Energy Savings in Commercial Buildings

<table>
<tr><th></th><th></th><th>PATH
A
Stretch Design Strategies
Select OPTION ONE or OPTION TWO and all other strategies required</th><th>PATH
B
Stretch Prescriptive Measures
All measures required</th></tr>
<tr><td>Envelope</td><td rowspan="2">Select OPTION ONE or OPTION TWO</td><td>OPTION ONE
A.1.1 Thermal Performance of the Envelope
A.1.2 Reduced Thermal Bridges
A.1.3 Solar Management
A.1.4 Minimized Infiltration</td><td>B.1.1 Opaque and Below Grade Assemblies
B.1.2 Fenestration Performance
B.1.3 Reduced Thermal Bridges
B.1.4 Solar Load Management
B.1.5 Air Barrier Performance</td></tr>
<tr><td>HVAC</td><td>OPTION TWO
A.2.1 Efficient Equipment Selection
A.2.2 Efficient Distribution Systems
A.2.3 Efficient Ventilation (and ERV)</td><td>B.2.1 Efficient HVAC Equipment
B.2.2 Efficienc Ventilation
B.2.3 Energy Recovery Ventilation
B.2.4 HVAC Vacancy Control
B.2.5 Fan Power Limit</td></tr>
<tr><td>Hot Water</td><td></td><td colspan="2">A.3.1 Service Water System Efficiency</td></tr>
<tr><td rowspan="2">Lighting and Lighting Controls</td><td rowspan="2"></td><td>A.3.1 Lighting Controls
A.3.2 Highly Efficiency Lumniaires</td><td>B.4.1 Interior Lighting Controls
B.4.2 Daylight Responsive Control Function
B.4.3 Interior Lighting Power Density</td></tr>
<tr><td colspan="2">B.4.4 Exterior Lighting Power Allowance
B.4.5 Exterior Lighting Controls</td></tr>
<tr><td rowspan="3">Electric Systems</td><td rowspan="3"></td><td>A.4.1 Reducing Plug Loads
A.4.2 Plug Load Controls
A.4.3 ENERGY STAR® Rated Appliances and Equipment</td><td>B.5.1 Plug Load Controls and Power Management
B.5.2 Efficient Elevators and Appliances</td></tr>
<tr><td colspan="2">B.5.3 Energy Metering</td></tr>
<tr><td>A.5.1 Renewable Energy</td><td>B.5.4 Onsite Renewable Energy</td></tr>
<tr><td>Commissioning</td><td></td><td colspan="2">B.6.1 Building System Commissioning</td></tr>
</table>

guides are also helpful to jurisdictions unable to adopt a stretch code; the guidance can serve as a blueprint for incentive programs and/or policies that drive energy improvements in the building sector.

When evaluating incremental measure improvements, achieving a 40% reduction in energy use (beyond ASHRAE 90.1-2013 or IECC 2015) represents a key milepost on the road to zero energy buildings. Borrowing lessons from low and zero energy (ZE) buildings, we understand that it is possible to design and construct buildings that achieve at least a 40% energy reduction with design approaches that are being practiced today and technologies that are readily available in the marketplace. The *40% Stretch Energy Standard* can serve as a bridge between highly prescriptive energy codes and the more descriptive technical guidance used to explain fundamental approaches to ultra-low and zero energy buildings.

Two paths for achieving significant energy savings

The prescriptive approach used by the model energy codes is beginning to encroach upon the technical limits of what is achievable when it comes to delivering high performance buildings. Two of the biggest reasons for this are that a number of key building loads are outside the scope of energy codes and because the code is limited in terms of what it can require when it comes to the design of buildings (eg. shape, massing and system selection) when key decisions are made that impact the energy outcome of a project. As a result of these factors, this document includes two different measure paths: *Stretch Design Strategies (Path A)* and *Stretch Prescriptive Measures (Path B).* Path A takes a broad approach to the design and specification process and is meant to be applied through building policy and programmatic mechanisms. Path B is more in line with current model energy codes that can be bundled and applied as a stretch code or stretch energy measures. The *Stretch Design Strategies* section describes a systems approach to reducing energy associated with heating, ventilation and air conditioning (HVAC) loads and applies best practices for reducing lighting, hot water and plug loads. As noted in Table 1, The *Stretch Design Strategies* (Path A) allows project teams to reduce HVAC loads by selecting either the envelope strategies (A.1.1 – A.1.4) or the HVAC strategies (A.2.1 – A.2.3). The additional required Stretch Design Strategies are described in Path A or reference requirements from the *Stretch Prescriptive Measures* (Path B).

Structuring Path A in this manner offers two foundational design-based options to reduce HVAC energy use, which is the largest component of building energy use regulated by energy codes. This path allows design teams the flexibility to select the HVAC system option that best applies to their project. Picking one of these options is the basis of our targeted savings goal of 40%. However, additional savings may be possible by applying both options. While Path A allows for the selection of one of the two options, it is critical that careful consideration is given to the relationship between the envelope design and the HVAC system design.

Project Handoff

Also critical to high performance is operational handoff where information regarding design intent and system performance characteristics is communicated to the individuals tasked with building operations and maintenance. This process is initiated by the development of the Owners Project Requirements (OPR) which establishes the performance goals for a project and allows all parties involved in the project to determine whether they've met the owner's defined objectives and criteria. The OPR should detail the requirements of the building envelope and all systems using energy. It should be clear about specific programmatic requirements; operational patterns and schedules; plug load assumptions; and other factors that impact the building's energy consumption. The project team applies the OPR when developing the Basis of Design, which documents the reasoning and decisions made during the design phase of a project. The design team should regularly update these documents throughout design and construction. Finally, the BOD should be used to develop an operations manual for the owner describing how the building should be operated in order to achieve the performance goals set forth in the OPR.

PATH

A

STRETCH DESIGN STANDARD

The following system-based strategies outline a set of discrete energy efficiency measures that have the potential to deliver significant energy savings. These strategies represent fundamental approaches to high performance buildings that can be applied separately or in combination. It should also be recognized that there can be greater benefits from interactive effects when multiple strategies are combined. As cities and jurisdictions continue to target improved energy performance outcomes in buildings, these strategies can be incorporated into stretch codes, incentivized through energy efficiency programs, or adopted as a voluntary green building policy.

A.1 ENVELOPE AS A SYSTEM

Investing in a high performance thermal envelope—walls, roof and foundation—is one of the most important decisions a design team can make when it comes to delivering a high performance building that benefits occupants and owners over the life of the building. An efficient thermal envelope reduces a building's heating and cooling load, which in turn reduced the size of the building's mechanical system. This approach is a core component of Passive House building standards[2], which requires a high performance envelope by setting stringent limits for how much energy can be used by mechanical equipment to meet heating and cooling loads. This approach is covered in more detail in Section 2 under thermal energy demand intensity (TEDI).

In order to achieve a 40% reduction in energy loads as specified in this guide, the design team must address the following four measures that apply to the building envelope. The criteria associated with these four measures complement one another but are described individually to highlight the importance that each one plays in the overall outcome.

2 Published by the Passive House Institute (PHI) internationally and by the Passive House Institute U.S. (PHIUS) for North America.

A.1.1 Thermal Performance of the Envelope

The thermal envelope of a building is comprised of many different elements that can be combined into a wide variety of assembly types. Each decision represents an opportunity to improve the thermal performance of the envelope and impact the energy outcome of the building. From the earliest stages of design, the team must consider building components and configurations that take advantage of climate conditions and reduce thermal, solar and internal loads. To achieve a high performance thermal envelope the following strategies must be prioritized:

- Limit overall **window-to-wall ratio (WWR)** to 30% of gross wall area.
- Specify **high performance windows** with U-factors less than 0.30.
- Target low **area-weighted average U-factors** for opaque envelope elements and fenestration as indicated in Table 2.
- When the total area of penetrations from mechanical equipment exceeds 1 percent of the opaque above-grade wall area, the mechanical equipment penetration area shall be calculated as a separate wall assembly with a default U-factor of 0.5.

A.1.2 Reduced Thermal Bridges

Thermal bridging occurs when thermally conductive materials break the continuity of the insulation layer of an assembly and create a bridge between the exterior and interior thermal environments. Metal window frames, uninsulated parapet walls, slab edges, and metal or concrete structural extrusions often used to support balconies can create thermal bridges. Failing to adequately detail and construct these connections creates thermal bridges and greater thermal transmittance through the envelope, which can appreciably lower the performance of the assembly. The following strategies must be met in order to reduce thermal bridging conditions in the thermal envelope:

- Use the **area-weighted average** for the opaque envelope to account for thermal bridging. Structural elements that comprise a direct, uninsulated path to the building exterior and have a surface area that exceeds 0.5%

Table 2: U-factors for high performance building envelope

	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8
Total area weighted average U-factor for opaque walls and fenestration	0.099	0.099	0.087	0.071	0.071	0.053	0.053	0.050
Roofs, flat	0.028	0.028	0.028	0.023	0.023	0.023	0.020	0.020
Roofs, sloped	0.017	0.017	0.017	0.017	0.017	0.015	0.015	0.015

U-factors for assemblies shall be calculated on an area weighted average basis for the whole wall assembly and calculated in accordance with ASHRAE Standard 90.1 Appendix A and shall account for thermal bridging as described in Section b.

of area of the envelope component of which they are part (roof, wall, etc.) shall be included as discrete building areas in the area weighted average calculation of envelope thermal performance.

- Opaque portions of the envelope shall include **continuous insulation.** Structural elements of balconies and parapets that penetrate the building thermal envelope shall meet one of the following requirements:
  - » Structural elements that penetrate the building thermal envelope shall be insulated with continuous insulation having a minimum thermal resistance of R-5. This information shall be called out in the construction documents and adequately detailed.
  - » Structural elements that penetrate the building thermal envelope shall incorporate a minimum R-3 thermal break where the structural element penetrates the building thermal envelope. This information shall be called out in the construction documents and adequately detailed.
- Align glazing layer in all vertical fenestration with opaque wall insulation by meeting one of the following requirements:
  - » When the opaque wall includes continuous insulation the glazing layer shall be aligned within the thickness of the continuous insulation layer.
  - » When the opaque wall does not include continuous insulation, the glazing layer shall be aligned within the thickness of the wall insulation layer.

***Exception:** A thermal break with a minimum of R-3 shall be installed between the frames of the vertical fenestration and opaque elements of the building structure.*

- Specify **thermally efficient spacers and clips** to support cladding material. Low conductivity materials such as fiberglass and stainless steel can provide improved thermal efficiency of the opaque envelope.

A.1.3 Solar Load Management

Early design decisions related to building orientation, massing and window configuration can have significant impacts on solar exposure and available strategies for managing solar loads. By following a primary east-west orientation, design teams can use horizontal shading elements to limit summer thermal gains for glazing oriented to the south and leverage the daylight benefits from glazing oriented to the north. Uncontrolled solar gains through glazed assemblies can significantly drive cooling loads and can cause building occupant comfort challenges especially in spaces adjacent to south, east and west facing windows. Vertical fenestration exposed to direct sun shall reduce direct solar exposure by a minimum of 25% during cooling hours by utilizing any combination of the following strategies:

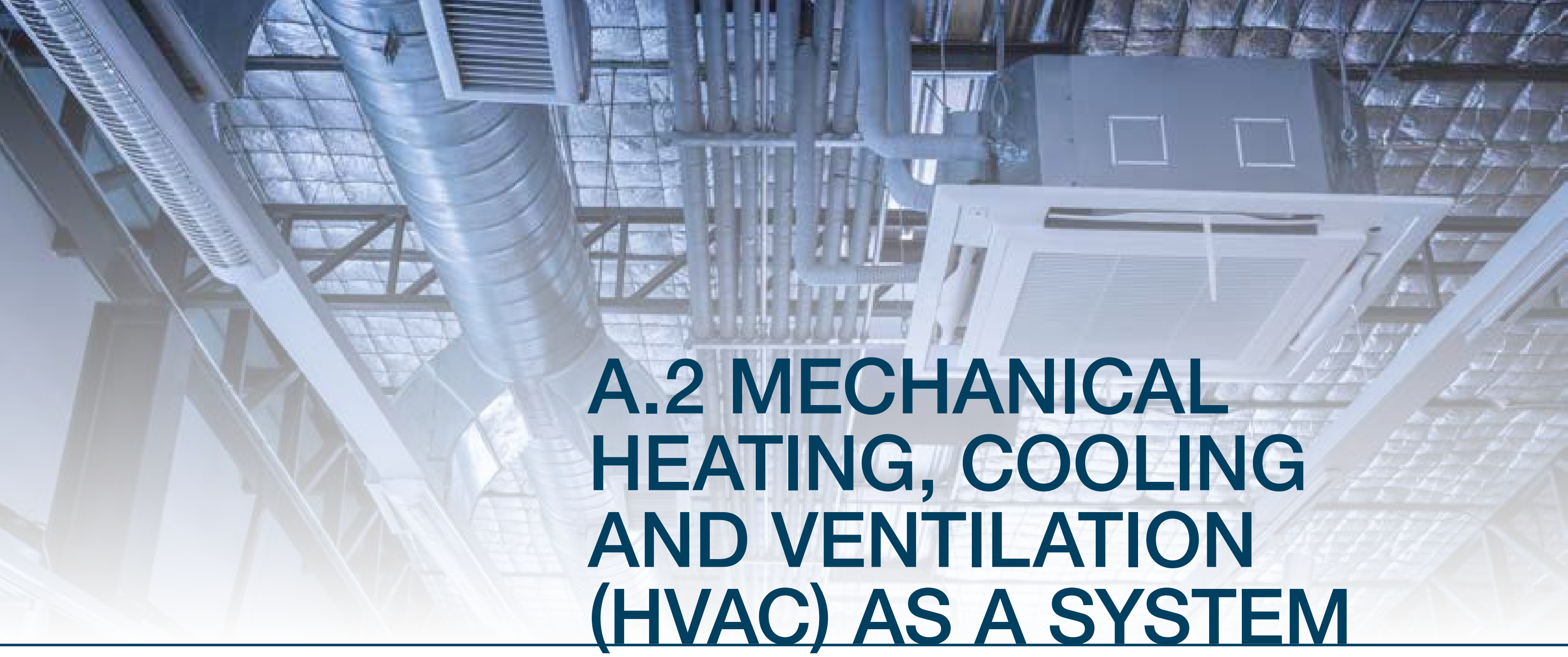
- Be shaded by **permanent projections** that have an area-weighted average projection factor of no less than 0.50. In some cases a vertical projection can be used to provide a greater or equal amount of shading from direct solar gain.

- Incorporate **automatically controlled shading devices** capable of providing at least 90% coverage of the fenestration in the closed position and modulating in multiple steps the amount of solar gain and light transmitted into the space in response to daylight levels or solar intensity.
- Vertical fenestration with **automatically controlled dynamic glazing** capable of modulating the tint of the window to regulate solar intensity. The dynamic glazing shall feature the following:
  - A labeled SHGC equal to or less than 0.12, lowest labeled VT no greater than 0.05 and highest labeled VT no less than 0.40.

A.1.4 Minimized Infiltration

The use of a continuous air barrier in building enclosures is required by most energy codes. This requirement aims to reduce uncontrolled airflow through the building assembly, which cuts back on heat loss and can improve occupant health and envelope durability by limiting water and vapor infiltration through the envelope. Ensuring performance of the air barrier starts with careful design and appropriate detailing. During construction, blower door testing verifies the continuity and quality of the installed air barrier and helps identify areas where continuity has been broken. This allows the design team to use the results of the blower door test to make adjustments while the air barrier is still accessible. The following strategies must be undertaken in order to minimize infiltration through the envelope:

- Include an **air barrier continuity plan** in construction documents. This must include a schedule of details showing typical joints between air-barrier materials, assemblies and fenestration.
- **Testing of air barrier** such that the air leakage rate is not greater than 0.25 cfm/ft^2 by conducting a whole-building blower door test of the building thermal envelope in accordance with ASTM E779 at a pressure differential of 0.3-inch water gauge (75 Pa).
  Projects taller than 75 feet or greater than 50,000 square feet can alternatively use one of the following options to verify the performance of the air barrier where the air leakage rate is not greater than 0.25 cfm/ft^2:
  - Conduct a floor isolation blower door test at a pressure differential of 0.3-inch water gauge (75 Pa) of the envelope area for the specific floor.
  - Compartmentalization testing at a pressure differential of 0.3-inch water gauge (75 Pa) of the enclosure area of individual units. The unit enclosure area shall be the combined area of all floors, walls and ceiling that abut the exterior of the building, another dwelling unit, a common area space, an unconditioned space, or another occupancy in a mixed-use building.



A.2 MECHANICAL HEATING, COOLING AND VENTILATION (HVAC) AS A SYSTEM

Total System Performance Ratio (TSPR)

Current energy codes focus on regulating the efficiency of components that do not value the performance of a whole HVAC system. Recent development of provisions for the state energy code in Washington centers on a code protocol that is meant to reward a systems approach to mechanical design. The HVAC TSPR[1] creates a code pathway for designers that considers the performance of the whole mechanical system, encourages the selection of high performance equipment, and leverages some of the efficient design approaches described in this section of the guide.

1 For additional information on the TSPR refer to this FAQ: https://fortress.wa.gov/es/apps/sbcc/File.ashx?cid=7294

Building systems associated with HVAC are key drivers of energy outcomes. Low-energy buildings often feature HVAC systems that leverage passive design principles by taking a whole-system approach to space conditioning and ventilation. Taken together, these active and passive systems must respond to a variety of factors, including internal loads such as occupant behavior and equipment as well as external factors such as climate and solar exposure. The design team's ability to reduce internal loads to the greatest extent possible, and right-size the equipment can have a large impact on overall building performance.

The following three measures outline an approach to improve the performance of the whole HVAC system. To achieve a 40% reduction in energy loads as specified in this guide, design teams must follow the criteria of the three measures. While inherently complementary, each measure is described individually to highlight the importance each plays in achieving the overall outcome.

A.2.1 Efficient Equipment Selection and Appropriate Sizing

The type and configuration of a building's mechanical system will greatly impact its performance outcomes. Following are several examples of currently available energy-efficient technologies that can reduce energy use associated with heating and cooling commercial buildings.

All mechanical equipment should be appropriately sized to the load it is meeting and should never be oversized as a rule. This is accomplished by basing all building shell and interior load assumptions on specific design characteristics of the building, and performing a second set of load calculations using part-load conditions. Several notable building programs and policies are setting space conditioning energy limits as a way to improve thermal envelope design and performance. See the sidebar on Thermal Energy Design Intensity (TEDI) below for additional information on this approach.

Select one of the following efficient heating and cooling equipment choices for the primary building loads

- **A variable capacity heat pump (VCHP) system** such as a variable refrigerant flow (VRF) or variable refrigerant volume (VRV) system that uses refrigerant instead of air as the primary medium for transporting heating and cooling energy. This system shall include the following efficiency characteristics:
  - » Reduced refrigerant piping runs in order to improve capacity. Manufacturers provide piping length and rise limits but any opportunity to further reduce piping runs can help improve system performance.

Thermal Energy Demand Intensity (TEDI)

TEDI provides a measure of the amount of energy a building requires to maintain an indoor temperature that is comfortable for occupants per square foot of conditioned floor area per year. It considers both passive gains (solar radiation and internal gains from appliances and lights) and losses (from thermal transmittance) as well as the energy used for the purposes of space and ventilation conditioning. This includes all central systems as well as terminal equipment regardless of fuel type. This is a useful metric for calculating energy consumption associated with heating and cooling loads as a function of the envelope design. TEDI can be calculated with modelling software and is the amount of heating and cooling energy delivered to the project that is outputted from any and all types of space conditioning equipment, per unit of gross floor area. TEDI targets are being applied in British Columbia's Step Code[1], and the Canada Green Building Council's (CaGBC) Zero Carbon Buildings Standard (CaGBC 2017).

1 https://www2.gov.bc.ca/gov/content/industry/construction-industry/building-codes-standards/energy-efficiency/energy-step-code

» A compressor that is capable of varying the amount of refrigerant provided to each zone based on the zone loads.

» A heat recovery unit that can reduce heating and cooling loads needing to be met by the outdoor unit. This reduction is achieved by allowing the system to provide simultaneous heating and cooling to multiple zones on the same refrigerant loop.

» In climates with low-temperature ambient conditions, include frost protection to defrost the outdoor heat exchanger and improve system efficiency when in heating mode.

- **A ground source heat pump (GSHP) system** that utilizes the high thermal capacitance of the earth as a source of heating and cooling. This system shall include the following efficiency characteristics:

» The ground heat exchange portion of the system shall be a closed-loop in which all the fluid is recirculated in order to prevent groundwater contamination.

» Specify variable speed pumps for systems where central pumping is larger than 1 horsepower (hp) and where multiple heat pumps are served by a single ground loop.

» Reduce pumping energy by controlling all pumps serving the GSHP system so that pumps only cycle on when there is a call for heating or cooling.

» The ground heat exchange portion of the piping shall be designed to attain a pressure drop no greater than 25 feet of static head under typical operation.

» Ground loop source side distribution system loss shall be no more than 40 feet of static head under typical operation.

A.2.2 Efficient Distribution Systems

An air-based distribution system is a common system used to heat and cool commercial buildings. Yet it's not nearly as efficient as a radiant or ductless distribution system. Air has a very low ability to carry heat, making it a poor medium for delivering and removing heat from space compared to water. Generally, this means that a larger mass of air is required to heat and cool a building with an air-based distribution system when compared to a hydronic system. Additionally, the fan power associated with moving that mass of air can result in a less efficient system when compared to hydronic systems.

The efficiency benefit of using refrigerant instead of air as the medium for transporting heating and cooling energy around the building comes from utilizing variable speed compressors with multiple-capacity control. These technologies, which are common in variable capacity heat pumps, can achieve high efficiencies by varying the amount of refrigerant provided to

Efficient Hot Water Heating and Conservation

The energy use associated with heating and distributing water is commonly the largest building load in some commercial building types, such as multifamily residential and restaurants. To achieve the 40% energy reduction targeted by the guide, the design team must consider strategies that reduce hot water heating and distribution. Following is a list of measures that can be taken:

- Utilize waste heat recovery from service hot water, heat recovery chillers, building equipment or process equipment or on-site renewable energy water-heating systems to meet at least 25% of the buildings annual hot water energy use.
- Specify high efficiency hot water heating equipment where the combined input-capacity-weighted-average equipment rating of all water heating equipment in the building is not less than 94% Et or 0.94 UEF.
- Specify ENERGY STAR® (EPA, 2016) labeled dishwashers and WaterSense (EPA) labeled fixtures for all lavatory faucets (2007) and showerheads (2018).

See Section *A.3 Efficient Service Water Heating* for specific requirements that can be adopted in order to reduce energy loads associated with hot water loads.

each zone depending on fluctuating zone loads. With numerous variable capacity heat pump options and configurations available, the design team can customize the system for each project.

The following section describes the strategies associated with a radiant distribution system and a ductless refrigerant approach, both of which offer significant efficiency improvements over air-based distribution systems.

Select one of the following efficient distribution methods:

- **A radiant heating and cooling system** with the following efficiency characteristics:
  - Select a radiant space-conditioning configuration by considering floor slabs, wall or ceiling mounted panels and chilled beams. Analyze each approach and select the configuration that best meets the specific space conditioning needs of each space.
  - No less than 90% of the conditioned floor area shall utilize radiant-based systems as the primary source for space conditioning. In these areas fans shall be limited to distribute ventilation air (for "active chilled beams" or similar systems that incorporate fan distribution systems directly into the design of the radiant system).
  - Optimize radiant system design and reduce pumping energy by using larger piping, reduced pipe runs and smooth transitions.

- » All pipes conveying heated or cooled fluid to the radiant equipment shall be insulated to a thickness no less than the nominal diameter of the pipe.
  - » All pumps over 1 horsepower (hp) in the distribution system shall have variable speed drives (VSDs) and single-phase pumps shall use electronically commutated motors (ECMs).
  - » Distribution pumps shall be controlled to eliminate continuous pumping. Pumps shall only cycle when there is a call for heating or cooling.
  - » Each separate zone shall have an independent method for zone control or balancing.
- **A refrigerant-based distribution system** with the following efficiency characteristics:
  - » Maximum refrigerant piping lengths shall be limited to manufacturer specifications.
  - » All indoor units shall include an expansion valve capable of continually controlling the flow rate of refrigerant in the system.
  - » Ductless interior fan coils shall not exceed 50 watts/ton of heating or cooling.
  - » Ducted indoor-units shall not exceed 100 watts/ton of heating or cooling and shall account for less than 25% of the total installed airflow. All installed ducted units shall be low/medium stat models (no more than ¾" SP dirty filter).
  - » Indoor-unit fans shall be set up to cycle on a call for heating or cooling only. Continuous fan operation shall not be used.

Natural and Mixed Mode Ventilation

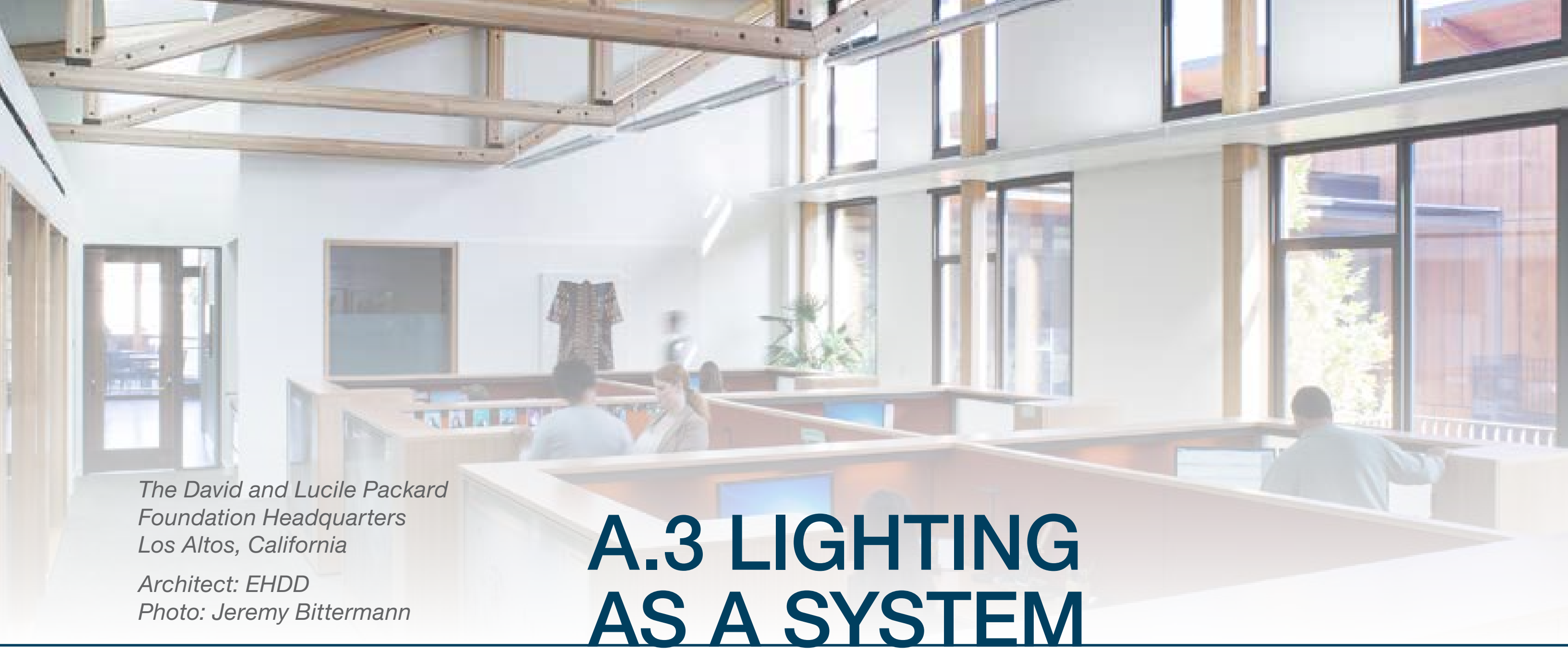
Natural and mixed mode ventilation refers to a hybrid approach to meeting space ventilation requirements (and sometimes cooling) that combines operable windows and the mechanical supply of fresh air from a DOAS. This passive design strategy can contribute to lower energy consumption by expanding the thermal comfort range when no mechanical HVAC is required. However, careful consideration needs to be given to exterior air quality and noise conditions as both of these factors can negatively impact building occupants. How this strategy uses controls to interface with the mechanical systems in the building should also be considered. This is especially important when combined with a radiant based system, as the DOAS would have to account for any additional dehumidification that might be needed. Heating and cooling control systems must be configured to lockout system operation when the building is in passive ventilation mode.

A.2.3 Efficient Ventilation

Meeting the ventilation requirements of a building can be most efficiently achieved by "decoupling" it from the heating and cooling systems. Known as a dedicated outdoor air system (DOAS), this system is designed to meet 100% of the code ventilation requirements for all indoor spaces. These systems can be highly tailored to leverage efficient strategies such as demand controlled ventilation (DCV) and energy recovery ventilation (ERV). When outside air does not require tempering, a DOAS can serve as an economizer, efficiently meeting the building's space-conditioning needs. In addition to being highly efficient, DOAS work well with the radiant and ductless distribution systems described in the previous section.

The following section describes the strategies associated with meeting all building ventilation and humidity control requirements with a DOAS.

- **Utilize a DOAS** to ventilate at least 90% of the building conditioned floor area that requires ventilation, which delivers 100% percent outdoor air without requiring operation of the heating and cooling system fans for ventilation air delivery.
- The system shall be **sized in accordance with Standard 62.1** (ASHRAE, 2016) and shall not be oversized for backup heating and cooling purposes.
- **Ventilation air shall not** use heating or heat recovery to warm supply air greater than 60°F when the radiant system is in cooling mode.
- The DOAS shall **include energy recovery ventilation** with the following efficiency characteristics:
  - » The capability to provide a change in the enthalpy of the outdoor air supply of not less than 60% of the difference between the outdoor air and return air enthalpies at design conditions.
  - » The control capability to redirect air around the energy recovery device when the difference between the return air temperature and the outside air temperature is 10% or less or when the energy recovery system is not is use.
  - » Designed to generate a pressure drop of no greater than 0.85 inches water column (w.c.) on the supply side and 0.65 inches w.c. on the exhaust side.



The David and Lucile Packard Foundation Headquarters
Los Altos, California

Architect: EHDD
Photo: Jeremy Bittermann

A.3 LIGHTING AS A SYSTEM

The wide proliferation of solid-state lighting combined with deep and ongoing improvements in the efficacy of LED lighting technology has resulted in very low-power lighting installations that often exceed the values in even the most efficient energy codes. This strategy offers an approach that varies from the current code approach of limiting the lighting power consumption. Rather, it sets minimum efficacy levels for common applications that reflect LED technology. This has the benefit of allowing lighting designer to focus on selecting highly efficient fixtures instead of focusing on total connected load.

The second component of this strategy requires that high efficacy fixtures be controlled by a networked lighting control (NLC) system. This type of networked system is capable of individual or even fixture-level control based on ambient light levels, occupancy, schedule or use patterns.

In order to realize the savings targeted by this guide, design teams need to meet the requirements indicated for high efficiency luminaires as well as those for lighting controls.

A.3.1 Lighting Controls

More advanced lighting control strategies are capable of individual space control when provided by a NLC system or a fixture-level control approach as provided by a luminaire level lighting control (LLLC) system. These systems can reduce lighting levels based on ambient light needs, occupancy, schedule, or use patterns. Interior lighting in spaces with a total of more than 100 watts of general lighting shall be controlled with the following:

- A **NLC system** that is capable of performing all of the following functions:
  - Networking of luminaires and devices at the room, space or area level where individual luminaires and control devices can exchange digital data with other luminaires and control devices on the system.
  - Luminaire and device addressability where each luminaire, sensor, controller and user interface device in the lighting system is uniquely identified and or addressed allowing the control zones to be configured and reconfigured independent of electrical circuiting.
  - Zoning where luminaires are grouped to form unique lighting control zones via software-defined means based on the control strategy being implemented.
  - Scheduling where the operation of lighting equipment is automatically controlled based on time of day.
  - Occupancy sensing control function that automatically turns on the lighting to not more than 50% power with manual control to 100%. They shall automatically turn off lights within 20 minutes after all occupants have left the space.
  - Continuous dimming where the control system provides sufficient resolution in output to support light level changes perceived as smooth.

Plug Load Control and Energy Monitoring

Many of the NLC packages currently available on the market include plug load control and energy monitoring functionality. The plug load control component leverages the scheduling or occupancy sensing capabilities of the lighting control system to control the power delivered to receptacles in the building. The energy monitoring component generally applies to the energy consumption at the luminaire level but can also apply to a group of luminaires depending on how the system is configured. This monitoring functionality is enabled by the control systems ability to wirelessly communicate data across the network through the use of a gateway. This energy consumption information is critical to reducing plug loads and should be made available to building occupants as a way to reinforce plug load reduction strategies. A number of manufactures include a user interface with their software packages.

  - Daylight harvesting and photocell control that can dim lights continuously from full light output to 10% of full light output or lower.
  - Task tuning or high-end trim that is field configurable where the light output can be set to meet the specific lighting needs of a space. At the time of installation or commissioning, the controls shall be configured for less-than-maximum state output for the luminaire(s) being controlled.
- Spaces with workstations shall provide **personal control at the task** level via networked means, where an individual can set their personal preferences using a personal control interface without having access to the system-wide settings. This includes such interfaces as a wireless dimmer switch and software-based approaches.

A.3.2 Highly Efficient Luminaires

This measure sets luminaire efficacy requirements. It differs from the lighting power density (LPD) approach used in most energy codes, which seeks to regulate total connected load. Luminaire efficacy describes the efficiency of the entire luminaire in converting energy to delivered light (in lumens/watt). It accounts for the entire luminaire, including the light source, ballast and luminaire losses.

Specify high efficacy luminaires that reflect the efficiency improvements from LEDs. Luminaires used in the applications indicated in Table 3 shall meet the indicated minimum efficacies.

Table 3: Minimum Efficacies by Application

Application	Minimum Efficacy (lumens/watt)
Interior directional	90
Case lighting	125
Troffer	125
Linear ambient	130
High bay	130

A.4 PLUG LOAD REDUCTION

Implementing strategies and building features that reduce plug and process loads (PPLs) is a critical component of improving whole building energy performance, especially as these loads continue to increase relative to the other primary building loads. PPLs are typically defined as electric loads that result from electric devices that are not responsible for space heating, cooling, water heating or lighting. Plug loads are generated by hard-wired and plug-in devices such as computers, monitors, printers, projectors, kitchen equipment, data center servers and, elevators, as well as other portable equipment such as space heaters and fans.

This strategy consists of three measures spanning from the design phase to the occupancy phase of a project. It requires cooperation and coordination of the design team, building owner, operator and occupants in order to be effectively implemented. The intent of the first measure is to enable the reduction of PPLs through the use of best design practices. The second measure focuses on PPL control approaches. And the final measure addresses a variety of policies and management practices that can be implemented by building occupants.

A.4.1 Reducing Plug Loads

PPLs represent a detail of a project that can be easy for designers or owners to lose sight of since they are not inherently integrated into the building form, structure and systems. The following section describes design considerations that can serve to reduce PPLs.

- **Designate a PPL champion** early in the design process and task this individual with making sure that PPL management and planning is integrated into the project design and followed through at each step of the project delivery process. The PPL champion is responsible for making sure that PPL goals and management is addressed in project documentation, including the Operational Performance Requirement (OPR) narrative, and ensuring that the PPL metering plan is completed and included in the owner/user guide and the operations and maintenance manual.
- **Permanently submeter PPLs** using one of the following approaches:
  - » Permanently meter all PPLs by aggregating them on a dedicated electrical circuit that is labeled at the electrical panel and organized by tenant or floor. Include information about dedicated PPL circuits and metering in the final construction documents. This will help ensure there is adequate space in the panel for the installation of the metering equipment, and that the electrical contractor is aware of the circuiting requirement.
  - » The designated PPL champion works with the design team and building owner to generate a detailed PPL metering plan. This metering plan should identify the most cost- effective metering approach based on how the electric circuits are configured and the type and density of plug load equipment. For example, larger pieces of equipment with irregular use patterns should be individually metered, while cubicles with similar equipment configurations and use patterns can apply a sample-based metering approach.
- **Provide project documentation** that includes the features of the design and control approach that will reduce PPLs to the building owner and PPL champion.

A.4.2 Plug Load Controls

Specifying building controls that are capable of turning off PPL equipment when they are not in use or when the building is not occupied is the most effective approach to managing and reducing PPLs.

- **Automatically control** 50% of all receptacles with a device or devices through one, or a combination of, the following approaches:
  - » Programmed to turn off receptacles at specific times based on a schedule or timer. Occupants should be able to manually override the device for to up to two hours.

    - Use an automated signal from another control (such as a luminaire level lighting control system (LLLC) or building energy management system (BEMS) or alarm system to turn receptacles off within 20 minutes of all occupants leaving a space.

    - Use an occupant sensor to turn receptacles off within 20 minutes of all occupants leaving a space.

- **Documentation** covering the PPL control strategies shall be provided to the building owner as part of the Operations Manual. This shall include information on the following:

    - An overview of the PPL control approach, including information on what equipment should be plugged into controlled receptacles.

    - An overview of the PPL metering approach and an introduction to actionable feedback from the user interface.

A.4.3 ENERGY STAR® Rated Appliances and Equipment

Beyond controlling receptacles, PPLs can be further reduced by requiring the use of efficient equipment and appliances. All equipment and appliances specified in the project documentation shall meet the following requirements:

- Comply with the equivalent criteria required to achieve the ENERGY STAR® label. This applies to, but is not limited to, the following equipment and/or appliance types:

    - Electronics
    - Office equipment
    - Commercial food service
    - Heating and cooling
    - Lighting
    - Water heating

- All task lighting shall utilize LED lamps.

- Water coolers shall be provided with timers capable of turning the power off during off hours.

A.5 RENEWABLE ENERGY SOURCES

The four system-based strategies in the previous sections are presented and described here as design guidance that can be applied to most building types and will likely result in significant energy savings across a variety of US climate zones. Energy from renewable energy sources must be included in most newly constructed buildings in order to meet higher building performance goals going forward and achieve zero energy buildings.

A.5.1 Renewable Energy

Table 4: Renewable Energy Targets

Building Type	Renewable Energy Targets (kBtu/sf/yr)
Office	4
Retail	6
School	5
Healthcare	10
Restaurant	10
Hotel	9
Apartment	5
Warehouse	2
All Others	6

Projects shall offset a portion of their energy load by either generating renewable energy onsite or by procuring renewable energy from offsite sources by meeting the requirements of one of the following options. The Renewable Energy Credits (RECs) associated with any energy produced on-site shall be retained and retired by the owner. Renewable energy generated by offsite sources shall be purchased for a duration of no less than 20 years. The duration shall be stated in the procurement documentation and retained by the building owner.

1. Building projects shall meet the renewable energy targets indicated in Table 4 from onsite photovoltaic energy systems, offsite procurement or through a combination of such sources. Renewable energy generated onsite shall be factored at 1.0 while all energy delivered or credited to the building project from offsite renewable energy sources shall be multiplied by a factor of 0.75. Any offsite renewable energy counted towards this renewable energy target shall be procured from any of the following three sources.

    a. Directly owned offsite renewable energy system that is owned by the same entity that owns the building.

    b. A community renewable energy system, which enables the building owner to purchase or lease renewable energy capacity from a community-owned solar system.

    c. A virtual Power Purchase Agreement (PPA) which enables the building owner to sign a contract with a renewable energy developer to buy renewable energy for a specified period of time.

2. Building projects shall contain onsite photovoltaic energy systems with a rated capacity of no less than 1.0 W/ft^2 multiplied by the horizontal projection of the gross roof area or other renewable energy systems that result in an equal or greater annual energy production.

3. Building project shall comply with the renewable energy chapter of *The Zero Code* (Architecture 2030, 2018).

4. Building project shall comply with the renewable energy requirements of the *International Green Construction Code (IgCC) - 2018* (ICC, 2018).

PATH

B

PRESCRIPTIVE STRETCH MEASURES

The following measures represent the most advanced code measures pulled from NBI's advanced codes work, including the 20% Model Stretch Code Provisions, the NYStretch-Energy Code 2018, and advanced code proposals developed for a variety of States. These measures are presented as a resource for jurisdictions looking to improve their energy code beyond ASHRAE Standard 90.1-2013 and reference the ASHRAE and IECC model codes by citing what code sections these stretch measures correspond to. This approach identifies measures that could be incorporated into local codes and therefore is more limited in scope when compared to the Path A measures, which describes strategies that look beyond what can be applied in an energy code. When combined with an efficient energy code (such as ASHRAE 90.1-2013 or IECC 2015) backstop, these prescriptive stretch measures will result in buildings with significantly reduced regulated loads. To achieve the 40% level of performance targeted by this guide all measures in Path B must be applied, and none of the measures may be traded off.

B.1 ENVELOPE REQUIREMENTS

Improvements in building envelope performance reduce heating and cooling loads and improve occupant comfort. Envelope components tend to be among the longest-lasting building elements. Therefore, it's important to invest in good building envelope performance by going beyond current code requirements. The following provisions represent opportunities to exceed most energy codes and deliver energy savings over the life of a building.

B.1.1 Opaque and Below-Grade Assemblies

Code Correspondence

2015 & 2018 IECC:
Section C402.1.4

ASHRAE 90.1-2013:
Section 5.5.3

Exception: *Where mechanical equipment has been tested in accordance with testing standards approved by the authority having jurisdiction, the mechanical equipment penetration area may be calculated as a separate wall assembly with the U-factor as determined by such test.*

Description of Measure

Reduces the transfer rate of heat through above- and below-grade opaque building assemblies by requiring more stringent U-factors and reducing thermal bridges.

The U-factors represent an increase in stringency over current codes and can be achieved through standard building practices.

Purpose

Reduce energy losses due to thermal conductance through the thermal envelope.

Technical Requirements

All wall, roof and floor assemblies that are part of the building thermal envelope shall meet the U-factor requirements shown in Table 5.

When the total area of penetrations from mechanical equipment exceeds 1% of the opaque above-grade wall area, the mechanical equipment penetration area shall be calculated as a separate wall assembly with a default U-factor of 0.5.

B.1.2 Fenestration Performance

Code Correspondence

2015 & 2018 IECC:
Section C402.4.3

ASHRAE 90.1-2013:
Section 5.5.4.3

Description of Measure

Reduces energy losses through the fenestration system by reducing the heat transfer rate (U-factor) allowed through the assembly. This measure also limits the amount of heat gain in the form of solar radiation (SHGC) allowed to pass through the glazed components while still requiring a certain amount of visible light transmission (important for quality daylighting) relative to the SHGC rating.

Purpose

Reduce energy losses via the building's envelope through the installation of more efficient fenestration assemblies.

Technical Requirements

All fenestration assemblies shall comply with the following requirements:

- The weighted average of all fenestration assemblies shall meet the U-Factor and SHGC requirements shown in Table 6.
- All vertical fenestration assemblies shall have a Visible Light Transmission (VLT) rating of no less than 1.5 times the SHGC rating of the assembly.

All fenestration assemblies shall be rated according to the requirements of the National Fenestration Rating Council (NRFC) with respect to the performance of the fenestration in the categories of U-Factor, SHGC and VLT, and air leakage rate.

Table 5: Insulation Requirements for Above and Below Grade Assemblies, Slab Edge and Below Grade Slabs

Climate Zone	1		2		3		4 except 4C		5 and 4C		6		7		8	
	Non Res	Res	Non Res	Res	Non Res	Res	Non Res	Res	Non Res	Res	Non Res	Res	Non Res	Res	Non Res	Res
ROOF																
Roof, Flat	0.048	0.039	0.039	0.039	0.039	0.039	0.029	0.029	0.029	0.029	0.029	0.029	0.025	0.25	0.025	0.025
Metal Building	0.041	0.035	0.035	0.035	0.035	0.035	0.033	0.033	0.033	0.033	0.028	0.026	0.026	0.026	0.023	0.023
Roof, Sloped	0.027	0.027	0.027	0.027	0.027	0.27	0.019	0.019	0.019	0.019	0.019	0.019	0.015	0.015	0.015	0.015
WALLS																
Mass	0.151	0.151	0.151	0.123	0.123	0.104	0.094	0.081	0.081	0.072	0.072	0.064	0.064	0.061	0.043	0.043
Metal Building	0.079	0.079	0.079	0.079	0.079	0.052	0.052	0.045	0.045	0.045	0.045	0.045	0.040	0.039	0.035	0.035
Streel Framed	0.077	0.077	0.077	0.064	0.064	0.064	0.058	0.058	0.050	0.050	0.044	0.044	0.044	0.038	0.033	0.033
Wood Framed and Other	0.064	0.064	0.064	0.064	0.064	0.064	0.058	0.058	0.046	0.046	0.046	0.046	0.046	0.046	0.029	0.029
FLOORS																
Mass	0.322	0.322	0.107	.087	0.074	0.074	0.051	0.046	0.051	0.046	0.046	0.046	0.038	0.038	0.034	0.034
Joist/ Framing	0.066	0.066	0.033	0.033	0.033	0.033	0.03	0.03	0.03	0.03	0.024	0.024	0.024	0.024	0.024	0.024
Slab-on-Grade Floors (unheated)	0.73	0.73	0.73	0.73	0.73	0.54	0.468	0.468	0.468	0.459	0.459	0.391	0.040	0.391	0.391	0.382
Slab-on-Grade Floors (heated)	0.70	0.70	0.70	0.70	0.70	0.70	0.65	0.619	0.619	0.619	0.58	0.58	0.55	0.55	0.55	0.336

Table 6: Performance values for vertical fenestration assemblies and skylights

	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8
VERTICAL FENESTRATION – U-FACTOR Windows rated in accordance with AAMA/WDMA/CSA 101/I.S/A440[A] (Class AW windows) and curtain walls								
Fixed fenestration	U-0.48	U-0.48	U-0.44	U-0.36	U-0.36	U-0.34	U-0.28	U-0.28
Operable fenestration	U-0.62	U-0.62	U-0.57	U-0.43	U-0.43	U-0.41	U-0.35	U-0.35
ALL OTHER VERTICAL FENESTRATION								
All fenestration	0.40	0.40	0.30	0.30	0.27	0.27	0.27	0.27
VERTICAL FENESTRATION - SHGC								
All fenestration	0.25	0.25	0.25	0.35	0.35	0.35	NR	NR
SKYLIGHTS								
U-Factor	0.65	0.55	0.50	0.48	0.48	0.48	0.48	0.48
SHGC	0.30	0.30	0.30	0.38	0.38	0.38	NR	NR

[A] Curtain wall, and storefront fenestration shall comply with the U-factor and SHGC requirements for Class AW fixed windows.

B.1.3 Reduced Thermal Bridges

Code Correspondence

2015 & 2018 IECC:
Section C402.1.4

ASHRAE 90.1-2013:
Section 5.5.3 and Appendix A

Description of Measure

Thermal bridging occurs where components of the envelope create an uninsulated pathway through the thermal envelope. These conditions frequently occur when the envelope design requires that different materials, such as at slab edges, window frames and parapets, interface with each other. This measure requires that insulation or thermal breaks are used to reduce thermal bridges associated with parapets, balconies and window frames.

Purpose

Reduce heating and cooling losses through the thermal building envelope as a result of a discontinuity in the thermal envelope.

Technical Requirements

Reduce thermal bridges in the thermal envelope by meeting the following requirements:

- Structural elements of balconies and parapets that penetrate the building thermal envelope shall comply with one of the following:
  - » Structural elements penetrating the building thermal envelope shall be insulated with continuous insulation with a minimum thermal resistance of R-3.
  - » Structural elements of penetrations of the building thermal envelope shall incorporate a minimum R-3 thermal break where the structural element penetrates the building thermal envelope.
- Align glazing layer in all vertical fenestration with opaque wall insulation by meeting one of the following requirements:
  - » When the opaque wall includes continuous insulation the glazing layer shall be aligned within the thickness of the continuous insulation layer.
  - » When the opaque wall does not include continuous insulation, the glazing layer shall be aligned within the thickness of the wall insulation layer.

Exception: *A thermal break with a minimum of R-3 shall be installed between the frames of the vertical fenestration and opaque elements of the building structure.*

B.1.4 Solar Load Management

Code Correspondence

2015 & 2018 IECC:
Sections C402.4.3 and C402.4.3.3

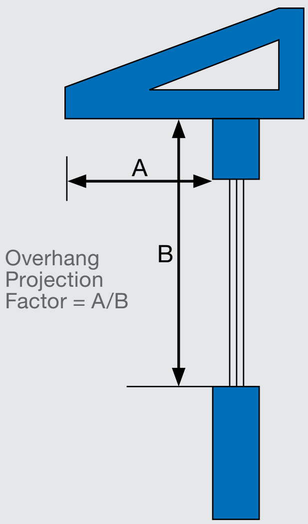
ASHRAE 90.1-2013: Section 5.5.4.5

Description of Measure

Reduce mechanical cooling loads as a result of uncontrolled solar gains through south-, east- and west-facing vertical fenestration.

Purpose

Uncontrolled solar gains through glazed assemblies can significantly drive cooling loads and can cause building occupant comfort challenges, especially in spaces adjacent to south-, east- and west-facing windows. This measure requires the adoption of a solar heat gain reduction strategy.



***Projection Factor** is the ratio of the external shading projection divided by the sum of the height or width of the fenestration perpendicular to the projection, and the distance from the edge of the fenestration closest to the external shading projection to the edge of the farthest point of the external shading projection, in consistent units.*

Technical Requirements

Vertical fenestration oriented towards the south, east and west shall utilize one of the following strategies to control and reduce solar heat gains. The building may be rotated up to 45 degrees to the nearest cardinal orientation for purposes of calculations and showing compliance.

- Shaded by permanent projections that have an area-weighted average projection factor (PF) of not less than 0.50. Note that in some cases, a vertical projection such as a fin can be used to provide a greater or equal amount of shading during periods of the day when spaces with direct solar exposure are occupied.
- Incorporate automatically controlled shading devices capable of modulating in multiple steps the amount of solar gain and light transmitted into the space in response to daylight levels or solar intensity that comply with all of the following:
    - » Exterior and interior shading devices shall be capable of providing at least 90% coverage of the fenestration in the closed position
- Vertical fenestration with automatically controlled dynamic glazing capable of modulating the amount of solar gain and light transmitted into the space in response to daylight levels or solar intensity. The dynamic glazing shall feature the following:
    - » A labeled SHGC equal to or less than 0.12, lowest labeled VT no greater than 0.05 and highest labeled VT no less than 0.40.
    - » A manual override shall be accessible by building occupants and override the operation of the automatic controls no longer than 4 hours.

B.1.5 Air Barrier Performance

Code Correspondence

2015 & 2018 IECC:
Section C402.5

ASHRAE 90.1-2013:
Section 5.4.3.1.3

Description of Measure

Reduces energy losses and moisture transmission through the building's thermal envelope due to infiltration by ensuring proper installation and performance of the air barrier. Air leakage testing or air barrier commissioning provides assurance that the measure will be effective.

Purpose

Reduce energy losses and moisture transmission through the building's thermal envelope due to infiltration through verification and commissioning of the code-required air barrier.

Technical Requirements

All buildings having a gross conditioned floor area less than 50,000 square feet and less than or equal to 75 feet in height shall conduct building thermal envelope testing of the continuous air barrier using the following method:

The building thermal envelope shall be tested and the measured air leakage shall not exceed 0.25 cfm/ft^2 (0.2 $L/s•m^2$) of the building thermal envelope area at a pressure differential of 0.3 inch water gauge (75 Pa) at the upper 95% confidence interval in accordance with ASTME E 779 or an equivalent method approved by the code official. A report that includes the tested surface area, floor area, air by volume, stories above grade, and leakage rates shall be submitted to the code official and the building owner.

All other buildings shall verify air barrier performance by one of the following methods:

- Conducting air leakage testing on the following portions of the building to verify that the area-weighted average of the tested surfaces areas does not exceed 0.25 cfm/ft2 of the building thermal envelope.

  1. The entire floor area of all stories that have any spaces directly under a roof.
  2. The entire floor area of all stories that have a building entrance or loading dock.
  3. Representative above-grade sections of the building totaling not less than 25 percent of the wall area enclosing the remaining conditioned space.

- Participation in a continuous air barrier-commissioning program conducted by a third-party entity responsible to the building owner. The commissioning program shall include:

  » Documentation of the continuous air barrier components included in the design documents

  » Third-party review of details to ensure continuity of the air barrier over the building envelope components and penetrations including, but not limited to, air barrier elements in the compliance checklist in section 6 of ICC G4-2012 Guideline for Commissioning.

  » A field inspection checklist clearly showing all requirements necessary for maintaining air barrier continuity and durability.

  » A final commissioning report showing compliance with the continuous air barrier requirements shall be provided to the building owner and code official.

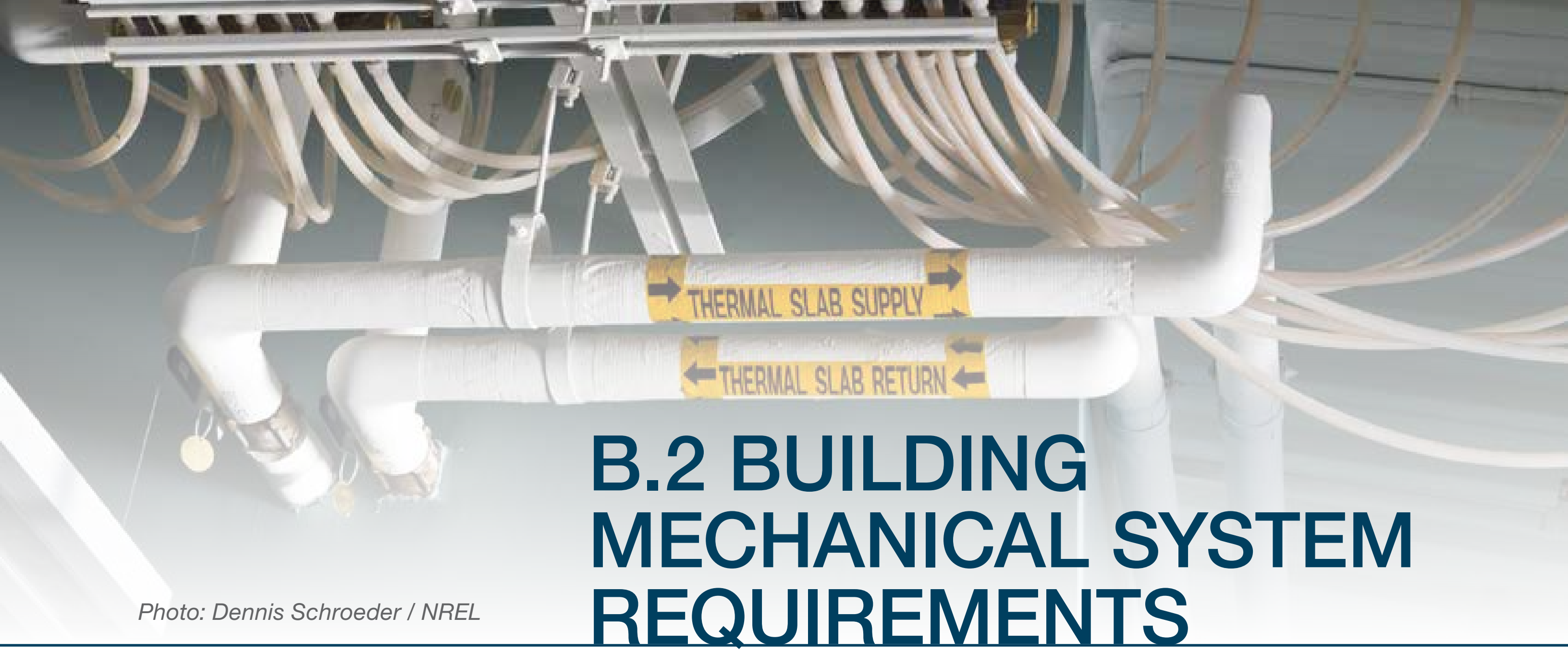


Photo: Dennis Schroeder / NREL

B.2 BUILDING MECHANICAL SYSTEM REQUIREMENTS

Continued efficiency improvements are possible in conventional mechanical systems, while significant efficiency gains are possible through better system configurations. Separating ventilation systems from heating and cooling systems provides opportunities to incorporate heat recovery into ventilation systems and improve the responsiveness of these systems to occupancy and vacancy characteristics for both ventilation and temperature control. System configurations that reduce fan energy also contribute to energy use reductions.

B.2.1 Efficient HVAC Equipment

Code Correspondence

2015 IECC: Section C403.2.3

2018 IECC: Section C403.3.2

ASHRAE 90.1-2013:
Section 6.8.1

Measure Description

Requires the selection of above-code levels of performance for HVAC equipment.

Purpose

Reduce the energy consumption associated with HVAC equipment through the installation of efficient equipment.

Technical Requirements

All specified space conditioning equipment shall meet the Consortium for Energy Efficiency (CEE) 2019 Commercial Unitary Air Conditioning and Heat Pump Specification[3] efficiency requirements or exceed the minimum HVAC efficiency provisions of ANSI/ASHRAE/IESNA 90.1 - 2016 by 10%.

3 https://library.cee1.org/system/files/library/7559/Appendix_B_2019_CEE_ComACHP_Unitary_Spec.pdf

B.2.2 Efficient Ventilation

Code Correspondence

2015 IECC:
Sections C403.2.7 and C406.6

2018 IECC:
Sections C403.7.4 and C406.6

ASHRAE 90.1-2013:
6.5.4.5 and 6.4.3.4

Measure Description

Requires the use of a Dedicated Outdoor Air System (DOAS) to meet 100% of the code ventilation requirements for all indoor spaces.

Purpose

Efficiently meet ventilation requirements by decoupling the ventilation system from the heating and cooling system.

Technical Requirements

All office, retail, education, and libraries shall provide outdoor air to each occupied space by a dedicated outdoor air system (DOAS) that delivers 100% outdoor air without requiring the operation of the heating and cooling system fans for ventilation air delivery.

Exception: *Spaces that are ventilated by a natural ventilation system per Section 402 of the International Mechanical Code.*

- The DOAS shall be capable of either energy recovery ventilation or demand control ventilation.
- Heating and cooling equipment fans, heating and cooling circulation pumps, and terminal units fans shall be controlled to cycle off, and terminal unit primary cooling air shall be shut off when there is no call for heating or cooling the zone.

B.2.3 Energy Recovery Ventilation

Code Correspondence

2015 IECC: Section C403.2.7

2018 IECC: Section C403.7.4

ASHRAE 90.1-2013:
Sections 6.4.3.4 and 6.5.3.3

Description of Measure

Builds upon existing ventilation control code requirements by requiring energy recovery systems for a wider range of exhaust air scenarios such as exhaust fans or outlets located in hallways and common spaces in multifamily buildings.

Purpose

Reduces energy use associated with tempering outside air by recovering energy from the exhaust air stream.

Technical Requirements

When multiple exhaust fans or outlets are located within a 30-foot radius of the outdoor air supply unit in buildings with a design supply airflow larger than 80 cfm, this shall be considered a single-exhaust location and shall include an energy recovery system.

B.2.4 HVAC Vacancy Control

Code Correspondence

2015 IECC: Section C403.2.4

2018 IECC: Required in Section C403.7.6

ASHRAE 90.1-2013: NA

Networked Guest Room Control System

A control system, accessible from the front desk or other central location, associated with a Group R-1 building that is capable of identifying the occupancy status of each guest room according to a timed schedule. It's capable of controlling HVAC in each hotel and motel guest room separately.

Description of Measure

Requires the use of a networked guest room control system to control HVAC in each hotel and motel guest room separately.

Purpose

Reduce guest room energy use by resetting the temperature set point during the period when a guest room is unoccupied or unrented.

Technical Requirements

Group R-1 buildings containing more than 50 guest rooms shall be provided with a networked control system in each guest room with the following functional requirements:

- Capable of, and configured to, automatically raise the cooling set point and lower the heating set point by not less than 4°F from the occupant set point within 30 minutes after the occupants have vacated the guest room.
- Capable of, and configured to, automatically raise the cooling set point to not lower than 80°F and lower the heating set point to not higher than 60°F when the guest room is unrented, has been continuously unoccupied for 16 hours, or the networked guest room control system indicates that the guest room is unrented and has been unoccupied for 16 hours.
- Capable of, and configured to, automatically turn off room ventilation and exhaust fans within 30 minutes of most recent occupancy, or isolation devices capable of automatically shutting off outdoor air supply and exhaust air.

Table 7: Fan Power Limitation

	Limit	Constant volume	Variable volume
Option 1: Fan system motor nameplate hp	Allowable nameplate motor hp	hp < CFM_s*0.0009	hp < CFM_s* 0.0011
Option 2: Fan system bhp	Allowable fan system bhp	bhp ≤ CFM_s X 0.00088 + A	bhp ≤ CFM_s X 0.0010 + A

For SI: 1 bhp = 735.5 W, 1 hp = 745.5 W, 1 cfm = 0.4719 L/S

Where:

CFM_s = The maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute.

hp = The maximum combined motor nameplate horsepower.

bhp = The maximum combined fan brake horsepower.

A = Sum of [PD X CFMD/4131]

Where:

PD = Each applicable pressure drop adjustment from Table 8 in. w.c.

CFM_D = The design airflow through each applicable device from Table 8 in cubic feet per minute.

Table 8 Fan Power Limitation Pressure Drop Adjustment

Device	Adjustment
Return air or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms	0.5 inch w.c. (2.15 inches w.c. for laboratory and vivarium systems)
Return and exhaust airflow control devices	0.5 inch w.c.
Exhaust filters, scrubbers or other exhaust treatment	The pressure drop of device calculated at fan system design condition
Particulate filtration credit: MERV 9 thru 12	0.5 inch w.c.
Particulate filtration credit: MERV 13 thru 15	0.9 inch w.c.
Particulate filtration credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2x clean filter pressure drop at fan system design condition
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition
Biosafety cabinet	Pressure drop of device at fan system design condition
Energy recovery device, other than coil runaround loop	For each airstream, (2.2 x energy recovery effectiveness - 0.5) inch w.c.
Coil runaround loop	0.6 inch w.c. for each airstream
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design conditions
Sound attenudation section (fans serving spaces with design background noise goals below NC35)	0.15 inch w.c.
Exhaust system serving fume hoods	0.35 inch w.c.
Laboratory and vivarium exhaust systems in high-rise buildings	0.25 inch w.c./100 feet of vertical duct exceeding 75 feet
Deductions	
Systems without central cooling device	-0.6 inch w.c.
Systems without central heating device	-0.3 inch w.c.
Systems with central electric resistance heat	-0.2 inch w.c.

For SI: 1 inch w.c. = 249 Pa, 1 inch = 25.4 mm. **w.c.:** water column **NC:** Noise criterion.

The following control system functional capabilities should be considered but do not preclude the other requirements listed in this section:

- Networked guest room control systems that can return the thermostat to default occupied set points 60 minutes prior to the time a guest room is scheduled to be occupied.
- Cooling systems that can limit relative humidity with a set point not lower than 65% relative humidity during unoccupied periods.
- Guest room ventilation systems having an automatic daily pre-occupancy purge cycle that provides daily outdoor air ventilation during unrented period at the design ventilation rate for 60 minutes, or at rate and duration equivalent to one air change.

B.2.5 Fan Power Limits

Code Correspondence

2015 IECC: Section C403.2.12

2018 IECC: Section C403.8.1

ASHRAE 90.1-2013:
Section 6.5.3.13

Description of Measure

Includes system-level requirements, including upper fan power limits, for most air-based HVAC systems as well as requirements for fan efficiency.

Purpose

Reduce energy consumption associated with fans by increasing the efficiency of the duct and distribution systems and by increasing the efficiency of fan motors.

Technical Requirements

Design all air distribution systems to meet the following criteria:

- Each HVAC system having a total fan system motor nameplate horsepower exceeding 5 hp (3.7 kW) at fan system design conditions shall not exceed the allowable fan system motor nameplate hp (option 1) or fan system bhp (option 2) shown in Table 7. This includes supply fans, exhaust fans, return/relief fans, and fan-powered terminal units associated with systems providing heating or cooling capability. Single-zone variable air volume systems shall comply with the constant volume fan power limitation.

Hospitals and laboratory systems that utilize flow control devices on exhaust or return to maintain space pressure relationships necessary for occupant health and safety or environmental control are permitted to use variable volume fan power limitation.

- Fans that aren’t integrated directly into packaged equipment shall have:
  - Electronic commutation for single-phase motors (brushless motors).
  - For fans attached to motors over 1hp, an FEG (Fan Efficiency Grade) of 71 or higher. Total efficiency of the fan at the point of operation should be within 10% of the fan’s maximum total efficiency.
- Duct systems shall be designed to operate at a static pressure of 2.0 inches water gauge (w.g.) (500 Pa) or less. ‘High’ pressure duct systems shall not be used. Specific building use areas with concentrated loads (i.e. lab areas) may include ‘Medium’ pressure duct systems (up to 3.0” w.g) if specific calculations of the need for increased airflow are provided.
- All fans shall be controlled based on actual loads or occupancy schedule rather than for continuous uncontrolled operation.

B.3 EFFICIENT SERVICE WATER HEATING

In certain building types, water-heating loads often represent a significant portion of the total building loads. Strategies to reduce these loads include reducing fixture flows, installing more efficient water-heating equipment, incorporating heat recovery systems, and reducing distribution system heat loss. Solar-thermal heating systems can also be deployed to serve hot water needs.

B.3.1 Service water system efficiency

Code Correspondence

2015 IECC:
Section C403.4.5 and C404.2

2018 IECC:
Section C403.9.5 and C404.2

ASHRAE 90.1-2013:
Section 6.5.6.2 and 7.4.2

Description of Measure

Requires the use of high-efficient equipment or reduce the load through the use of heat recovery and/or solar thermal water heating to improve the performance of hot water heating equipment serving commercial kitchens, laundries, dwelling units and sleeping units.

Purpose

Improve the performance of the hot water system by selecting efficient equipment or reducing the load through the use of heat recovery and/or solar thermal water heating.

Technical Requirements

All installed water-heating equipment and systems in buildings with commercial kitchens, laundries, dwelling units and sleeping units shall comply with one of the following requirements:

1. Where a singular piece of water-heating equipment serves the entire building, or where the combined input rating of multiple pierces of water-heating equipment is 1,000,000 Btu/h (293 kW) or greater, such equipment shall be a heat pump water heater with a rated coefficient of performance (COP) of no less than 2.0[4] or have a thermal efficiency (Et) or energy factor (EF) of no less than 90%.

2. Not less than 25% of the annual service water-heating requirement is provided from any combination of the following sources:

   a. Renewable energy generated onsite.

   b. Heat recovered onsite from the building's wastewater, or from air that would otherwise be exhausted to the outdoors without heat recovery.

4 The COP rating will be reported at the design leaving heat pump water temperature with an entering air temperature of 60°F or lower.

West Berkeley Public Library, Berkeley, CA.

Architect: Harley Ellis Devereaux
Photo: Mark Luthringer Photography

B.4 LIGHTING AND LIGHTING CONTROL SYSTEMS

Reduce connected lighting load by deploying state-of-the-art solid-state LED lamp technologies and control systems that respond directly to the presence of occupants. These systems ensure that lights are only in use when needed by occupants.

Increase the use of daylighting to offset electric lighting energy use.

Reduce the lighting power for exterior uses by requiring more efficient lamp and fixture technologies, and incorporate advanced controls, which can reduce exterior lighting use when not needed.

B.4.1 Interior Lighting Controls

Code Correspondence

2015 & 2018 IECC:
Sections C405.2.1 and C405.2.4

ASHRAE 90.1-2013:
Section 9.4.1.1

Description of Measure

Requires the use of occupancy sensors to control lighting in most interior spaces.

Purpose

Reduce lighting energy use through the installation of automatic lighting controls and adjustable lighting level strategies.

Technical Requirements

Interior lighting shall meet the following lighting control requirements:

- Occupant sensor controls shall be installed to control lights in the following space types:
    - Classrooms/lecture/training rooms.
    - Conference/meeting/multipurpose rooms.
    - Copy/print rooms.
    - Corridor/transition areas.
    - Dining areas.
    - Lounges/breakrooms.
    - Enclosed offices.
    - Open plan office areas.
    - Restrooms.
    - Storage rooms.
    - Locker rooms.
    - Other spaces 300 square feet (28 m^2) or less that are enclosed by floor-to-ceiling height partitions.
    - Warehouse storage areas.
- Luminaires serving the exit access and providing means of egress illumination required by Section 1006.1 of the *International Building Code,* including luminaires that function as both normal and emergency means of egress illumination shall be controlled by a combination of listed emergency relay and occupancy sensors, or signal from another building control system, that automatically reduces the lighting power by 50% when unoccupied for a period longer than 15 minutes.

  Exception: *Means of egress illumination serving the exit access that does not exceed 0.02 watts per square foot of building area is exempt from this requirement.*

- Shall incorporate a manual control to allow occupants to turn lights off.

B.4.2 Daylight Responsive Control Function

Code Correspondence

2015 & 2018 IECC:
Section C405.2.3

ASHRAE 90.1-2013:
Section 9.4.1.1

Description of Measure

Increases the portion of the building within a daylight area and reduces the general lighting threshold for when daylight responsive controls are required.

Purpose

The incorporation of daylighting controls to reduce lighting energy use while maintaining the desired illumination level within the daylighting zone.

Technical Requirements

The building shall have no less than 35% of its conditioned net floor area within a daylit zone meeting the following requirements:

- The daylit zone area shall be determined using the area definition specified by the most currently adopted base code.
- In spaces within the daylit zone with a total of more than 100 watts of general lighting the electric lights shall be controlled by daylight-responsive controls with the following capabilities:
    - » A 15-minute delay or other means to avoid cycling due to rapidly changing sky conditions.
    - » The lighting in each daylighting zone shall be separately controlled unless it is an adjacent zone associated with one building façade.

B.4.3 Interior Lighting Power Density

Code Correspondence

2015 IECC: Section C405.4.2.1

2018 IECC: Section C405.3.2.1

ASHRAE 90.1-2013: Section 9.5.1

Description of Measure

Reduced lighting power density values for a number of interior spaces reflecting advancements in LED lighting technologies.

Purpose

Reduce the energy consumption of lighting systems through the installation of efficient lamps, ballasts and luminaires.

Technical Requirements

Installed lighting power density (LPD) shall not exceed the values in Table 9. These LPD's shall be calculated based on luminaire efficiency, including lamps and ballasts.

Table 9: Interior Lighting Power Allowances – Building Area Method

Building Area Type	LPD
Auto Facility	0.64
Convention Center	0.70
Courthouse	0.74
Dining: bar lounge/leisure	0.69
Dining: cafeteria/fast food	0.66
Dining: family	0.61
Dormitory[a]	0.52
Exercise Center	0.65
Fire station[a]	0.50
Gymnasium	0.67
Health care clinic	0.68
Hospital[a]	0.86
Library	0.78
Manufacturing facility	0.60
Hotel/motel[a]	0.70
Motion picture theater	0.62

Building Area Type	LPD
Multifamily[a]	0.49
Museum	0.68
Office	0.69
Parking Garage	0.12
Penitentiary	0.67
Performing arts theater	0.85
Police station	0.68
Post office	0.62
Religious building	0.72
Retail	0.91
School/University	0.67
Sports arena	0.76
Town Hall	0.72
Transportation	0.51
Warehouse	0.41
Workshop	0.83

[a] Dwelling units are excluded. Neither the area of the dwelling units nor the wattage of lighting in the dwelling units is counted.

B.4.4 Exterior Lighting Power Allowance

Code Correspondence

2015 IECC: Section C405.5.1

2018 IECC: Section C405.4.2

ASHRAE 90.1-2013: Section 9.4.2

Description of Measure

Improved lamp efficacy for exterior site, landscape and architectural lighting reflecting advancements in LED lighting technologies.

Purpose

Reduce energy associated with site lighting through improved lamp efficacy.

Technical Requirements

All exterior lighting shall meet the following requirements:

- All luminaires with a total fixture wattage over 50W used for exterior lighting shall have a total luminaire efficacy of less than 100 lumens/Watt including light sources, drives and ballasts.
- All other luminaires shall have total luminaire efficacy of no less than 60 lumens/watt.

Exception: *solar-powered lamps not connected to an electrical service.*

B.4.5 Exterior Lighting Controls

Code Correspondence

2015 IECC: Section C405.2.5

2018 IECC: Section C405.2.6

ASHRAE 90.1-2013: Section 9.4.1.4

Description of Measure

Requires controls to automatically turn off lights during daylight hours and reduce the power of certain luminaires located in parking lots.

Purpose

Reduce energy use associated with parking lot lighting through the use of automatic controls that can reduce lighting power during unoccupied periods.

Technical Requirements

Outdoor parking area luminaires mounted 24 feet or less above the ground shall be controlled to automatically reduce the power of each luminaire by a minimum of 50% when no activity has been detected for at least 15 minutes.

B.5 ELECTRIC SYSTEMS

Plug and equipment loads to serve occupant needs are becoming one of the most significant loads in building energy use. Strategies that help ensure equipment is turned off when not in use and that the most energy-efficient technologies and appliances are installed can significantly reduce overall building energy use.

B.5.1 Plug Load Control and Power Management

Code Correspondence

2015 & 2018 IECC: NA

ASHRAE 90.1-2013: Section 8.4.2

Description of Measure

Requires that 50% of receptacles be controlled by time clock or occupancy sensor.

Purpose

Reduce energy use associated with plug loads by controlling receptacles and the utilization of power management settings to reduce computer related power consumption.

Technical Requirements

At least 50% of all 125 V, 15- and 20-amp receptacles in all private offices, conference rooms, rooms used primarily for printing and/or copying functions, break rooms, classrooms and individual workstations shall be automatically controlled by one of the following methods:

- Automatically turn receptacles off at specific programmed times, and allow the occupant to manually override the control device for up to two hours. An independent program schedule shall be provided for controlled areas of not more than 5,000 square feet and not more than one floor.
- Be an occupant sensor to automatically turn receptacles off within 20 minutes of all occupants leaving a space.
- Be an automated signal from another control or alarm system to automatically turn receptacles off within 20 minutes of all occupants leaving a space.

Exceptions:

» *Receptacles specifically designated for equipment intended for continuous operation (24 hours/day, 365 days/year).*

» *Spaces where an automatic shutoff would endanger occupant safety or security.*

All controlled receptacles shall be permanently marked to visually differentiate them from uncontrolled receptacles and are to be uniformly distributed throughout the space. Plug-in devices shall not be used to comply with this measure.

B.5.2 Efficient Elevators and Appliances

Code Correspondence

2015 & 2018 IECC: NA

ASHRAE 90.1-2013: NA

Description of Measure

Requires the use of traction elevators and the specification of ENERGY STAR® rated kitchen equipment.

Purpose

Reduce energy use associated with plug and equipment loads through the selection of more efficient equipment.

Technical Requirements

- New traction elevators with a rise of 75 feet or more shall have a power conversions system that meeting the following requirements:
    - » Induction motors with a Class IE2 efficiency ratings as defined by IEC EN 60034-30 (IEC, 2014), or alternative technologies, such as permanent magnet synchronous motors that have equal or better efficiency, shall be used.
    - » Transmissions shall not reduce the efficiency of the combined motor/transmission below that shown for the Class IE2 motor. Gearless machines shall be assumed to have a 100% transmission efficiency.
    - » Potential energy released during motion shall be recovered with a regenerative drive that supplies electrical energy to the building electrical system.
- The following kitchen equipment shall comply with the equivalent criteria required to achieve the ENERGY STAR® label:
    - » Commercial fryers
    - » Commercial dishwashers
    - » Commercial steam cookers or compartment steamers
    - » Hot food holding cabinets
    - » Commercial griddles
    - » Commercial ovens

B.5.3 Energy Metering

Description of Measure

Requires submetering of the primary building end-uses and the collection of energy data through the use of a data acquisition system.

Purpose

Helps assure that the building is performing to design levels through the gathering and reviewing of actual energy consumption data. Meaningful diagnostic information can be obtained by comparing energy use, outdoor temperature and building energy use over time.

Technical Requirements

Meters or other approved measurement devices shall be provided to collect energy use data for each end-use category specified in Table 10. These meters shall have the capability to collect energy consumption data for the whole building and/or for each separately metered portion of the building. Where multiple meters are used to measure any end-use category, the data acquisition system shall total all the energy used by that category. Not more than 5% of the measured load for each end-use category specified in Table 10 shall be from a load not within that category.

Table 10: Energy Use Categories

Load Categories
HVAC systems including hot water
Interior lighting
Exterior lighting
Receptacle circuits
Onsite generated electrical energy
Total electrical energy

The metering system shall include the following components and functionality:

- Meters and other measurement devices required by this section shall be configured to automatically communicate energy consumption data to the required data acquisition system. Source meters shall be any digital-type meter. Lighting, HVAC and other building systems that can monitor their energy consumption shall not require meters. Current sensors are an alternative to meters, provided that they have a tested accuracy of +/-1 percent. Required metering systems and equipment shall be able to provide not less than hourly data that is fully integrated into the data acquisition system and produce a graphical energy report.
- A data acquisition system shall have the capability to store data from the required meters and other sensing devices for not less than 5 years. The data acquisition system shall be able to store real-time energy consumption data and provide hourly, daily, monthly and yearly logged data for each end-use category required by Table 10.
- A permanent reporting mechanism shall be provided in the building that can be accessed by building operation and management personnel. The reporting mechanism shall be able to graphically provide the energy consumption data for each end-use category required by Table 10 for not less than every hour, day, month and year for the previous 5 years.

B.5.4 Onsite Renewable Energy

Description of Measure

Projects shall include renewable energy through onsite generation or offsite procurement by participating in a community solar project.

Purpose

Ensures that projects offset a portion of their energy load with energy from renewable sources.

Technical Requirements

Projects shall offset a portion of their energy load with energy from renewable sources through one of the following methods:

1. The total minimum rating of onsite renewable energy systems shall not be less than 1.71 Btu/hr/ft^2 (5.4 w/m^2) or 0.50 w/ft^2 of conditioned floor area.
2. The total minimum rating of onsite renewable energy systems shall not be less than 3 percent of energy use within the building for mechanical, service hot water heating and lighting loads.
3. Procure a percentage share membership securing electricity generating capacity of not less than 1.71 Btu/hr/ft^2 (5.4 w/m^2) or 0.50 w/ft^2 of conditioned floor area for a period of not less than 15 years in a community distributed generation system.

B.6 COMMISSIONING

Building system commissioning ensures that a building is delivered according to the Owners Project Requirements (OPR) and design specifications. Commissioned buildings operate more efficiently, are more comfortable, and have lower operations and maintenance costs.

B.6.1 Building System Commissioning

Description of Measure

This measure goes beyond code-level requirements by requiring that mechanical, renewable and service water-heating systems and their associated controls undergo commissioning by a registered design professional prior to final inspections.

Purpose

Building commissioning ensures proper sequencing and operation of critical building systems and can identify and correct errors and/or defects that can lead to inefficient operations and poor occupant comfort.

Technical Requirements

Commissioning of mechanical, renewable and service water-heating systems is required when one of the following conditions is met:

1. The building is greater than or equal to 25,000 square feet (2,325 m^2).
2. The total mechanical equipment capacity being installed is greater than 480,000 Btu/h (140.7 kW) cooling capacity.
3. The combined service water-heating and space-heating capacity is greater than 600,000 Btu/h (175.8 kW).

Prior to passing the final mechanical and plumbing inspections, a registered design professional or approved agency shall provide evidence of system commissioning and completion in accordance with the provisions of this section.

Construction document notes shall clearly indicate provisions for commissioning and completion requirements in accordance with this section and are permitted to refer to specifications for further requirements. Copies of all documentation shall be given to the owner or owner's authorized agent and made available to the code official upon request.

Mechanical systems, renewable energy and service water-heating systems shall include but are not limited to, at a minimum, the following systems (mechanical and/or passive) and associated controls:

1. Heating, cooling, air handling and distribution, ventilation and exhaust systems, and their related air-quality monitoring systems.

2. Air, water and other energy recovery systems.

3. Manual or automatic controls, whether local or remote, on energy using systems including but not limited to temperature controls, setback sequences and occupancy-based control, including energy management functions of the building management system.

4. Plumbing, including insulation of piping and associated valves, domestic and process water pumping and mixing systems.

5. Mechanical heating systems and service water-heating systems.

6. Refrigeration systems.

7. Renewable energy and energy-storage systems where installed generating capacity is not less than 25kW.

Other systems, equipment and components that are used for heating, cooling or ventilation and that affect energy use.

A. APPENDIX: REFERENCED STANDARDS

2015 International Energy Conservation Code; International Code Council, Country Club Hills, IL (2015)

ANSI/ASHRAE/IES Standard 90.1 – 2016 Energy Standard for Buildings Except Low-Rise Residential Buildings; ASHRAE, Atlanta, GA (2016)

ANSI/ASHRAE Standard 62.1-2016 Ventilation for Acceptable Indoor Air Quality; ASHRAE, Atlanta, GA (2016)

ANSI/ASHRAE/ICC/USGBC/IES Standard 189.1 – 2017 Standard for the Design of High-Performance of Green Buildings; ASHRAE, International Code Council, and U.S. Green Building Council, Atlanta, GA (2017)

ENERGY STAR® Dishwasher Specification; US EPA, Washington D.C (2016)

PHI – 16: Low Energy Building Standard; Passive House Institute, Darmstadt, Germany (2016)

Standard IEC/EN 60034-30; International Electrotechnical Commission, Geneva, Switzerland (2014)

WaterSense Specification for Showerheads Version 1.1; US EPA, Washington D.C. (2018)

WaterSense Specification for High-Efficiency Lavatory Faucet Specification; US EPA, Washington D.C. (2007)

Zero Carbon Building Standard; Canada Green Building Council, Ottawa, Canada (2017)

Zero Code; Architecture 2030, Santa Fe, NM (2018)

2019 Commercial Unitary Air Conditioning and Heat Pumps Specification (Appendix B); Consortium for Energy Efficiency, Boston, MA (2018)

2018 International Green Construction Code (IgCC); International Code Council; Country Club Hills, IL (2018)

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