



U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

2011

Standard 189.1-2009 for High-Performance, Green Buildings

Lawrence Schoen, P.E., Fellow
Larry@SchoenEngineering.com

ASHRAE Will Give You The World

NETWORK

Give Back To ASHRAE

GROW

LEARN

TEACH

SHARE





ASHRAE Standard 189.1

- What is it?
- Why have it?
- Highlights

ANSI/ASHRAE/USGBC/IES
Standard 189.1-2009

**Standard for
the Design of
High-Performance
Green Buildings**

<http://www.ashrae.org/greenstandard>

Except Low-Rise
Residential Buildings



Compare Standard 189.1 to LEED

LEED 2009 FOR
NEW
CONSTRUCTION
AND MAJOR RENOVATIONS

ANSI/ASHRAE/USGBC/IES
Standard 189.1-2009

**Standard for
the Design of
High-Performance
Green Buildings**

Except Low-Rise
Residential Buildings

- Std. 189.1:
 - Improvement in all topical areas
 - Pushes the envelope

■ **Voluntary vs. mandatory**

ASHRAE Standard 189.1-2009

- An optional compliance path (“Jurisdictional Compliance Option”) to the International Green Construction Code (IGCC)

Official description of Standard 189.1 within U.S.



“the ANSI/ASHRAE/USGBC/IES Standard 189.1-2009, a jurisdictional compliance option of the International Green Construction Code.”



Sponsors and Project Committee

- Consensus process
- Sponsor and co-sponsors:
 - ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers)
 - USGBC (U.S. Green Building Council)
 - IES (Illuminating Engineering Society)
- Project committee:
35+ voting members;
variety of disciplines,
industries & organizations





Standard 189.1: Intent

■ What Standard 189.1 is:

- a standard
- applies to all buildings except low-rise residential buildings (same as ASHRAE Std 90.1)
- intended for adoption into model building codes

■ What Standard 189.1 is not:

- not a design guide
- not a rating system

*Even if not adopted by your local authorities,
this Standard is an indication of future industry trends*



U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

2011

ASHRAE STANDARD
90.1 (current version)

Energy Standard for
 Buildings Except Low-Rise
 Residential Buildings



ASHRAE STANDARD
Standard 62.1

Ventilation
 for Acceptable
 Indoor Air Quality

ANSI/ASHRAE/USGBC/IES
 Standard 189.1-2009

**Adopt, with
 modifications**

**Adopt,
 with minor
 modifications**

**Standard for
 the Design of
 High-Performance
 Green Buildings**

Except Low-Rise
 Residential Buildings

Adopt



Standard 55
ASHRAE STANDARD

Thermal
 Environmental
 Conditions for
 Human Occupancy



**ASHRAE/USGBC/IESNA Standard 189.1,
Standard for the Design of High-Performance Green Buildings
Except Low-Rise Residential Buildings**

| SECTION | PAGE |
|---|-------------|
| Foreword..... | 2 |
| 1 Purpose..... | 5 |
| 2 Scope..... | 5 |
| 3 Definitions, Abbreviations, and Acronyms | 6 |
| 4 Administration and Enforcement..... | 23 |
| 5 Site Sustainability | 24 |
| 6 Water Use Efficiency | 38 |
| 7 Energy Efficiency | 46 |
| 8 Indoor Environmental Quality (IEQ)..... | 65 |
| 9 The Building’s Impact on the Atmosphere, Materials and Resources..... | 75 |
| 10 Construction and Plans for Operation..... | 81 |
| 11 Normative References..... | 96 |



Standard 189.1 Basic Structure *For Each Section*

- x.1: Scope
- x.2: Compliance
- x.3: Mandatory
(required for all projects)
- x.4: Prescriptive path
(simple option, minimal choices,
very few calculations)
- x.5: Performance path
(more sophisticated, flexibility, but more effort)



Section 6 – Water Use Efficiency

Mandatory Provisions

- Site water use
- Building water use
- HVAC Systems, equipment
- Water consumption management





Section 6 – Water Use Efficiency

Mandatory Provisions

- **Site water use:** bio-diverse plantings for 60% of improved landscape, hydrozoning & smart irrigation controllers



Section 6 – Water Use Efficiency

Mandatory Provisions

- **Building water use:**
 - (§6.3.2.1) plumbing fixtures & fittings per U.S. EPA WaterSense or ASME Standards, with specific limit on flow amount or rate
 - (§6.3.2.2) appliances per U.S. EPA EnergyStar, with water use factor for dwelling unit or public access



Section 6 – Water Use Efficiency

Mandatory Provisions (cont.)

- **HVAC Systems (§6.3.2.3):**

- Subsystem metering above thresholds
- Cooling tower cycles of concentration limit, efficient drift eliminators
- Condensate collection from units >19 kW (65,000 Btu/h)

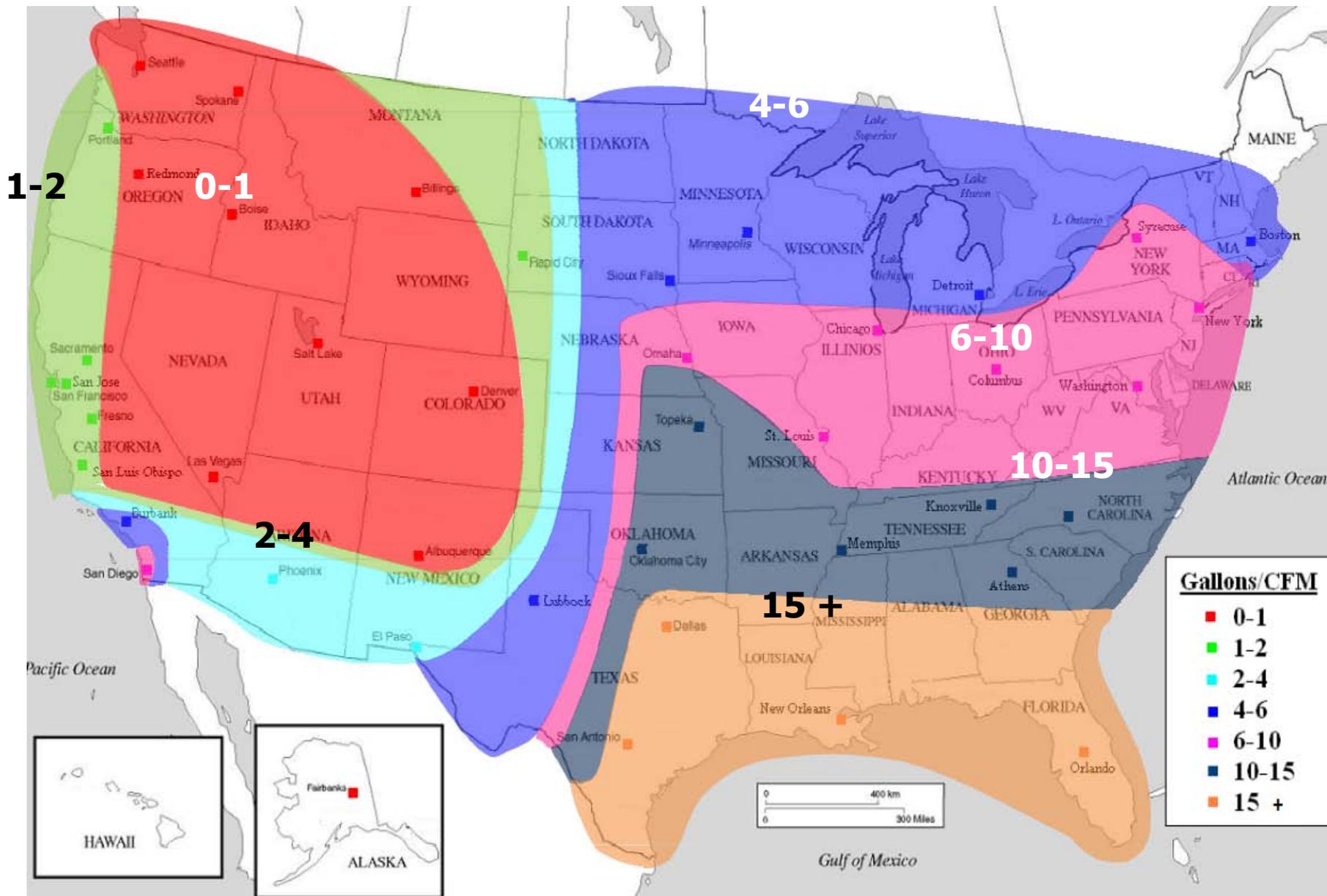
Annual condensate collection

**Georgia: ~ 12.6 gal/cfm Outdoor air
or about 100 liters water/(l/s)**

Iowa: ~ 6.1 gal/cfm OA

Sacramento: ~ 1.3 gal/cfm OA



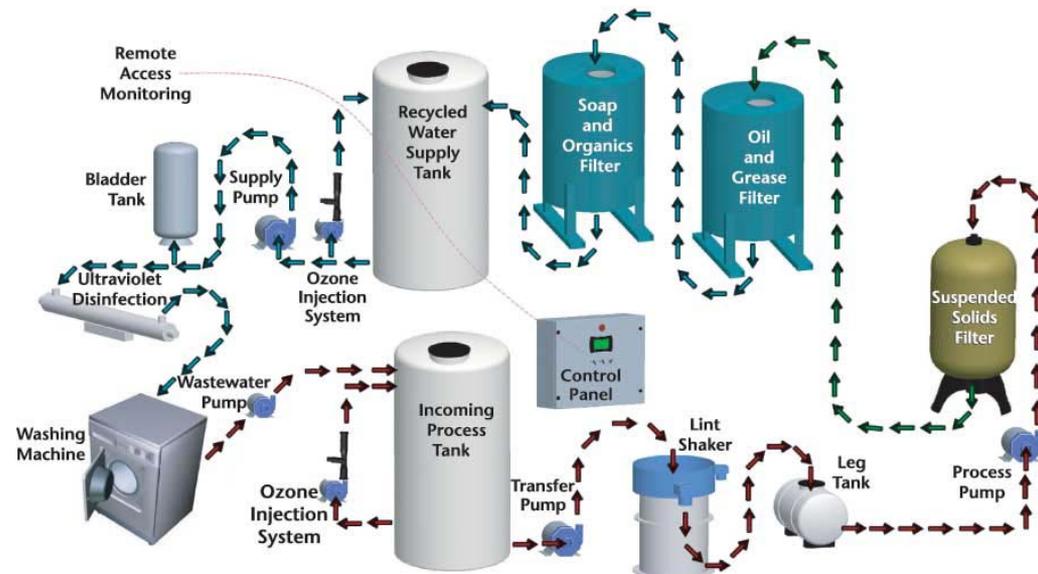




Section 6 – Water Use Efficiency

- **Site water use reduction:**
Potable water for irrigation
<35% of landscape water demand (based on Eto)
- **Building use:**

Proposed use < [mandatory
+ prescriptive]





U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

2011

Energy – Section 7

Highlights for Energy (Section 7)

Energy – General Highlights:

- Basic goal 30% lower than Standard 90.1-2007 **INCLUDING PROCESS**
- Appendix G from Standard 90.1 is incorporated as a Normative Appendix
- Metering for verification
- Peak load reduction
- Other areas increase stringency beyond Standard 90.1



ASHRAE Energy Goals

- ASHRAE goal to have net-zero energy and carbon by 2030
- ASHRAE's Tech Council will suggest EUI targets for Standards 189.1 and 90.1
- Monitoring of progress based on standardized computer modeling
- Goal is to have 189.1 reach Net Energy Use Intensity targets (but not net zero) by 2020



What is EUI, NEUI?

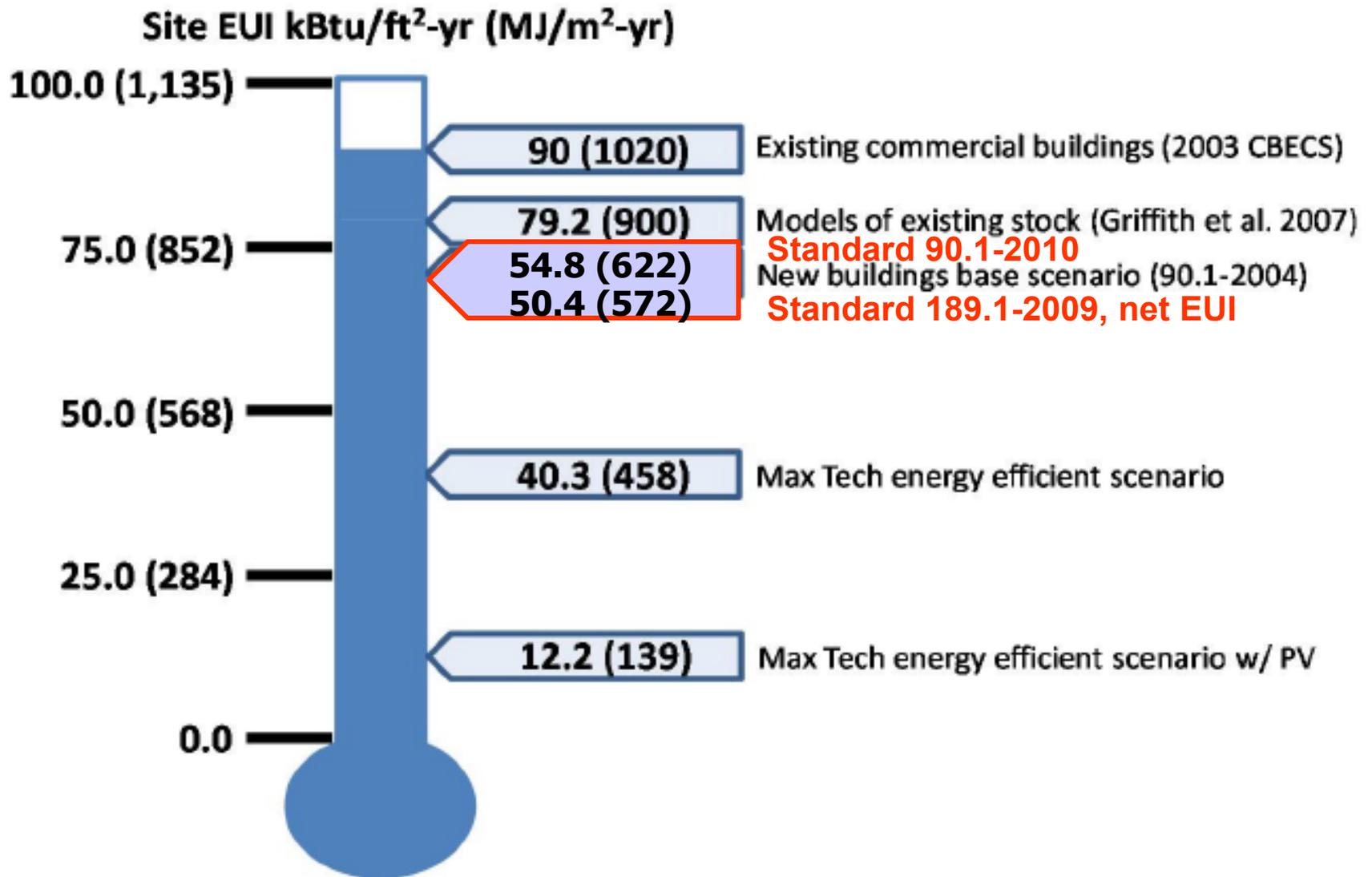
$$\text{Total Energy Use Intensity (EUI)} = \frac{\text{TotalAnnualEnergyUse}}{\text{GrossFloorArea}} \text{ kBtu/ft}^2 \text{ yr (kWh/m}^2 \text{ yr)}$$

$$\text{Net Energy Use Intensity (NEUI)} = \frac{\text{NetAnnualEnergyUse}}{\text{GrossFloorArea}} \text{ kBtu/ft}^2 \text{ yr (kWh/m}^2 \text{ yr)}$$

$$\text{Energy Cost Intensity (ECI)} = \frac{\text{NetAnnualCost}}{\text{GrossFloorArea}} \text{ \$US/ft}^2 \text{ yr (\$US/m}^2 \text{ yr)}$$

Source (June 2010):

**REPORT OF THE TECHNOLOGY COUNCIL AD HOC COMMITTEE ON
ENERGY TARGETS**





Highlights for Energy (Section 7)

- **Mandatory Requirements:**

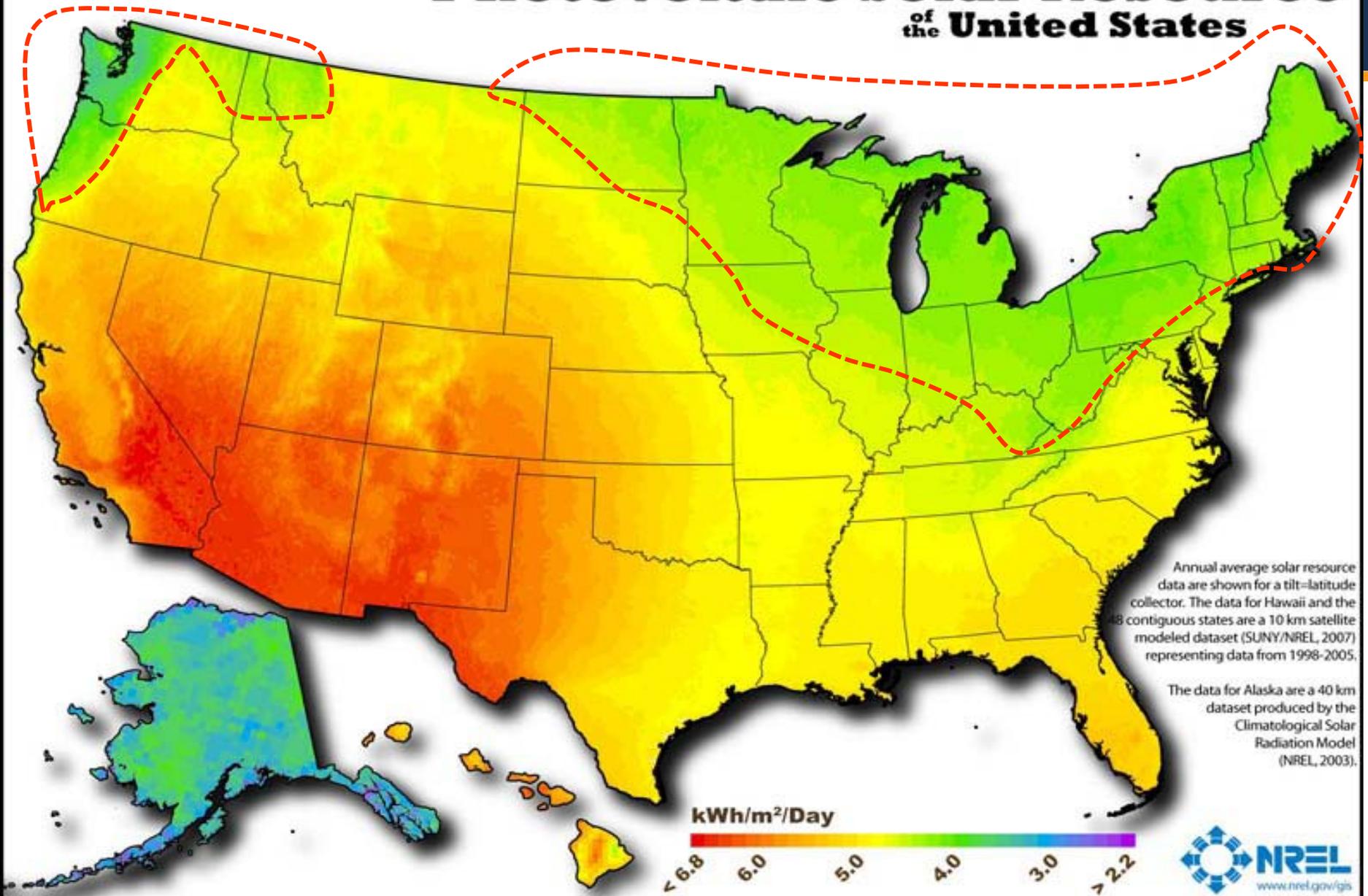
- **On-site renewable power (§7.3.2)**

Provisions for future installation annual energy production ≥ 6 kBtu/ft² (20 kWh/m²) single-story; ≥ 10 kBtu/ft² (32 kWh/m²) multi-story

Exception for areas with low incident solar (4.0 kWh/m²/day), *account for local shading*

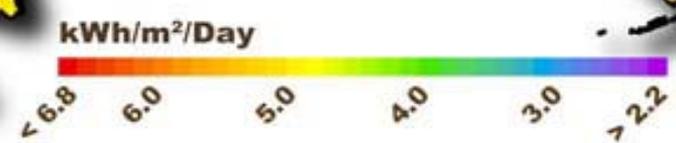


Photovoltaic Solar Resource of the United States



Annual average solar resource data are shown for a tilt-latitude collector. The data for Hawaii and the 48 contiguous states are a 10 km satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2005.

The data for Alaska are a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).



This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.

Author : Billy Roberts - October 20, 2008

Highlights for Energy (Section 7)

Energy – Mandatory (cont.):

- **Remote or automatic reading meters (§7.3.3)** *criteria based on size*
 - Energy sources (Table 7.3.3-1)
 - Key systems (Table 7.3.3-2)
- Meters communicate to central recording system
- Data storage for minimum 36 months

Exception: Residential portions of buildings complying with this Standard



Energy Metering Thresholds

Table 7.3.3.1-1 Energy Source Thresholds

| Energy Source | Threshold |
|----------------------------------|------------------------------------|
| Electrical service | > 200 kVA |
| On-site renewable electric power | All systems > 1 kVA (peak) |
| Gas and district services | > 1,000,000 Btu/h (300 kW) |
| <i>Geothermal energy</i> | > 1,000,000 Btu/h (300 kW) heating |
| On-site renewable thermal energy | > 100,000 Btu/h (30 kW) |

Table 7.3.3.1-2 System Energy Use Thresholds

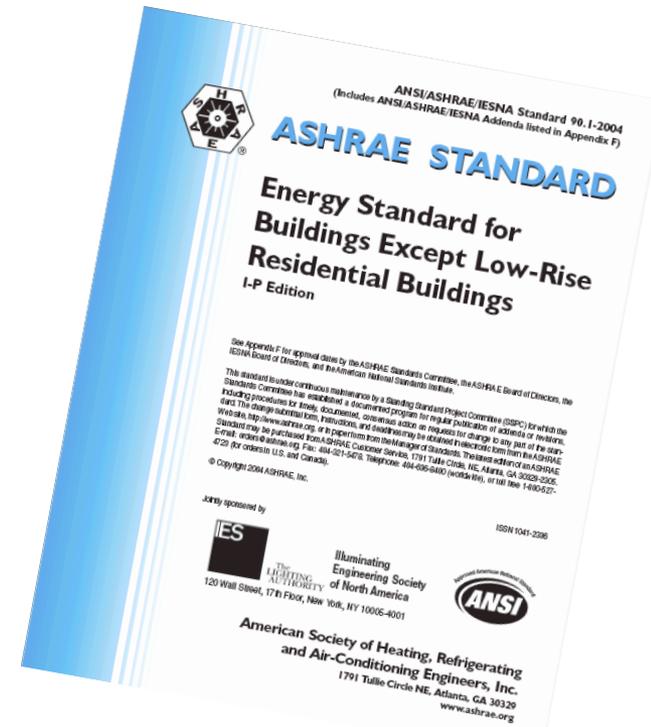
| Use (total of all loads) | Sub-System Threshold |
|---------------------------------|--|
| HVAC System | Connected electric load > 100kVA |
| HVAC System | Connected gas or district services load > 500,000 Btu/h (150 kW) |
| People moving | Sum of all feeders > 50 kVA |
| Lighting | Connected load > 50 kVA |
| Process and Plug | Connected load > 50 kVA |
| Process | Connected gas or district services load > 250,000 Btu/h (75 kW) |



Highlights for Energy (Section 7)

Prescriptive Option (General)

- From DOE Study –
Std. 189.1 30.2% lower than
Standard 90.1-2007
(9% due to renewables)
Average EUI = 50 kBtu/ft²
- Standard 189.1 builds
from 90.1-2007...



7.4.1 General Comprehensive Prescriptive Requirements. When a requirement is provided below, it supersedes the requirement in ASHRAE/IESNA Standard 90.1. For all other criteria, the *building project* shall comply with the requirements of ASHRAE/IESNA Standard 90.1.

Highlights for Energy (Section 7)



Prescriptive Option

- Prescriptive Option: Renewable Energy
 - On-site renewable energy system with ≥ 6 kBtu/ft²-yr [20 kWh/m²-yr], *based on roof area*

Exception (meet both of these):

- Low incident solar locations
- Purchase of green power in terms of “7 kWh/ft²-yr [75 kWh/m²-yr]” annually until cumulative purchase of 70 kWh/ft²-yr [750 kWh/m²-yr]

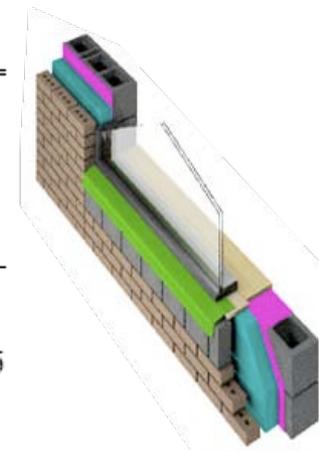
Highlights for Energy (Section 7)

Prescriptive Option (Building Envelope)

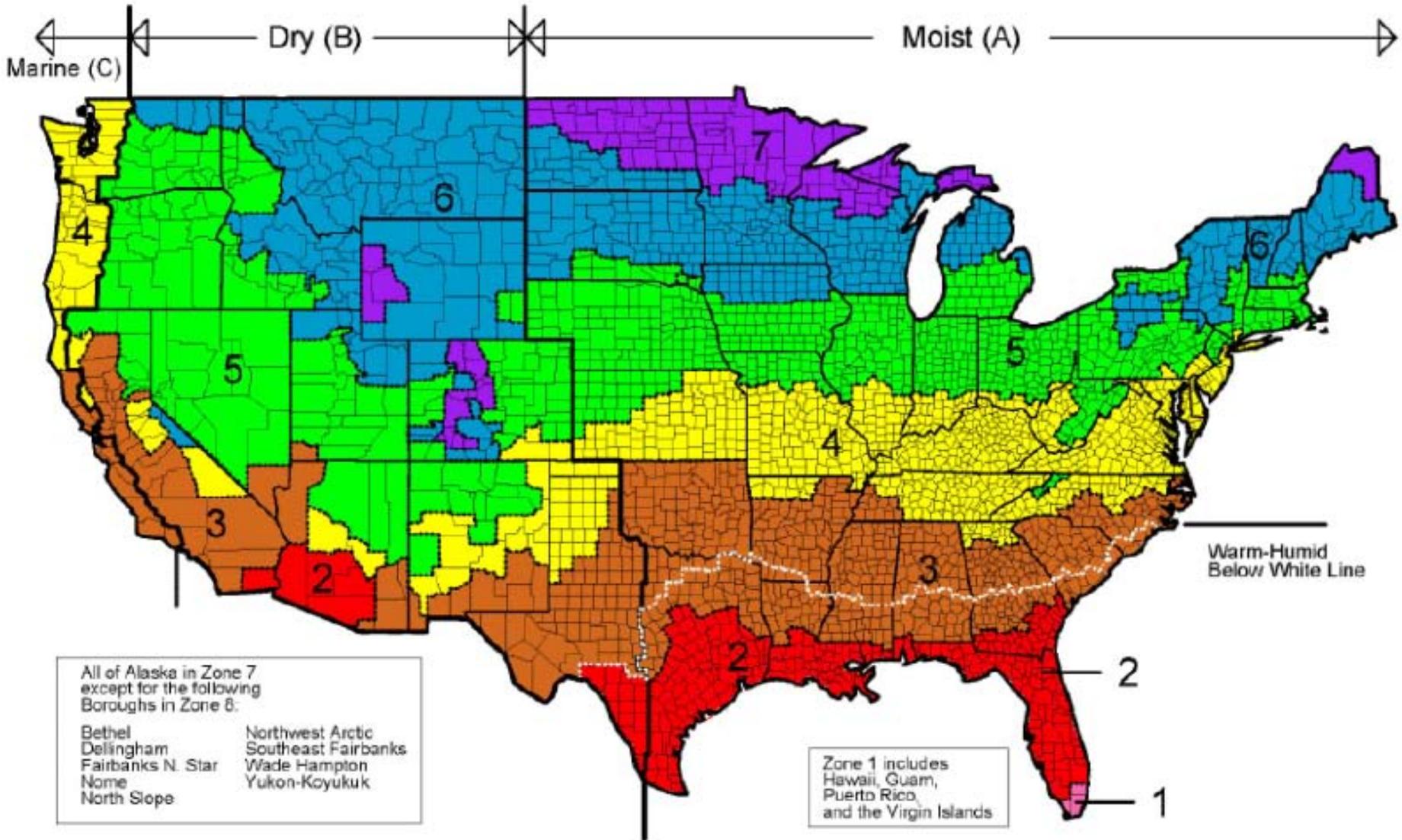
Tables on building envelope, for example:

Table A-3 (supersedes Table 5.5-3 in ASHRAE/IESNA Standard 90.1)
Building Envelope Requirements For Climate Zone 3 (A,B,C) (I-P)

(§7.4.2)



| Opaque Elements | Nonresidential | | Residential | | Semiheated | |
|--------------------------------|----------------|-------------------------|---------------|-------------------------|----------------------|-------------------------|
| | Assembly Max. | Insulation Min. R-Value | Assembly Max. | Insulation Min. R-Value | Assembly Max. | Insulation Min. R-Value |
| <i>Roofs</i> | | | | | | |
| Insulation Entirely above Deck | U-0.039 | R-25.0 ci | U-0.039 | R-25.0 ci | U-0.119 | R-7.6 ci |
| Metal Building | U-0.035 | R-19.0 + R-11.0 Ls | U-0.035 | R-19.0 + R-11.0 Ls | U-0.068 | R-13.0 + R-19.0 |
| Attic and Other | U-0.021 | R-49.0 | U-0.021 | R-49.0 | U-0.034 | R-30.0 |
| <i>Walls, Above-grade</i> | | | | | | |
| Mass | U-0.104 | R-9.5 ci | U-0.090 | R-11.4 ci | U-0.151 ^a | R-5.7 ci ^a |
| Metal Building | U-0.079 | R-13.0 + R-6.5 ci | U-0.052 | R-13.0 + R-13.0 ci | U-0.079 | R-13.0 + R-6.5 ci |
| Steel Framed | U-0.077 | R-13.0 + R-5.0 ci | U-0.055 | R-13.0 + R-10.0 ci | U-0.084 | R-13.0 + R-3.8 ci |
| Wood Framed and Other | U-0.064 | R-13.0 + R-3.8 ci | U-0.064 | R-13.0 + R-3.8 ci | U-0.064 | R-13.0 + R-3.8 ci |



Prescriptive Option (Building Envelope)

- Example comparisons:

Example:

Climate zone 3

Std 90.1 Std 189.1

More stringent SHGC

Insulation above deck **R=3.5 (SI) R=4.4**

Example for <40% window area:

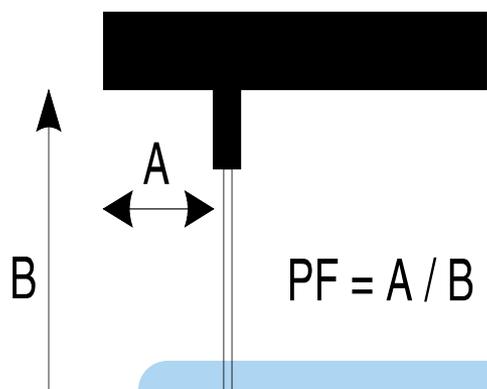
Climate zone 5

Std. 90.1: 0.40 solar heat gain coefficient

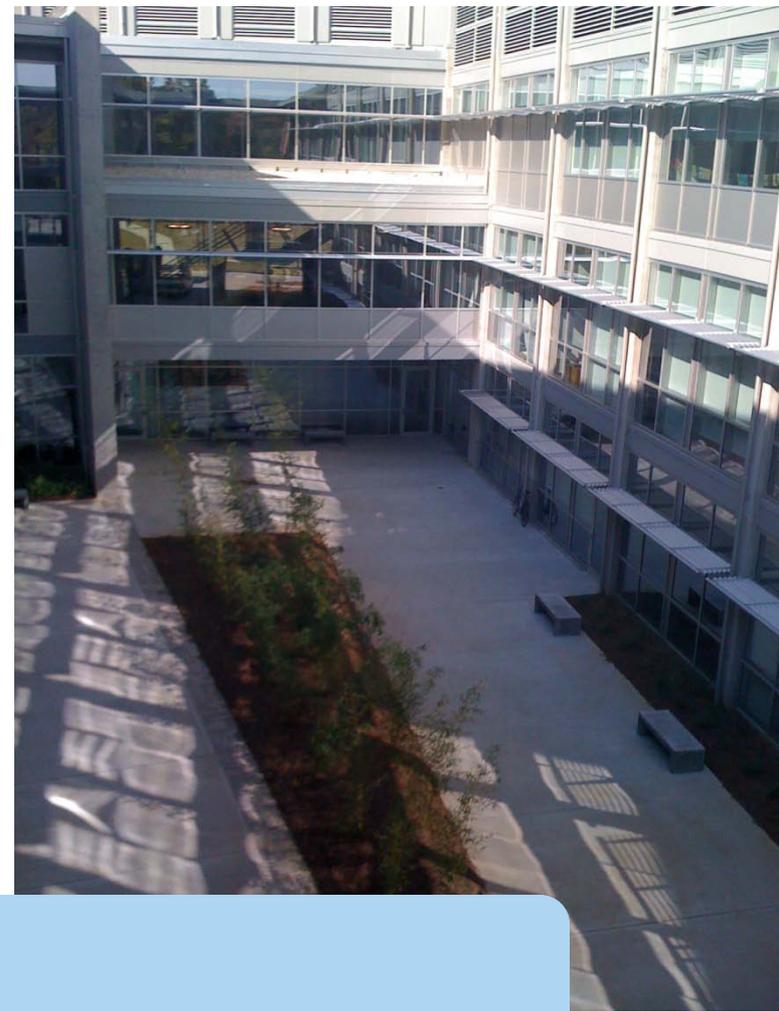
Std. 189.1: 0.35 all orientations

Prescriptive Option (Building Envelope)

- Vertical fenestration
<40% gross wall area
(§7.4.2.4)
- Overhang: PF >0.5
(§7.4.2.5)
Permanent projections: west, east & south
 - Climate zones 1-5



Exception for cases with <250 hours per year direct sunlight



Prescriptive Option (Building Envelope)

- Continuous air barrier requirement
(§7.4.2 10)

(defines areas of envelope to be sealed, caulked, gasketed or weather-stripped)



Peel and stick membrane



Fluid applied air barrier



§7.4.3 HVAC

ASHRAE STANDARD

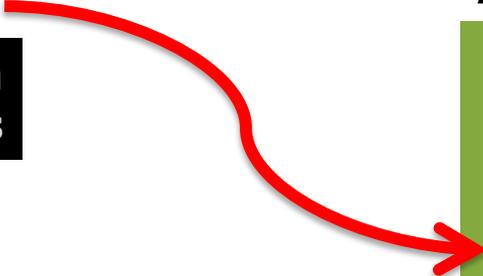
90.1 (current version)

**Energy Standard for
Buildings Except Low-Rise
Residential Buildings**

General Concept:

*Based on Standard 90.1, but
modify to gain improved energy
performance over code
minimum standards*

**Adapt, with
modifications**



ANSI/ASHRAE/USGBC/IES
Standard 189.1-2009

**Standard for
the Design of
High-Performance
Green Buildings**

Except Low-Rise
Residential Buildings



§7.4.3 HVAC

- Overview of modifications to Std. 90.1
 - §7.4.3.1 **Minimum equipment efficiency**

Equipment Efficiency Compliance Options

EPAct Baseline

- Use equipment with EPAct baseline efficiency levels, and:**
- Renewable energy system producing 6.0 kBtu/ft² conditioned floor space annually
 - Peak electrical load reduction of 10%

Higher efficiency

- Use higher efficiency of Energy Star requirements and Appendix C, and:**
- Renewable energy system producing 4.0 kBtu/ft² conditioned floor space annually
 - Peak electrical load reduction of 5%

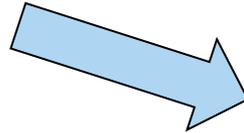


- Lower occupancy threshold for demand-controlled ventilation (DCV)

ASHRAE STANDARD

90.1 (current version)

**Energy Standard for
Buildings Except Low-Rise
Residential Buildings**



**Standard 90.1-2010: 40 people/1000 ft²
(100 m²) and area >500 ft² (50 m²)**

ANSI/ASHRAE/USGBC/IES
Standard 189.1-2009

**Standard for
the Design of
High-Performance
Green Buildings**

Except Low-Rise
Residential Buildings



25 people/1000 ft²

**Note: Type of DCV
used is not specified in
Standard 189.1**



- §7.4.3.3 Duct sealing everywhere
- §7.4.3.4 **Expanded economizer requirement**

| Climate Zones | Cooling Capacity for Which an Economizer is Required |
|---|--|
| 1A, 1B, 2A | No Economizer Requirement |
| 2B, 3A, 3B, 3C, 4A, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8 | ≥ 9.7 kW (33,000 Btu/h) ^a |

- Rooftop units <5 tons: two stage (first stage economizer then second stage adds mechanical)
- VAV supply air temp reset by at least 5° F (3° C)

Standard 90.1

- **Exempted 3A and 4A**
- **Capacity > 65,000 Btu/h (19 kW)**



§7.4.3 HVAC

- §7.4.3.5 Zone controls for limit on reheatme reheated, re-cooled or remixed not to exceed *design OA flow rate* or 15% of total peak supply
- §7.4.3.6 Fan power limits



- 10%

§7.4.3 HVAC

- §7.4.3.8 Expand energy recovery req't

TABLE 7.4.3.8 Energy Recovery Requirement (I-P)

| Climate Zone | % Outside Air at Full Design Flow | | | | | | | |
|------------------------|-----------------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|-------|
| | ≥10% and < 20% | ≥20% and < 30% | ≥30% and < 40% | ≥40% and < 50% | ≥50% and < 60% | ≥60% and < 70% | ≥70% and < 80% | ≥80% |
| | Design Supply Fan Flow, cfm | | | | | | | |
| 3B, 3C, 4B, 4C, 5B | NR | NR | NR | NR | NR | NR | ≥5000 | ≥5000 |
| 1B, 2B, 5C | NR | NR | NR | NR | ≥26,000 | ≥12,000 | ≥5000 | ≥4000 |
| 6B | NR | ≥22,500 | ≥11,000 | ≥5500 | ≥4500 | ≥3500 | ≥2500 | ≥1500 |
| 1A, 2A, 3A, 4A, 5A, 6A | ≥30,000 | ≥13,000 | ≥5500 | ≥4500 | ≥3500 | ≥2000 | ≥1000 | ≥0 |
| 7, 8 | ≥4000 | ≥3000 | ≥2500 | ≥1000 | ≥0 | ≥0 | ≥0 | ≥0 |

- 60% energy recovery effectiveness (enthalpy)
- Provisions to bypass to allow air economizing

- §7.4.3.9 Kitchen hoods add variable speed, 50% reduction in flow (*significant impact*)
- §7.4.3.12 Unoccupied hotel/motel
>50 guest rooms





Continued: Highlights for Energy (Section 7)

Prescriptive Option (cont.)

- §7.4.5 Power

Peak load reduction:

- *Reduce peak capacity of the building through demand-limiting or load shifting measures (10%)*
- *Standby generation does not count...*



Highlights for Energy (Section 7)

Prescriptive Option (Lighting)

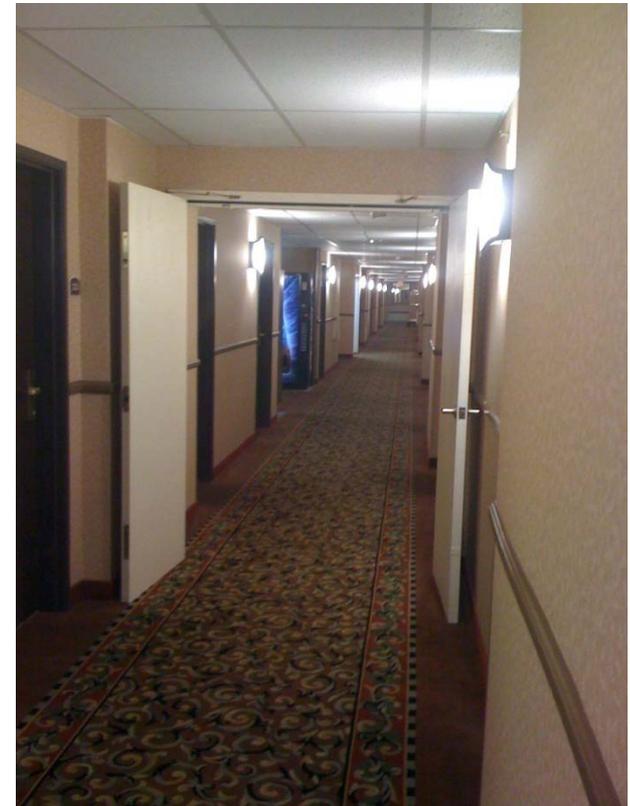
- Interior lighting power to be less than ASHRAE Standard 90.1 for some space types (§7.4.6.1)
- Occupancy sensor controls (§7.4.6.2)
 - Offices <250 ft² (25 m²)
 - Classrooms, lecture, training, conference or meeting rooms (<1000 ft² or 100 m²)



Prescriptive Option (Lighting)

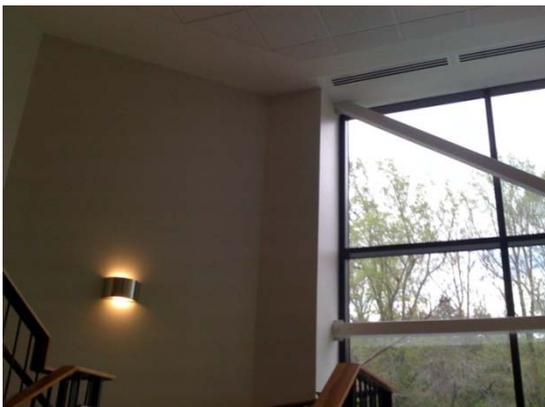
- (§7.4.6.3) Occupancy sensor control to reduce power to <50% for:
 - Hotel, motel hallways
 - Storage stack aisles
 - Library stacks

*Exception: HID lit areas
< 0.8 W/ft² or 8 W/m²*
- Egress lighting control,
< 0.1 W/ft² (1 W/m²)
Additional allowed if w/ auto shut-off



Prescriptive Option (Lighting)

- Auto-controls for daylight areas, outdoor lighting (§7.4.6.5)
 - Continuous dimming,
 - Stepped switching with auto-off



Exceptions:

***combined
daylight area
>250 ft² per room***

1. Window display and exhibition lighting.
2. Conference rooms greater than 250 ft² (25 m²) that have a lighting control system with at least four scene options.
3. Lighting in conference rooms that is dimmable and controlled by dimming controls that are located within the space and accessible to the space occupants.
4. Saunas, steam rooms, and spaces containing swimming pools or spa pools.
5. Spaces where medical procedures are performed.
6. Spaces within dwelling units.
7. Spaces within hotel and motel guest rooms and suites.
8. *Daylight zones* where the height of existing adjacent structures above the window is at least twice the distance between the window and adjacent structures, measured from the top of the glazing.



§7.5 Performance Based Option:

- Demonstrated equivalent performance in **both energy cost** and **CO₂ equivalent** compared to if using the Prescriptive path

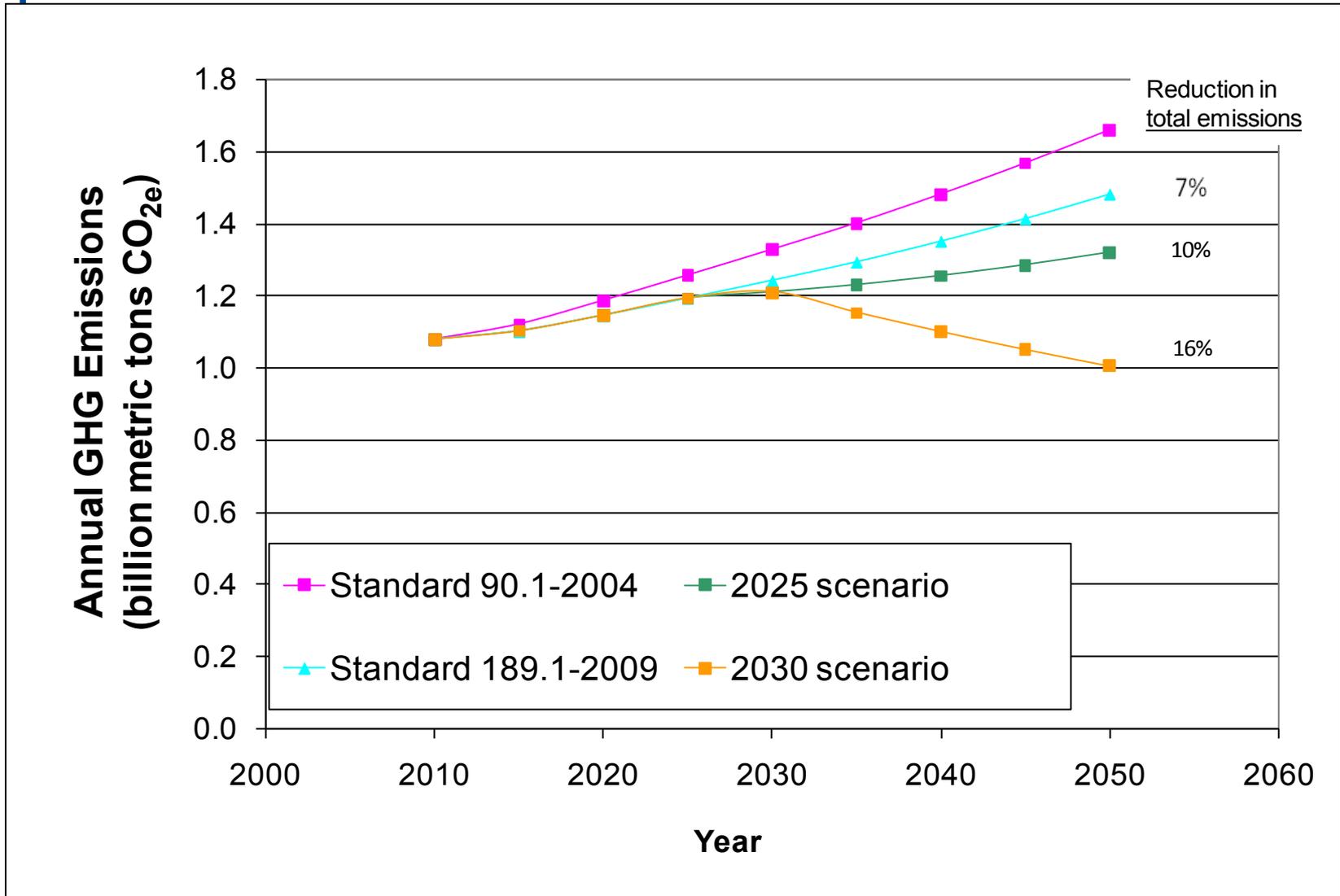
**Proposed \leq Mandatory +
Prescriptive Path**



**Using Normative Appendix D
“Performance Option for Energy
Efficiency”**



Impact on GHG Emissions



Highlights for Energy (Section 7)

Performance Based Option:

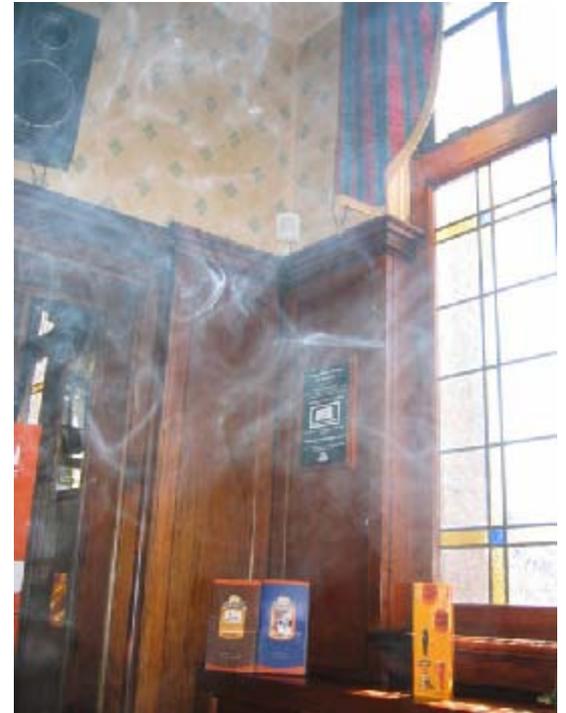
§7.5.4 Annual Load Factor/ Peak Electric Demand

- Same or less peak electric demand as if following the prescriptive path
- Minimum annual electrical load factor of 0.25

Section 8

Indoor Environmental Quality

- **Key Items**
 - **Outdoor airflow**
 - **Tobacco smoke control**
 - **Outdoor air monitoring**
 - **Filtration and air cleaning**
 - **Daylighting**
 - **Thermal comfort**
 - **Acoustics**



§8.3.1 IAQ

- Minimum ventilation design outdoor airflow rate per Standard 62.1, using Ventilation Rate Procedure (Table method)

§8.3.2 Outdoor Air Monitoring

- Permanently mounted, direct outdoor airflow measurement $\pm 15\%$ of ***minimum outdoor airflow***
(Differs from LEED in that CO₂ monitoring for densely occupied spaces not specified)
- Constant volume air supply, damper position feedback allowable instead



- **§8.3.1.3 Filtration**

- (a) Particulates - Minimum MERV 8. MERV 13 when in “non-attainment” area for PM_{2.5}



(Modifies and strengthens Std. 62.1 §6.2.1.1)

- (b) Ozone cleaners for outdoor air in building projects located in non-attainment areas for ozone. *(Ozone removal efficiency = 40%, per Std. 62.1 §6.2.1.2)*
- (c) Filter frames, air cleaner racks, access doors sealed to eliminate bypass pathways



Indoor Environmental Quality

- §8.3.1.4

Environmental Tobacco Smoke Control

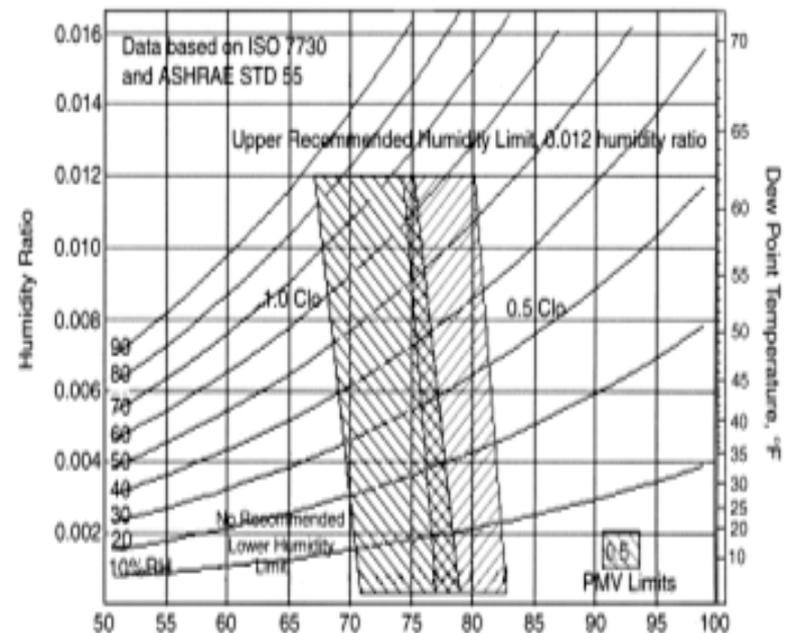
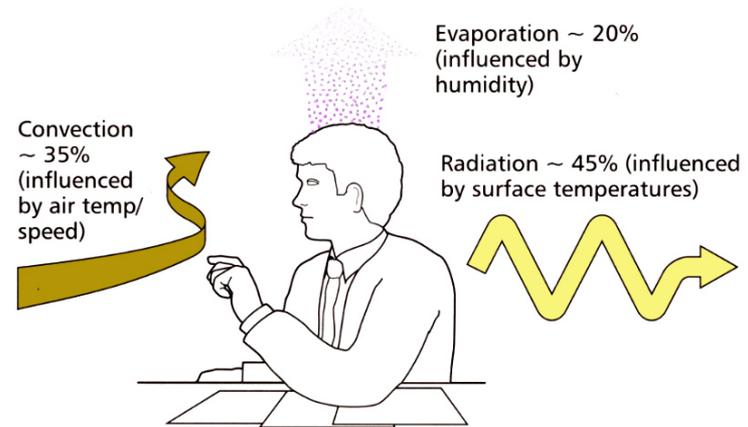
- *No smoking inside, with signage*
- *No smoking within 25 feet (7.5 m) of entrance, outdoor air intakes or operable windows*





Other Mandatory:

- **Thermal Comfort**
- **Mat systems at building entrances**
- **Sound transmission thru wall**



Performance Option (§8.5):

- Daylighting simulation
 - Office space and classrooms
 - Minimum illuminance target:
300 lux (30 fc) on work surfaces in 75%
of daylight zone, at noon equinox
- Direct sun limitation on office
workspace
 - Direct sunlight on worksurface <20% of
occupied hours on equinox day
(worksurface = 2.4 feet [0.75 m] above
floor)



Building's Impact on Atmosphere, Materials and Resources (Section 9)

Mandatory:

- Construction waste management
- No CFC based refrigerants

Prescriptive Option:

- Reduced impact materials (recycled, regional, biobased)

Performance Option:

- Life Cycle Assessment



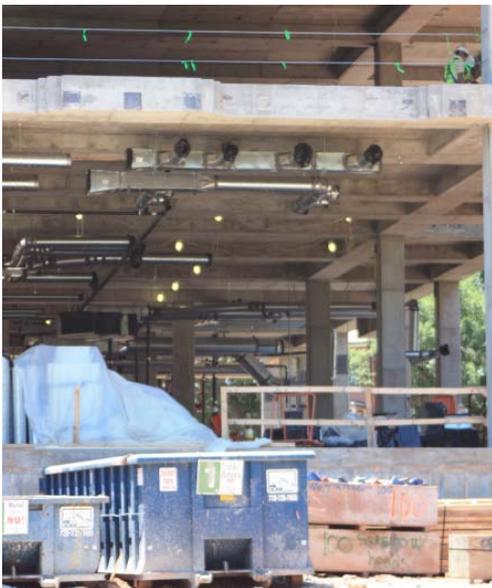
§10.3.1.2 Building Project Commissioning

- Full commissioning for >500 m² (5,000 ft²)
 - HVAC, building envelope, lighting, irrigation, plumbing, domestic water, renewable energy
- Designate CxA
- Develop OPR and Basis of Design
- Design reviews at 50% and 'final' construction documents



§10.3.1.4 IAQ Construction Mgmt

- Develop and implement an IAQ Construction Management Plan, to include:
 - Air duct materials
 - Permanent HVAC shall not be used during construction (except testing)
 - Flush-out or baseline IAQ monitoring





§10.3.2 Plans for Operation

1. High Performance Building Operation
 - Site Sustainability
 - Water Use Efficiency
 - Energy Efficiency
 - Indoor Environmental Quality
2. Maintenance
3. Service Life
4. Transportation Management



More Information

- Information on ASHRAE standards:
www.ashrae.org then follow
*“Standards”, includes listserv for
Standard 189.1*



Thank you!

- Comments, questions, concerns, advice ...

Lawrence "Larry" Schoen, P.E.
Larry@SchoenEngineering.com