Trane Engineers Newsletter Live: March 2012
High-Performance Green Buildings: Impact of ASHRAE Standard 189.1-2011

Presenter biographies

Susanna Hanson,
Applications engineer, Trane

Susanna is an applications engineer at Trane with over twelve years of experience with chilled-water systems and HVAC building load and energy analysis. Her primary responsibility is to aid system design engineers and Trane personnel in the proper design and application of HVAC systems. Her main areas of expertise include chilled-water systems and ASHRAE Standard 90.1. She is also a Certified Energy Manager.

She has authored several articles on chilled water plant design, and is a member of ASHRAE SSPC 90.1 *Energy Standard for Buildings Except Low-Rise Residential Buildings*. Susanna earned a bachelor's degree in industrial and systems engineering from the University of Florida, where she focused on building energy management and simulation.

Dennis Stanke,
Staff application engineer, Trane

With a BSME from the University of Wisconsin, Dennis joined Trane in 1973, as a controls development engineer. He is now a Staff Applications Engineer specializing in airside systems including controls, ventilation, indoor air quality, and dehumidification. He has written numerous applications manuals and newsletters, has published many technical articles and columns, and has appeared in many Trane Engineers Newsletter Live broadcasts.

An ASHRAE Fellow, he currently serves as Chairman for ASHRAE Standard 189.1, *Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings*. He recently served as Chairman for ASHRAE Standard 62.1, *Ventilation for Acceptable Indoor Air Quality*, and he served on the USGBC LEED Technical Advisory Group for Indoor Environmental Quality (the LEED EQ TAG).

Chris Hsieh,
Systems engineer, Trane

Chris Hsieh specializes in all HVAC industry-related green and environmental initiatives, including programs such as Energy Star®, USGBC LEED®, and the Collaborative for High-Performance Schools. He holds bachelor and masters degrees in electrical engineering from National Kaohsiung Institute of Technology in Taiwan and Southern Methodist University, respectively.

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Agenda

Presenters: Susanna Hanson, Chris Hsieh, Dennis Stanke,

Abstract:

Buildings in the US account for 39% of CO2 emissions, 40% of energy consumption and 13% of water consumption. They also occupy valuable land, contribute to urban heat islands, atmospheric pollution, and landfill waste. More and more building owners andmunicipalities want a standard to use as the basis for code requirements for buildings designed to exceed minimum building codes. ASHRAE Standard 189.1 2011 "Design of High Performance Green Buildings" recognizes these facts – it's a mandatory language code-intended standard with provisions related to building sites, water use, energy efficiency, and general environmental impact, in addition to indoor environmental quality.
This program presents an overview of the standard and its reference standards, and provides some insight regarding its potential impact on building designs, building codes and rating systems.

Learning objectives

After viewing this program Participants will be able to:

1. Summarize what ASHRAE defines as a high performance building
2. Summarize the relationship between standards, codes, and building rating systems
3. Identify the updates to ASHRAE Standard 189.1 for each section
4. Identify updates to referenced ASHRAE standards and how they impact Standard 189.1

Agenda

1) Introductions/Agenda
2) Who cares and why?
    a) Owners, examples
    b) Focus on energy efficiency/standards
3) Standards, codes, rating systems and buildings: How do things fit?
4) ASHRAE Standard 189.1 2011 intention
    a) How 90.1 feeds IECC, how 62.1 feeds IMC,
    b) IECC 2012, IMC 2012 and 189.1 2011 contribute to IGCC 2012.
    c) Std 90.1 and Std 62.1 contribute to LEED 2009 rating
5) What's new in Standard 189.1?
    a) Site sustainability
    b) Water use efficiency
    c) Energy efficiency/new in 90.1
    d) Indoor Environmental Quality (new in 62.1)
    e) Atmosphere, Materials and Resources
    f) EPP/LCA/LCI
    g) Construction, Plans for Operation
6) Wrap up

TRANE

High Performance Green Buildings: The Impact of ASHRAE Standard 189.1-2011

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GBCI CMP

High-Performance Green Buildings/ASHRAE Standard 189.1-2011 Course ID: 0090007407

Approved for 1.5 GBCI hours for LEED professionals

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www.NCEES.org

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learning objectives

After today's program you will be able to:

- Summarize the ASHRAE definition for a high-performance green building
- Summarize the relationship between standards, codes, and building rating systems
- Identify updates to ASHRAE Standard 189.1 for each section
- Identify updates to referenced ASHRAE standards and how they impact Standard189.1

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Agenda

- Why high performance green buildings?
- Standards, codes and “green” building ratings
- What’s new for Standard 189.1-2011?
  - Site sustainability
  - Water use efficiency
  - Energy efficiency (Standard 90.1 updates)
  - Indoor environmental quality (Standard 62.1 updates)
  - Atmosphere, materials and resources
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- Summary

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Today’s Presenters

Dennis Stanke
Applications Engineer

Susanna Hanson
Applications Engineer

Chris Hsieh
Systems Engineer

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What's a High Performance Green Building? According to ASHRAE Std 189.1 …

"…a building designed, constructed and capable of being operated in a manner that **increases environmental performance and economic value** over time, seeks to establish **an indoor environment that supports the health** of occupants, and **enhances** satisfaction and **productivity** of occupants through integration of **environmentally preferable building materials** and **water-efficient and energy-efficient systems."**

ANSI/ASHRAE/IES 189.1-2009

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Why Do We Care?

- Building owners
  - InerfaceFLOR, Wal-Mart, Target, Starbucks, Google, Ingersoll Rand
- Government buildings (GSA, U.S. Army)
- Jurisdictions (Rhode Island, California, Seattle)
- Green buildings are simply better for earth and its occupants

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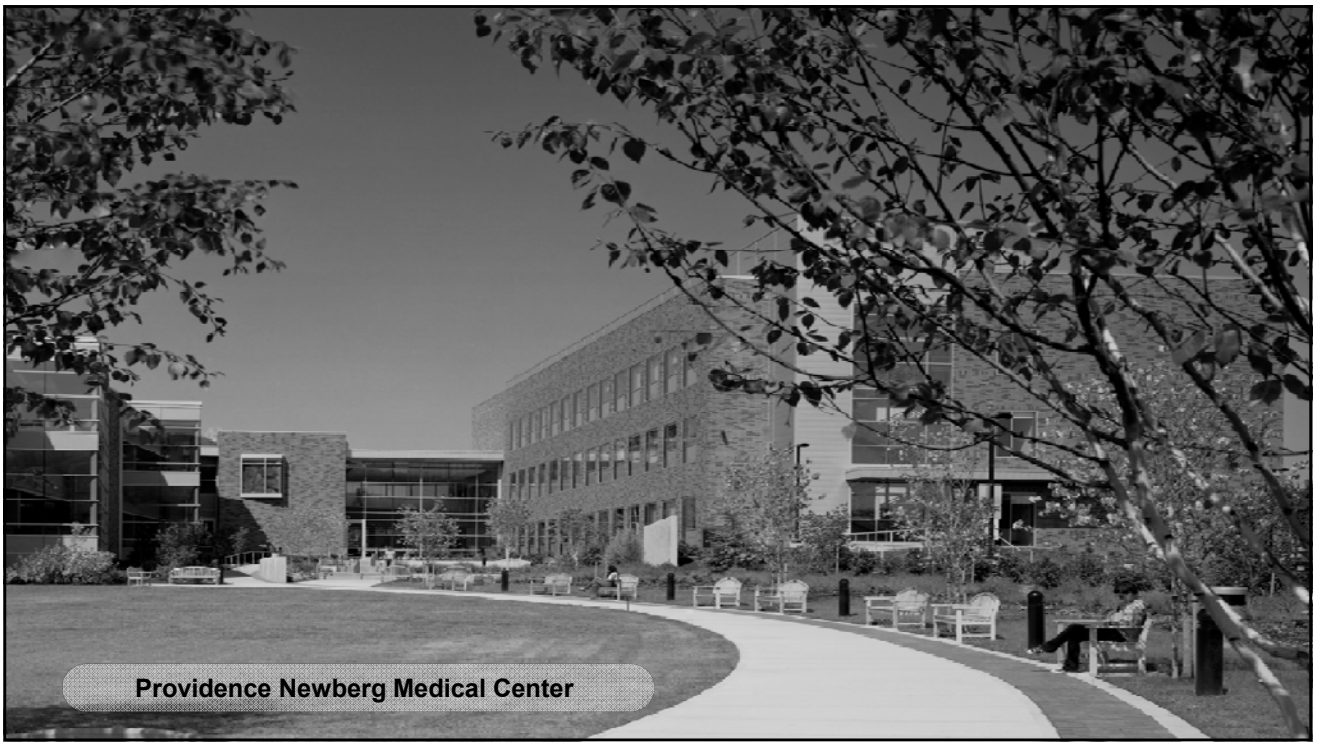
U.S. EPA Science and Technology Center (Kansas City, KS)



Why Do We Care?

- Because building ***owners*** care!
- Model codes (IGCC, CalGreen) are coming
- Rating systems (LEED® and Green Globes) are here
- Owners want HPGB because they:
  - Enhance company image
  - Reduce operating costs in many cases
  - Increase building value (both rent and resale)
  - Increase occupant comfort, health and productivity

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Why Do We Care?

- Owners, architects, designers, contractors, commissioning agents, operators and others all contribute to successful HPGB

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Why Do We Care?

- Regardless of profession, valuable HPGB project members should know what it takes to comply with:
  - Minimum energy requirements (Std 90.1-2010)
  - Minimum ventilation requirements (Std 62.1-2010)
  - High-performance green building requirements (Std 189.1-2009)
  - Others: thermal comfort (Std 55), maintenance (Std 180)

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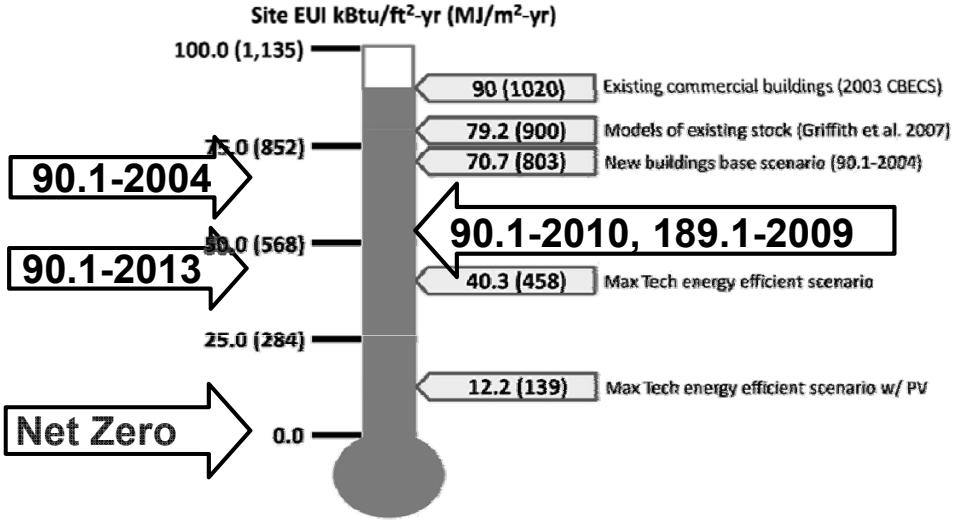
Commercial Buildings



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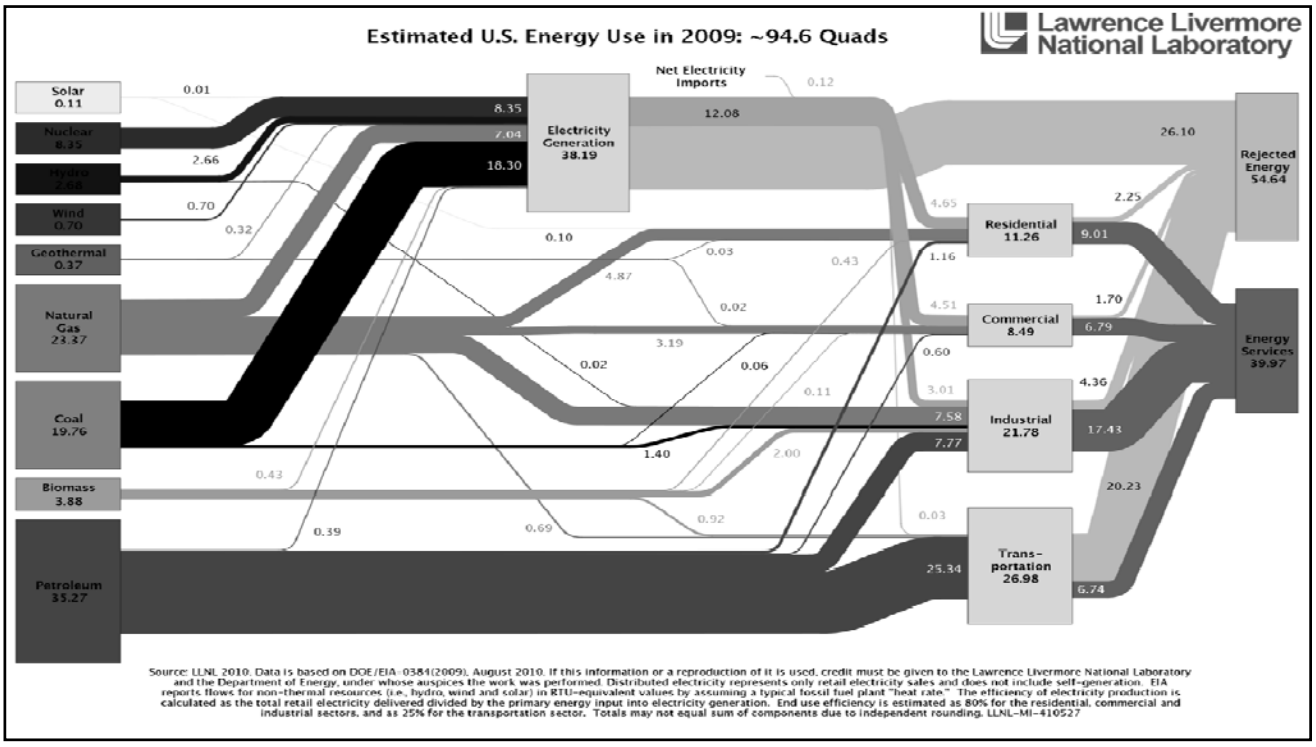
Estimated U.S. Energy Use in 2009: ~94.6 Quads
Lawrence Livermore National Laboratory
Solar 0.11
Nuclear 8.35
Hydro 2.68
Wind 0.70
Geothermal 0.37
Natural Gas 23.37
Coal 19.76
Biomass 3.88
Petroleum 35.27
Electricity Generation 38.19
Net Electricity Imports 12.08
Residential 11.26
Commercial 8.49
Industrial 21.78
Trans-portation 26.98
Rejected Energy 54.64
Energy Services 39.97
Source: LLNL 2010. Data is based on DOE/EIA-0384(2009), August 2010. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527


Lake Lanier, Georgia


Ga. Claims 'Total Victory' In Tri-State Water War
Waukesha water war key for Great Lakes diversion policy


Source: www.noaa.gov
Arizona 7/2011


Source: http://www.nrel.gov/docs/fy04osti/33905.pdf.

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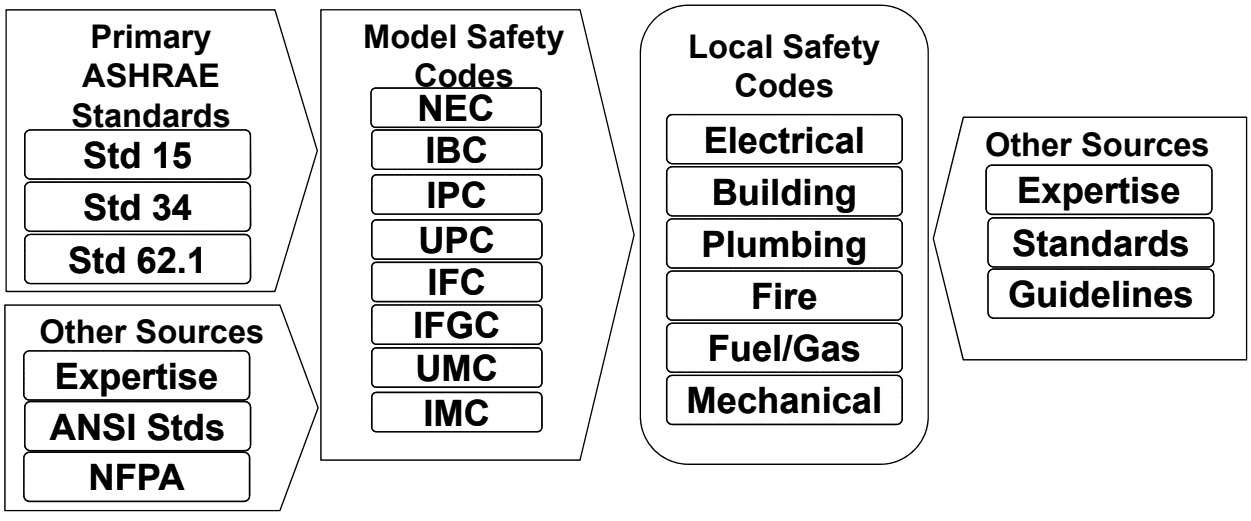
how standards fit with Safety Codes



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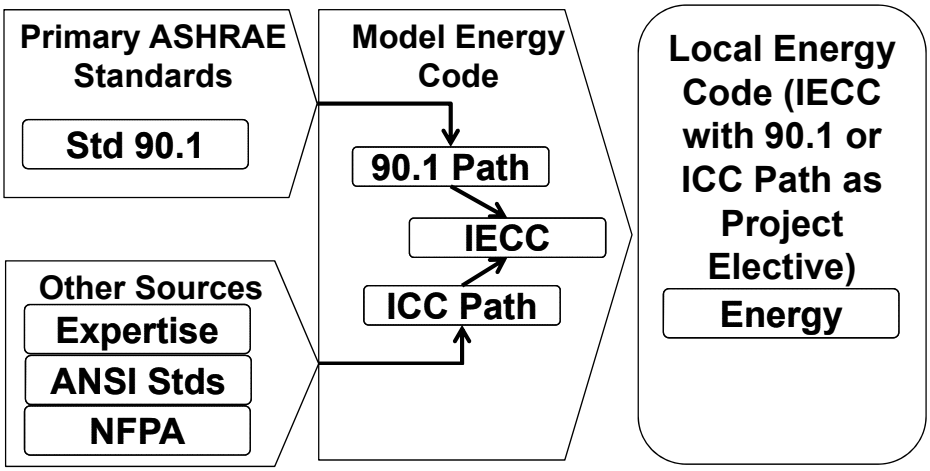
how standards fit with
Energy Codes



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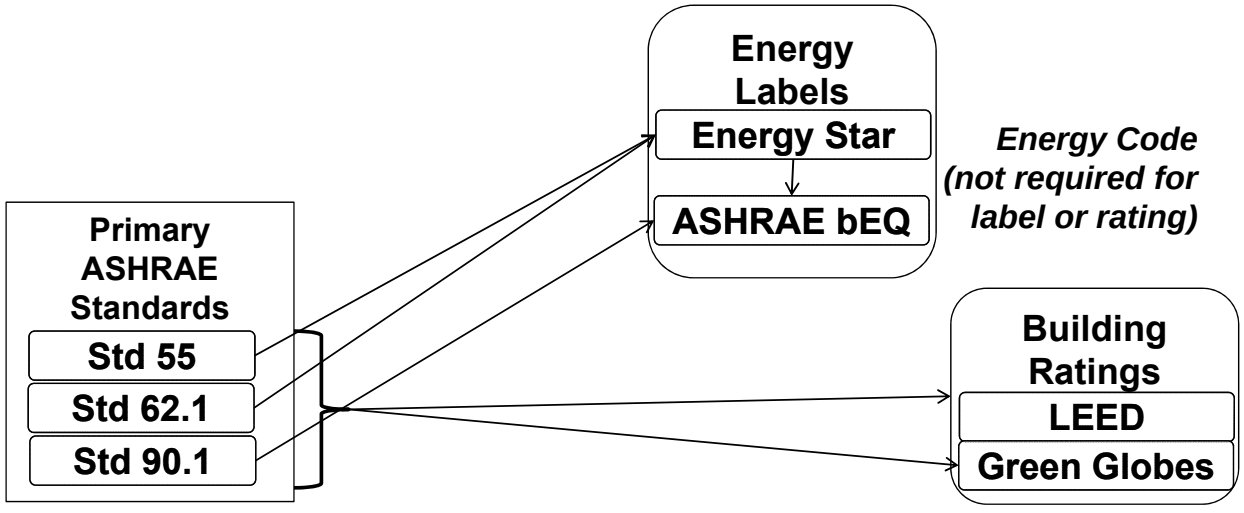
how standards fit with
Labels and Ratings



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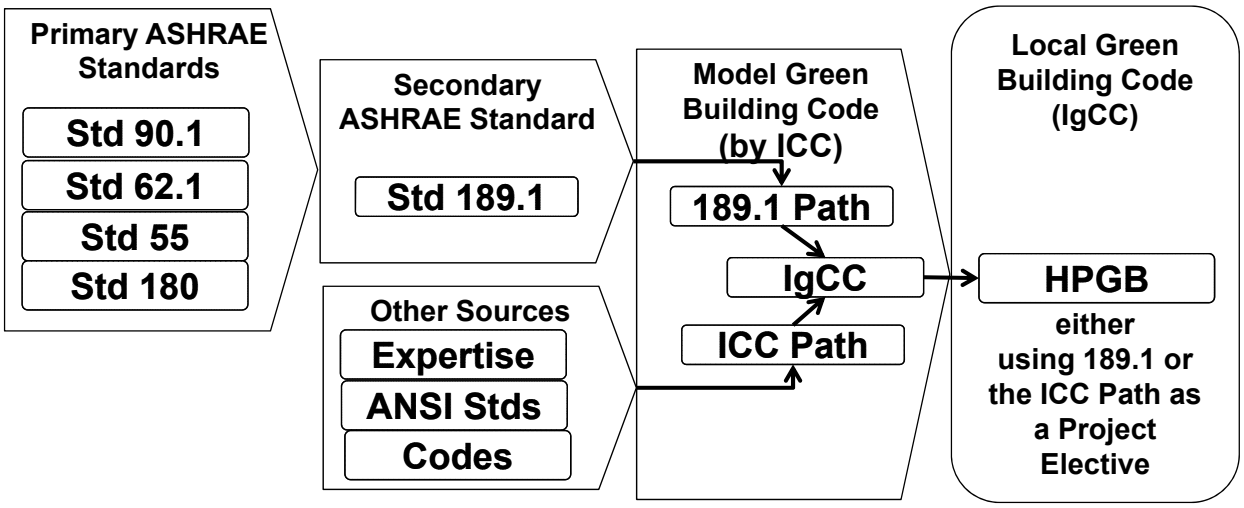
how standards fit with
Green Building Codes



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What is Standard 189.1?

- An ANSI standard in mandatory-language, co-sponsored by ASHRAE, USGBC, and IES, that:
  - Provides minimum design requirements for high-performance green buildings (HPGB)
  - Applies to new buildings and additions, new systems and new equipment in existing buildings
  - Does not apply to low rise residential (like Std 90.1)

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What's Its Intent?

- It builds on the requirements in other standards, primarily Std 90.1 and Std 62.1
- In addition, it provides:
  - A design elective compliance option for the new ICC model green-building codes (the IgCC-2012)
  - Technical content for green-building rating programs (like LEED)

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std 189.1-2011
HPGB Provisions

- Site sustainability: e.g., site location, heat island, rainwater
- Water use efficiency: e.g., turf, fixtures, once-through, condensate recovery
- Energy efficiency: Std 90.1 compliance **plus…**
- Indoor environmental quality (IEQ): e.g., Std 62.1 all sections, **plus** OA sensing and no smoking, Std 55 compliance, acoustics, daylighting

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std 189.1-2011
HPGB Provisions

- Atmosphere, materials and resources: e.g., recycle, reuse, no CFC's allowed
- Construction and plans for operation, including Std 189 maintenance manual compliance

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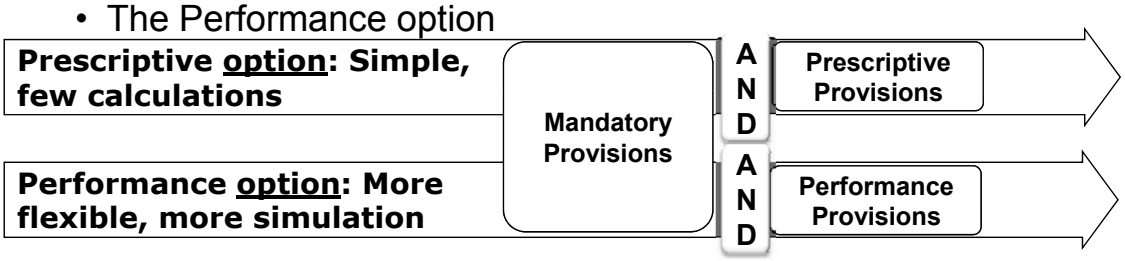
section 4:
Administration and Enforcement

- *Building projects* shall comply with sections 4 thru 11
- Sections 5 thru 10 require compliance with either of two optional compliance options:
  - The Prescriptive option or
  - The Performance option



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Site Sustainability

Mandatory

Site selection, e.g.:
- **Use *brownfield site***
- **Use *greyfield site***
- **Use *greenfield site*, with many restrictions**

Mitigate heat island effect, e.g.:
- **Shade >50% of site**

Reduce light pollution, e.g.:
- **Uplight <5% in high activity commercial areas**

AND

Prescriptive

Site development, e.g.:
- **Use >40% vegetated or pervious surfaces**

OR

Performance

Site development, e.g.:
- **Manage >50% of rainfall on *greenfield sites***

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site sustainability

Mandatory (5.3)

Select sustainable site

- Allowable sites
  - Within an existing *building envelope*
  - *Brownfield site* (e.g., documented as contaminated)
  - *Greyfield site* (with >20% impervious surfaces)
  - *Greenfield site* (with 20% or less impervious surfaces) with significant restrictions

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site sustainability

Mandatory (5.3)

Select sustainable site

- Disallowed sites:
  - Near floodplain
  - Near fish/wildlife conservation areas
  - Near wetlands

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site sustainability

Mandatory (5.3)

Reduce urban heat island effect

- For site hardscape provide > 50% of site with combination of
  - Trees and plants for shading
  - Paving materials SRI ≥ 29
  - Structures for shading
  - Under-building parking

site sustainability
Mandatory (5.3)

Reduce urban heat island effect

- Shade above-grade east and west walls >30%
- Cover at least 75% of roof surface with:
  - >78 SRI materials for low-sloped roofs (<2:12)
  - >29 SRI materials for steep sloped roof

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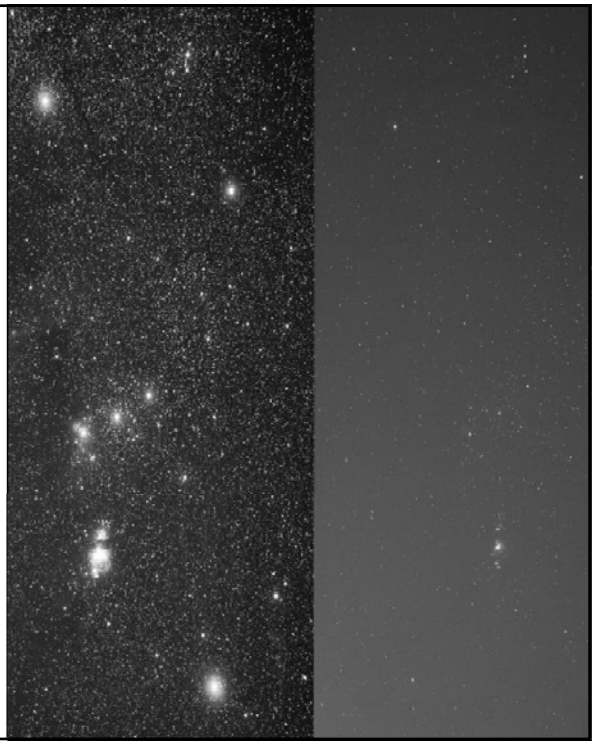
site sustainability
Mandatory (5.3)

- Reduce light pollution
  - Comply with Std 90.1, section 9
  - Comply with allowable Backlight and Glare Ratings
  - Comply with allowable Uplight Ratings



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site sustainability

Prescriptive Option (5.4)

- Comply with mandatory requirements (5.3)
- To limit rainwater runoff:
  - Provide >40% of any site with any combination of:
    - Vegetation
    - Vegetated (green) roof
    - Porous pavers
    - Permeable pavement or pavers

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site sustainability

Prescriptive Option (5.4)

- Comply with mandatory requirements (5.3)
- To limit rainwater runoff:
  - On a *greenfield site*
    - Retain or restore or develop native or adapted plants on at least 20% of site

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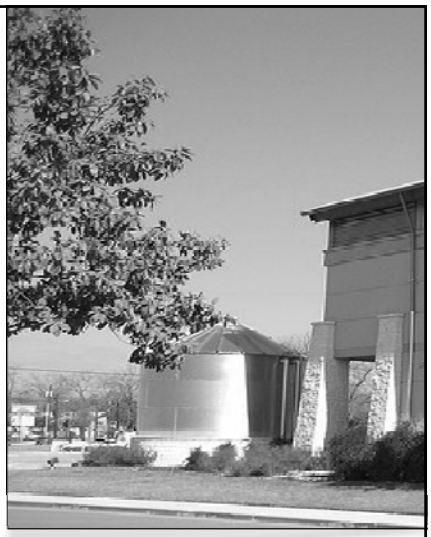
site sustainability

Performance Option (5.5)

- Comply with mandatory requirements (5.3)
- To prevent excessive rainwater runoff:
  - For projects within existing *building envelope*, manage at least 20% of annual rainfall



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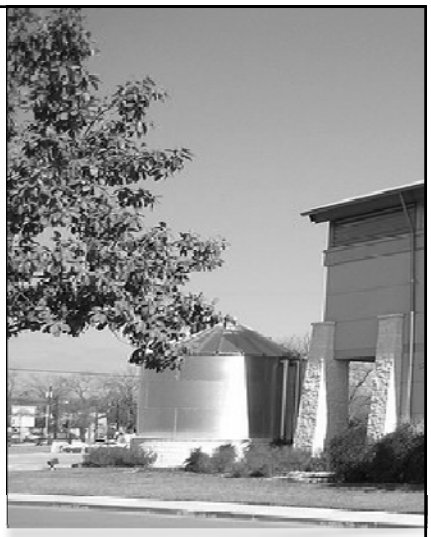
site sustainability

Performance Option (5.5)

- Comply with mandatory requirements (5.3)
- To prevent excessive rainwater runoff:
  - On *grayfield* or *brownfield sites,* manage at least 40% of annual rainfall
  - On all other sites, manage 50% of annual rainfall



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site sustainability

New for 2011

- No invasive plants may be used, and if there already, must be removed and destroyed
- Improved requirements for tree growth rate
- Porous pavers & open graded aggregate—no SRI requirement
- Permeable pavement and pavers minimum percolation rate—water runs through more than off

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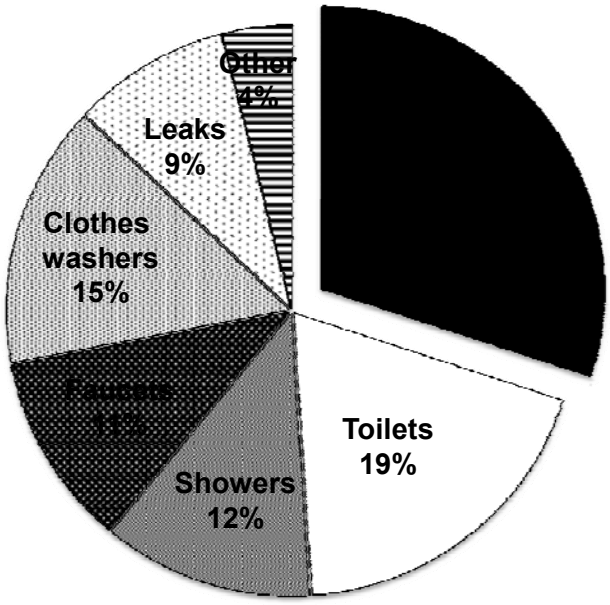
Water Use in the U.S.

Outdoor water use can be as high as 70% depending on region and season



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Water Use Efficiency

Mandatory

Site water use reduction, e.g.:
- **Use <40% turf grass**

Bldg water use reduction, e.g.:
- **Use <1.28 gal/flush toilets**
- **For HVAC**
  - **No once-through systems with potable water**
  - **Tower drift <0.002% volume**
  - **Recover condensate from units >5 tons**

Consumption measurement, e.g.:
- **Measure potable water consumption if >1000 gal/day**

AND

Prescriptive

Site water use reduction, e.g.:
- **Irrigate <33% landscaped area with potable water**

Bldg water use reduction, e.g.:
- **Cooling towers w/soft water, cycles of concentration >5**

OR

Performance

Site water use reduction, e.g.:
- **Irrigation <35% potable water**

Bldg water use reduction, e.g.:
- **Water use < mandatory plus prescriptive requirements**

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water use efficiency

Mandatory (6.3)
Reduce site water-use

- At least 60% of *improved landscape* must be bio-diverse plants, not *turf grass*
- Automatic irrigation systems must use *hydrozoning*

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water use efficiency

Mandatory (6.3)
Reduce site water-use

- Irrigation systems *smart controllers* must use *evapotranspiration* (ETc) and weather data to adjust schedules and irrigation amounts, set for:
  - Irrigation adequacy at least 80% of ETc
  - Irrigation excess no more than 10%

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water use efficiency

Mandatory (6.3)

Reduce building water-use

- Plumbing fixtures and fittings shall comply with listed requirements (e.g., 1.28 gal/flush toilets)
- Clothes washers and dishwashers – ENERGY STAR requirements

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water use efficiency

Mandatory (6.3)

Reduce building water-use

- HVAC systems
  - Don't use *once-through cooling* with potable water
  - Counter-flow tower drift reduction limit - 0.002%
  - Recover condensate from > 5T HVAC equipment
  - Roofs
- Measure water consumption and manage data

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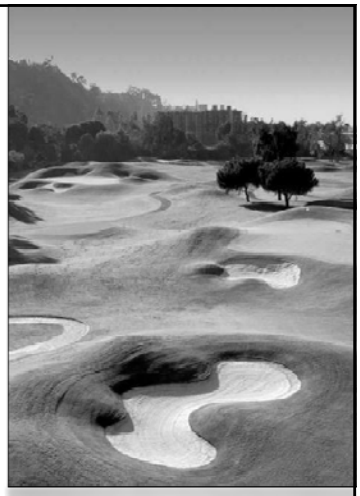
water use efficiency

Prescriptive (6.4)

Reduce building water-use

- Comply with mandatory (6.3) requirements
- Reduce site water-use
  - Golf courses: irrigate with reclaimed or on-site-recovered water only
  - Other landscapes: irrigate < 33% of improved landscaped area with potable water



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water use efficiency

Prescriptive (6.4)

Reduce building water-use

- Cooling tower – limit *cycles of concentration* of 5 or 3.5 based on makeup water hardness
- Commercial food service – high efficiency pre-rinse spray valves, hands-free faucet controllers
- Medical, laboratory facilities – many equipment water-use efficiency requirements
- Special water features:
  - Fountains – measure water, detect leaks, recirculate
  - Pools – recover filter backwash, use reusable or backwash filters

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water use efficiency

Performance Path (6.5)

Reduce building water-use

- Comply with mandatory (6.3) requirements
- Reduce site water-use
  - Use < 35% potable water for irrigation
  - Water demand must be based on *ET* for climate
- Reduce building water-use
  - Design for total annual water use < level achieved by compliance with Section 6.3.2, 6.4.2, and 6.4.3

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water use efficiency

Summary

- Site
  - Design, control
- Building
  - Fixtures, equipment
  - HVAC systems
    - No more once-through cooling HVAC systems
    - Cooling tower
    - Recover condensate

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engineers newsletter LIVE

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Energy

Mandatory

- **General**
  - **Meet mandatory provisions of Std 90.1-2010 and provisions of either the prescriptive or performance option**
- **On-site renewable energy systems, e.g.:**
  - **Prepare for renewable energy capacity >13.0 kBtu/ft² times roof area (1 story), or >10 kBtu/ft² (>1 story)**
- **Consumption management, e.g.:**
  - **Measure electrical energy used and communicate to data acquisition system**

AND

Prescriptive

- **General, e.g.:**
  - **Std 189.1-2011 requirements equal or supersede Std 90.1-2010 requirements**
  - **Provide on-site annual renewable energy >6 KBtu/ft² times roof area (1 story), or >10 kBtu/ft² (> 1 story)**

OR

Performance

- **Annual limits on: energy cost, CO_2 equivalent emissions, load factor/peak electrical demand**

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energy

Prescriptive Option (7.4)

- Reduce energy use by meeting mandatory Std 90.1-2010 requirements
  - Section 5.4: envelope
  - Section 6.4: HVAC
  - Section 7.4: service water heating
  - Section 8.4: electrical power
  - Section 9.4: lighting
  - Section 10.4: other equipment
  - Do not use Section 11: ECB method

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energy

Prescriptive Option (7.4)

- Prepare the site for future installation of renewable energy with minimum ***production equivalent*** of
  - 10 kBtu/ft² (32 kWh/ft²) of roof area for two or more story buildings or
  - 6 kBtu/ft² (20 kWh/ft2) of roof area for single-story buildings

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energy

Prescriptive Option (7.4)

- As an alternative to the renewable energy site preparation requirement, if the project shows the annual solar radiation is unsuitable (less than 4 kWh/m^2-day), it can commit to purchase renewable electricity of:
  - At least 7 kWh/ft^2 of conditioned space each year until the cumulative purchase totals 70 kWh/ft^2 of conditioned space

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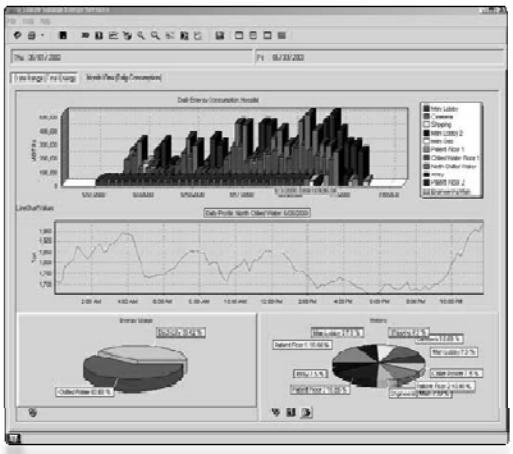
energy

Prescriptive Option (7.4)

- Measure energy used and report via remote communications



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energy

Prescriptive Option (7.4)

- Submeter systems meeting a size threshold
  - HVAC system
    - Connected electric load > 100kVA
    - Connected gas or district services load > 500,000 Btu/h
  - People moving
  - Sum of all feeders > 50 kVA
  - Lighting connected load > 50 kVA
  - Process and plug process connected load > 50 kVA
  - Connected gas or district services load > 250,000 Btu/h

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energy

Prescriptive Option (7.4)

- Comply with mandatory requirements (7.3), except as amended depending on some other choices
- Comply with Sections 5, 6, 7, 10 of 90.1-2010 except as modified

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energy

Prescriptive Option (7.4)

- Reduce energy use by exceeding some prescriptive Std 90.1-2010 requirements, for example:
  - Envelope – provide more insulation
  - HVAC – Use one of two minimum equipment efficiency options (7.4.3.1)
    - EPAct baseline, or
    - Higher efficiency

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minimum equipment efficiencies (7.4.3.1)

Equipment Efficiency Compliance Options

EPAct baseline

- Use equipment with minimum efficiency levels established by NAECA, EPAct, and EISA
- Provide on-site renewable energy sources sized to produce >6 or 10 kBtu/ft^2 of *roof* area annually
- Provide controls to reduce peak load by >10%

Higher Efficiency

- Use equipment with efficiency greater of ENERGY STAR or Appendix C requirements and
- Provide on-site renewable energy sources sized to produce >4 or 7 kBtu/ft^2 of *roof* area annually
- Provide controls to reduce peak load by >5%

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energy

Prescriptive Option (7.4)

- **7.4.5.1 Peak Load Reduction.** ***Building projects shall*** contain automatic systems, such as demand limiting or load shifting, that are capable of reducing electric peak demand of the building by not less than 10% of the projected peak demand. Standby power generation shall not be used to achieve the reduction in peak demand.
  - 5% if use the Appendix C or Energy Star equipment efficiency option

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energy

Prescriptive Option (7.4)

- **7.4.7.3 ENERGY STAR Equipment. The following** equipment within the scope of the applicable ENERGY STAR program shall comply with the equivalent criteria required to achieve the ENERGY STAR label if installed prior to the issuance of the certificate of occupancy

  Examples: washing machines, dishwashers, room air cleaners, residential heating and cooling equipment, ceiling fans, dehumidifiers, programmable thermostats, ventilating fans, electronics, office equipment, commercial food service equipment, battery charging equipment, power adaptors, vending machines, etc.

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System Design and Control

1. Pump pressure optimization is required
2. Maximum flow rates defined for pipe sizes
3. VSD-like performance required on smaller systems
4. Pipe insulation more stringent, especially hot pipes
5. Two-position valves on water-cooled air conditioners and heat pumps

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System Design and Control

1. Ventilation reset – system level
2. Low leak dampers in more areas and applications
3. Supply air temperature reset – 25% of delta T
4. VAV minimum airflow/reheat minimums – dual setpoints and more sophisticated control (UC400 update 4Q2010)
5. Max. overhead heating temp. 20ºF above space setpoint
6. Economizers
7. Energy recovery ventilation

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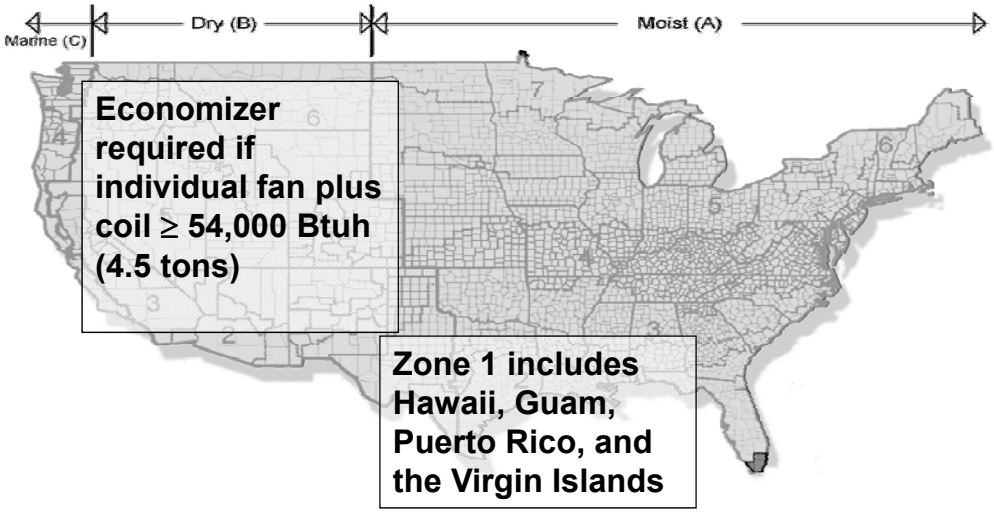
Economizers



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Economizers

- In all climates, except
  - 1A-hot, humid: such as South Florida
  - 1B-hot, dry: such as Dubai, Saudi Arabia
- Down to ~~54,000~~ 33,000 Btu/h (2.75 tons)
- Efficiency tradeoff for applied as well as unitary
  - % improvement over full or part load metric

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Economizers

- Exempted from requirement on not more than 20% of building air economizer capacity or more than 40 tons of total capacity of all systems
- Exception for water source heat pumps with 55°F ECWT
- Units with discharge temp control reset 5°F during econ.

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Economizers

No economizer required if equipment efficiency is improved

Table 6.3.2 Eliminate Required Economizer for Comfort Cooling by Increasing Cooling Efficiency

Climate Zone	Efficiency Improvement[a]
2a	17%
2b	21%
3a	27%
3b	32%
3c	65%
4a	42%
4b	49%
4c	64%
5a	49%
5b	59%
5c	74%
6a	56%
6b	65%
7	72%
8	77%

[a] If a unit is rated with an IPLV, IEER or SEER then to eliminate the required air or water economizer, the minimum cooling efficiency of the HVAC unit must be increased by the percentage shown. If the HVAC unit is only rated with a full load metric like EER or COP cooling then these must be increased by the percentage shown.

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Energy Recovery

TABLE 7.4.3.6 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

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energy

Prescriptive (7.4) Other Prescriptive Option Differences

- HVAC
  - Apply DCV to more zones
  - CO_2 sensor quantity and accuracy
  - Limit fan power by a further 10%
- Service water heating
  - Higher efficiency, insulation-including on spa pools

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energy

Prescriptive (7.4) Other Prescriptive Option Differences

- Lighting
  - Reduced lighting power allowance
  - More occupancy sensors, more automatic control

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energy

Performance (7.5)

- Comply with mandatory requirements (7.3)
- Design for and demonstrate per Appendix D:
  - Annual energy cost < compliance with Section 7 mandatory and prescriptive provisions plus other energy-related requirements in Section 5, 6, and 8.
  - Annual CO_2 equivalent < compliance with Section 7 mandatory and prescriptive provisions plus other energy-impact requirements in Section 5, 6, and 8. Use emission factors from Table 7.5.3.

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energy
Performance (7.5)

- Design for and demonstrate per Appendix D (cont'd):
  - Annual peak electric demand < compliance with Section 7 mandatory and prescriptive provisions plus other energy-impact requirements in Section 5, 6, 8

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Indoor Environmental Quality

Mandatory

- **Indoor air quality: Meet sections 4-7 of Std 62.1-2010. Supersede some Std 62.1 provisions, e.g.:**
- **OA flow ≥ VRP OA flow**
- **Monitor OA flow**
- **No smoking**
- **Thermal conditions: Comply with section 6.1 and 6.2 of Std 55-2010**
- **Acoustics: Limits sound, e.g.:**
- **envelope STC > 50**
- **Daylighting with toplighting, e.g.:**
- **skylights haze value >90%**
- **Soil gases: Use *soil gas retarding systems* in some areas (EPA Zone 1 Radon areas)**

AND

Prescriptive

- **Daylighting by sidelighting, e.g.:**
  - **Shading on east, south and west facades with PF > 0.50**
- **Materials, e.g.:**
  - **Use adhesives complying with VOC emission or content limits**

OR

Performance

- **Daylighting simulation, e.g.:**
  - **Simulate to show daylight illuminance >30 fc at 3 ft level**
- **Materials, e.g.:**
  - **Model to prove VOC limits**

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indoor environmental quality

Mandatory (8.3)

- Improve IAQ, e.g.:
  - Meet all Std 62.1-2010 requirements (VRP for min OA)
  - Monitor OA intake flow for VAV
  - For coils, use MERV 8 filters
  - For OA cleaning use:
    - MERV 8 in PM10 non-attainment areas
    - MERV 13 in PM2.5 non-attainment areas
    - 40% O_3 air cleaners in all 8-hour O_3 non-attainment areas

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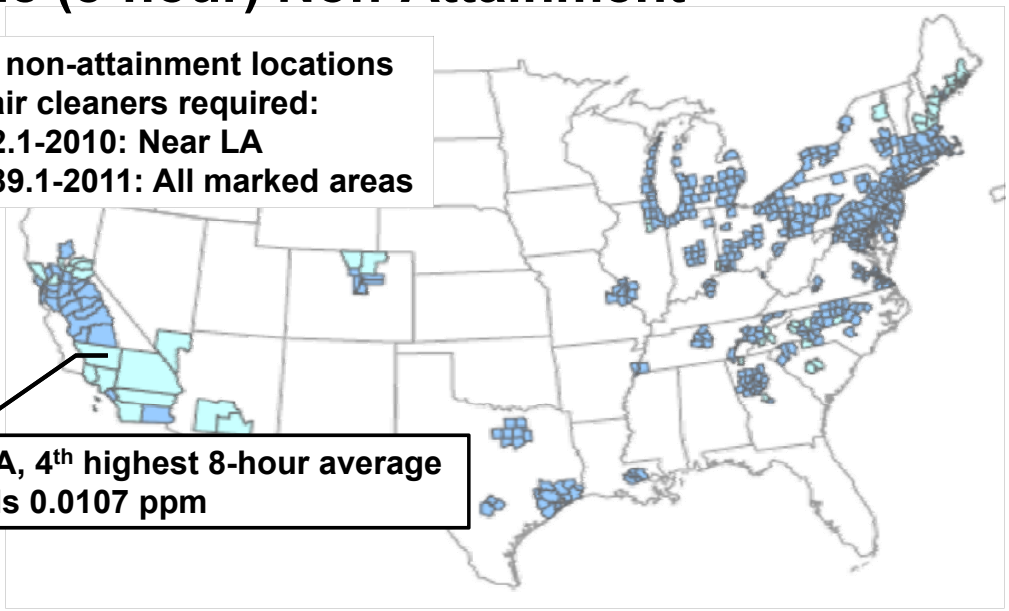
indoor environmental quality

Mandatory (8.3)

- Improve IAQ, e.g.:
  - NO SMOKING
  - Use walk-off mat systems at entrances

Ozone (8-hour) Non-Attainment

- **Many O_3 non-attainment locations**
- **40% O_3 air cleaners required:**
  - **Per 62.1-2010: Near LA**
  - **Per 189.1-2011: All marked areas**



Near LA, 4th highest 8-hour average exceeds 0.0107 ppm

Source: US EPA AQS Database January 17, 2007

indoor environmental quality

Mandatory (8.3)

- Improve IAQ
- Provide thermal comfort – comply with Std 55-2010
- Acoustical control – limit sound transmission from both external and internal sources
- Daylighting – toplighting required in some low-rise buildings (e.g., 50% of the area directly under a roof)
- Soil pollutants – use gas retarding systems in EPA “Zone 1” locations for radon

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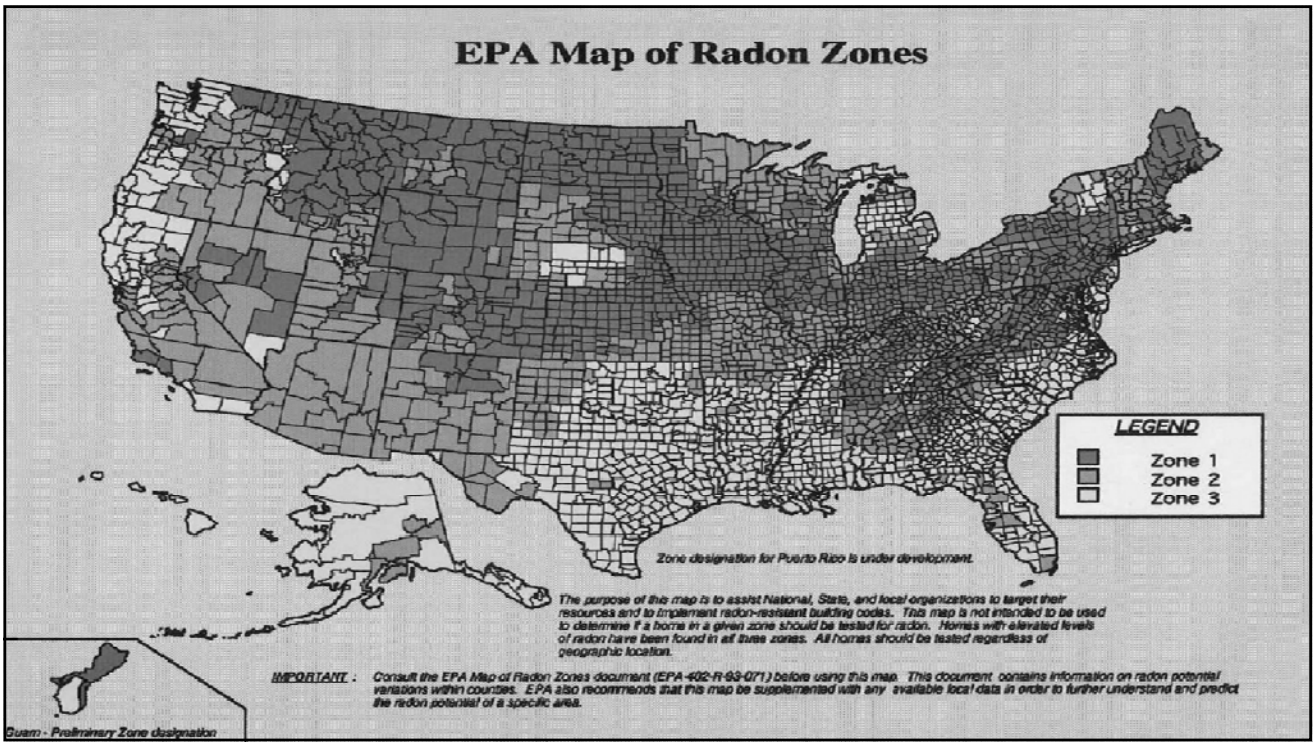

indoor environmental quality

Prescriptive Option (8.4)

- Daylighting by sidelighting – e.g., use prescribed minimum opening areas (Table 8.4.1.1) for sidelighting, and prescribed minimum shading factors for east, south and west facades
- Materials – choose materials (adhesives, paints, etc.) with no more than the maximum prescribed VOC emission rates and VOC content levels

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indoor environmental quality

Performance Option (8.5)

- Daylighting – use simulation to demonstrate compliance with:
  - Illuminance requirements (30 fc) in daylight zones
  - Direct sunlight limitations (20% or less of occupied hours)
- Materials – use models and simulation to find:
  - VOC emissions from specific materials listed
  - VOC concentrations to demonstrate compliance with levels specified in CA/DHS/EHLB/R-174 (California Section 01350)

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indoor environmental quality

New for 2011

- The filter requirement upstream of wet surfaces was changed from MERV 6 to MERV 8, and MERV 13 filters were added for PM2.5 non-attainment areas
- Daylighting simulation requirements were updated to be consistent with Std 90.1-2010
- Regarding material VOC emissions and content, references to California Section 01350 were updated to reflect changes made to Section 01350 in 2010

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What's New with Filtration?

Provisions	Std 62.1-2007	Std 62.1-2010 (Std 189.1-2011)
Filters upstream of wet surfaces	MERV 6	MERV 6 (MERV 8)
Filters in PM10 non-attainment areas	MERV 6	MERV 6 (MERV 8)
Filters in PM2.5 non-attainment areas	No requirement	MERV 11 (MERV 13 for 189)
Air cleaners in Ozone non-attainment areas	40% in high O_3 areas	40% in high O_3 areas (40% in all na areas)

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What About the IAQ Procedure?

Provisions	Std 62.1-2007	Std 62.1-2010 (Std 189.1-2011)
Is IAQ procedure a compliance option?	Yes	Yes (Yes, if intake > VRP)
Must designs consider mixtures of concern?	No	Yes (Yes)
Is a mass balance analysis required?	No. It's 1 of 4 options	Yes, in all cases (Yes, in all cases)
Is a subjective evaluation required?	No. It's 1 of 4 options	Yes, in most cases (Yes, in most cases)

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What's New with Natural Ventilation?

Provisions	Std 62.1-2007	Std 62.1-2010 (Std 189.1-2011)
NV area distance from OA opening	Fixed value	Geometry-dependent (Geometry-dependent)
Single-side opening (assuming 9 ft ceiling)	25 ft	2H = 18 ft (2H = 18 ft)
Double-side opening (assuming 9 ft ceiling)	25 ft	2H = 45 ft
OA opening area for perimeter spaces	4% of floor area	4% of floor area (4% of floor area)
Mixed mode ventilation design	Optional	Required (Required)

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What's New with Exhaust?

Provisions	Std 62.1-2007	Std 62.1-2010 (Std 189.1-2011)
Minimum exhaust required for VRP?	Yes	Yes (Yes)
Minimum exhaust required for IAQP?	No	Yes (Yes)
Minimum exhaust required for NVP?	No	Yes (Yes)

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Atmosphere, Material, Resources

Mandatory

- **Construction waste, e.g.:**
  - **Divert >50% of waste from landfills by recycling and/or reuse**
- **Extract/harvest/manufacture, e.g.:**
  - **In compliance with laws and regulations of country of origin**
- **Refrigerants -- No CFC's**
- **Storage, collection of recyclables and discarded goods, e.g.:**
  - **Dedicate an area for collection and storage of materials for recycling and/or reuse**

AND

Prescriptive

- **Reduced impact materials, e.g.:**
  - **Assure recycled material content >10% of all mat'l cost**
  - **Assure regional materials >15% of cost of all materials**

OR

Performance

- **Life-cycle assessment (LCA), e.g.:**
  - **Perform LCA for at least two building alternatives**
  - **Show one alternative is >5% better than other approach(s)**

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atmosphere, materials, and resources

Mandatory (9.3)

- Manage construction waste – e.g.:
  - Divert > 50% of construction waste from landfills by recycling and/or reuse
  - Limit waste to 12,000 lbs per 10,000 ft^2 of floor area
- Extract, harvest and/or manufacture per local law
- Refrigerants – no CFC-based refrigerants in HVAC systems or fire suppression systems

atmosphere, materials, and resources

Mandatory (9.3)

- Storage and collection of recyclables – dedicate floor space for collection and storage of:
  - Recyclables and reusable materials
  - Fluorescent and HID lamps and ballasts

atmosphere, materials, and resources

Prescriptive (9.4)

- Comply with mandatory requirements (9.3)
- Use reduced impact materials – e.g. use:
  - Recycled content > 10% of total cost of building materials
  - Regional material content > 15% of total cost of building material
  - Biobased products > 5% of building materials

atmosphere, materials, and resources

Performance (9.5)

- Comply with mandatory requirements (9.3)
- Perform a life-cycle cost assessment (LCA) of at least two building alternatives
  - Show that one alternative represents > 5% improvement over the other(s) in at least two impact categories (land use, resource use, climate change, ozone layer depletion, human health effects, ecotoxicity, smog, acidification, eutrophication)
  - Follow LCA procedure specified
  - Submit LCA report to AHJ

Software Tools

- LCI database: http://www.nrel.gov/lci/ - by NREL
- LCA tool: The Environmental Impact Estimator: http://www.athenasmi.org/our-software-data/impact-estimator/ - by the ATHENA™ Sustainable Materials Institute.
- TRACI tool: http://www.epa.gov/nrmrl/std/sab/traci/ - by US EPA

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atmosphere, materials and resources

Summary

- Reduce
- Reuse
- Recycle
- Renewable
- LCA

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Construction, Plans for Operation

Mandatory – Construction

- **Building acceptance testing**
  - **e.g., verify preparation of "system manual"**
- **Building project commissioning**
  - **e.g., commission bldgs >5000 ft²**
- **Erosion and sediment control**
  - **e.g., develop and implement plan**
- **IAQ construction management**
  - **e.g., perform flush-out**
- **Moisture control**
  - **e.g., protect construction materials**
- **Construction pollution prevention**
  - **e.g., locate vehicle staging areas >100 ft from any OA intake**

Mandatory – Plans for Operation

- **High performance building operation plan**
  - **e.g., Master Building Plan for Operation shall be developed, addressing all aspects of the standard**
- **Maintenance plan**
  - **e.g., must be developed for mechanical, electrical, plumbing and fire protection systems**
- **Service-life plan**
  - **e.g., to estimate extent of specific building material repair and replacement**
- **Transportation management plan**
  - **e.g., preferred parking for carpools**

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construction and plan for operation
Mandatory (10.3)

- Assure "high performance" construction – e.g.:
  - Perform building acceptance testing
  - Employ project commissioning for buildings > 5,000 ft^2
  - Develop, implement erosion & sediment control plans
  - Develop, implement an IAQ construction plan
  - Control construction moisture – e.g., protect materials

construction and plan for operation
Mandatory (10.3)

- Assure "high performance" operation – e.g., develop:
  - Plans for operation
    - A Master Plan of Operation for all design aspects
  - Maintenance plan
    - In accordance with ANSI/ASHRAE/ACCA Std 180
  - Service-life plan
    - 50 years minimum service life for most buildings
  - Transportation management plan
    - Carpool parking

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LEED 2009 Comparison

LEED 2009 Category	Possible LEED Points	Std 189.1 Compliance: Estimated Point Range
Sustainable Sites	0 to 26	4 to 16
Water Efficiency	0 to 10	2 to 6
Energy & Atmosphere	0 to 35	3 to 30
Materials & Resources	0 to 14	1 to 3
IEQ	0 to 15	3 to 5
Innovation in Design	1 to 6	6
Regional Priority	0 to 4	0
Total Points	1 to 110	19 to 66

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The Standard and Codes are Here

- Some local jurisdictions have green building codes, some based on Std 189.1
  - Estimated: 20 local jurisdictions
  - Two state-wide green codes adopted – CA, RI
- Expect more HPGB codes in the near future:
  - IgCC-2012 will be published by March 2012 – local codes won't be far behind
  - Many designers will choose the Std 189.1 design elective as their compliance path
- **Get ready!**

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references for this broadcast

Where to Learn More

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Past program topics include:

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- USGBC LEED®
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- Acoustics
- Ventilation
- Dehumidification
- Ice storage
- Central geothermal systems

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- ASHRAE standard 62.1: Ventilation Rate Procedure
- ASHRAE 90.1-2010
- Energy Saving Strategies for Rooftop VAV Systems
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2012 ENL Programs

- **June**
  Energy-Saving Strategies for WSHP/GSHP Systems
- **October**
  Air-to-Air Energy Recovery

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TRANE

High Performance Green Buildings:
The Impact of ASHRAE Standard 189.1-2011

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March 2012

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http://www.trane.com/HighPerformanceBuildings
http://www.trane.com/LEED
http://www.epa.gov/watersense/index.html
LCI database(NREL): http://www.nrel.gov/lci/
LCA Environmental Impact Estimator by ATHENA™ Sustainable Materials Institute:
http://www.athenasmi.org/our-software-data/impactestimator/
TRACI tool: http://www.epa.gov/nrmrl/std/sab/traci/

ASHRAE Design Standard 189.1-2011 Overview

ANSI/ASHRAE/USGBC/IES Standard 189.1-2011, *Standard for the Design of High-Performance Green Buildings*, embodies a collaborative effort to establish a design standard for high-performance green-building projects. Written in mandatory, code-intended language by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers; the U.S. Green Building Council; and the Illuminating Engineers Society, the standard was first published in 2009 and has recently been revised to incorporate new provisions and to update references to other ASHRAE standards. The 2011 version has been adopted by the International Green Construction Code (IgCC) as a design elective, so it's becoming more and more important to know what the standard covers and some of its key provisions.

General Overview

Paraphrasing the ASHRAE definition, high-performance green buildings (HPGB) are buildings designed, constructed, and capable of being operated in a manner that increases environmental performance and economic value over time, while establishing an indoor environment that supports the health, satisfaction, and productivity of occupants; they do this by integrating environmentally preferable building sites and materials with water-efficient and energy-efficient systems.

The standard presents provisions in six major categories:

- Site sustainability
- Water use efficiency
- Energy efficiency
- Indoor environmental quality
- Impact (on atmosphere, materials and resources)
- Construction and plans for maintenance

Most sections include mandatory, prescriptive and performance-related provisions. The mandatory provisions must be met in all cases, along with either the prescriptive-option provisions or corresponding performance-option provisions. The following tables summarize key provisions in each major category.

Table 1. Site Sustainability (Section 5)

Section	Section Title	Mandatory Provision Summary	
5.3.1	Site selection	Use brownfield or greyfield sites. Use greenfield sites that meet specific restrictions, such as proximity to residential areas, basic services, or public transportation. Building projects are not allowed in floodplain sites or near conservation areas or wetlands (with exceptions).	
5.3.2	Mitigation of heat island effect	At least 50% of paved areas (hardscape) on the building site must be designed to reduce solar heat gain using techniques such as shading, materials with a solar reflectance index (SRI) of at least 29, or open-graded aggregate or permeable pavers. Walls must be shaded. At least 75% of roof area must reduce solar heat gain by, for example, using materials with a minimum SRI of 78 (low-sloped roofs) or 29 (steep-sloped roofing).	
5.3.3	Reduction of light pollution	Exterior lighting must meet *all* power limitations and control requirements of Standard 90.1-2010, Section 9.0, and exterior lights must meet minimum backlight, uplight and glare requirements, including those in Standard 90.1, Table 9.4.3B.	
5.3.4	Plants	Existing invasive plants must be removed from the site, and new invasive plants must not be planted.	
5.3.5	Mitigation of transportation impacts	A pedestrian walkway must connect each building entrance to a public way or transit stop.	
Section	Section Title	Prescriptive Option Summary	Alternative
5.4.1	Site development	To reduce storm water runoff, at least 40% of the building site must incorporate prescribed water management techniques, such as vegetation (no more than 40% turfgrass), vegetated roof, porous pavers, or permeable pavement. For greenfield sites, at least 20% of the site area must be planted with native or adapted plants.	Required in lieu of 5.5.1
Section	Section Title	Performance Option Summary	Alternative
5.5.1	Site development	A percentage of average annual rainfall must be managed as follows: 20% for building projects within an existing building, 40% for projects on brownfield or greyfield sites, and 50% for projects on all other sites.	Required in lieu of 5.4.1

Table 2. Water Use Efficiency (Section 6)

Section	Section Title	Mandatory Provision Summary	
6.3.1	Site water-use reduction	To reduce the amount of water needed on the site, at least 60% of the improved landscape must be planted with native or adapted plants other than turfgrass. Irrigation systems must be hydrozoned to prevent over-irrigating and must be controlled automatically based on the sensed need for water.	
6.3.2	Building water use reduction	Plumbing fixtures and fittings must meet maximum water volume limits, such as 1.28 gal/flush for toilets, 0.5 gpm for public lavatory faucets, and so on. Appliances, such as clothes washers and dishwashers must meet maximum water use limits set by ENERGY STAR. For HVAC systems, cooling towers and evaporative coolers must include controls to reduce excessive water use. In many locations (especially in the eastern and southern US), condensate must be collected from air-conditioning units larger than 5 tons and recovered for reuse. Potable water must not be used for roof-spray cooling systems or to irrigate vegetated roofs.	
6.3.3	Water consumption measurement	Potable and reclaimed water must be monitored using measurement devices with remote communication capability. Separate submetering must be provided for specific instances, such as for any tenant space of more than 50,000 ft^2, or for any subsystem that consumes more than 1000 gal/day. The water-use data management system must collect and store the data and be capable of printing reports showing hourly, daily, monthly and annual consumption for each measurement device.	
Section	**Section Title**	**Prescriptive Option Summary**	**Alternative**
6.4.1	Site water use reduction	Golf courses must use only municipally or site reclaimed water for irrigation. For other landscaped areas, potable water may be used for no more than 1/3 of all irrigation.	Required in lieu of 6.5.1
6.4.2	Building water use reduction	Cooling towers using “soft” makeup water must achieve a ratio of makeup rate to blowdown-plus-drift rate of 5 or 3.5. If the water is “hard,” this ratio must be 3.5 or higher. Commercial food service operations must use, for example, high-efficiency re-rinse spray valves, ENERGY STAR dishwashers, ENERGY STAR air-cooled ice machines, and so on. Medical and laboratory facilities must use, for example, steam sterilizers with water-tempering devices to assure hot water flow and with mechanical vacuum equipment, digital imaging and radiography systems, and so on.	Required in lieu of 6.5.2

Table 2. Water Use Efficiency (Section 6), continued

Section	Section Title	Prescriptive Option Summary, continued	Alternative
6.4.3	Special water features	Ornamental water features must use municipally reclaimed or on-site recovered water and must include makeup water meters, leak detection devices, and recirculation system. Pools and spas must recover filter backwash water for reuse; removable filters must use reusable cartridges and backwash filters must include a pressure gauge to determine when backwash is required.	Required in lieu of 6.5.2
Section	**Section Title**	**Performance Option Summary**	**Alternative**
6.5.1	Site water use reduction	The total irrigation water for improved landscape must not exceed 35% potable or municipally reclaimed water. Water demand for irrigation must be based on evapotranspiration (ET) for the climatic area and must not exceed 70% of ET for turfgrass and 55% for other plants.	Required in lieu of 6.4.1
6.5.2	Building water use reduction	Total annual indoor water use must be no more than that achieved by compliance with Section 6.3.2, 6.4.2 and 6.4.3.	Required in lieu of 6.4.2 and 6.4.3

Table 3. Energy Efficiency (Section 7)

Section	Section Title	Mandatory Provision Summary	
7.3.1	General	All requirements in *all mandatory* sections (i.e., all Section 5.4, 6.4, 7.4, 8.4, 9.4 and 10.4) of Standard 90.1-2010 must be met. These include requirements for the building envelope, HVAC equipment and systems, service water heating, power, lighting, and other equipment.	
7.3.2	On-site renewable energy systems	To encourage use of on-site renewable energy, most building projects must be designed to accommodate renewable energy production equipment and systems with the capacity to provide at least 6.0 kBtu/ft^2 of roof area (for single-story buildings) or at least 10 kBtu/ft^2 of roof area (for buildings with more than one story) annually.	
7.3.3	Energy consumption management	Buildings using more than a specified energy threshold must include measurement devices with remote communication capability for each energy supply (including electrical service, on-site renewable electric power, gas service, district energy service, geothermal energy, and on-site renewable thermal energy). Buildings using more than a specified energy threshold for HVAC systems, people-moving systems, lighting, or process and plug loads, must include measurement devices for such subsystems. Energy consumption data must be collected hourly using a data acquisition system, capable of storing the data for three years and creating reports to show hourly, daily, monthly, and annual energy consumption.	
Section	**Section Title**	**Prescriptive Option Summary**	**Alternative**
7.4.1	General comprehensive prescriptive requirements	HPGB projects complying with the prescriptive option must meet *all requirements* of Standard 90.1-2010; buildings must comply with several new or enhanced requirements.	Required in lieu of Section 7.5
7.4.2	Building envelope	In addition to meeting all Section 5 requirements of Standard 90.1-2010, Standard 189.1 adds envelope stringency, including: building envelope and roof insulation levels must be increased; maximum vertical fenestration area applies to more buildings; in some climates, permanent projects must be installed to provide minimum window shading; projection factors for fenestration shading must be increased; in most buildings, a continuous air barrier system must be installed.	Required in lieu of Section 7.5

Table 3. Energy Efficiency (Section 7), continued

Section	Section Title	Prescriptive Option Summary, continued	Alternative
7.4.3	Heating, ventilating, and air conditioning	In addition to meeting all Section 6 requirements of Standard 90.1-2010, Standard 189.1 prescriptive provisions supersede several Standard 90.1 requirements and add one new requirement.	Required in lieu of Section 7.5
7.4.4	Service water heating	In addition to meeting all Section 7 requirements of Standard 90.1-2010, Standard 189.1 requires: increased water heater efficiency, increased hot-water piping insulation and increased spa pool insulation.	Required in lieu of Section 7.5
7.4.5	Power	In addition to meeting all Section 8 requirements of Standard 90.1-2010, Standard 189.1 requires automatic controls to reduce electrical peak demand by not less than 10% of the projected peak demand.	Required in lieu of Section 7.5
7.4.6	Lighting	In addition to meeting all Section 9 requirements of Standard 90.1-2010, Standard 189.1 requires: a lower interior and exterior lighting power allowance; occupancy sensors to reduce lighting power by at least 50% (in hallways, storage areas and library stack areas); occupancy sensors with manual “on” and automatic “off” (except as noted); exterior sign lighting controls to automatically reduce power to 35% of full power (for lights that operate for more than one hour during daylight) or to 70% of full power after midnight (for all other lights).	Required in lieu of Section 7.5
7.4.7	Other equipment	In addition to meeting all Section 10 requirements of Standard 90.1-2010, Standard 189.1 requires: more efficient electric motors; in supermarkets with 25,000 ft^2 or more, heat recovery to recover either 25% of full load heat rejection or 80% of required space heat, service water heat and dehumidification reheat; ENERGY STAR label for specific appliances, heating and cooling, electronics, office equipment, water heaters, lighting, commercial food service, and so on; increased efficiency for commercial refrigerators, freezers, and clothes washers.	Required in lieu of Section 7.5
7.4.8	Energy cost budget	The energy cost budget option in Section 11 of Standard 90.1-2010 must not be used in lieu of Section 7.5 of Standard 189.1-2011.	NA

Table 3. Energy Efficiency (Section 7), continued

Section	Section Title	Performance Option Summary	Alternative
7.5.1	General comprehensive performance requirements	To reduce energy use by analyzing building project performance, designers must use simulation to comply with requirements in Sections 7.5.2 through 7.5.4.	Required in lieu of most provisions in Section 7.4
7.5.2	Annual energy cost	A proposed (simulated) design must result in annual energy cost equal or lower than that of a baseline building in compliance with Sections 5.3.2.2, 5.3.2.3, 6.3.2, 6.4.2, 7.3, 7.4, 8.3.1, 8.3.4 and 8.4.1, when compared using the requirements in Appendix D (which equal or exceed the requirements of Appendix G in Standard 90.1-2010).	Required in lieu of most provisions in Section 7.4
7.5.3	Annual carbon dioxide equivalent (CO_2e)	A proposed (simulated) design must result in annual carbon dioxide equivalent equal or lower than that of a baseline building in compliance with Sections 5.3.2.2, 5.3.2.3, 6.3.2, 6.4.2, 7.3, 7.4, 8.3.1, 8.3.4 and 8.4.1, when compared using the requirements in Appendix D (which equal or exceed the requirements of Appendix G in Standard 90.1-2010).	Required in lieu of most provisions in Section 7.4
7.5.4	Annual load factor/peak electric demand	A proposed (simulated) design must result in annual load factor or peak electric demand equal or lower than that of a baseline building in compliance with Sections 5.3.2.2, 5.3.2.3, 6.3.2, 6.4.2, 7.3, 7.4, 8.3.1, 8.3.4 and 8.4.1, when compared using the requirements in Appendix D (which equal or exceed the requirements of Appendix G in Standard 90.1-2010).	Required in lieu of most provisions in Section 7.4

Table 4. Indoor Environmental Quality (Section 8)

Section	Section Title	Mandatory Provision Summary
8.3.1	Indoor air quality	All provisions in Sections 4 through 7 of Standard 62.1-2010 must be met. • Section 4 requires outdoor air assessment. • Section 5 requires many requirements for systems and equipment, including building humidity limits, condensate management requirements, air system access, duct system material requirements, outdoor air intake location limitations to reduce the intake of outdoor pollutants. • Section 6 includes outdoor air intake rates and calculation procedures (the Ventilation Rate Procedure, the IAQ Procedure and the Natural Ventilation Procedure) and exhaust airflow requirements. • Section 7 covers installation and startup provisions, requiring that air systems must be balanced prior to occupancy, for instance. Standard 189.1 goes "beyond" Standard 62.1 in some cases, requiring, for instance, minimum outdoor air intake to be found using the VRP, coil filters with MERV 8 rather than MERV 6, intake air filters with MERV 13 rather than MERV 11 in PM2.5 non-attainment areas, and 40%-efficient ozone air cleaners in all ozone non-attainment areas. Smoking in or near the building must be prohibited and all building entrances must incorporate walk-off mat systems to reduce the introduction of particles and moisture.
8.3.2	Thermal environmental conditions for human occupancy	The building must be designed and controlled to comply with the thermal comfort range required by Sections 6.1 and 6.2 of Standard 55-2010 for each space within the building. (Comfort parameters vary by building design, systems and controls, and space type, so the compliant range of parameter values cannot be generalized and must be found using one of the methods presented in the standard.) Design method and calculations must be documented.
8.3.3	Acoustical control	Sound entering the building from exterior sources must be limited by designing the building envelope and selecting fenestration to achieve specific minimum sound transmission classes (STC equal to or greater than 40 for wall and roof-ceiling assemblies, for instance). Sound transmitted between occupied zones must also be limited by wall and floor-ceiling design to achieve specific minimum sound transmission classes (STC equal to or greater than 50 for wall and floor-ceiling assemblies separating dwelling units, for instance).

Table 4. Indoor Environmental Quality (Section 8), continued

Section	Section Title	Mandatory Provision Summary, continued	
8.3.4	Daylighting by toplighting	A minimum fenestration area must be provided for daylighting by toplighting in large spaces in most buildings with three or fewer stories. For instance, in a space with more than 20,000 ft^2, at least 50% of the floor area directly beneath a roof must be daylight area. In general, the haze value for skylights must exceed 90%.	
8.3.5	Isolation of building from pollutants in soil	On brownfield sites and on sites in areas designated "Zone 1" for radon by the EPA, building projects must include a soil gas retarding system between the space and the soil.	
Section	Section Title	Prescriptive Option Summary	Alternative
8.4.1	Daylighting by sidelighting	Office spaces and classrooms must comply with specific minimum sidelighting effective aperture requirements (the ratio of total window area times visible light transmission to total area of sidelighted area), depending on climate. For instance, the sidelighting effective aperture in climate zones 1, 2, 3A and 3B must be at least 0.10. For offices, west-, east- and south-facing windows must be shaded with a projection factor of at least 0.5.	Required in lieu of 8.5.1
8.4.2	Materials	To limit odors and health effects from volatile organic compounds (VOC), specific materials used within the building must be tested or certified to meet specific maximum VOC emission or content limits. For instance, for adhesives and sealants, VOC emissions must not exceed limits set by California Section 01350 for either office or classroom spaces, or VOC content must not exceed limits set by SCAQMD 1168.	Required in lieu of 8.5.2
Section	Section Title	Performance Option Summary	Alternative
8.5.1	Daylighting simulation	The building project design must achieve a minimum illuminance of 30 fc at 2.5 ft above the floor within at least 75% of the daylight area at noon on the equinox day, as demonstrated using daylight simulation computer models. Direct sunlight on work surfaces in offices must be limited to 20% of occupied hours during an equinox day.	Required in lieu of 8.4.1
8.5.2	Materials	Specific VOC emissions from specific materials must be modeled and computer simulation must be used to show the resulting concentrations to be in compliance with the maximum concentration limits listed in Section 4.3 of California Section 01350.	Required in lieu of 8.4.2

Table 5. The Building's Impact on the Atmosphere, Materials and Resources (Section 9)

Section	Section Title	Mandatory Provision Summary	
9.3.1	Construction waste management	At least 50% (by weight or by volume) of all non-hazardous construction and demolition materials must be diverted from landfills and incinerators by recycling and/or reuse. Specific construction site areas must be designated for collection of such materials. For many new buildings, the total construction waste generated must not exceed 12,000 lbs per 10,000 ft^2 of building floor area.	
9.3.2	Extracting, harvesting and/or manufacturing	Materials, products and assemblies installed at the building site must be harvested, extracted or manufactured according to local regulations in the "source" country.	
9.3.3	Refrigerants	CFC-based refrigerants must not be used in HVAC systems. CFC-, HCFC- or Halon-based fire suppression systems must not be used.	
9.3.4	Storage and collection of recyclables and discarded goods	Areas must be designated for: the collection and storage of recyclable non-hazardous materials, reusable materials and in buildings with residential spaces, and fluorescent and HID lamps and ballasts.	
Section	Section Title	Prescriptive Option Summary	Alternative
9.4.1	Reduced impact materials	Assuming that the cost of permanently installed materials is 45% of the total construction cost of the building (or using calculated material cost): 1) recycled content must constitute at least 10% of the cost of installed material, 2) regional materials (those extracted, harvested, recovered or manufactured within 500 miles of the site) must constitute at least 15% of the cost of installed materials, or 3) biobased products must constitute at least 5% of the cost of installed materials.	Required in lieu of 9.5.1
Section	Section Title	Performance Option Summary	Alternative
9.5.1	Life-cycle assessment	A life-cycle assessment (LCA) must be performed per ISO 14044 for at least two building design alternatives that comply with Section 6, 7 and 8 and consider at least those materials considered for compliance with Section 9.4.1. Service life must be no less than 10, 25 or 75 years, depending on building type. Each design approach must be analyzed using a three-step LCA calculation procedure and a specific LCA report must be submitted, showing that the alternative selected improves all other alternatives analyzed by at least 5% in at least two impact categories.	Required in lieu of 9.4.1

Table 6. Construction and Plans for Operation (Section 10)

Section	Section Title	Mandatory Provision Summary
10.3.1	Construction	In the context of this standard, requirements related to construction include acceptance testing, project commissioning, site erosion control, IAQ during construction, moisture control and local vehicle exhaust control.
10.3.1.1	Building acceptance testing	Buildings of 5,000 ft^2 or less must be acceptance tested in accordance with a specification, rule, guide, or procedure, generally accepted as authoritative. The design and construction of the building project must incorporate a testing process that verifies that specific systems perform in accordance with the construction documents. Specific activities must be executed prior to issuance of the building permit and other activities must be executed prior to occupancy. The following must be acceptance tested: mechanical systems, lighting, fenestration control, renewable energy, water-measurement and energy-measurement systems. Completed acceptance testing forms must be retained by the owner.
10.3.1.2	Building project commissioning	Buildings larger than 5,000 ft^2 must be commissioned in accordance with a specification, rule, guide, or procedure, generally accepted as authoritative, or a handbook. The pre-design, design, construction and first year of occupancy phase of the building project must incorporate a testing process that verifies that specific systems perform in accordance with the construction documents. The commissioning process must verify that the building project complies with the owner's project requirements. A systems manual with procedures, documentation, tools and training information must be assembled and provided to the building operating staff. Specific activities must be executed prior to issuance of the building permit, other activities must be executed prior to occupancy, and still other activities must be executed after occupancy. The following must be commissioned: mechanical systems and control sequences, building envelope systems and air tightness, lighting systems, fenestration control systems, irrigation systems, plumbing systems, service water heating systems, renewable energy systems, water-measurement and energy-measurement systems. The system manual and final commissioning report must be retained by the owner.
10.3.1.3	Erosion and sediment control	An erosion and sediment control plan, compliant with EPA or local code requirements, for all construction activities must be developed and implemented.

Table 6. Construction and Plans for Operation (Section 10), continued

Section	Section Title	Mandatory Provision Summary, continued
10.3.1.4	Indoor air quality construction management	An IAQ construction management plan must be developed and implemented. It must include provisions to help assure that: stored air conveyance materials remain clean, filters are in place when air handlers are operated, and air handlers are not operated during construction. It must provide for a pre-occupancy building flush-out.
10.3.1.5	Moisture control	Absorptive materials installed or stored on-site must be protected from moisture damage. Materials displaying evidence of biological growth must not be installed.
10.3.1.6	Construction activity pollution prevention: No-idling of construction vehicles	Vehicles loading or unloading materials must wait in staging areas located at least 100 ft from any outdoor air intakes, operable openings, and specific existing facilities.
10.3.2	Plans for operation	In the context of this standard, requirements related to operation include a building operation plan, a maintenance plan, a service-life plan, and a transportation management plan.
10.3.2.1	High performance building operation plan	A Master Building Plan for Operations must be developed and it must include provisions related to: site sustainability (including plans to maintain healthy vegetation), water-use efficiency (including verification activities to track and assess water consumption), energy efficiency (including energy performance verification activities to track and assess building energy performance), and indoor environmental quality (including the requirements found in Standard 62.1, Section 8, and procedures for an IEQ measurement and verification program).
10.3.2.2	Maintenance plan	A Maintenance Plan must be developed for mechanical, electrical, plumbing, and fire protection systems. The plan must address all elements in Section 4 of Standard 180 and must include inspection and maintenance tasks similar to those in Section 5 of Standard 180. The Maintenance Plan and documentation of completed procedures must be maintained on the building site.
10.3.2.3	Service life plan	A Service Life Plan, consistent with the owner's performance requirements, must be developed for the service life of the building. The plan must include an estimate of the extent to which structural, envelope and hardscape materials will need to be repaired or replaced, and an estimate of the extent to which building assemblies, products and materials will need to be inspected, repaired and/or replaced. The owner must retain a copy of the Service Life Plan for use during the life of the building.

Table 6. Construction and Plans for Operation (Section 10), continued

Section	Section Title	Mandatory Provision Summary, continued	
10.3.2.4	Transportation management plan	A transportation management plan must be developed and retained by the owner. It must include preferred parking for carpools and a plan for bicycle transportation. For owner-occupied buildings, the plan must obligate the owner to offer employees either: incentives to use mass transit, carpools, or non-motorized transportation; a telework or flexible work schedule to reduce commuting hours; or ridesharing or carpool matching program. The plan must obligate the owner to provide for: access to emergency ride home, a central point-of-contact for commuter benefits, and active promotion of commuter benefits. For tenant occupied buildings, the plan must obligate the owner to provide a copy of the plan to tenants and to exclude parking fees from lease rates.	
Section	Section Title	Prescriptive Option Summary	Alternative
10.4	Prescriptive option	All Section 10 provisions are mandatory.	NA
Section	Section Title	Performance Option Summary	Alternative
10.5	Performance option	All Section 10 provisions are mandatory.	NA