Model Stretch Code Provisions
for a 20% 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

CONTENTS

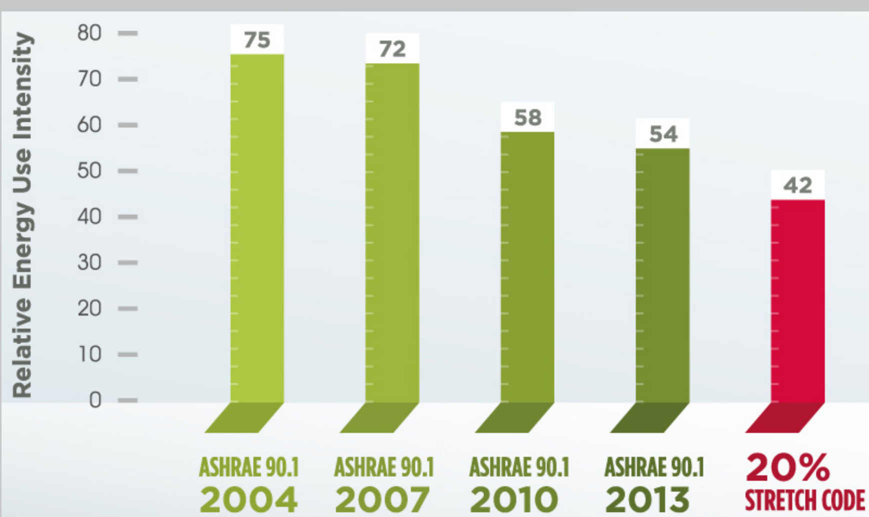
	Summary	**3**
	Measures	**7**
Case Study: Massachusetts		6
1.	**Envelope Requirements**	**9**
	1.1 Opaque and Below Grade Assemblies	9
	1.2 Fenestration Performance	10
	1.3 Reduced Solar Gains	11
	1.3. Air Barrier Performance	11
	1.4. Minimized Thermal Bridges	13
Case Study: Santa Monica, CA		14
2.	**Building Mechanical System Requirements**	**15**
	2.1. HVAC Equipment Options	15
	2.1.1 Efficient HVAC Equipment	15
	2.1.2 Dedicated Outdoor Air Systems	18
	2.2. HVAC Vacancy Control	19
	2.3. Energy Recovery Ventilation	19
	2.4. Fan Power Limits	20
Case Study: Boulder, CO		21
3.	**Service Water Heating**	**22**
	3.1. Heat Recovery	22
	3.2. Efficient Plumbing Fixtures	23
Case Study: Palo Alto, CA		**24**
4.	**Lighting and Lighting Control Systems**	**25**
	4.1. Interior Lighting Controls	25
	4.2. Daylight Responsive Control Function	26
	4.3. Interior Lighting Power Density	26
	4.4. Exterior Lighting Power Allowance	27
	4.5. Exterior Lighting Controls	29
5.	**Electric Systems**	**31**
	5.1. Plug Load Control	31
	5.2. Efficient Equipment	31
6.	**Pathways to Higher Performance**	**33**
	6.1. Limited Window to Wall Ratio	33
	6.2. Enhanced Mechanical System Selection and Decoupled Ventilation	33

SUMMARY

Many U.S. cities and states have adopted meaningful goals to reduce carbon impacts and energy use, often aligned with the recent Paris Climate Accord. To achieve these goals, local governments are looking for tools and strategies to guide improvements in the energy performance of the building stock. Although energy codes have been a critical tool to drive efficiency improvements in the building sector, jurisdictions have realized that current energy codes are not delivering the level of building energy performance needed to meet energy and climate action goals. Stretch codes, or sometimes called “reach codes,” are meant to provide a series of additional building performance strategies that can be adopted by cities as more aggressive or incentivized stretch standards to drive improvements in the building sector.

The 20% Stretch Code Provisions measures are the first outcome of a larger project that is focused directly on the technical development of stretch codes and standards, and on support for jurisdictions in adopting and implementing these policies. The goal of this effort is to develop a series of stretch codes/provisions for both commercial and residential construction of increasing stringency that can be adopted by cities as policy or incentive programs to support progress toward energy or climate goals. As jurisdictions move forward with the adoption of codes and policies that support building stock performance improvement, a set of increasingly stringent performance metrics are anticipated, ranging from a 20% improvement over baseline code performance to a policy that delivers zero energy performance in buildings.

Benefits of Adopting a Stretch Code



- Adopting stretch codes offers a winning solution for cities, the building industry, and utilities.
- Adopting stretch codes puts cities and states on the path to achieving zero carbon emissions from the building sector.
- Adopting stretch codes reduces building energy use and costs, reduces overall load on the power system and helps cities meet carbon reduction goals.
- Cities and states can exercise flexibility and creativity in the way they adopt codes—via policy, voluntary programs, incentives and other methods.

A key characteristic of the 20% Stretch Code Provisions is that it is designed to be 'adoptable' as an energy code strategy. This means that the measures will align with current code scope and limitations, and primarily impact building components that are currently regulated by city building departments. It is also focused on prescriptive strategies, which is what most building departments and design projects are familiar with.

This documentation describes a set of code strategies that represent a 20% performance improvement for commercial buildings over the ASHRAE 90.1-2013 code baseline (and approximately similar savings over the IECC 2015 baseline). The 20% Stretch Code Provisions a set of individual building performance measures which can serve as an overlay on current code requirements to achieve improved energy performance. The savings of these strategies have been analyzed by the Pacific Northwest National Lab (PNNL) to demonstrate achievement of the 20% threshold on average across the building stock. Cities which control their own code destiny (meaning they can adopt energy codes at the city level) can use part or all of the measures in this set of stretch code provisions to increase code stringency or adopt a stretch code strategy with incentives. They can also be aligned with local utility incentive programs to drive higher compliance rates. For jurisdictions that are not able to adopt codes outside of a state process, the stretch code strategies could be used as part of a zoning policy or in conjunction with utility or other incentives.

Residential

For residential building performance, a 20% improvement is based on the Home Energy Rating System (HERS), under which discrete performance improvements can be targeted using lower HERS scores as the basis of improvement. Residential characteristics are described in a separate document that is being developed by New Building Institute (NBI).

Commercial

In collaboration with the PNNL, NBI has developed technical content and requirements in the form of adoptable stretch energy measures for commercial buildings that can deliver 20% energy savings beyond the most recently implemented model energy codes (IECC 2016 and ASHRAE Standard 90.1 2013).

The 20% Stretch Code Provisions development process included reviewing content from variety of other advanced code sources (ASHRAE Standard 189.1, International Green Construction Code and NYStretch-Energy) and current best building practices. This research was used to inform the measures selection process and content development.

Subsequent work will focus on strategies which achieve 40% improvement over base code, and policies to deliver zero energy building energy performance.

The 20% Stretch Code Provisions

To achieve savings of approximately 20% over the 90.1-2013 baseline, the following strategies are described that should be adopted into stretch code language.

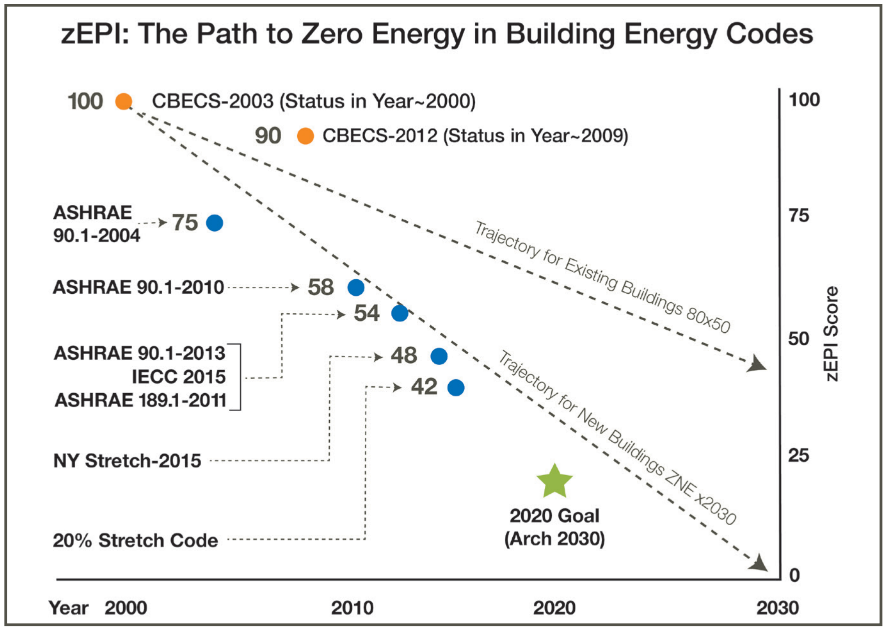
Envelope Performance Improvements

Improvements in building envelope thermal performance reduce heating and cooling loads and improve occupant comfort. Envelope components tend to be among the longest lasting building elements, so it is important to invest in good building envelope performance. The required strategies include:

- Reduce energy losses through fenestration by increasing window assembly thermal performance (U-factor), reducing solar gain (SHGC), and managing overall window area. These performance improvements should not significantly reduce visible light transmittance through the glazing, to maintain daylighting performance and occupant views.
- Increase insulation levels in all opaque building envelope components. These improvements represent a slight increase in stringency over current code and can be achieved through standard building practices.
- Reduce heat transmission losses through uninsulated building elements. Thermal bridging occurs at uninsulated structural elements, like slab edges, window frames, and framing elements. When these components are uninsulated, the thermal performance of the overall building envelope is significantly degraded.
- Improve air barrier performance to reduce energy loss and moisture transmission through the building's thermal envelopes. This strategy also requires testing and commissioning of the building air barrier at a time when improvements can be incorporated.

Lighting System Performance

- 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 to insure that lights are only in use when needed by occupants.
- Increase the use of daylighting to off-set electric lighting energy use.
- Reduce the lighting power for exterior spaces by requiring more efficient lamp and fixture technologies, and incorporate advanced controls which can reduce exterior lighting use when not needed.



Heating, Cooling, and Ventilation Systems

Continued efficiency improvements are possible in conventional mechanical systems, while significant efficiency gains are possible through better system configurations.

Adopt requirements for increased equipment efficiency, or select alternative mechanical systems with more efficient distribution strategies, particularly those that reduce or eliminate fan energy use.

- Separate ventilation systems from heating and cooling systems, and incorporate heat recovery into ventilation systems.
- Improve the responsiveness of these systems to occupancy and vacancy characteristics for both ventilation and temperature control.

Domestic Hot Water

Domestic hot water use is a particularly large component of building energy use in residential and hospitality project types.

- Reduce fixture flows to reduce overall hot water demand.
- Reduce supply run length and volume to reduce standby heat loss.
- Incorporate waste heat recovery or solar thermal systems to serve hot water needs.

Plug and Equipment Loads

As HVAC and lighting demand decrease, plug and equipment loads to serve occupant needs are becoming one of the most significant loads in building energy use. Strategies to insure that equipment is off when not in use, and to deploy the most energy efficient appliances can significantly reduce overall building energy use .

CASE STUDY: MASSACHUSETTS

In 2008, Massachusetts became one of the first states to adopt a stretch code appendix to its base building energy code that went into effect January 1, 2009. Since then, more than 200 of the state's 351 municipalities, representing approximately 70% of the population, have voluntarily adopted the stretch code. The code was one of the first implementing performance based requirements.The Green Communities Act of 2008, called for a stretch code designed to achieve a 30% energy reduction, and 40% emissions reduction beyond code minimum buildings. State officials also passed the Global Warming Solutions Act which set a goal for Massachusetts to achieve a 25% reduction of greenhouse gas emissions beyond 1990 levels by 2020, with an 80% reduction by 2050. To aid in this process, a Zero Net Energy Buildings Task Force created a plan to achieve zero energy performance in all new construction by 2030.

The state has an advanced base energy code which it is required to update every three years to reflect updates to the International Energy Conservation Code (IECC). As of January 1, 2017, the base code follows the 2015 IECC which includes a solar-ready roof requirement for all low-rise buildings. The appended stretch code is a simplification over its predecessor and is designed to save 20% more energy than the base code. Under the stretch code, new commercial buildings larger than 100,000 square feet must consume 10% less energy than that allowed by ASHRAE 90.1-2013. Because heating loads dominate building energy use in Massachusetts, the residential portion of the code focuses on sealing and insulation. The stretch code also requires new single family residential development to have a maximum Home Energy Rating System (HERS) index of 55, or alternatively Energy Star V3.1 or Passive House certification.

> Green Communities Act in 2008, which called for a stretch code designed to achieve a 30% energy reduction and 40% emissions reduction beyond code minimum buildings.

Voluntary implementation of the stretch code is incentivized by the inclusion of stretch code adoption as a requirement for a municipality to be awarded Green Community designation. Green Communities are eligible for additional state funding for energy efficiency and renewable energy projects. Studies have demonstrated the cost effectiveness of the stretch code for jurisdictions, and the estimated payback period on efficiency measures necessary to meet the stretch code is a maximum of three years.

MEASURES

This Stretch Code Package was developed to be used as an overlay document to national model energy codes by jurisdictions looking to adopt a selection of building energy measures that will deliver 20% energy savings beyond a base code. The modeling analysis to support this savings level uses ASHRAE 90.1-2013 as a baseline. These measures represent performance improvements above the base code, with specific code sections referenced for each measure. The measures are also cross-referenced to the 2015 IECC. This section is focused on commercial and multifamily building types. Residential stretch code strategies are provided in a separate document.

To achieve savings of approximately 20% over the 90.1-2013 baseline, the following strategies need to be adopted into stretch code language.

Measure	Description	ASHRAE 90.1-2013 Referenced Section	IECC 2015 Referenced Section
Opaque and Below Grade Assemblies	Reduces the transfer rate of heat through above and below grade opaque building assemblies by requiring more stringent U-factors. These can be achieved through standard building practices.	5.5.3	C402.1.4
Fenestration Performance	Reduces energy losses through the fenestration system by reducing the heat transfer rate (U-factor) allowed through the assembly. Also limits the amount of heat 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.	5.5.4.3	C402.4
Reduced Solar Gains	Controlling solar heat gains through glazed assemblies can significantly reduce cooling loads and can improve building occupant comfort in spaces adjacent to vertically glazed surfaces. This strategy is focused on south, and east/west-facing glazing that is subject to low-angle direct solar gain.	5.5.4.5	NA
Air Barrier Performance	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 and by requiring air leakage testing or air barrier commissioning.	5.4.3.1.3	C402.5
Minimized Thermal Bridges	Thermal bridging at structural elements can be significantly reduced by accounting for it in the design and construction phases and through improved detailing of the thermal envelope. This measure includes a list of prescriptive requirements that will help reduce common occurrences of thermal bridging and standards for calculating the U-factor of the thermal envelope to better account for the impact of thermal bridges.	Appendix A	NA

Measure	Description	ASHRAE 90.1-2013 Referenced Section	IECC 2015 Referenced Section
HVAC Equipment Options	Option 1: Above code levels of performance for HVAC equipment that generally correspond to the Consortium for Energy Efficiency's (CEE) Tier 2 requirements for HVAC equipment[1].	6.8.1	C403.2.3
	Option 2: Outdoor air for ventilation shall be provided to occupied zones by a dedicated outside air system (DOAS) that operates independently of building heating and cooling systems.	6.5.4.5 & 6.4.3.4	C403.4 & C406.6
HVAC Vacancy Control	Reduces guestroom energy usage by resetting the temperature set point during the period when a guestroom is unoccupied or unrented.	NA	C403.2.4
	Not applicable to referenced model codes	NA	
Energy Recovery Ventilation	Builds upon existing ventilation control requirements by ensuring that the system responds efficiently to the ventilation requirements of a space and does not waste energy when the system is operating in energy recovery mode.	6.43.4 & 6.5.3.3	C403.2.7
Fan Power Limits	Includes system level requirements including upper fan power limits for most air-based HVAC systems as well as requirements for fan efficiency.	6.5.3.13	C403.2.12
Heat Recovery for Service Water Heating	Specifies that 40% of hot water needs are met through a waste heat recovery method, such as drain water heat recovery, or using a solar thermal water heating system or a combination of both.	6.5.6.2	C403.4.5
Efficient Plumbing Fixtures	Requires the use of low-flow fixtures in kitchens and bathrooms.	NA	C404.5
Interior Lighting Controls	Requires the use of occupancy sensors to control lighting in all interior spaces.	9.4.1.1	C405.2.1 & C405.2.4
Daylight Responsive Control Function	Increases the portion of the building within a daylight area provided with automatic lighting controls.	9.4.1.1	C405.2.3
Interior Lighting Power Density	Reduced lighting power density values for a number of interior spaces reflecting advancements in solid state (LED) lighting technologies.	9.5.1	C405.4.3
Exterior Lighting Power Density	Reduced lighting power density values for parking lots, building facades and exterior doors reflecting advancements in LED lighting technologies.	9.4.2	C405.5.1
Exterior Lighting Control	Requires controls to automatically turn off lights during daylight hours and reduce the power of certain luminaires located in parking lots.	9.4.1.4	C405.5.1
Plug Load Control and power management	Requires that 50% of receptacles be controlled by time clock or occupancy sensor and the utilization of power management settings to reduce computer related power consumption.	8.4.2	NA
Efficient Kitchen Equipment	Requires the specification of Energy Star Rated kitchen equipment and appliances.	NA	NA
Additional Efficiency Measures			
Limited Window to Wall Ratio:	Limits the percentage of vertical glazed components to 30% of the total exterior wall area.	5.5.4.2.1	C402.4.1.1
Enhanced Mechanical System Selection plus DOAS	Requires the use of radiant or liquid-based delivery systems for space heating and cooling and a separate dedicated outdoor air system (DOAS) to supply 100% outdoor air to all spaces where ventilation is required.	6.5.4.5 & 6.4.3.4	C403.4 & C406.6
	Not applicable to referenced model codes	NA	

1 The Consortium for Energy Efficiency establishes three Tiers of above-code HVAC equipment efficiency.

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, so it is important to invest in good building envelope performance.

1.1 Opaque and Below Grade Assemblies

Description of Measure

Reduces the transfer rate of heat through above and below grade opaque building assemblies by requiring more stringent U-factors. These 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 requirements shown in Table 1.

Table 1: 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	0.054	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

Climate Zone	1		2		3		4 except 4C		5 and 4C		6		7		8	
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

CODE CORRESPONDENCE: **2015 IECC: Section C402.1.4**
ASHRAE 90.1-2013 Section 5.5.3

1.2 Fenestration Performance

Description of Measure

Reduces energy loses through the fenestration system by reducing the heat transfer rate (U-factor) allowed through the assembly. Additionally, this measure limits the amount of heat in the form of solar radiation (SHGC) allowed to pass through the glazed components while still requiring a certain amount of visible light transmission (VLT) relative to the SHGC rating.

Purpose

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

Technical Requirements

The weighted average of all fenestration assemblies shall meet the U-Factor and SHGC requirements shown in Table 2.

All vertical fenestration assemblies shall have a 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, Solar Heat Gain Coefficient and Visible Light Transmittance, and air leakage rate.

Table 2: Performance values for vertical fenestration assemblies and skylights

	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8
U-factor	0.40	0.40	0.30	0.30	0.27	0.27	0.27	0.27
SHGC	0.25	0.25	0.25	0.35	0.35	0.35	NR	NR
For Class AW windows[2] rated in accordance with AAMA/WDMA/CSA 101/I.S.2/A440								
Fixed Window U-factor	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 Window U-factor	U-0.62	U-0.62	U-0.57	U-0.43	U-0.43	U-0.41	U-0.35	U-0.35

CODE CORRESPONDENCE: **2015 IECC: Section C402.4**
ASHRAE 90.1-2013: Section 5.5.43.3

2 "AW" stands for Architectural which is a fenestration performance classification defined by the North American Fenestration Standard for product commonly used in high-rise and mid-rise building to meet increased loading requirements and limits on deflection and in building where frequent and extreme use of the fenestration products is expected.

1.3 Reduced Solar Gains

Description of Measure

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

Purpose

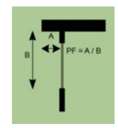
Uncontrolled solar gains through glazed assemblies can significantly drive cooling loads and can cause building occupant comfort challenges especially in spaces adjacent to south, east, and west facing windows. This measure requires the selection of a solar heat gain reduction strategy.

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 is allowed to 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. In some cases a vertical projection can be used to provide a greater or equal amount of shading during occupied hours.

Projection Factor – 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.



- 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
    - A manual override shall be accessible by building occupants and override the operation of the automatic controls for no longer than four hours
- 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 for no longer than 4 hours.

CODE CORRESPONDENCE: 2015 IECC: NA
ASHRAE 90.1-2013: Section 5.5.4.5

1.4 Air Barrier Performance

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 by requiring air leakage testing or air barrier commissioning.

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 the value specified in Table 3 shall conduct building thermal envelope testing of the continuous air barrier.

Table 3: Maximum Building Size Requiring Air Leakage Testing

Occupancy Groups R[3] & I[4]	All Other Occupancy and Use Groups
9,000	50,000

The building thermal envelope shall be tested in accordance with ASTM E 779 or an equivalent method approved by the code official. The measured air leakage shall not exceed 0.40 cfm/ft2 (0.2 L/s•m2) of the building thermal envelope area at a pressure differential of 0.3 inch water gauge (75 Pa).

Where the measured air leakage rate exceeds 0.40 cfm/ft2 (2.0 L/s•m2) but does not exceed 0.60 cfm/ft2 (3.0 L/s•m2), a diagnostic evaluation using a smoke tracer or infrared imaging shall be conducted while the building is pressurized and any leaks noted shall be sealed where such sealing can be performed without destruction of existing building components. In addition, a visual inspection of the air barrier shall be conducted and any leaks noted shall be sealed where such sealing can be performed without destruction of existing building components. An additional report identifying the corrective actions taken to seal leaks shall be submitted to the code official and the building owner, and shall be deemed to satisfy the requirements of this measure.

Buildings over 50,000 gross square feet shall verify air barrier performance by one of the following methods:

- Conducting air leakage testing on the following portions of the building:
    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. The measured air leakages shall be area-weighted by the surface areas of the building envelope addressed in items 1 through 3, to determine a whole building value. The test of the areas in item 3 shall be applied to the remainder of the building envelope surface area not included in items 1 through 3.
- 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 envelop 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

CODE CORRESPONDENCE: 2015 IECC: Section C402.5
ASHRAE 90.1-2013: Section 5.4.3.1.3

3 Residential Group R includes, among others, the use of a building or structure, or a portion thereof, for sleeping purposes when not classified as an Institutional Group I or when not regulated by the International Residential *Code. See section 310.2 in the International Building Code for a detailed definition of the Group R Use and Occupancy Classification.*

4 Institutional Group I occupancy includes, among others, the use of a building or structure, or a portion thereof, in which care or supervision is provided to persons who are or are not capable of self-preservation without physical assistance or in which persons are detained for penal or correctional purposes, or in which the liberty of the occupants is restricted. Institutional occupancies shall be classified as Group I-1, I-2, I-3 or I-4. See section 308.2 in the International Building Code for a detailed definition of the Group I Use and *Occupancy Classification.*

1.5 Minimized Thermal Bridges

Description of Measure

Thermal bridging occurs where structural elements and details create an uninsulated pathway through the building envelope. These conditions can be significantly reduced by accounting for them in the design and construction phases and through improved detailing of the thermal envelope. This measure requires that the impact of thermal bridging on overall envelope thermal performance be accounted for when demonstrating that envelope insulation requirements have been met.

Purpose

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

Technical Requirements

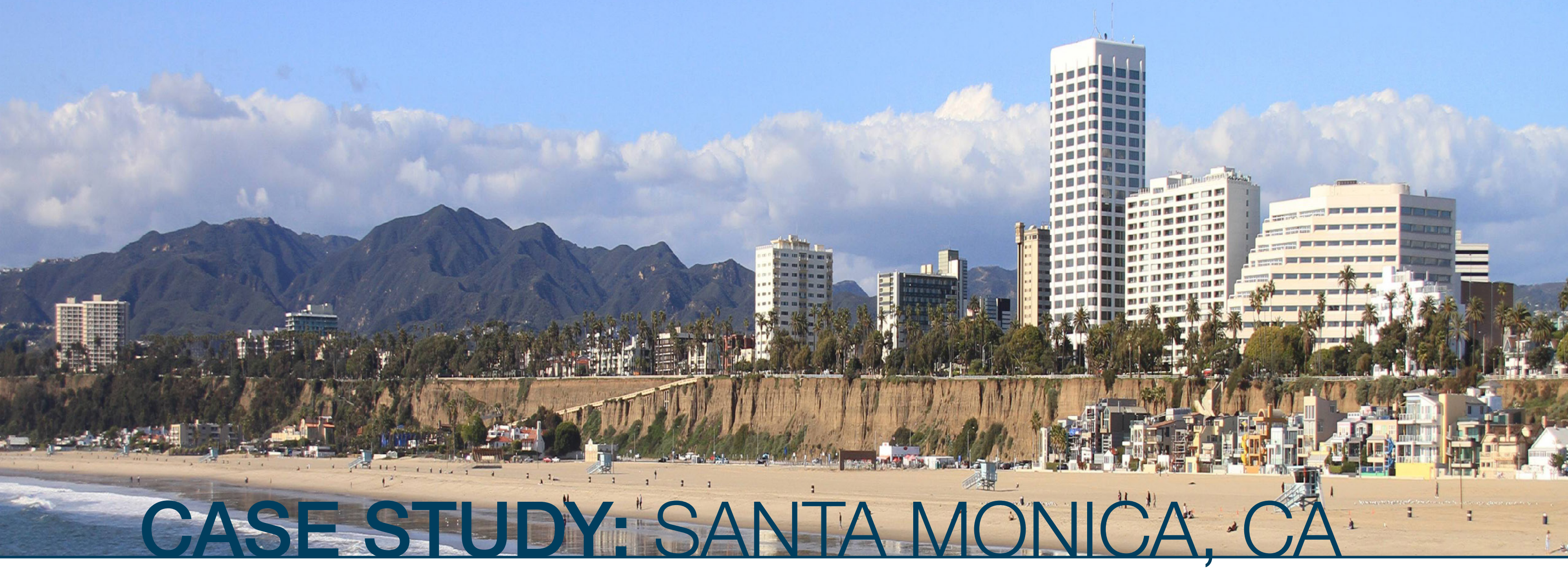
The impact of thermal bridging components shall be accounted for when demonstrating that the opaque envelope performance requirements for each building component (eg Roofs, Above-Grade Walls, Floors, etc.) have been met. The thermal impact of connections and structural elements shall be accounted for using the Area-Weighted Average of each envelope component.

Structural elements that comprise a direct, uninsulated path to the building exterior and have a surface area that exceeds 1% 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. (Exception: Structural elements which are insulated with at least R-5 continuous insulation, and those representing less than 1% of the area of a given envelope component, may be considered part of a representative assembly of that component.) Metal and wood framing members (i.e. joists and studs) which are part of a conventional framing assembly are not considered discrete structural elements in this context. These framing members are accounted for in the thermal performance calculations described in ASHRAE 90.1 Appendix A.

Structural elements and building details to be considered in this calculation include, but are not limited to:

- Floor-to-wall interfaces
- Wall-to-wall corner interfaces
- Floor & slab edges, especially projecting balconies
- Other structural interfaces
- Mechanical fasteners that compose more than 0.5% of the assembly area

CODE CORRESPONDENCE: **2015 IECC: NA**
ASHRAE 90.1-2013: Appendix A



CASE STUDY: SANTA MONICA, CA

Keeping with its reputation as a frontrunner in sustainable policy, in October 2016, the Santa Monica City Council adopted a ZE ordinance and stretch code (referred to as a “reach” code) requiring all new single-family residential construction to achieve zero net energy (ZNE). This makes Santa Monica the first city in the world to adopt a mandatory policy. The code went into effect a full three years before 2020, the date of a statewide ZE goal for residential construction in California. The code was passed unanimously as part of Santa Monica’s path to achieve carbon neutrality by 2050.

Prior to passing the code, Santa Monica analyzed the cost-effectiveness of a local ZE standard. The study confirmed that given the rising cost of grid power, ZE offers long-term benefits for homeowners. Meeting the solar requirement adds less than 3% to project costs on average.

The ZE ordinance is only one component of Santa Monica’s energy stretch code. The code also requires that all new residential projects be designed to consume 15% less than the energy budget allowed by the already-ambitious 2016 California energy code, with commercial construction using 10% less energy. Residential buildings in Santa Monica must meet both the ZE and energy consumption targets, neither of which guarantees compliance with the other. Furthermore, the city requires photovoltaic installations on all new construction—both residential and commercial—and is the fourth municipality in California to do so. The State of California only requires that 15% of newly constructed rooftops be solar ready.

Prior to passing the code, Santa Monica analyzed the cost-effectiveness of a local ZE standard. The study confirmed that, given the rising cost of grid power, ZE offers long-term benefits for homeowners, with the solar requirement adding less than 3% to project costs on average. Santa Monica opted to use the ZE (or zero net energy) definition as defined in the California Green Building Standards Code, which relies on time dependent valuation (TDV) of energy. Under TDV, energy is assigned a value on an hourly basis. For a building to achieve ZE with TDV, the value of the energy produced on-site by renewable resources (most often photovoltaic panels) must equal the value of the energy consumed by the building annually. This definition reflects the cost of energy for both consumers and the utility.

Santa Monica is also working to ensure larger buildings meet the state’s ZE goals for commerical constriction by 2030. The October 2016 stretch code requires that all new high-rise residential, non-residential, hotels, and motel buildings are constructed to use 10% less energy than what is required.

To assist in the transition, the city’s Office of Sustainability and the Environment provided resources for the residential building community to become more familiar with ZE design. Santa Monica’s policy will help drive the ZE market forward and familiarize the design community with ZE design and construction practices.

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.

2.1 Efficient HVAC Equipment

Measure Description
Requires the selection of either above code levels of performance for HVAC equipment that corresponds to the Consortium for Energy Efficiency's (CEE) Tier 2 requirements for HVAC equipment, or the use of dedicated outdoor air systems (DOAS).

Purpose
Reduce the energy consumption associated with heating, air conditioning, and ventilation through the installation of efficient equipment.

Technical Requirements
Projects must comply with the requirements of number 2.1.1 or number 2.1.2 below:

2.1.1 The selection of more efficient space conditioning equipment that meets the following requirements:

- All HVAC equipment shall meet the minimum efficiency requirements in Table 4 through Table 7.
- Newly installed open-circuit cooling towers serving condenser water loops which total 900 gpm or greater, shall have a rated efficiency of no less than 80 gpm/hp[5].
- Gas and oiled fired boilers shall have a minimum thermal efficiency of 94.5%[6].

5 Test procedure: CTI ATC–105 and CTI STD-201
6 Test procedure: 10 CFR part 430 and 431

Table 4: Unitary Air Conditioners

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air Conditioners, Air Cooled (Cooling Mode)	<65,000 Btu/h	All	Split System	16 SEER 13 EER	AHRI 210/240
			Single Package	16 SEER 12 EER	AHRI 340/360
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.2 EER 14 IEER	
		All Other	Split System and Single Package	12 EER 13.8 IEER	
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	12.2 EER 13.2 IEER	
		All Other	Split System and Single Package	12 EER 13 IEER	
	≥240,000 Btu/h and <760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.8 EER 12.3 IEER	
		All Other	Split System and Single Package	10.6 EER 12.1 IEER	
	≥760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.4 EER 11.6 IEER	
		All Other	Split System and Single Package	10.2 EER 11.4 IEER	
Air Conditioners, Water Cooled	<65,000 Btu/h	All	Split System and Single Package	14 EER	AHRI 210/240
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	14 EER 15.3 IEER	AHRI 340/360
		All Other	Split System and Single Package	13.8 EER 15.1 IEER	
	≥135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	14 EER 14.8 IEER	
		All Other	Split System and Single Package	13.8 EER 14.6 IEER	
Air Conditioners, Evaporatively Cooled	<65,000 Btu/h	All	Split System and Single Package	14 EER	AHRI 210/240
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	14 EER 15.3 IEER	AHRI 340/360
		All Other	Split System and Single Package	13.8 EER 15.1 IEER	
	≥135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	13.5 EER 14.3 IEER	
		All Other	Split System and Single Package	13.3 EER 14.1 IEER	

Table 5: Unitary Heat Pumps

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air Cooled (Cooling Mode)	<65,000 Btu/h	All	Split System	16 SEER 13 EER	AHRI 210/240
			Single Package	16 SEER 12 EER	AHRI 340/360
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.8 EER 13.6 IEER	
		All Other	Split System and Single Package	11.6 EER 13.4 IEER	
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.9 EER 11.6 IEER	
		All Other	Split System and Single Package	10.7 EER 11.4 IEER	
	≥240,000 Btu/h and <760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.3 EER 10.6 IEER	
		All Other	Split System and Single Package	10.1 EER 10.4 IEER	
Air Cooled (Heating Mode)	<65,000 Btu/h	-	Split System	9 HSPF	AHRI 210/240
		-	Single Package	8.2 HSPF	
	≥65,000 Btu/h and <135,000 Btu/h	-	47°F db/43°F wb Outdoor Air	3.4 COP	AHRI 340/360
		-	17°F db/15°F wb Outdoor Air	2.4 COP	
	≥135,000 Btu/h	-	47°F db/43°F wb Outdoor Air	3.2 COP	
		-	17°F db/15°F wb Outdoor Air	2.1 COP	
Water Source (Cooling Mode)	<135,000 Btu/h	All	86°F Entering Water	14 EER	ISO-13256-1
Water Source (Heating Mode)	<135,000 Btu/h	-	68°F Entering Water	4.6 COP	ISO-13256-1

Table 6: Variable Refrigerant Flow Multisplit Air-Conditioners

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
VRF Air Cooled (Cooling Mode)	<65,000 Btu/h	All	Multisplit System	16 SEER 13 EER	AHRI 1230
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Multisplit System	11.7 EER 14.9 IEER	
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Multisplit System	11.7 EER 14.4 IEER	
	≥240,000 Btu/h	Electric Resistance (or None)	Multisplit System	10.5 EER 13 IEER	

Table 7: Variable Refrigerant Flow Multisplit Heat Pumps

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
VRF Air Cooled (Cooling Mode)	<65,000 Btu/h	All	Multisplit System	16 SEER 13 EER	AHRI 1230
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Multisplit System	11.3 EER 14.2 IEER	
			Multisplit System with Heat Recovery	11.1 EER 14 IEER	
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Multisplit System	10.9 EER 13.7 IEER	
			Multisplit System with Heat Recovery	10.7 EER 13.5 IEER	
	≥240,000 Btu/h	Electric Resistance (or None)	Multisplit System	10.3 EER 12.5 IEER	
			Multisplit System with Heat Recovery	10.1 EER 12.3 IEER	
VRF Air Cooled (Heating Mode)	<65,000 Btu/h	-	Multisplit System	9.0 HSPF	
	≥65,000 Btu/h and <135,000 Btu/h	-	47°F db/43°F wb Outdoor Air	3.4 COP	
			17°F db/15°F wb Outdoor Air	2.4 COP	
	≥135,000 Btu/h	-	47°F db/43°F wb Outdoor Air	3.2 COP	
			17°F db/15°F wb Outdoor Air	2.1 COP	
VRF Water Source (Cooling Mode)	<135,000 Btu/h	All	Multisplit System 86°F Entering Water	14 EER	
			Multisplit System with Heat Recovery 86°F Entering Water	13.8 EER	
VRF Water Source (Heating Mode)	<135,000 Btu/h	-	68°F Entering Water	4.6 COP	

CODE CORRESPONDENCE: **2015 IECC: Section C403.2.3**
ASHRAE 90.1-2013: Section 6.8.1

2.1.2 Meet all ventilation requirement with the supply of 100% outside air using a DOAS that meets the following requirements:

- Outdoor air for ventilation shall be provided to occupied zones by a dedicated outside air system (DOAS) that operates independently of building heating and cooling systems.
- DOAS system shall include energy recovery capabilities and be controlled based on occupancy (demand control ventilation) in conjunction with applicable building ventilation requirements.
- Control system should be capable of cycling off zone heating and cooling equipment fans and or pumps when there is no call for heating or cooling in the zone

CODE CORRESPONDENCE: **2015 IECC: C403.4 and C406.6**
ASHRAE 90.1-2013: 6.5.4.5 and 6.4.3.4

2.2 HVAC Vacancy Control

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

Reduces guestroom energy usage by resetting the temperature set point during the period when a guestroom is unoccupied or unrented.

Technical Requirements

Each guest room in Group R-1 buildings containing over 50 guest rooms shall be provided with a networked control system 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.

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, and is capable of controlling HVAC in each hotel and motel guest room separately.

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 percent 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 periods at the design ventilation rate for 60 minutes, or at rate and duration equivalent to one air change.

CODE CORRESPONDENCE: 2015 IECC: Section C403.2.4
ASHRAE 90.1-2013: NA

2.3 Energy Recovery Ventilation

Description of Measure

Builds upon existing ventilation control code requirements by ensuring that the system responds efficiently to the ventilation requirements of a space and includes an energy recovery system.

Purpose

Reduces energy use associated with ventilation requirements by using control strategies to optimize ventilation performance by automatically reducing outdoor air intake flow based on occupancy and recovering energy from the exhaust air stream.

Technical Requirements

Multiple-zone VAV systems with DDC of individual zone boxes reporting to a central control panel shall include an energy recovery ventilation system meeting the requirements of the base energy code (section 6.5.6.1 in ASHRAE 90.1 - 2013). In addition, the energy recovery ventilation system shall be designed to generate a pressure drop of no greater than 0.85 in. w.c. on the supply side and 0.65 in. w.c. on the exhaust side, and shall be capable of the following:

- 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
- When the difference between the return air temperature and the outside air temperature is 10°F or less, or when the energy recovery system is not in use, the exhaust air is redirected around the energy recovery device through the use of bypass dampers to reduce resistance to airflow
- When combined with an economizer, operation of the economizer shall be controlled to take precedence over operation of the energy recovery system

CODE CORRESPONDENCE: **2015 IECC: Section C403.2.7**
ASHRAE 90.1-2013: Sections 6.4.3.4 and 6.5.3.3

2.4 Fan Power Limits

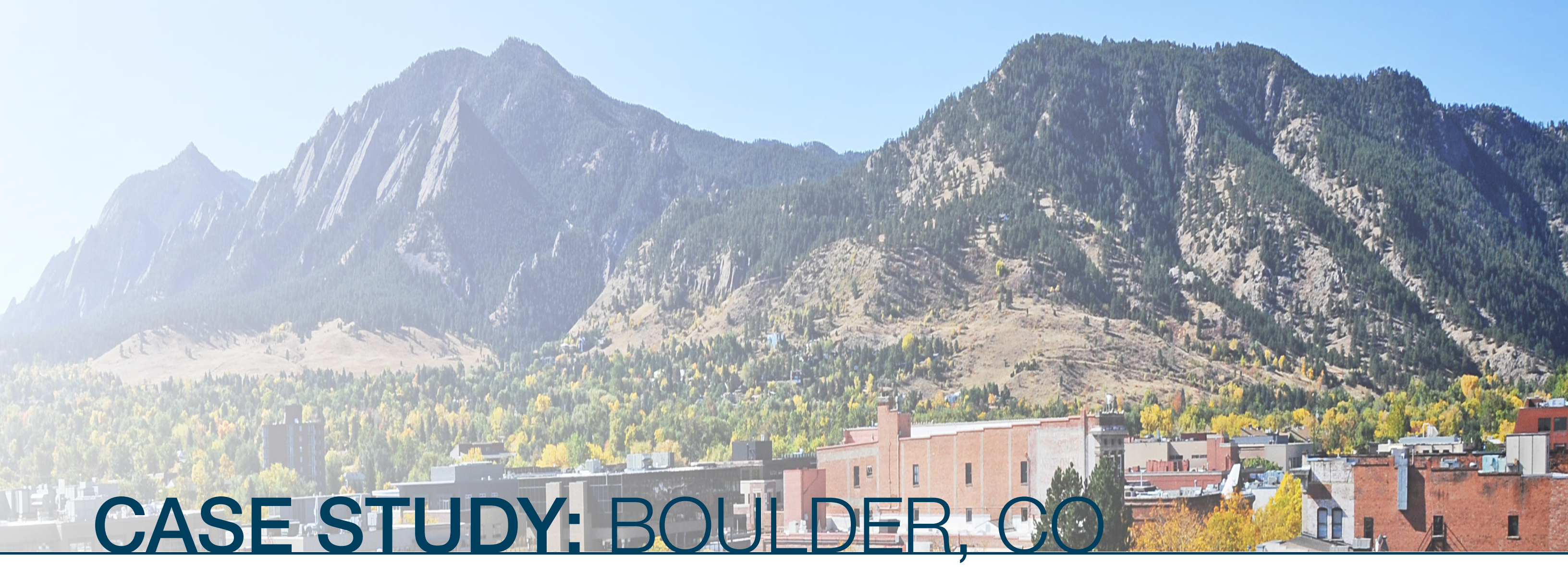
Description of Measure
Includes system level requirements including upper fan power limits for most air-based HVAC systems as well as requirements for fan efficiency.

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:

- Limit the fan energy used to meet design heating, cooling, and ventilation requirements. Specify no more than 0.8 watts of fan power per cfm delivered for variable volume systems. For constant volume systems, limit fan power to 0.65 watts/cfm delivered. For packaged equipment with pre-installed integral fans, the total capacity of the system shall not exceed one nominal ton of cooling capacity (12,000 Btu) for each 800sf of conditioned building floor area. Buildings that need to exceed these guidelines must complete full load calculations to demonstrate higher-than-average load conditions justifying additional fan power or system capacity.
- 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 Fan Efficiency Grade (FEG) of 71 or higher. Total efficiency of the fan at the point of operation should be within 10 percentage points 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 designed to be controlled based on actual loads or occupancy schedule rather than for continuous uncontrolled operation. Fans are permitted to operate continuously if they meet the control requirements and the load or occupancy schedule requires such operation.

CODE CORRESPONDENCE: **2015 IECC: Section C403.2.12**
ASHRAE 90.1-2013: Section 6.5.3.13



CASE STUDY: BOULDER, CO

Colorado is one of only six home-rule states in which jurisdictions set their own energy codes. The City of Boulder has acted on this opportunity to set stringent codes targeting ambitious energy goals. Boulder aims to achieve an 80% reduction of 2005 greenhouse gas emissions levels by 2050. City-owned buildings are leading the way, targeting an 80% reduction from 2008 levels by 2030. Furthermore, the city is also striving for 100% clean energy systems for both buildings and transportation by 2030.

To help achieve this goal, Boulder is targeting zero energy construction by 2031. It anticipates that reaching this target will save one million metric tons of greenhouse gas emissions by 2031, which advances Boulder toward its 2050 carbon goal. After a unanimous vote, the City of Boulder Energy Conservation Code (COBECC) went into effect in May of 2017. The prescriptive code provides energy standards for both new construction and renovations based on the 2012 International Energy Conservation Code (IECC). COBECC simplified existing regulations by unifying IECC language with the progressive amendments from the Boulder Revised Code.

Under this code, large new construction must perform 30% better than the 2012 IECC targets. Large single family construction is required to perform at zero energy. All other residential construction must meet specific Energy Rating Index targets. Additionally, electric vehicle

> To help achieve this goal, Boulder is targeting zero energy construction by 2031. The City anticipates that reaching this target will save one million metric tons of greenhouse gas emissions by 2031.

charging stations and solar ready infrastructure are required. COBECC allows energy purchased from a community renewable energy system to count toward energy savings, which makes zero energy achievable for all building types, and even projects with site or solar access constraints.

Boulder's building codes not only address energy, but also water efficiency, landscaping, shading, construction waste management, and radon mitigation. These requirements aim to improve public health, the local economy, and the resilience of the city's building stock. To increase compliance, codes are designed to be implementable and enforceable, and they receive regular updates. A 2015 ordinance requires commercial energy reporting which provides data useful to develop energy use intensity targets for future commercial building code upgrades.

3. SERVICE WATER HEATING

In certain building types, water heating loads can be a significant portion of the total building loads. Strategies to reduce these loads include reducing fixture flows, installing more efficient equipment, incorporating heat recovery systems, or with solar thermal systems to serve hot water needs.

3.1 Heat Recovery for Service Water Heating

Description of Measure
Require the adoption of waste hear recovery or solar thermal hot water generation to meet a portion of domestic hot water loads.

Purpose
Reduce the energy consumed by water heating equipment by reducing hot water loads with waste heat recovery or solar thermal hot water, or by installing more efficient water heating equipment.

Technical Requirements
Hot water systems shall comply with not less than one of the following:

1. At least 40% of domestic hot water load met by a waste heat recovery system
2. At least 40% of domestic hot water load met by solar thermal water heating system (options 1 and 2 may be combined to achieve a minimum of 40% load reduction)
3. Water heating equipment with minimum efficiency in accordance with Table 8**.**

Table 8: Water Heating equipment efficiency requirements

Fuel	Storage Water Heater Less than 55 Gallons	Storage Water Heater Larger than 55 Gallons	Boiler
Gas	0.95 EF		97% AFUE/94% Et/94% Ec
Electric	2.0 EF	2.5 EF	NA

Code Correspondence: **2015 IECC: Section C403.4.5**
ASHRAE 90.1-2013: Section 6.5.6.2

3.2 Efficient Plumbing Fixtures

Description of Measure

Requires the use of efficient heater water supply piping and low-flow fixtures in kitchens and bathrooms.

Purpose

Reduce energy consumption from hot water loads by requiring the use of efficient heated water supply piping, low-flow faucets, and shower heads.

Technical Requirements

The flow rate for all lavatory faucets shall not exceed 1.5 gpm at 60 psi and the flow rate of fixed and handheld shower heads shall not exceed 2.0 gpm at 80 psi[7].

Heated water supply piping shall comply with one of the following options:

1. The maximum allowable piping length from the nearest source of heated water to the termination of the fixture supply pipe shall be in accordance with Table 9.

Table 9: Piping Volume and Maximum Piping Lengths[7]

		Maximum Piping Length	
Nominal Pipe Size (inches)	**Volume (liquid ounces per foot of length)**	Public lavatory faucets	Other fixtures and appliances
¼	0.33	6	50
5/16	0.5	4	50
3/8	0.75	3	50
½	1.5	2	43
5/8	2	1	32
¾	3	0.5	21
7/8	4	0.5	16
1	5	0.5	13
1 1/4	8	0.5	8
1 1/2	11	0.5	6
2 or larger	18	0.5	4

2. The water volume in the pipe from the nearest source of heated water to the termination of the fixture supply shall be in accordance with Table 10. The water volume includes the sum of the internal volumes of pipe, fittings, valves, meters, and manifolds; and shall be determined from the "volume" column in Table 9. Where heated water is supplied by a recirculating system or heat-traced piping, the volume shall include the portion of the fitting on the branch pipe that supplies water to the fixture.

Table 10: Fixture supply pipe volume limits

Public lavatory faucet	Other fixtures or plumbing appliances
Not more than 2 ounces	Not more than 0.5 gallons

CODE CORRESPONDENCE: **2015 IECC: Section C404.5**
ASHRAE 90.1-2013: Section None

7. Table excerpted from the 2018 International Energy Conservation Code; Copyright 2017. Washington D.C.: International Code Council. Reproduced with permission. All rights reserved

CASE STUDY: PALO ALTO, CA

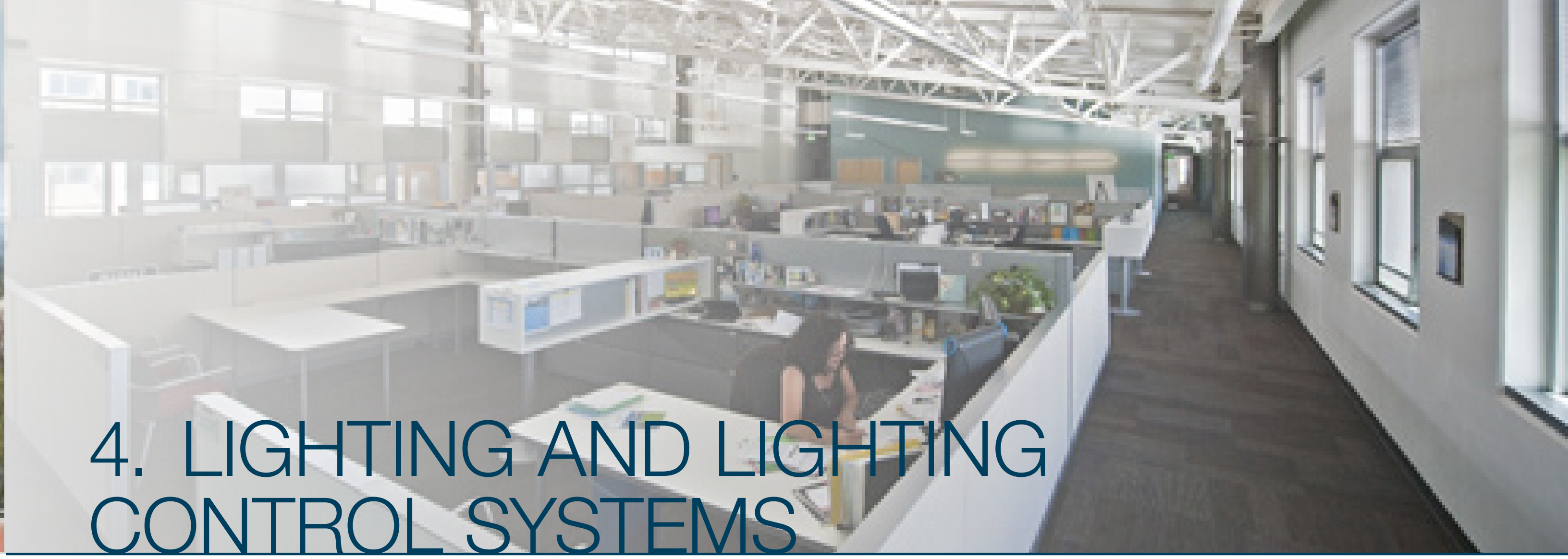
Palo Alto is one of the first jurisdictions in California to have implemented an incremental energy policy ahead of state goals. The City's journey started in 2007 when it implemented a stretch code calling for a 15% improvement over the state energy code. With each subsequent code cycle, the local code has remained 15% ahead of the state targets. In 2013, Palo Alto established the Green Building Advisory group, an organization of city officials, construction and design professionals, and environmentalists working to establish long-term goals and a plan to achieve these targets.

The city's Sustainability and Climate Action Plan calls to reduce greenhouse gas emissions by 40% of 1990 levels by 2030, and 80% by 2050. Palo Alto already operates a 100% carbon-neutral electric supply portfolio. The plan paves the way to achieve zero energy in all new residential buildings by 2018 and new commercial buildings by 2025 – years ahead of the state's goals of 2020 for residential and 2030 for commercial. Furthermore, the Downtown Palo Alto Net Zero Energy Initiative targets 100 existing commercial buildings in downtown Palo Alto to be retrofit to zero energy by 2018.

The City Council unanimously approved a zero net energy-ready stretch code which went into effect on January 1, 2017. The code emphasizes flexibility for design teams through two performance-based compliance options. New single-family residences must perform 10% better than required by the 2016 state energy code, and they must include 500 square feet of solar ready infrastructure. Alternatively, the design can include photovoltaic panels which count toward a required 20% energy reduction beyond code. New multifamily developments must achieve a 10% improvement over state code, or 12% with photovoltaics. As part of the city's electrification efforts, projects which do not incorporate gas are not required to exceed state code. Commercial projects must either outperform code by 10% or install a minimum of 5kW of photovoltaics.

The City's Sustainability and Climate Action Plan calls to reduce its greenhouse gas emissions by 40% of 1990 levels by 2030, and 80% by 2050.

Through this effort, Palo Alto hopes to establish a replicable efficiency model for other jurisdictions in California. City officials note that the key to this is a cost-effective program. In addition to cost savings, Palo Alto hopes to add value to its building stock through the improved health—including indoor air quality and comfort—of its buildings. To assist in this transition, the city's Development Services Department provides training and outreach on zero energy to the design and construction community.



4. LIGHTING AND LIGHTING CONTROL SYSTEMS

Reduce connected lighting load by deploying state-of-the-art 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 spaces by requiring more efficient lamp and fixture technologies, and incorporate advanced controls which can reduce exterior lighting use when not needed.

4.1 Interior Lighting Controls

Description of Measure
Requires the use of occupancy sensors to control lighting in all 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 with the following capabilities shall be installed to control lights in all space types other than warehouses, sleeping units, and open plan office areas 300 square feet or greater:
  1. Automatically turn off lights within 30 minutes of leaving the space
  2. Be manual on or controlled to automatically turn the lighting on to no more than 50 percent power

  Exception: Full automatic-on controls shall be permitted to control lighting in public corridors, stairways, restrooms, primary building entrance areas, and lobbies: and area where manual-on operation would endanger the safety or security of the room or building occupants.

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

Occupant sensor control – An automatic control device or system that detects the presence or absence of people within an area and causes lighting, equipment, or appliances to be regulated accordingly.

- Occupant sensor controls in open office areas 300 square feet or greater shall comply with the following:
  1. The controls shall be configured so that general lighting within the open plan office can be controlled separately in control zones with floor areas not greater than 600 square feet.
  2. The controls shall automatically turn off general lighting in all control zones within 20 minutes of inoccupancy.
  3. The controls shall be configured so that general lighting power in each control zone is reduced by not less than 80 percent of the full zone general lighting power in a reasonably uniform illumination pattern within 20 minutes of inoccupancy. Control functions that switch control zone lights completely off when the zone is

vacant meet this requirement.

4. The controls shall be configured such than any daylight responsive control will activate open plan office space general lighting or control zone general lighting only when occupancy for the same area is detected.

- Sleeping units shall have control devices of systems that automatically switch off all permanently installed luminaires and switched receptacles within 20 minutes of inoccupancy.

Exception: lighting and switched receptacles controlled by card key controls and spaces where patient care is directly provided.

CODE CORRESPONDENCE: 2015 IECC: Sections C405.2.1 and C405.2.4
ASHRAE 90.1-2013: Section 9.4.1.1

4.2 Daylight Responsive Control Function

Description of Measure
Increases the portion of the building within a daylight area provided with automatic lighting controls.

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 percent 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.
- All lighting power in the daylit zone shall be controlled by automatic daylighting 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.

CODE CORRESPONDENCE: 2015 IECC: Section C405.2.3
ASHRAE 90.1-2013: Section 9.4.1.1

4.3 Interior Lighting Power Density

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 10. These LPD's shall be calculated based on luminaire efficiency, including lamps and ballasts.

Table 11: Interior Lighting Power Allowances – Building Area Method[8]

Building Area Type	LPD	Building Area Type	LPD
Auto Facility	0.71	Multifamily [c]	0.68
Convention Center	0.76	Museum	1.06
Courthouse	0.90	Office	0.79
Dining: bar lounge/leisure	0.90	Parking Garage	0.15
Dining: cafeteria/fast food	0.79	Penitentiary	0.75
Dining: family	0.78	Performing arts theater	1.18
Dormitory [a,b]	0.61	Police station	0.80
Exercise Center	0.65	Post office	0.67
Fire station [a]	0.53	Religious building	0.94
Gymnasium	0.68	Retail	1.06
Health care clinic	0.82	School/University	0.81
Hospital [a]	1.05	Sports arena	0.87
Library	0.78	Town Hall	0.80
Manufacturing facility	0.90	Transportation	0.61
Hotel/motel [a,b]	0.75	Warehouse	0.48
Motion picture theater	0.83	Workshop	0.90

a. Where sleeping units are excluded from lighting power calculations, neither the area of the sleeping units nor the wattage of lighting in the sleeping units is counted.

b. Where dwelling units are excluded from the lighting power calculations, neither the area of the dwelling units nor the wattage of lighting in the dwelling units is counted.

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

CODE CORRESPONDENCE: 2015 IECC: Section C405.4.3
ASHRAE 90.1-2013: Section 9.5.1

4.4 Exterior Lighting Power Allowance

Description of Measure

Reduced lighting power density values for parking lots, building facades, and exterior doors reflecting advancements in LED lighting technologies.

Purpose

Reduce energy associated with site lighting through better design or by improving lamp efficacy.

Technical Requirements

The total exterior lighting power allowance for all exterior building applications is calculated from the values in the tables below. The total allowed exterior lighting is the sum of the base site allowance plus the individual allowances for areas that are to be illuminated and are permitted in Table 13 for the applicable lighting zone. Tradeoffs are allowed only among exterior lighting applications listed in Table 13, in the Tradable Surfaces section. The lighting zone for the building exterior is determined from Table 12.

> **Exception:** Lighting used for the following exterior lighting applications is exempt where equipped with a control device independent of the control of the nonexempt lighting:
>
> - Lighting approved because of safety considerations
> - Emergency lighting automatically shut off during normal business operation
> - Exit signs

8. Table excerpted from the 2018 International Energy Conservation Code; Copyright 2017. Washington D.C.: International Code Council.

- Specialized signal, directional and marker lighting associated with transportation
- Advertising signage or directional signage
- Integral to equipment or instrumentation and is installed by its manufacturer
- Theatrical purposes, including performance, stage, film production, and video production
- Athletic playing areas
- Temporary lighting
- Industrial production, material handling, transportation sites, and associated storage areas
- Theme elements in theme/amusement parks
- Use to highlight features of public monuments and registered historic landmark structures or buildings

Table 12: Exterior Lighting Zones[9]

Lighting Zone	Description
1	Developed area of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use, and residential mixed-use areas
3	All other areas not classified as lighting zone 1, 2 or 4
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

Table 13: Individual Lighting Power Allowances for Building Exteriors[10]

		LIGHTING ZONES			
		Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance (Base allowance is usable in tradable or nontradable surfaces.)		350 W	400 W	500 W	900 W
Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies, overhangs, and outdoor sales areas are tradable.)	Uncovered Parking Areas				
	Parking areas and drives	0.03 W/ft2	0.03 W/ft2	0.05 W/ft2	0.05 W/ft2
	Building Grounds				
	Walkways and ramps less than 10 feet wide	0.50 W/linear foot	0.50 W/linear foot	0.60 W/linear foot	0.70 W/linear foot
	Walkways and ramps 10 feet wide or greater, plaza areas special feature areas	0.10 W/ft2	0.10 W/ft2	0.11 W/ft2	0.14 W/ft2
	Dining areas	0.65 W/ft2	0.65 W/ft2	0.75 W/ft2	0.95 W/ft2
	Stairways	0.60 W/ft2	0.70 W/ft2	0.70 W/ft2	0.70 W/ft2
	Pedestrian tunnels	0.12 W/ft2	0.12 W/ft2	0.14 W/ft2	0.21 W/ft2
	Landscaping	0.03 W/ft2	0.04 W/ft2	0.04 W/ft2	0.04 W/ft2
	Building Entrances and Exits				
	Pedestrian and vehicular entrances and exits	14 W/linear foot of opening width	14 W/linear foot of opening width	21 W/linear foot of opening width	21 W/linear foot of opening width
	Entry canopies	0.20 W/ft2	0.25 W/ft2	0.40 W/ft2	0.40 W/ft2
	Loading docks	0.35 W/ft2	0.35 W/ft2	0.35 W/ft2	0.35 W/ft2
	Sales Canopies				
	Free-standing and attached	0.40 W/ft2	0.40 W/ft2	0.60 W/ft2	0.70 W/ft2
	Outdoor Sales				
	Open areas (includingvehicle sales lots)	0.20 W/ft2	0.20 W/ft2	0.35 W/ft2	0.50 W/ft2
	Street frontage for vehicle sales lots in addition to "open area" allowance	No allowance	7 W/linear foot	7 W/linear foot	21 W/linear foot

9 and 10. Tables excerpted from the 2018 International Energy Conservation Code; Copyright 2017. Washington D.C.: International Code Council. Reproduced with permission. All rights reserved.

Nontradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	Building facades	No allowance	0.075 W/ft2 of gross above-grade wall area	0.113 W/ft2 of gross above-grade wall area	0.15 W/ft2 of gross above-grade wall area
	Automated teller machines (ATM) and night depositories	135 W per location plus 45 W per additional ATM per location	135 W per location plus 45 W per additional ATM per location	135 W per location plus 45 W per additional ATM per location	135 W per location plus 45 W per additional ATM per location
	Uncovered entrances and gatehouse inspection stations at guarded facilities	0.50 W/ft2 of covered and uncovered area	0.50 W/ft2 of covered and uncovered area	0.50 W/ft2 of covered and uncovered area	0.50 W/ft2 of covered and uncovered area
	Uncovered loading areas for law enforcement, fire, ambulance, and otheremergency service vehicles	0.35 W/ft2 of covered and uncovered area	0.35 W/ft2 of covered and uncovered area	0.35 W/ft2 of covered and uncovered area	0.35 W/ft2 of covered and uncovered area
	Drive-up windows/doors	200 W per drive-through	200 W per drive-through	200 W per drive-through	200 W per drive-through
	Parking near 24-hour retail entrances	400 W per main entry	400 W per main entry	400 W per main entry	400 W per main entry

Any increase in the exterior lighting power allowance is limited to the specific lighting application indicated in Table 14. The additional power shall be used only for the luminaires that are serving these applications and shall not be used for any other purpose.

Table 14: Lighting Power Application for Special Exterior Areas[11]

	LIGHTING ZONES			
	Zone 1	**Zone 2**	**Zone 3**	**Zone 4**
Building facades	No allowance	0.0950 W/ft^2 of gross above-grade wall area	0.1425 W/ft^2 of gross above-grade wall area	0.1900 W/ft^2 of gross above-grade wall area
Automated teller machines (ATM) and night depositories	270 W per location plus 90 W per additional ATM per location			
Entrances and gatehouse inspection stations at guarded facilities	0.75 W/ft^2 of covered and uncovered area.			
Loading areas for law enforcement, fire, ambulance, and other emergency service vehicles	0.5 W/ft^2 of covered and uncovered area			
Drive-up windows and doors	400 W per drive through			
Parking near 24-hour retail entrances.	800 W per main entry			

CODE CORRESPONDENCE: **2015 IECC: Section C405.5.1**
ASHRAE 90.1-2013: Section 9.4.2

4.5 Exterior Lighting Controls

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 turn off lights during daylight hours and reduce lighting power during unoccupied periods.

11. Table excerpted from the 2018 International Energy Conservation Code; Copyright 2017. Washington D.C.: International Code Council. Reproduced with permission. All rights reserved.

Technical Requirements

Outdoor luminaires serving uncovered parking areas and open areas in outdoor sales lots shall meet the following requirements:

- Be controlled by a device that automatically turns off the luminaire during daylight hours
- Be controlled by a timeclock or other control device that automatically turns off the luminaire according to a timed schedule
- For luminaires having a rated input wattage of more than 50 watts where the bottom of the luminaire is mounted 24 feet or less above the ground, the luminaires shall be controlled by one or more devices that automatically reduce lighting power of each luminaire by a minimum of 50% when there is no activity detected in the controlled zone for a period of no longer than 15 minutes. No more than 1,500 input watts of lighting power shall be controlled together.

Exception: Lighting serving street frontage for vehicle sales lots and lighting for covered vehicle entrances or exits from buildings or parking structures where required for safety, security, or eye adaption.

CODE CORRESPONDENCE: **2015 IECC: Section C405.5.1**
ASHRAE 90.1-2013: Section 9.4.1.4

5. ELECTRIC SYSTEMS

Plug and equipment loads to serve occupant needs are becoming one of the most significant loads in building energy use. Strategies to insure that equipment is off when not in use, and to deploy the most energy efficient appliances can significantly reduce overall building energy use.

5.1 Plug Load Control and power management

Description of Measure

Requires that 50% of receptacles be controlled by time clock or occupancy sensor and the utilization of power management settings.

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

A minimum of 50% of all 125-volt 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 meet the following requirements:

- Be controlled by a time clock or occupancy sensor that de-powers the receptacles during unoccupied hours
- Controlled receptacles shall be clearly labeled or color-coded
- At least one controlled receptacle shall be installed within 6 feet of each uncontrolled receptacle

When a project includes an energy management system it shall include a power management program capable of enabling power management setting on all networked personal computers, laptops, and servers.

CODE CORRESPONDENCE: **2015 IECC: NA**
ASHRAE 90.1-2013: Section 8.4.2

5.2 Efficient Equipment

Description of Measure

Requires the specification of Energy Star rated kitchen equipment.

Purpose

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

Technical Requirements

- The following kitchen equipment and appliances installed in the building shall be Energy Star certified using the most up to date version:
  - Commercial fryers
  - Commercial dishwashers
  - Commercial steam cookers or compartment steamers
  - Hot food holding cabinets

CODE CORRESPONDENCE: **2015 IECC: NA**
ASHRAE 90.1-2013: NA

6. PATHWAYS TO HIGHER PERFORMANCE

Additional strategies can be adopted to increase the savings associated with a stretch code strategy, or to provide additional flexibility to projects in meeting a set of stretch code guidelines. The following additional strategies represent opportunities for increased energy savings in buildings.

6.1 Limited Window to Wall Ratio

Description of Measure
Reducing overall glazing area improves the thermal performance of building envelopes, reducing energy use.

Purpose Reduce the energy impact of excessive glazing areas in buildings.
Technical Requirements
Overall window area (including window frames) may not exceed 30% of gross wall area.

CODE CORRESPONDENCE: 2015 IECC: Section C402.4.1.1
ASHRAE 90.1-2013: Section 5.5.4.2.1

6.2 Enhanced Mechanical System Selection and Decoupled Ventilation

Description of Measure
Decoupling ventilation air delivery systems from primary heating and cooling systems provide an opportunity to select more efficient liquid-based delivery systems for meeting heating and cooling loads in a building. This measure requires the use of a Dedicated Outside Air Systems (DOAS) to provide ventilation and the incorporation of liquid-based distribution systems to deliver heating and cooling to building spaces.

Purpose Reduce energy use associated with heating, cooling, and ventilation distribution systems.
Technical Requirements

- Outdoor air for ventilation shall be provided to occupied zones by a dedicated outside air system (DOAS) that operates independently of building heating and cooling systems.
- DOAS system shall include energy recovery capabilities and be controlled based on occupancy (demand control ventilation) in conjunction with applicable building ventilation requirements.
- Primary distribution of heating and cooling to occupied zones should utilize liquid-based distribution systems rather than air based distribution systems.
- Control system should be capable of cycling off zone heating and cooling equipment fans and/or pumps when there is no call for heating or cooling in the zone

CODE CORRESPONDENCE: 2015 IECC: C403.4 and C406.6
ASHRAE 90.1-2013: 6.5.4.5 and 6.4.3.

nbi new buildings institute

623 SW Oak St., 3rd Floor
Portland, OR 97205

503 761 7339

newbuildings.org

New Buildings Institute (NBI) is a nonprofit organization driving better energy performance in commercial buildings. We work collaboratively with industry market players—governments, utilities, energy efficiency advocates, and building professionals—to promote advanced design practices, innovative technologies, public policies, and programs that improve energy efficiency. We also develop and offer guidance and tools to support the design and construction of energy efficient buildings.

Throughout its 20-year history, NBI has become a trusted and independent resource helping to drive buildings that are better for people and the environment. Our theory of change includes setting a vision and defining a path forward. We then set out to create the research that serves as the basis for tool and policy development necessary to create market change.