New Buildings Institute (NBI)

NBI is redefining energy efficiency in the built environment.

Program Areas:
- Best practices in new and existing buildings
- Continuous code and policy innovation
- Zero energy leadership and market development
Acknowledgements

New Buildings Institute would like to thank Energy Trust of Oregon, Northwest Energy Efficiency Alliance, and CLEARresult for funding and coordinating this training.

New Buildings Institute would like to thank PNNL, DOE & ODOE for making this presentation available.

Background

Figure 2.6: Oregon’s Projected GHG Emissions vs. Goals

- 2016 Actual Emissions: 62 Million MTCO2e
- Paris Goals: 26-28% below 2005 by 2025
- Oregon’s 2030 Goal: 51 million MTCO2e
- Oregon’s 2050 Goal: 14 million MTCO2e
Executive Order 17-20

D. Increasing Energy Efficiency in Commercial Construction. The appropriate advisory board(s) and BCD are directed to conduct code amendment of the state building code to require, by October 1, 2022, that newly constructed commercial buildings, averaged across building types, will exceed International Energy Conservation Code and ASHRAE 90.1 by achieving at least equivalent performance levels with the measurable prescriptive energy efficiency portions of the most current version of ASHRAE 189.1 that are construction-related.

Zero-Ready Code

ASHRAE 90.1-2016 by October 2019
ASHRAE 90.1-2019 by October 2020

Incorporation of Architecture 2030 Framework for estimating energy consumption and renewables for a Zero Net Energy Building
Zero-Ready Code

1. Design an energy efficient building
   - Efficiency Standard, ASHRAE 90.1-2014 minimum
   - Efficient building envelope / daylighting
   - Passive heating / cooling / ventilation
   - Efficient systems / equipment / controls

2. Address the remaining building’s energy needs with:
   - On-site renewable energy
   - And/or off-site renewable energy
   - Wind, solar, hydro (other non-CO2 emitting sources)

Source: Architecture 300
Graphical adaptation: Soliris, DOE
Statewide Alternate Method

Structure of Standard 90.1-2016

• 1 Purpose
• 2 Scope
• 3 Definitions, Abbreviations, and Acronyms
• 4 Administration and Enforcement
• 5 Building Envelope
• 6 Heating, Ventilating, and Air Conditioning
• 7 Service Water Heating
• 8 Power
• 9 Lighting
• 10 Other Equipment
• 11 Energy Cost Budget Method
• 12 Normative References
• Normative Appendices A-H
Section 2 – Scope
2.1 – 2.4

• Applies to:
  – New buildings and their systems
  – New portions of buildings and their systems
  – New systems and equipment in existing buildings, and
  – New equipment or building systems specifically identified in the standard that are part of industrial or manufacturing processes
  – Criteria for determining compliance with requirements

• Does not apply to:
  – Single-family houses, low-rise multi-family < 3 stories above grade, manufactured houses (mobile or modular)
  – Buildings that use neither electricity nor fossil fuel
  – Certain other buildings or elements may be exempt
  – Does not circumvent any safety, health, or environmental requirements

Compliance Path

Compliance Paths for 2016
1. Prescriptive
2. Energy Cost Budget
3. Appendix G (New)
Compliance Path

Compliance Paths for 2016
1. Prescriptive
2. Energy Cost Budget
3. Appendix G (New)

HVAC Compliance

Building System
- Envelope
- HVAC
- SWH
- Power
- Lighting
- Other

Compliance Options
- Mandatory Provisions (required for most compliance options)
- Prescriptive Option
- Trade Off Option
- Energy Cost Budget
- Simplified
- Performance Rating Method
You have to follow Sections

- 6.1 General,
- 6.7 Submittals, and
- 6.8 Minimum Equipment Efficiency

And then you can follow either

- Section 6.3 Simplified Approach
- Sections 6.4 Mandatory Provisions and 6.5 Prescriptive Path
- Sections 6.4 Mandatory Provisions and 6.6 Alternative Compliance Path (for Computer Rooms)

Alternatively, you can follow Section 11 (ECB) or Appendix G, in which case Section 6.4 is mandatory.
Section 6 – 6.3
Simplified Approach Option

The simplified approach is an optional path for compliance when the following are met:

- Buildings with 1 or 2 stories
- Buildings with gross floor area < 25,000 ft²
- System serving single HVAC zone
- Each system complies with 6.3.2

Section 6 – 6.3
Simplified Approach Criteria

a. Single HVAC zone
b. Variable flow requirements (6.5.3.2.1)
c. Cooling equipment efficiency (6.8.1)
d. Air economizers (6.5.1 and 6.4.3.12)
e. Heating equipment efficiency (6.8.1)
f. Exhaust air energy recovery (6.5.6.1)
g. Dual setpoint thermostat or manual changeover
h. Heat pump auxiliary heat control
i. No reheat or simultaneous cooling and heating for humidity control
j. Off-hour shutoff and temperature setback/setup
k. Systems serving hotel/motel guest rooms comply with Section 6.4.3.3.5
l. Piping insulation (Tables 6.8.3-1 and 6.8.3-2)
m. Ductwork insulation and sealing (6.4.4.2.1)
n. Air balancing of ducted system
o. Outdoor air intake and exhaust systems (6.4.3.4)
p. Zone thermostatic controls to prevent simultaneous heating and cooling
q. Optimum start controls
r. Demand control ventilation (6.4.3.8 and 6.5.3.7)
s. Door switch requirements (6.5.10)
**Section 6 – 6.5.3.2 (6.3.2.b)**

**Fan Control**

- Air-handling and fan coil unit supply fans controlled by two-speed motors or variable speed drives
  - Chilled-water cooling coils where the supply fans have motors ≥ 1/4 hp
  - Direct expansion units ≥ 65,000 Btu/h cooling capacity
  - Two speeds of fan control required during economizer operation

<table>
<thead>
<tr>
<th>Temperature Control</th>
<th>Typical Zones</th>
<th>Minimum fan speed</th>
<th>Fan power at min speed</th>
<th>Fan control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Air</td>
<td>Multiple</td>
<td>≤ 50% *</td>
<td>≤ 30%</td>
<td>Modulating</td>
</tr>
<tr>
<td>Room Temperature</td>
<td>Single</td>
<td>≤ 66% *</td>
<td>≤ 40%</td>
<td>Two-speed, Multi-speed or Modulating</td>
</tr>
</tbody>
</table>

* or volume of outdoor air required to meet Standard 62.1

**Section 6 – 6.8.1 (6.3.2c)**

**Equipment Efficiency**

- [Table of equipment efficiency](image)

[Example: 1/2 HP Motor]
Prescriptive Approach – 6.4.2 Equipment Sizing

- Sizing systems and equipment to be done in accordance with ANSI/ASHRAE/ACCA Standard 183

Section 6 – 6.5.1 (6.3.2.d) Economizers

The system shall either have an economizer, or use the economizer Trade-off Option

- Limited to unitary systems
- Requires higher minimum cooling efficiency (EER)
- Trade-off EER by
  - System size
  - Climate zone

- Eliminated separate table for computer rooms. They must follow the same thresholds as other spaces.
### Table 6.5.1.1.3 High-Limit Shutoff Control Settings for Air Economizers

<table>
<thead>
<tr>
<th>Control Type</th>
<th>Allowed Only in Climate Zone at Listed Set Point</th>
<th>Required High-Limit Set Points (Economizer Off when)</th>
<th>Equation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed dry-bulb temperature</td>
<td>6B, 1B, 2B, 3B, 4B, 5B, 6B, 7, 8</td>
<td>$T_{OA} &gt; 75^\circ F$</td>
<td>$T_{OA} &gt; 75^\circ F$</td>
<td>Outdoor air temperature exceeds 75°F</td>
</tr>
<tr>
<td></td>
<td>5A, 6A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5A, 1A, 2A, 3A, 4A</td>
<td>$T_{OA} &gt; 70^\circ F$</td>
<td>$T_{OA} &gt; 70^\circ F$</td>
<td>Outdoor air temperature exceeds 70°F</td>
</tr>
<tr>
<td></td>
<td>5A, 6A</td>
<td>$T_{OA} &gt; 65^\circ F$</td>
<td>$T_{OA} &gt; 65^\circ F$</td>
<td>Outdoor air temperature exceeds 65°F</td>
</tr>
<tr>
<td>Differential dry-bulb temperature</td>
<td>6B, 1B, 2B, 3B, 4B, 5B, 6B, 7, 8</td>
<td>$T_{OA} &gt; T_{DA}$</td>
<td>$T_{OA} &gt; T_{DA}$</td>
<td>Outdoor air temperature exceeds return air temperature</td>
</tr>
<tr>
<td>Fixed enthalpy with fixed dry-bulb temperature</td>
<td>All</td>
<td>$h_{OA} &gt; 28$ Btu/lb</td>
<td>$h_{OA} &gt; 28$ Btu/lb</td>
<td>Outdoor air enthalpy exceeds 28 Btu/lb of dry air or outdoor air temperature exceeds 75°F</td>
</tr>
<tr>
<td></td>
<td>5A</td>
<td>$h_{OA} &gt; 28$ Btu/lb</td>
<td>$h_{OA} &gt; 28$ Btu/lb</td>
<td></td>
</tr>
<tr>
<td>Differential enthalpy with fixed dry-bulb temperature</td>
<td>All</td>
<td>$h_{OA} &gt; R_{DA}$</td>
<td>$h_{OA} &gt; R_{DA}$</td>
<td>Outdoor air enthalpy exceeds return air enthalpy or outdoor air temperature exceeds 75°F</td>
</tr>
</tbody>
</table>

### Table 6.5.1.2 Eliminate Required Economizer for Comfort Cooling by Increasing Cooling Efficiency

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Efficiency Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>17%</td>
</tr>
<tr>
<td>2B</td>
<td>21%</td>
</tr>
<tr>
<td>3A</td>
<td>27%</td>
</tr>
<tr>
<td>3B</td>
<td>32%</td>
</tr>
<tr>
<td>3C</td>
<td>60%</td>
</tr>
<tr>
<td>4A</td>
<td>42%</td>
</tr>
<tr>
<td>4B</td>
<td>49%</td>
</tr>
<tr>
<td>5A</td>
<td>49%</td>
</tr>
<tr>
<td>5B</td>
<td>50%</td>
</tr>
<tr>
<td>5C</td>
<td>74%</td>
</tr>
<tr>
<td>6A</td>
<td>56%</td>
</tr>
<tr>
<td>6B</td>
<td>65%</td>
</tr>
<tr>
<td>7</td>
<td>72%</td>
</tr>
<tr>
<td>8</td>
<td>77%</td>
</tr>
</tbody>
</table>
Section 6 – 6.5.6.1 (6.3.2f)
Exhaust Air Energy Recovery

- Required if: Supply air capacity ≥ value listed in Tables 6.5.6.1-1 and 6.5.6.1-2
  - Values are based on climate zone and % of outdoor air flow rate at design conditions
- Table 6.5.6.1-1 used for all ventilation systems operating < 8,000 hrs/yr
- Table 6.5.6.1-2 used for all ventilation systems operating ≥ 8,000 hrs/yr

Revised Exhaust Air Energy Recovery Tables
Recovery system effectiveness $\geq 50\%$
- required thresholds have changed to account for minimum size availability of small energy recovery products

A new definition was added for energy recovery efficiency
- **enthalpy recovery ratio**: change in the enthalpy of the outdoor air supply divided by the difference between the outdoor air and entering exhaust air enthalpy, expressed as a percentage
- **sensible energy recovery ratio**: change in the dry-bulb temperature of the outdoor air supply divided by the difference between the outdoor air and entering exhaust air dry-bulb temperatures, expressed as a percentage.

**Section 6 – 6.5.6.1 (6.3.2f)**
Exhaust Air Energy Recovery Exceptions

- Lab systems meeting 6.5.7.3
- Systems serving uncooled spaces that are heated to $< 60^\circ$F
- Where $> 60\%$ of outdoor heating energy is provided from site-recovered or site solar energy
- Cooling energy recovery in climate zones 3c, 4c, 5b, 5c, 6b, 7, and 8
- Where **sum of airflow rates exhausted and relieved within 20 ft** of each other is $< 75\%$ of the design outdoor airflow
- Systems requiring dehumidification that employ energy recovery in series with the cooling coil
- Systems operating $< 20$ hrs/week at outdoor air % in Table 6.5.6.1-1
Section 6 – 6.3 (6.3.2g-j) Simplified Approach Option (cont'd)

- g. Manual changeover or dual set-point thermostat
- h. Heat pump supplementary heat lockout
- i. No reheat or simultaneous heating and cooling for humidity control
- j. Time clocks (except hotel/motel guest rooms and systems requiring continuous operation)

Section 6 – 6.4.3.3.5 (6.3.2k) Hotel/Motel Controls

If > 50 guest rooms, controls capable of and configured to:

- Unoccupied: within 30 minutes of guest leaving, automatically raise/lower setpoint by 4F
- Unrented and unoccupied: setpoints automatically reset to 80F or higher cooling and 60F or lower heating
- Unrented and unoccupied determined by either
  - Continuously unoccupied for up to 16 hours
  - Networked guest room control system indicates room is unrented and is unoccupied for 30 minutes
Section 6 – 6.4.3.3.5 (6.3.2k)
Hotel/Motel Controls

- Hotel/Motel Guestroom Ventilation
  - Within 30 minutes of all occupants leaving the guest room, turn off ventilation and exhaust fans or use isolation devices to shut off outdoor air to the guest room and exhaust air from the guest room. Daily OA purge is allowed for 60 minutes or 1 air change.
- Captive key card systems can be used to comply with setpoint and ventilation requirements.

Section 6 – 6.4.4.1.3 (6.3.2l)
Piping Insulation

<table>
<thead>
<tr>
<th>Fluid Operating Temperature Range (°F) and Usage</th>
<th>Insulation Conductivity, Btu/in·h·°F</th>
<th>Mean Rating Temperature, °F</th>
<th>1&lt;1</th>
<th>1 to &lt;1-1/2</th>
<th>1-1/2 to &lt;2</th>
<th>2 to &lt;4</th>
<th>4 to &lt;8</th>
<th>≥8</th>
</tr>
</thead>
<tbody>
<tr>
<td>350 to 450</td>
<td>0.32 to 0.34</td>
<td>250</td>
<td>4.5</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>251 to 350</td>
<td>0.29 to 0.32</td>
<td>200</td>
<td>3.0</td>
<td>4.0</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>201 to 250</td>
<td>0.27 to 0.30</td>
<td>150</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>141 to 200</td>
<td>0.25 to 0.29</td>
<td>125</td>
<td>1.5</td>
<td>1.5</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>105 to 140</td>
<td>0.22 to 0.28</td>
<td>100</td>
<td>1.0</td>
<td>1.0</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Section 6 – 6.4.4.1.3 (6.3.2l)
Piping Insulation

Exceptions

✓ Factory-installed
✓ Piping conveying fluids
   – design operating temperature range between 60°F-105°F, inclusive
   – that haven’t been heated or cooled through the use of fossil fuels or electricity
✓ Where heat gain or loss won’t increase energy use
✓ For piping ≤ 1 in. No insulation required for strainers, control values, and balancing values

Section 6 – 6.4.4.1 (6.3.2.m)
Duct Insulation

Piping Insulation - Reference Tables 6.8.3-1 and 6.8.3-2 on pages 127 and 128 in 90.1-2016
Duct Insulation - Reference Table 6.8.2 on page 127 in 90.1-2016
Section 6 – 6.4.4.1 (6.3.2.m)  
Duct Insulation

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Duct Location</th>
<th>Unconditioned Space and Buried Ducts</th>
<th>Indirectly Conditioned Space*&lt;sup&gt;d&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 4</td>
<td>R-8</td>
<td>R-6</td>
<td>R-1.9</td>
</tr>
<tr>
<td>5 to 8</td>
<td>R-12</td>
<td>R-6</td>
<td>R-1.9</td>
</tr>
</tbody>
</table>

Supply and Return Ducts for Heating and Cooling

Supply and Return Ducts for Heating Only

Supply and Return Ducts for Cooling Only

Section 6 – 6.4.4.2 (6.3.2.m)  
Duct Sealing

- Ductwork and plenums with pressure class ratings constructed to Seal Class A
- Ductwork > 3" w.g. static pressure design shall be leak-tested (at least 25% representative sample) to 4cfm/ft²
n. Air balancing of ducted systems required
o. Outdoor air intake and exhaust systems meet 6.4.3.4
p. Interlocked thermostats for separate heating and cooling
q. System > 10,000 cfm:
o. optimum start controls
r. Demand control ventilation per 6.4.3.8
s. Door switch requirements
6.4.3.4.1 Stair and Shaft Vents
6.4.3.4.2 Shutoff Damper Controls
6.4.3.4.3 Damper Leakage
6.4.3.4.4 Ventilation Fan Controls
• Fans with motors > 0.75 hp shall have automatic controls complying with 6.4.3.3.1 to turn off fans when not required, unless they are intended to operate continuously.

Section 6 – 6.4.3.4 (6.3.2.o)
Outdoor Air Control

Simultaneous Heating and Cooling
• Where separate heating and cooling equipment serves the same temperature zone, thermostats shall be interlocked to prevent simultaneous heating and cooling.
**Section 6 – 6.4.3.4 (6.3.2.q) Optimum Start**

**optimum start controls:** controls that are designed to automatically adjust the start time of an HVAC system each day with the intention of bringing the space to desired occupied temperature levels immediately before scheduled occupancy.

- Systems with a design supply air capacity greater than 10,000 cfm

---

**Section 6 – 6.4.3.8 (6.3.2.r) Demand Control Ventilation**

**Demand control ventilation (DCV):** a ventilation system capability that provides for the automatic reduction of outdoor air intake below design rates when the actual occupancy of spaces served by the system is less than design occupancy.

DCV must be provided for each zone with an area > 500 ft² and the design occupancy > 25 people/1000 ft² where the HVAC system has:
- air-side economizer,
- automatic modulating control of OSA dampers
- design outdoor airflow > 3,000 cfm
Section 6 – 6.4.3.8 (6.3.2.r)
Demand Control Ventilation

Exceptions to DCV:
• Systems with exhaust air energy recovery meeting 6.5.6.1
• Multiple-zone systems without DDC of individual zones communicating with central control panel
• Systems with design outdoor air flow < 750 cfm
• Spaces where > 75% of space design outdoor airflow is required for makeup air exhausted from space or transfer air exhausted from other spaces
• Spaces with one of the following occupancy categories per ASHRAE 62.1
  – Correctional cells
  – Daycare sickrooms
  – Science labs
  – Barbers, beauty, and nail salons
  – Bowling alley seating

Section 6 – 6.5.10 (6.3.2.s)
Door Switch Controls

New requirement for controls that will, when door is open:
• Disable heating or adjust setpoint to 55F within 5 minutes
• Disable cooling or adjust setpoint to 90F within 5 minutes

Exceptions:
• Entries with automatically closing devices
• Spaces with no thermostat
• Alterations to existing buildings
• Loading docks
Section 7 – 7.4.3
Service Hot Water Piping Insulation

Insulate the following per Table 6.8.3-1
- Circulating water heater
  - Recirculating system piping, including supply and return piping
- Nonrecirculating storage system
  - First 8 ft of outlet piping
  - First 8 ft of branch piping connecting to recirculated, heat-traced, or impedance heated piping
  - Inlet pipe between storage tank and heat trap
-Externally-heated pipes (heat trace or impedance heating)

Section 7 – Table 6.8.3-1
Piping Insulation
Section 7 – 7.4.4
Service Water Heating System Controls

✓ Temperature Controls
✓ Temperature Maintenance Controls
✓ Outlet Temperature Controls
✓ Circulating Pump Controls

Section 7 – 7.4.4.1
Temperature Controls

Temperature controls shall be provided that allow for storage temperature adjustment from 120°F or lower to a maximum temperature compatible with the intended use.

Exception

• If manufacturer's installation instructions specify a higher minimum thermostat setting to minimize condensation and resulting corrosion
Systems designed to maintain usage temperatures in hot-water pipes, such as recirculating hot-water systems or heat trace, shall be equipped with *automatic time switches* or other controls that can be set to switch off the usage temperature maintenance system during extended periods when hot water is not required.

**Section 7 – 7.4.4.3**

Outlet Temperature Controls

Temperature controlling means shall be provided to limit the maximum temperature of water delivered from lavatory faucets in public facility restrooms to 110°F.
Section 7 – 7.4.4.4
Circulating Pump Controls

When used to maintain storage tank water temperature, recirculating pumps shall be equipped with controls limiting operation to a period from the start of the heating cycle to a maximum of five minutes after the end of the heating cycle.

Section 7 – 7.4.6
Heat Traps

Noncirculating systems to have heat traps on both the inlet and outlet piping as close as practical to storage tank (if no integral heat traps)
Combined space and water heating equipment is permitted when ONE of the following conditions is met:

1. Single boiler or component that is heating the service water has a standby loss in Btu/h not exceeding:
   
   \[\frac{(13.3 \times pmd + 400)}{n}\]; where \(pmd\) is probable maximum demand in gal/h and \(n\) is the fraction of the year when outdoor daily mean temperature is > 64.9°F

2. Jurisdiction agrees use of a single heat source will consume less energy than separate units

3. Energy input of the combined boiler and water heater system is < 150,000 Btu/h