Oregon Department of **ENERGY**

Overview of the Commercial HVAC Provisions of 2019 Oregon Energy Code

Blake Shelide, PE
November 7, 2019

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State Energy Background – Setting the Stage

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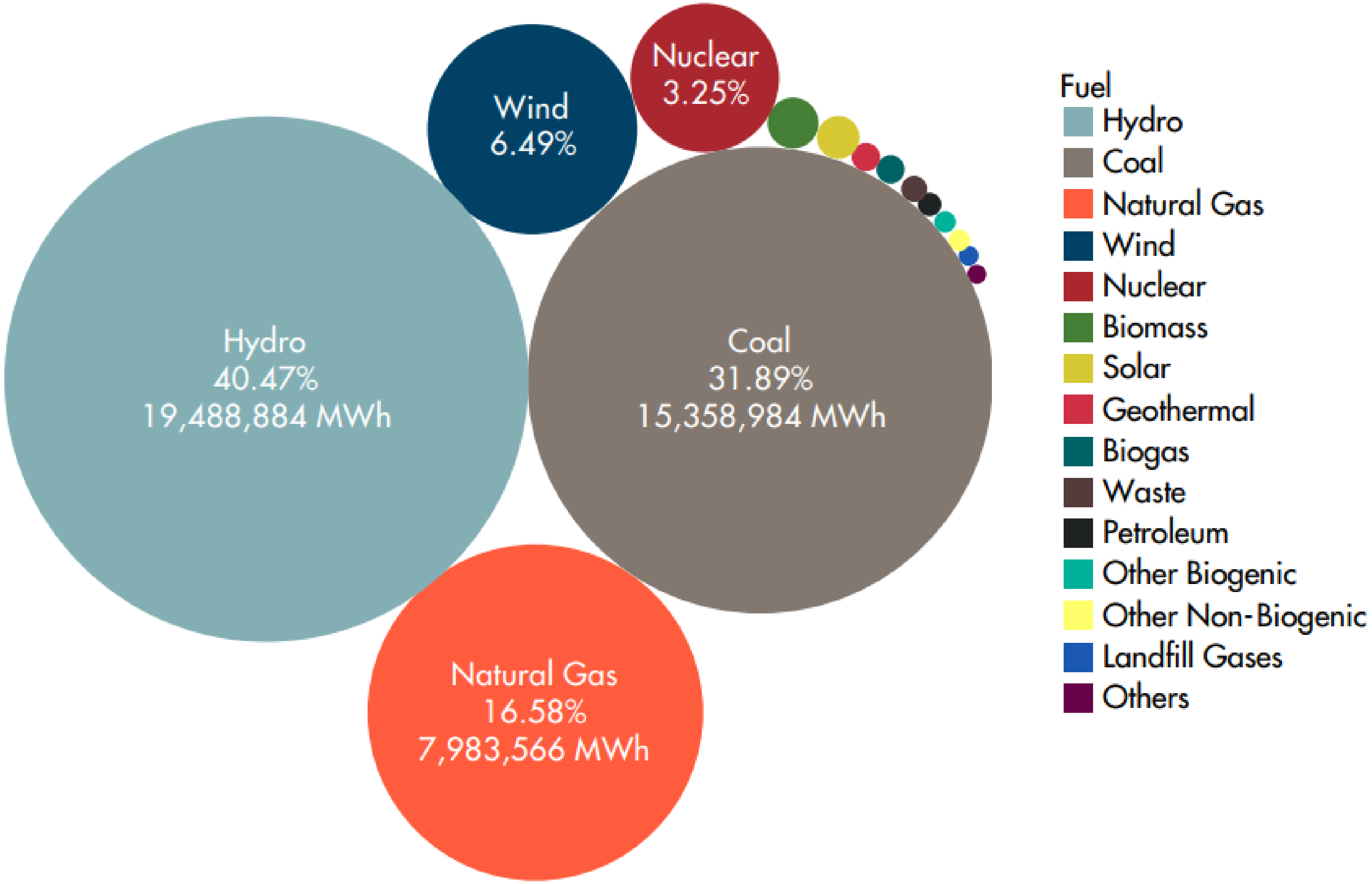
Oregon Electricity Resource Mix



Resources Used to Generate Oregon's Electricity

Based on a three-year average (2014-2016), this chart shows the energy resources used to generate the electricity that is sold to Oregon's utility customers.

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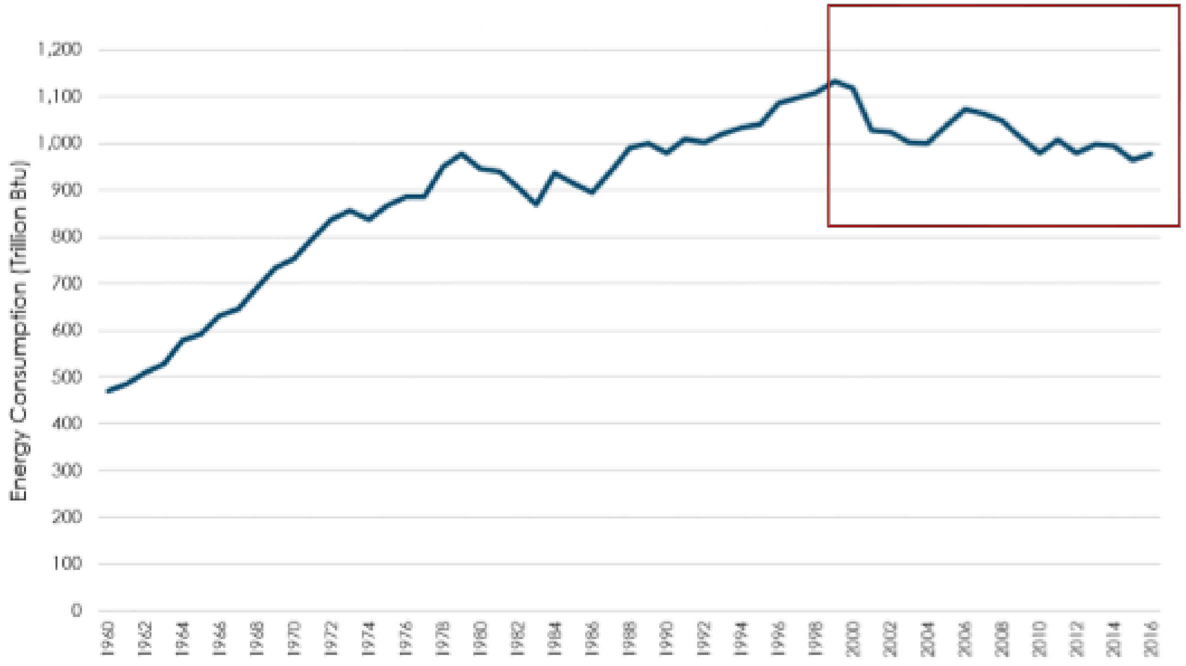
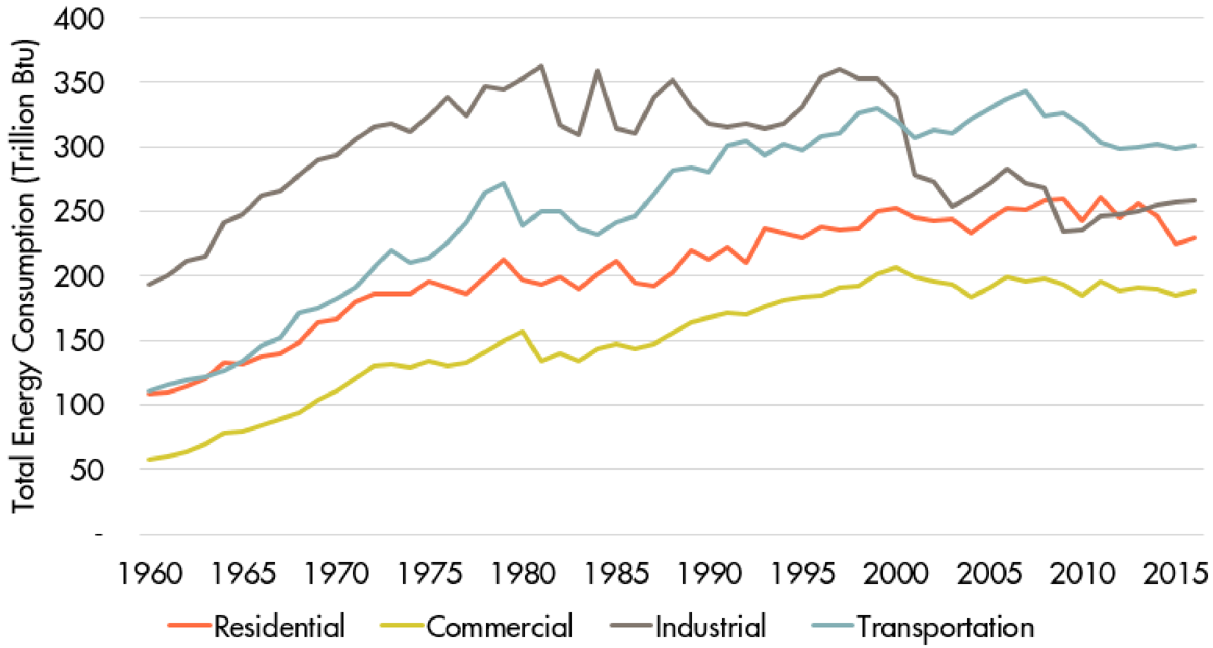
ENERGY CONSUMPTION OVER TIME

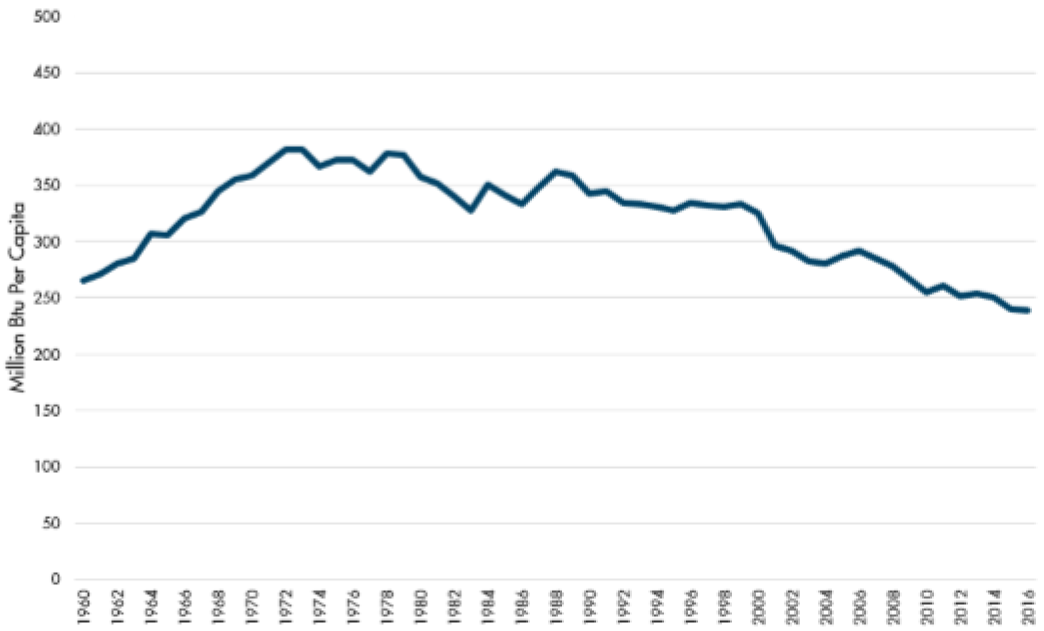


Oregon's Total Energy Consumption
Over Time

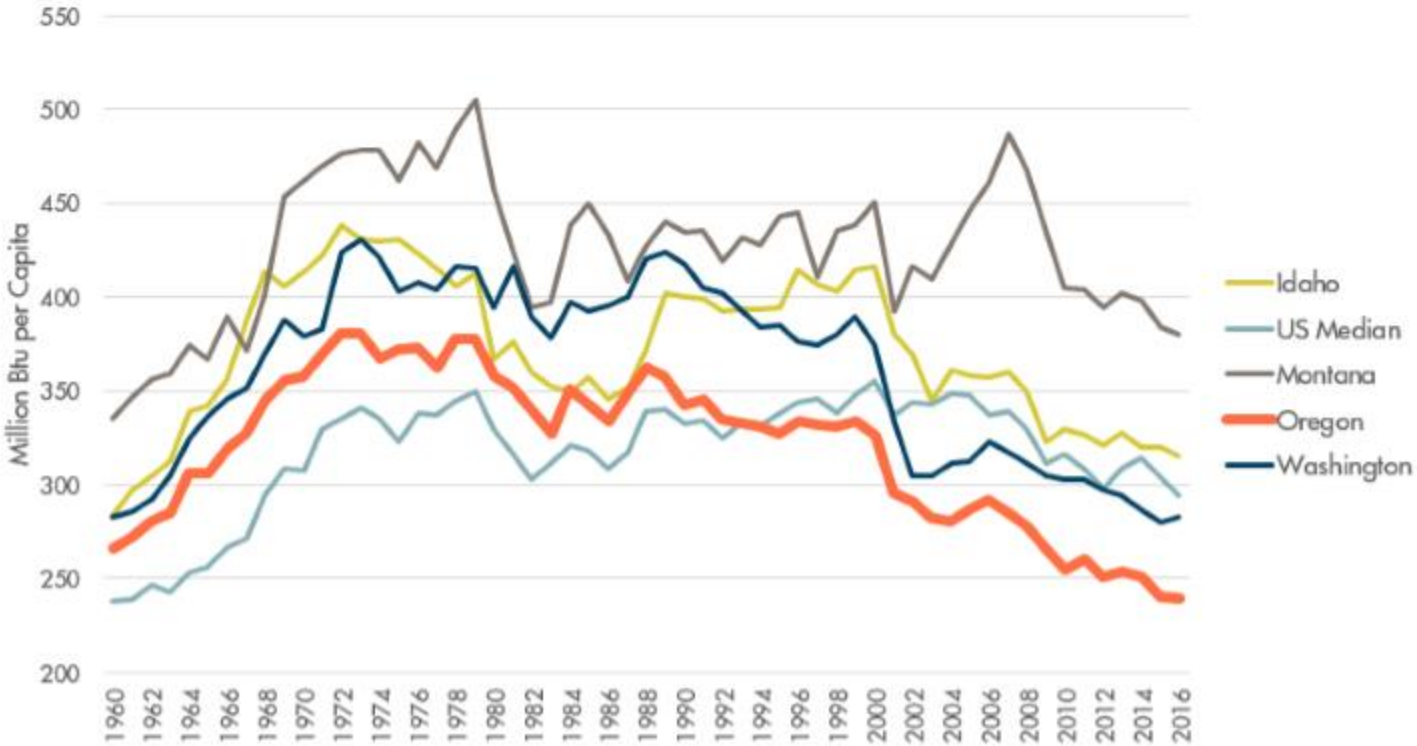


Oregon's Energy Consumption by Sector
Over Time

PER CAPITA ENERGY CONSUMPTION OVER TIME



Oregon’s Per Capita Energy Consumption Over Time



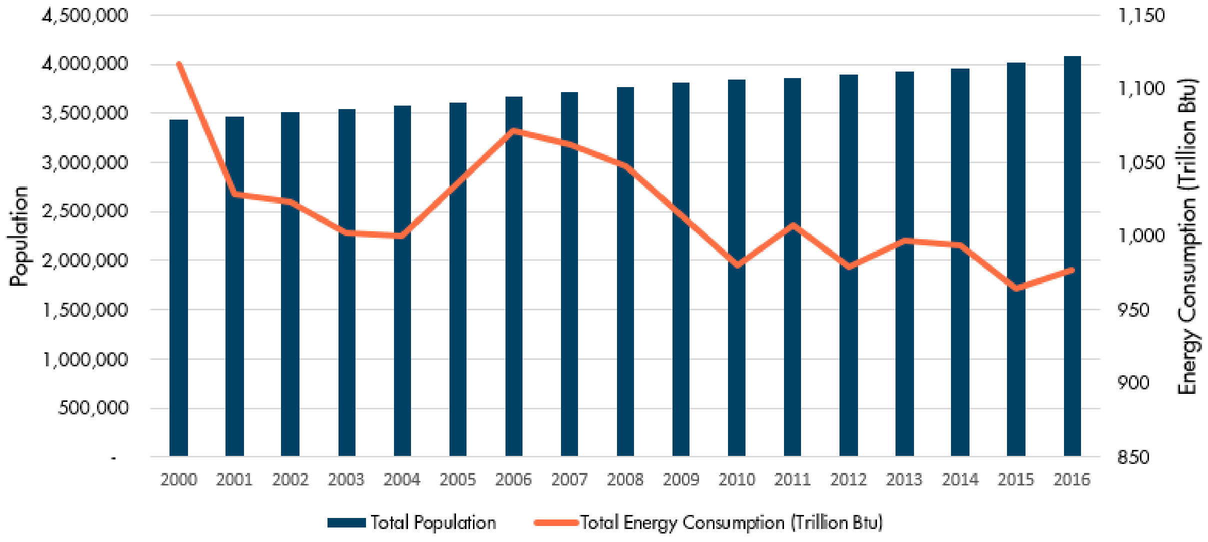
Oregon’s Per Capita Energy Consumption Over Time Compared to Northwest States

Energy Consumption & Oregon's Economy

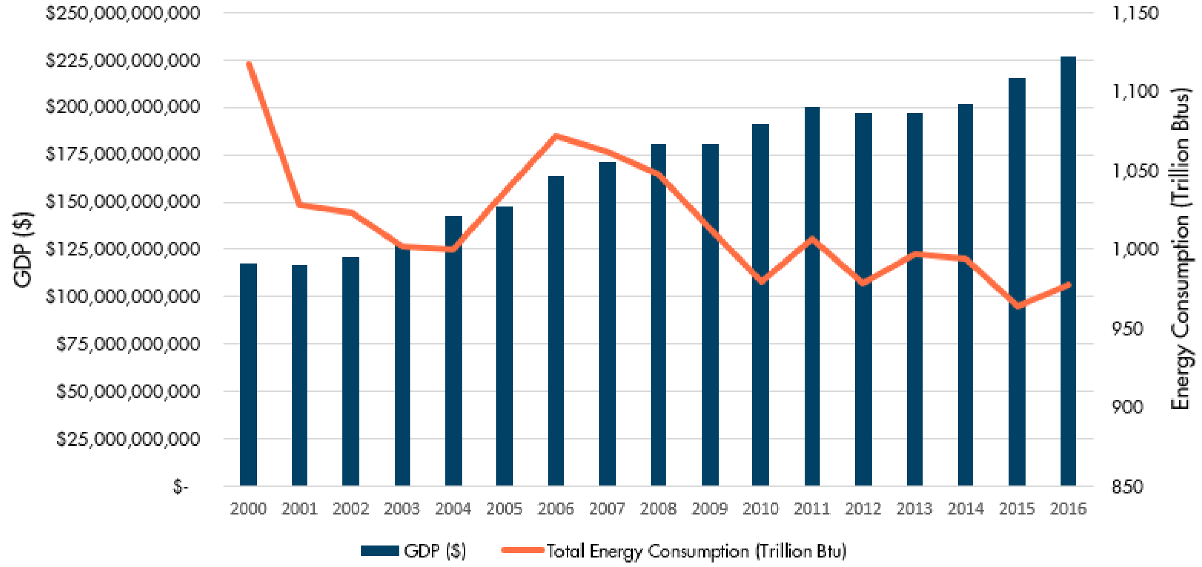
Between 2000 and 2016:

19%	**93%**	**12.5%**
Oregon Population	Oregon GDP	Oregon Energy Use

Oregon's Population and Energy Consumption: 2000-2016
Consumption axis starts at 850 TBtu

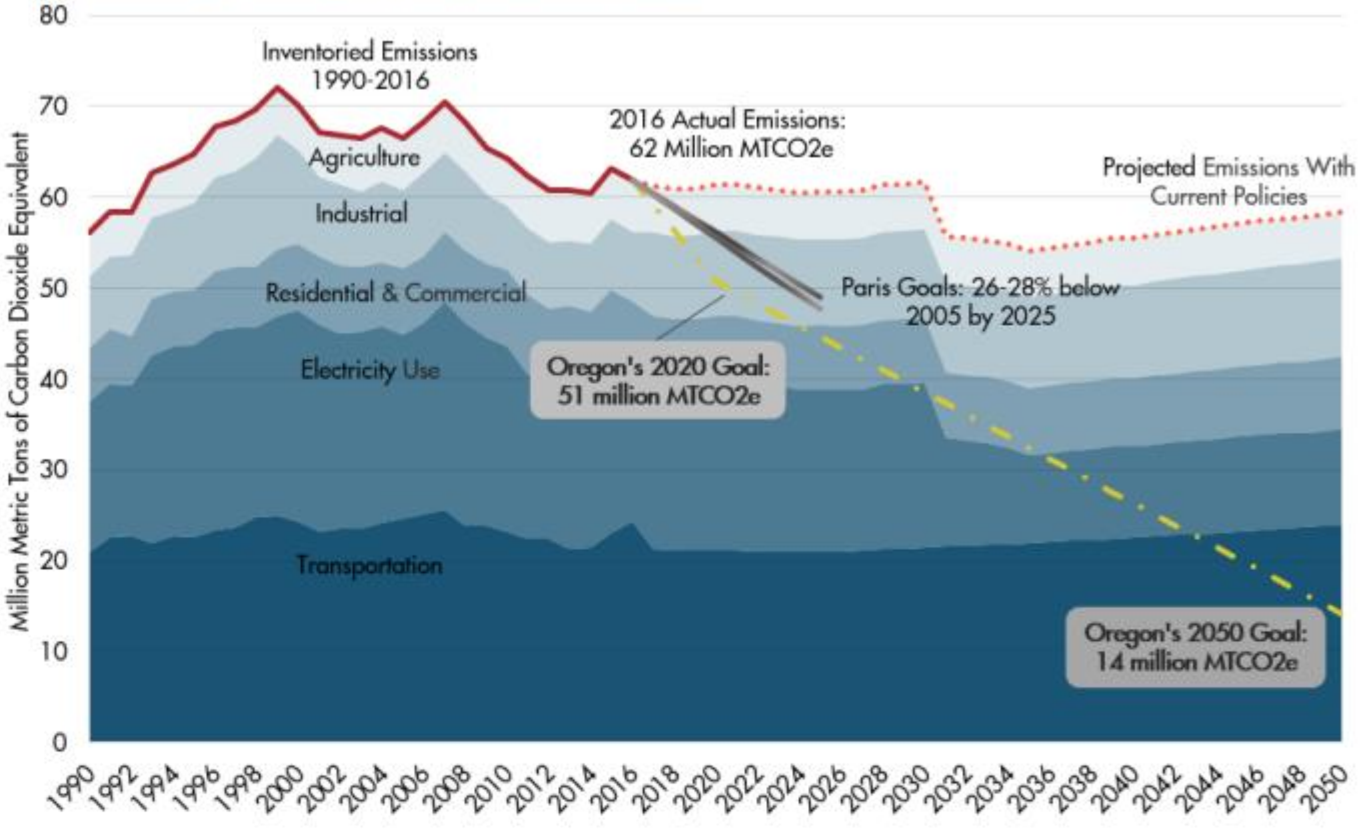


Oregon's GDP and Energy Consumption: 2000-2016
Consumption axis starts at 850 TBtu



OREGON GHG REDUCTION GOALS

Figure 2.6: Oregon's Projected GHG Emissions vs. Goals[20]



2007 House Bill 3543 set statewide statutory GHG reduction goals:

- By 2010, arrest the growth of Oregon's greenhouse gas emissions and begin to reduce greenhouse gas emissions.
- By 2020, achieve greenhouse gas levels that are 10 percent below 1990 levels.
- By 2050, achieve greenhouse gas levels that are at least 75 percent below 1990 levels.

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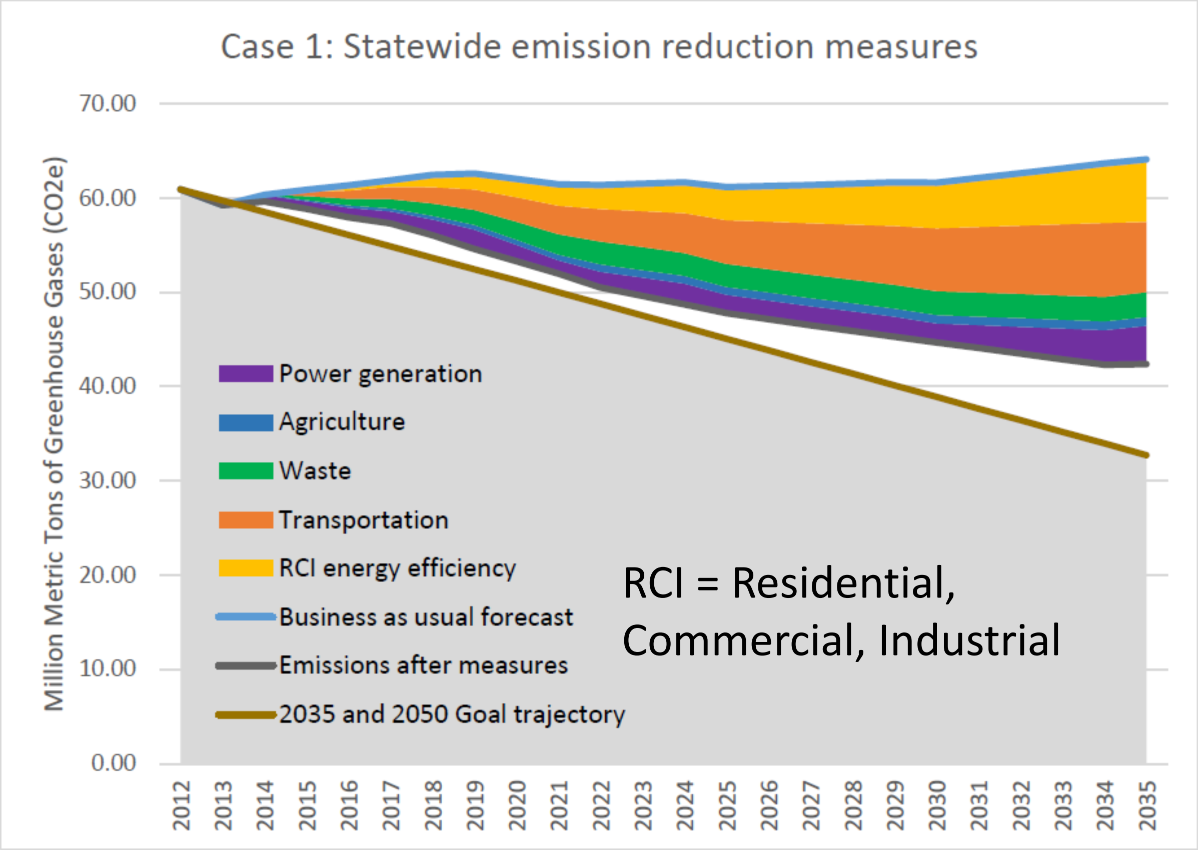
BUILDINGS & OREGON GHG REDUCTION GOALS

What role do buildings play toward Oregon's broader goals?

- Improve the energy efficiency and reduce the associated GHG emissions of the new building stock
- Critical piece of broader greenhouse gas reduction goals
- Combined with many other generation and demand side efficiency and renewable initiatives, contribute to progress toward goals



Oregon Global Warming Commission, Biennial Report to the Legislature 2015

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EO 17-20 (ENERGY EFFICIENCY)

Three key sections:

1. Energy efficiency leadership in state owned/leased buildings – Governor directives to DAS and ODOE
2. Targets for state-wide building codes & appliance standards – Governor directives to DCBS-BCD and ODOE
3. Retrofits and affordable housing – Governor directives to PUC, HCS, ODOE

Office of the Governor
State of Oregon

EXECUTIVE ORDER NO. 17-20

ACCELERATING EFFICIENCY IN OREGON'S BUILT ENVIRONMENT TO REDUCE GREENHOUSE GAS EMISSIONS AND ADDRESS CLIMATE CHANGE

WHEREAS, climate change presents a significant threat to our livelihoods, economic security, environment, health, and well-being.

WHEREAS, there has been an increase in extreme weather events, including more frequent and intense heat waves and wildfires. According to the Oregon Climate Change Research Institute and other regional studies, the best available science indicates Oregon is at risk of serious impacts to its natural resources due to climate change.

- Water resources are being affected by decreased winter snowpack, changes to seasonal runoff patterns, decreased precipitation in Eastern Oregon, and increased intensity and occurrence of flooding.
- Agricultural resources are being affected by increases in temperatures.
- Ocean acidification is increasing and there are changes in ocean currents.
- Significant parts of the Oregon coastal region, stretching 363 miles, will be impacted by an expected rise in sea level up to 1 to 4 feet by 2100, incurring billions of dollars of damages and losses to roadways and structures.
- Climate change impacts threaten the State's agricultural, fishing, timber, recreation, and tourism industries, thereby threatening the livelihood of the State's residents and an important source of Gross State Product for the state.

WHEREAS, energy efficiency leads to significant greenhouse gas reductions that are essential to meeting our state greenhouse gas reduction goals and addressing climate change.

WHEREAS, Oregon is committed to meeting the international Paris Agreement targets to reduce greenhouse gas emissions by 26 to 28 percent below 2005 levels by 2025.

WHEREAS, Oregon has adopted goals to reduce greenhouse gas emissions to 10 percent below 1990 levels by 2020 and at least 75 percent below 1990 levels by 2050 as described in ORS 468A.20.

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EO available: http://www.oregon.gov/gov/Documents/executive_orders/eo_17-20.pdf

WHY EFFICIENCY & ZERO EMISSION VEHICLES?

30%

- About 30% of Oregon's greenhouse emissions can be traced to how much and what type of energy we use in our buildings
- Electricity and other energy consumption in residential and commercial buildings are a large greenhouse gas contributor
- Reducing energy use and increasing efficiency will help lower emissions from the built environment

40%

- About 40% of Oregon's greenhouse gas emissions are from the transportation sector
- Transitioning to zero emission vehicles will result in emissions reductions in the transportation sector
- Supporting infrastructure and reducing EV costs will encourage adoption

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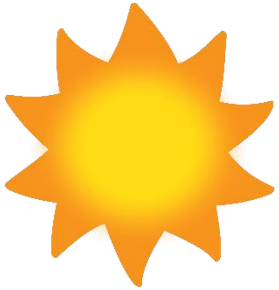
EO 17-20 – DIRECTIVE 4A, 4B
SOLAR AND EV READY



A. Solar Ready Building Construction. The appropriate advisory board(s) and the Department of Business and Consumer Services Building Codes Division (BCD) are directed to conduct code amendment of the state building code to require all newly constructed buildings will be ready for the installation of solar panels and related technologies by October 1, 2020 for residential structures and October 1, 2022 for commercial structures. BCD may establish limited specific exemptions to this solar-ready policy for buildings where solar applications are infeasible.

B. Electric Vehicle Ready Building Construction. The appropriate advisory board(s) and BCD are directed to conduct code amendment of the state building code to require that parking structures for all newly constructed residential and commercial buildings are ready to support the installation of at least a level 2 EV charger by October 1, 2022. BCD may establish limited specific exemptions related to types of parking lots, such as temporary parking lots.

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EXECUTIVE ORDER 17-20 COMMERCIAL ENERGY CODE

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.

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COMMERCIAL ENERGY CODE

Oregon **Building Codes Division** is moving towards quick adoption of ASHRAE 90.1 as state code within a year of publication

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

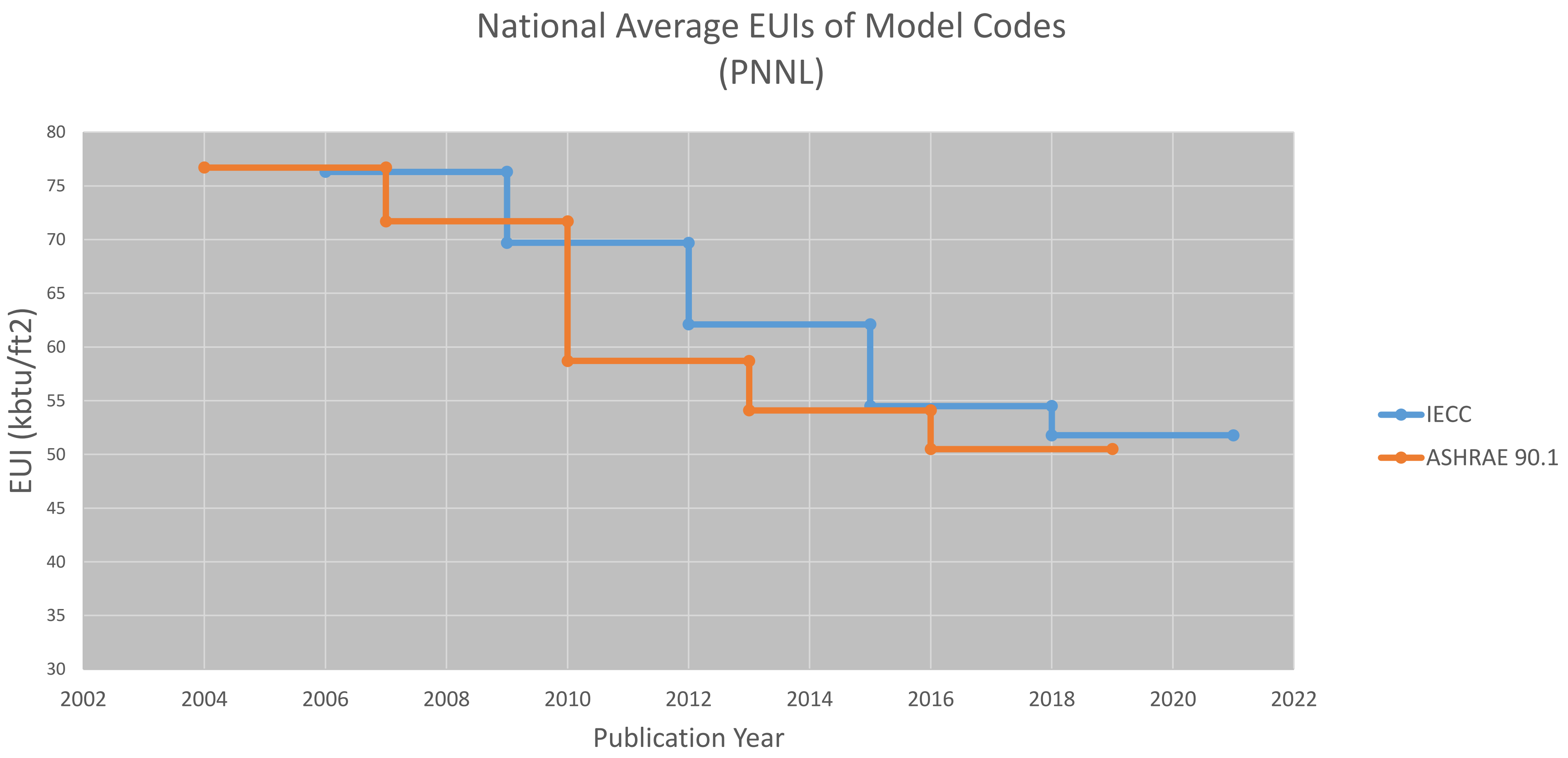
+

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

<u>Benefits of 90.1 include</u>

- Quicker, less resource-intensive, streamlined adoption (more buildings under advanced code)
- More predictable
- Comprehensive cost analysis
- Supported (COMcheck)
- Federal declaration/certification becomes easy

COMMERCIAL ENERGY CODE



Note: 2018 IECC is an estimate of reduction vs. 2015

2019 Oregon Energy Code Updates and 90.1

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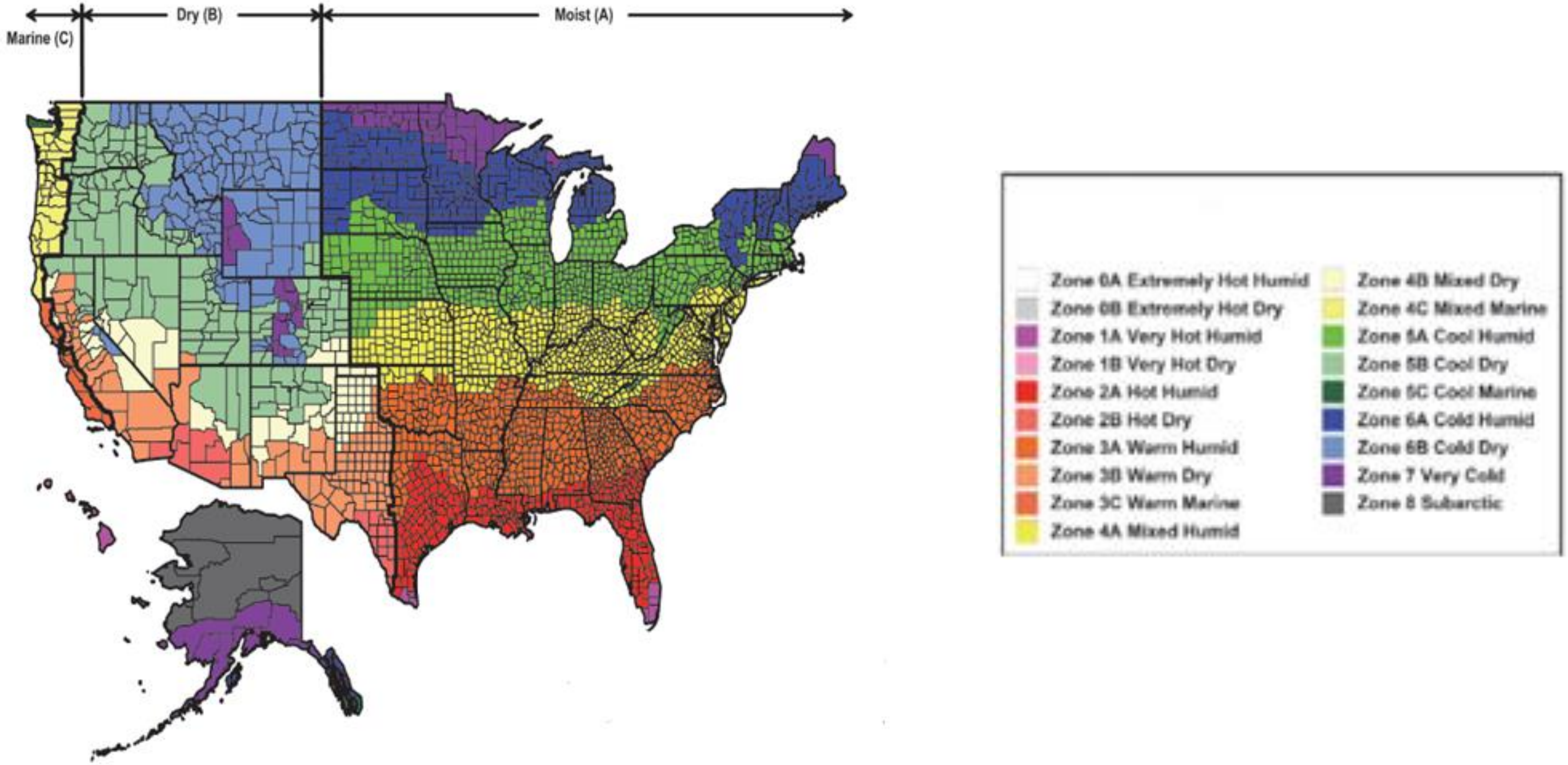
UPDATED CLIMATE ZONE MAP

- Aligns with new ASHRAE Standard 169-2013
- No climate zone changes for Oregon, but may impact other work you do across the country



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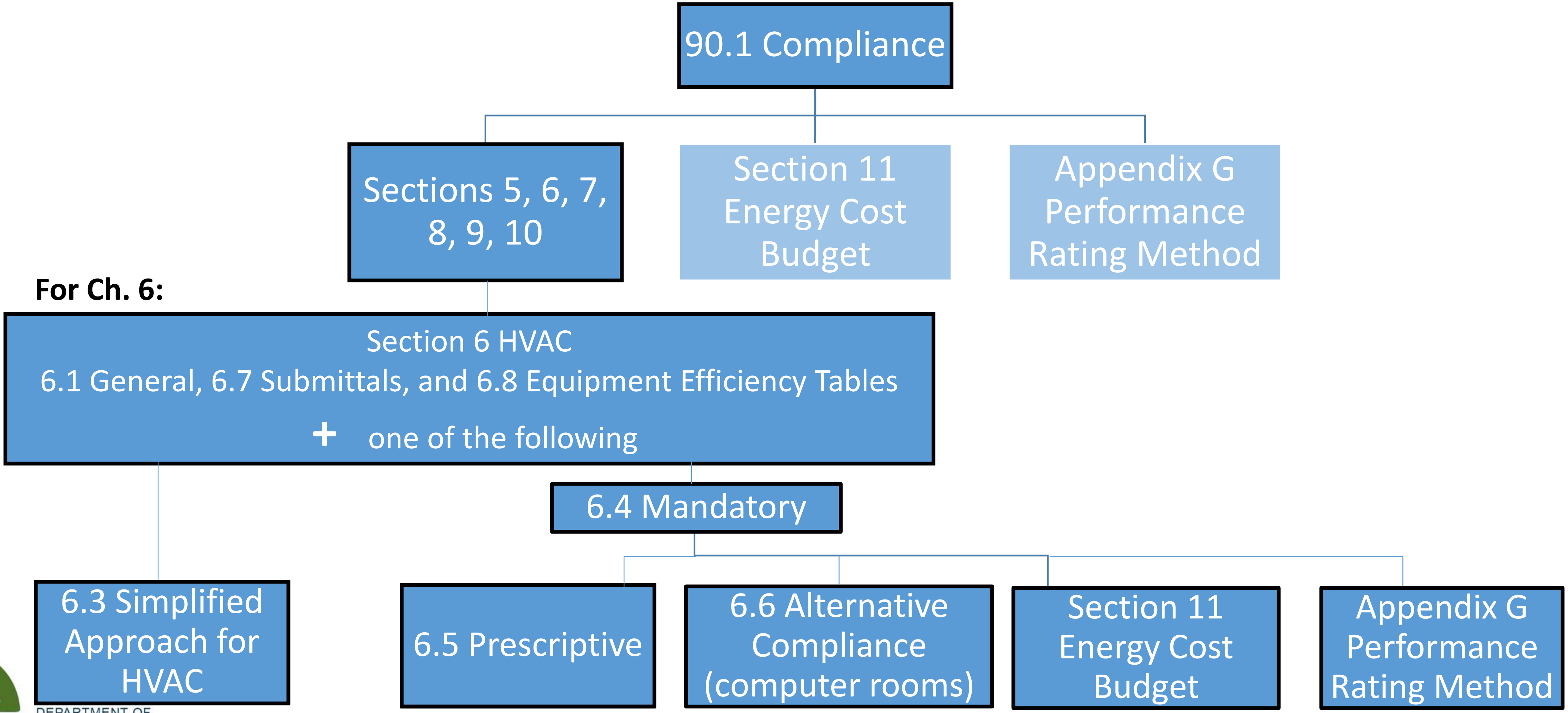
CHAPTER 6 HVAC COMPLIANCE PATHS



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Simplified Path

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.3	N/A

- Available if systems and building meet certain criteria
  - 2 stories or fewer
  - Floor area < 25,000 ft^2
  - Each HVAC system complies with a list of requirements in 6.3.2 (ALL must be met)
- 6.3.2 contains a host of requirements including
  - Single zone HVAC
  - Supply fan variable flow
  - Cooling and heating with packaged or SS that meets efficiency tables
  - Economizer if required by other sections
  - Electric resistance heat limitations for heat pumps
  - Piping and ductwork insulation in accordance with other sections
  - + some others

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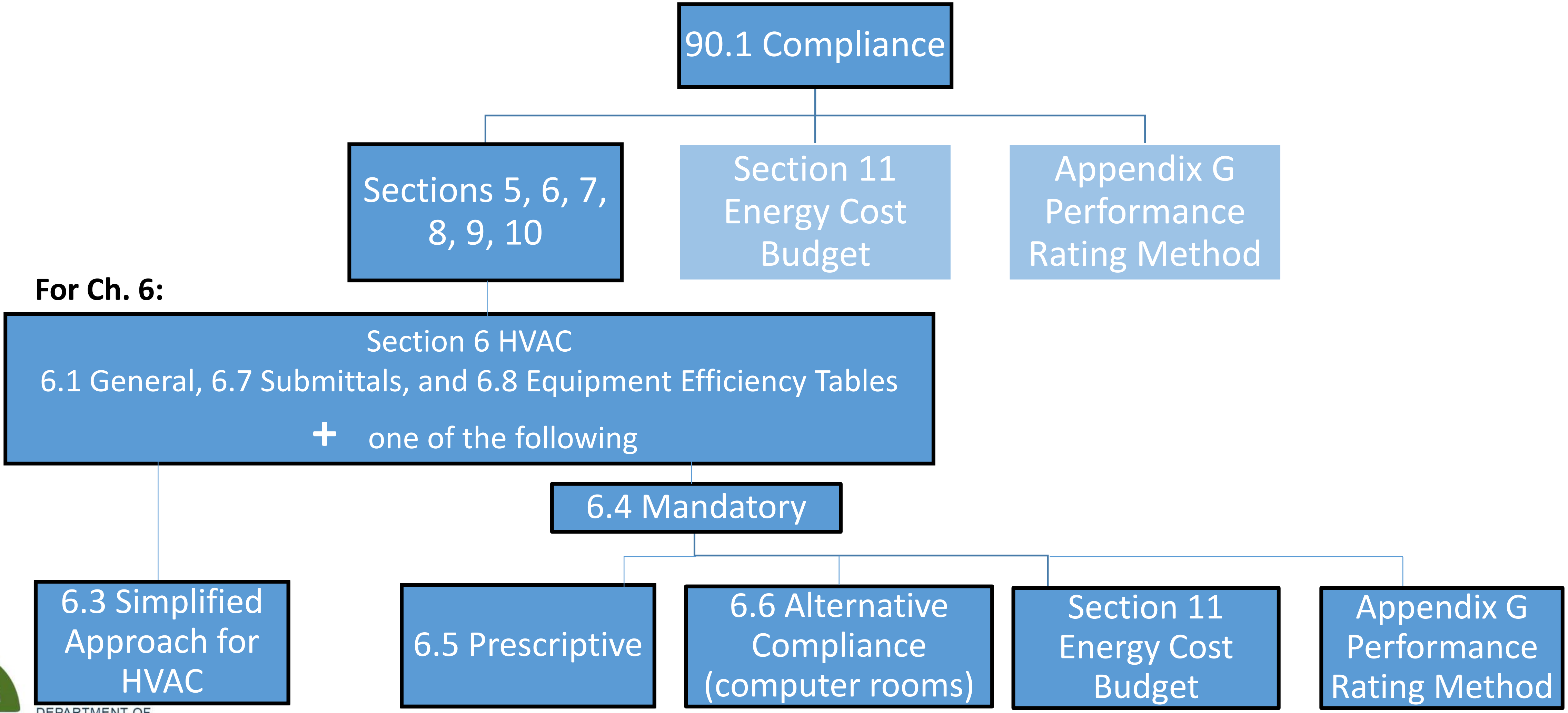
CHAPTER 6 HVAC COMPLIANCE PATHS



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6.4 – Mandatory Provisions

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EQUIPMENT EFFICIENCIES

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.1, Tables 6.8.1-x	503.2.3, Tables 503.2.3(x)

- General updates across multiple types of equipment
- These are pretty much the same as federal minimums
- Efficiency increases for some packaged AC/heat pumps, terminal AC/ heat pump units, boilers, VRF
- New efficiency table for DOAS units
- Previous Oregon code mostly from 90.1-2013

LOAD CALCULATIONS

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.2	503.2.1

- Similar requirement for calculation of heating and cooling loads for the purpose of sizing systems and equipment to be done in accordance with ANSI/ASHRAE/ACCA Standard 183
- New general requirement for pump differential pressure (head) to be determined in accordance with generally accepted engineering standards.

ZONE THERMOSTATIC CONTROLS

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.1	503.2.4.1

- Similar requirement for individual zone thermostatic control
- Dwelling units permitted to be considered a single zone
- Same exception for independent perimeter systems that are designed to offset building envelope loads only, are permitted to serve one or more zones

DEAD BAND / SETPOINT OVERLAP RESTRICTION

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.2, 6.4.3.1.2	503.2.4.2

- Similar requirements
- Where used to control both heating and cooling, zone thermostatic controls shall be ***capable and configured to*** a 5F deadband
- Where heating and cooling are controlled by separate zone thermostatic controls, provide means to prevent heating setpoint from exceeding the cooling setpoint

"Capable and configured to" change throughout the code

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OFF HOUR CONTROLS

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.3	503.2.4.3, 503.2.4.4, 503.2.4.7

- Automatic Shutdown
  - Time schedule controls (7 day) **OR** occupant sensor **OR** timer (up to 2 hours) **OR** security system interlock
- Setback controls
  - 2014 OEESC: specified setback capabilities down to 55F (heating) or up to 85F (cooling)
  - 90.1-2016: capable and configured to 10F below heating setpoint and 5F above cooling setpoint (or to prevent high humidity levels)
- Optimum start controls
  - 2014 OEESC: general requirement for optimum start
  - 90.1-2016: systems with setback controls and DDC shall have optimum start.
    - **Requires algorithm to be a function of difference between space T, occupied setpoint, OAT, and time until occupancy**
- Zone Isolation – similar requirements, some new exception language

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HOTEL HVAC - OFF HOUR CONTROLS

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.3.5	N/A

Hotel/Motel Guestroom HVAC

- 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

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OFF HOUR CONTROLS

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.3.5	N/A

- 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

STAIR AND SHAFT VENTS

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.4.1	502.4.4

Similar requirements between the two codes

- 90.1-2016: stair and elevator shafts capable and configured to automatically close during normal building operation

- 2014 OEESC: stair and elevator shafts and other ventilation openings integral to building envelope shall be equipped with not less than Class I motorized damper. Capable of being automatically closed during normal operation

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SHUTOFF DAMPER CONTROLS, LEAKAGE

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.4.2-3	503.2.4.5

New

- OA intake and exhaust equipped with motorized dampers that will automatically shut when system or spaces are not in use
- Capable of and configured to automatically shut off during warm-up, cool down, and setback (unless ventilation reduces energy or code-required)
- Leakage performance requirements of **10 cfm/ft^2** motorized, 20 cfm/ft^2 non-motorized <3 stories
- Exceptions
  - Gravity dampers okay for exhaust and relief in buildings <3 stories
  - Gravity dampers okay in systems with design OA <=300 cfm
  - Unconditioned space ventilation and exhaust
  - Systems serving Type 1 kitchen exhaust

Previous

- OA supply, exhaust, and relief need Class I motorized damper
- Maximum leakage **4 cfm/ft^2** at 1” wg tested in accordance with AMCA 500D
- Exceptions:
  - Gravity dampers okay if <= 300 cfm
  - Relief dampers integral to packaged equipment
  - Type I grease exhaust

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VENTILATION FAN CONTROLS

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.4.4	N/A

- 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
- Controls can be time schedules, occupant sensors, manual timer, or security system interlock

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ENCLOSED PARKING GARAGE VENTILATION

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.4.5	503.2.5.3

Requirements are mostly similar

90.1-2016: automatically detect contaminant levels and reduce flow by

- Staging fans or
- Modulating fan airflow

to rates 50% or less of design capacity as long as acceptable contaminant levels are maintained

- Contaminant and levels not defined
- Exceptions:
  - Garages <30,000 ft^2 with no mechanical cooling or heating
  - hp ratio > 1,500 ft^2/hp with no mechanical cooling or heating
  - Where not permitted by AHJ

2014 OEESC:

- Group S-2 only
- Same 30,000 ft^2
- Specified contaminant (CO) and ppm to maintain
- Minimum ventilation rate specified

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HEAT PUMP AUXILIARY HEAT CONTROL

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.5	503.2.4.1.1

- Similar requirements
- Requires heat pumps with internal resistance heat to have controls that prevent supplemental heater operation when the heat pump alone can meet the load
  - during both steady-state operation and setback recovery
  - Supplemental heat is okay during defrost cycles

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HUMIDIFICATION AND DEHUMIDIFICATION

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.6	503.2.4.9

- Similar requirements
- No fossil fuel or electricity for humidity control between 30% and 60% RH in both new and old code
- Similar exception for critical zones (museums, hospitals, etc.)
- New exceptions
  - Zones served by desiccant systems and used with direct evaporative cooling in series
  - Systems serving zones with precise +- 5% RH requirements

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FREEZE PROTECTION AND SNOW/ICE MELT

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.7	503.2.4.6

- Similar requirements
- Freeze protection piping required to have automatic control capable and configured to shut off when OAT > 40F
- Snow and ice-melt required to have
  - controls to shut off when OAT > 50F and no precipitation is falling
  - Automatic or manual control that will allow shutoff when OAT > 40F

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DEMAND CONTROLLED VENTILATION

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.8	503.2.5.1

- Similar requirements
- Continues to apply to spaces > 500 ft^2, with design occupancy for ventilation of >= 25 people per 1000 ft^2 and served by systems with either
  - Air-side economizer
  - Automatic modulating control of OA damper, or
  - Design OA flow > 3000 cfm
- Slightly different exceptions. 90.1-2016 exceptions are:

Exceptions to 6.4.3.8

1. *Systems* with exhaust air *energy* recovery complying with Section 6.5.6.1.
2. Multiple-zone *systems* without *DDC* of individual zones communicating with a central *control* panel.
3. *Systems* with a design outdoor airflow less than 750 cfm.
4. *Spaces* where >75% of the *space* design outdoor airflow is required for *makeup air* that is exhausted from the *space* or *transfer air* that is required for *makeup air* that is exhausted from other *spaces*.
5. *Spaces* with one of the following occupancy categories as defined in ASHRAE Standard 62.1: correctional cells, daycare sickrooms, science labs, barbers, beauty and nail salons, and bowling alley seating.

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HEATED OR COOLED VESTIBULES

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.9	N/A

- Automatic off required for vestibule heating when OAT > 45F
- Maximum 60F heating setpoint, minimum 85F cooling setpoint
- Exceptions: if energy used to condition the vestibule is from site-recovered energy or transfer air that would otherwise be exhaust

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DDC Requirements

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.10	N/A

- DDC required for certain applications and qualifications

Table 6.4.3.10.1 *DDC* Applications and Qualifications

Building Status	Application	Qualifications
New *building*	Air-handling *system* and all zones served by the *system*	Individual *systems* supplying more than three zones and with fan *system* bhp of 10 hp and larger
	Chilled-water plant and all coils and *terminal* units served by the *system*	Individual plants supplying more than three zones and with design cooling capacity of 300,000 Btu/h and larger
	Hot-water plant and all coils and *terminal* units served by the *system*	Individual plants supplying more than three zones and with design heating capacity of 300,000 Btu/h and larger
Alteration or addition	Zone *terminal* unit such as *VAV* box	Where existing zones served by the same air-handling, chilled-water, or hot-water *system* have *DDC*
	Air-handling *system* or fan coil	Where existing air-handling *systems* and fan coils served by the same chilled- or hot-water plant have *DDC*
	New air-handling *system* and all new zones served by the *system*	Individual *systems* with fan *system* bhp of 10 hp and larger and supplying more than three zones and more than 75% of zones are new
	New or upgraded chilled-water plant	Where all chillers are new and plant design cooling capacity is 300,000 Btu/h and larger
	New or upgraded hot-water plant	Where all *boilers* are new and plant design heating capacity is 300,000 Btu/h and larger

DDC Requirements

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.10	N/A

- Where DDC IS required, certain capabilities are required:

6.4.3.10.2 DDC Controls

Where *DDC* is required by Section 6.4.3.10.1, the *DDC system* shall be capable of and configured with all of the following, as required, to provide the *control* logic required in Section 6.5:

a. Monitoring zone and *system demand* for fan pressure, pump pressure, heating, and cooling.

b. Transferring zone and *system demand* information from zones to air *distribution system* controllers and from air *distribution systems* to heating and cooling plant controllers.

c. Automatically detecting those zones and *systems* that may be excessively driving the *reset* logic and generate an alarm or other indication to the *system* operator.

d. Readily allowing operator removal of zones from the *reset* algorithm.

CHW Plant Monitoring

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.11	N/A

For electric motor-driven CHW plants

- In new buildings
- New plants in existing buildings

Monitoring and measurement for energy use and efficiency (kW/ton) is required for all chiller plants over a certain capacity, which for Oregon climate zones is:

- Water-cooled CHW plants: > 1500 tons peak cooling capacity
- Air-cooled CHW plants: > 860 tons peak cooling capacity

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Economizer Fault Detection and Diagnosis

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.3.12	N/A

Air cooled DX units with an economizer shall include fault detection and diagnosis (FDD) with a host of required sensors and capabilities

6.4.3.12 Economizer Fault Detection and Diagnostics (FDD)

Air-cooled direct-expansion cooling units listed in Tables 6.8.1-1 and 6.8.1-2, where an *air economizer* is installed in accordance with Section 6.5.1, shall include a fault detection and diagnostics (FDD) *system* complying with the following:

a. The following temperature sensors shall be *permanently installed* to monitor *system* operation:
   1. *Outdoor air*
   2. Supply air
   3. Return air, where required for economizer *control*

b. The *system* shall have the capability of displaying the value of each sensor.

c. The FDD *system* or unit *controls* shall be capable of and configured to provide *system* status by indicating the following:
   1. Free cooling available
   2. Economizer enabled
   3. Compressor enabled
   4. Heating enabled
   5. Mixed-air low-limit cycle active

d. The FDD *system* or unit *controls* shall have provisions to manually initiate each operating mode so that the operation of compressors, economizers, fans, and the heating *system* can be independently tested and verified.

e. The FDD *system* shall be capable of and configured to detect the following faults:
   1. Air temperature sensor failure/fault
   2. Not economizing when the unit should be economizing
   3. Economizing when the unit should not be economizing
   4. Damper not modulating
   5. Excess *outdoor air*

f. The FDD *system* shall be capable of and configured to report faults to a fault management application or *DDC system* accessible by operating or *service* personnel, or annunciated locally on zone *thermostats*.

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HVAC Duct Insulation

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.4.1.2	503.2.7

New - 90.1-2016

- Based on location, type of duct
- Generally increase from R-5 to R-6 for unconditioned space
- Exterior requirement will depend on system type and CZ

Table 6.8.2 Minimum Duct Insulation R-Value[a]

Climate Zone	Duct Location: Exterior[b]	*Unconditioned Space* and Buried Ducts	*Indirectly Conditioned Space*[c,d]
Supply and Return Ducts for Heating and Cooling			
0 to 4	R-8	R-6	R-1.9
5 to 8	R-12	R-6	R-1.9
Supply and Return Ducts for Heating Only			
0 to 1	None	None	None
2 to 4	R-6	R-6	R-1.9
5 to 8	R-12	R-6	R-1.9
Supply and Return Ducts for Cooling Only			
0 to 6	R-8	R-6	R-1.9
7 to 8	R-1.9	R-1.9	R-1.9

a. Insulation *R-values*, measured in h·ft^2·°F/Btu, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where portions of the *building envelope* are used as a *plenum* enclosure, *building envelope* insulation shall be as required by the most restrictive condition of Section 6.4.4.1 or Section 5, depending on whether the *plenum* is located in the *roof*, *wall*, or *floor*. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a *mean temperature* of 75°F at the installed thickness.
b. Includes attics above insulated ceilings, parking garages and crawl *spaces*.
c. Includes return air plenums with or without exposed *roofs* above.
d. Return ducts in this duct location do not require insulation.

Old - 2014 OEESC:

- Unconditioned spaces: R-5
- Exterior: R-8
- Exceptions
  - When inside equipment
  - Inside/outside duct DT <15F

HVAC Duct Insulation

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.4.1.2	503.2.7

90.1-2016

- New area classification for “indirectly conditioned spaces” (such as a return plenum)
- Some exceptions

Exceptions to 6.4.4.1.2

1. Factory-installed plenums, casings, or *ductwork* furnished as a part of HVAC *equipment* tested and rated in accordance with Section 6.4.1.
2. Ducts or plenums located in *heated spaces*, *semiheated spaces*, or *cooled spaces*.
3. For runouts less than 10 ft in length to air *terminals* or air outlets, the *rated R-value of insulation* need not exceed R-3.5.
4. Backs of air outlets and outlet plenums exposed to *unconditioned space* or *indirectly conditioned space* with face areas exceeding 5 ft^2 need not exceed R-2; those 5 ft^2 or smaller need not be insulated.

ORE DEPARTMENT OF ENERGY

HVAC Piping Insulation

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.4.1.3	503.2.8

No changes. Old and new requirements (heating) are:

Table 6.8.3-1 Minimum *Piping* Insulation Thickness Heating and Hot Water Systems[a,b,c,d,e]
(Steam, Steam Condensate, Hot-Water Heating and Domestic Water *Systems*)

Fluid Operating Temperature Range (°F) and Usage	Insulation Conductivity		≥Nominal Pipe or Tube Size, in.				
	Conductivity, Btu·in/h·ft²·°F	Mean Rating Temperature, °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
			Insulation Thickness, in.				
>350	0.32 to 0.34	250	4.5	5.0	5.0	5.0	5.0
251 to 350	0.29 to 0.32	200	3.0	4.0	4.5	4.5	4.5
201 to 250	0.27 to 0.30	150	2.5	2.5	2.5	3.0	3.0
141 to 200	0.25 to 0.29	125	1.5	1.5	2.0	2.0	2.0
105 to 140	0.22 to 0.28	100	1.0	1.0	1.5	1.5	1.5

a. For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: $T = r\{(1 + t/r)^{K/k} - 1\}$, where T = minimum insulation thickness (in.), r = actual outside radius of pipe (in.), t = insulation thickness listed in this table for applicable fluid temperature and pipe size, K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu·in/h·ft²·°F]; and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

b. These thicknesses are based on *energy efficiency* considerations only. Additional insulation is sometimes required relative to safety issues/surface temperature.

c. For *piping* smaller than 1.5 in. and located in partitions within *conditioned spaces*, reduction of these thicknesses by 1 in. shall be permitted (before thickness adjustment required in footnote [a]) but not to thicknesses below 1 in.

d. For direct-buried heating and hot-water *system piping*, reduction of these thicknesses by 1.5 in. shall be permitted (before thickness adjustment required in footnote [a]) but not to thicknesses below 1 in.

e. The table is based on steel pipe. Nonmetallic pipes schedule 80 thickness or less shall use the table values. For other nonmetallic pipes having *thermal resistance* greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per metre than a steel pipe of the same size with the insulation thickness shown in the table.

OREGON DEPARTMENT OF ENERGY

HVAC Piping Insulation

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.4.1.3	503.2.8

No changes. Old and new requirements (cooling) are:

Table 6.8.3-2 Minimum *Piping* Insulation Thickness Cooling *Systems* (Chilled Water, Brine, and Refrigerant)[a,b,c,d]

Fluid Operating Temperature Range (°F) and Usage	Insulation Conductivity		Nominal Pipe or Tube Size, in.				
	Conductivity, Btu·in/h·ft²·°F	Mean Rating Temperature, °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
			Insulation Thickness, in.				
40 to 60	0.21 to 0.27	75	0.5	0.5	1.0	1.0	1.0
<40	0.20 to 0.26	50	0.5	1.0	1.0	1.0	1.5

a. For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: $T = r\{(1 + t/r)^{K/k} - 1\}$, where T = minimum insulation thickness (in.), r = actual outside radius of pipe (in.), t = insulation thickness listed in this table for applicable fluid temperature and pipe size, K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu·in/h·ft2·°F]; and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.
b. These thicknesses are based on *energy efficiency* considerations only. Issues such as water vapor permeability or surface condensation sometimes require vapor retarders or additional insulation.
c. For direct-buried cooling *system piping*, insulation is not required.
d. The table is based on steel pipe. Nonmetallic pipes schedule 80 thickness or less shall use the table values. For other nonmetallic pipes having *thermal resistance* greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot than a steel pipe of the same size with the insulation thickness shown in the table.

Piping insulation exceptions are mostly the same:

Exceptions to 6.4.4.1.3

1. Factory-installed *piping* within HVAC *equipment* tested and rated in accordance with Section 6.4.1.
2. *Piping* that conveys fluids having a design operating temperature range between 60°F and 105°F, inclusive.
3. *Piping* that conveys fluids that have not been heated or cooled through the use of *fossil fuels* or electricity (such as *roof* and condensate drains, domestic cold-water supply, and natural-gas *piping*).
4. Where heat gain or heat loss will not increase *energy* use (such as liquid refrigerant *piping*).
5. In *piping* 1 in. or less, insulation is not required for strainers, *control* valves, and balancing valves.

OREGON DEPARTMENT OF ENERGY

Sensible Heating Panel, Radiant Floor Insulation

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.4.1.4	N/A

- *Thermally ineffective panel surfaces* insulated to minimum of R-3.5. Adjacent building envelope insulation counts toward this requirement.

  thermally ineffective panel surface: any exterior surface of a panel, which is not intended to transfer heat between the panel and the occupants and/or the indoor *space*.

- Bottom surfaces of floor structures incorporating radiant heating insulated to minimum R-3.5. Adjacent building envelope insulation counts toward this requirement.

OREGON DEPARTMENT OF ENERGY

Ductwork and Plenum Leakage

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.4.2	503.2.7.1

- Changes in language and section organization, for the most part the requirements are the same
- Ductwork and plenums with pressure class ratings constructed to Seal Class A
- Ductwork > 3" static pressure design shall be leak-tested (at least 25% representative sample)
  - Reduced C_L from 6 cfm/ft^2 to 4 cfm/ft^2 duct surface area
  - Applicable equation: $$L_{max} = C_L P^{0.65}$$

L_{max} = maximum permitted leakage
C_L= constant, 4 (duct leakage class)
P = test pressure

OREGON DEPARTMENT OF ENERGY

Walk-In Coolers and Freezers

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.4.5	N/A

- 6.4.5 is a new section of energy code for Oregon, but not a new requirement
- Oregon has had standards for walk-in coolers and walk-in freezers since 2009
- Requirements in ASHRAE 90.1 are essentially a duplication of what are already federal standards that are preempted from state modification
- Also 6.5.11 has new requirements for refrigeration systems with remote compressors and condensers

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6.5 – Prescriptive Path

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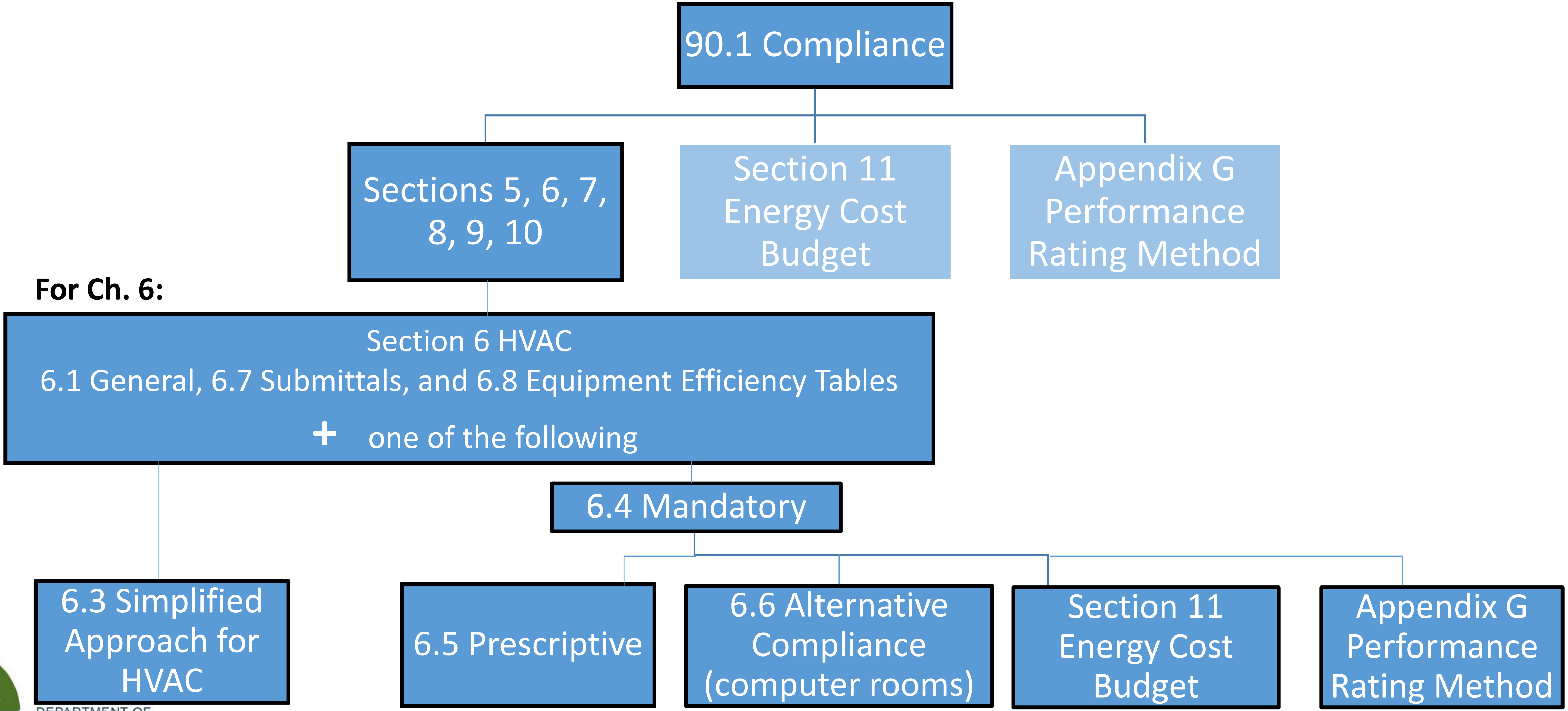
CHAPTER 6 HVAC COMPLIANCE PATHS



DEPARTMENT OF ENERGY

Economizers

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.1	503.3.1, 503.4.1

- Same general threshold for economizer requirement (capacity ≥ 54,000 btu/hr)
- Computer rooms in existing buildings: old requirements allowed exceptions for up to 600,000 Btu/hr (existing rooms) or 240,000 Btu/hr (new rooms)
- 90.1 computer room exceptions are a little more involved:

11. *Systems* primarily serving *computer rooms* where
    a. the total design cooling load of all *computer rooms* in the *building* is less than 3,000,000 Btu/h and the *building* in which they are located is not served by a centralized chilled water plant;
    b. the room total design cooling load is less than 600,000 Btu/h and the *building* in which they are located is served by a centralized chilled water plant;
    c. the local water authority does not allow cooling towers; or
    d. less than 600,000 Btu/h of *computer-room* cooling *equipment* capacity is being added to an *existing building*.

12. Dedicated *systems* for *computer rooms*, where a minimum of 75% of the design load serves
    a. those *spaces* classified as an *essential facility*,
    b. those *spaces* having a design of Tier IV as defined by ANSI/TIA-942,
    c. those *spaces* classified under NFPA 70 Article 708—*Critical Operations Power Systems* (COPS), or
    d. those *spaces* where core clearing and settlement *services* are performed such that their failure to settle pending financial transactions could present systemic risk as described in "The Interagency Paper on Sound Practices to Strengthen the Resilience of the U.S. Financial System" (April 7, 2003).

OREGON DEPARTMENT OF ENERGY

Economizers

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.1	503.3.1, 503.4.1

- New efficiency improvement alternative to economizers
- Other exceptions related to specific scenarios:
  - Chilled-water cooling systems without a fan or that use induced airflow, where the total capacity of these systems is less than 1,000,000 Btu/h in Climate Zone 4; less than 1,400,000 Btu/h in Climate Zones 5
  - Non-particulate air treatment
  - Hospitals and processes with humidity requirements
  - Condenser heat recovery is present
  - Smaller residential systems
  - Low load or load operating hours
  - Supermarkets with affected open refrigeration

Table 6.5.1-2 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 economizer, the minimum cooling *efficiency* of the HVAC unit must be increased by the percentage show If the HVAC unit is only rated with a full-load metric like *EER* cooling then these must increased by the percentage shown.

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Air Economizers – Capacity and Control

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.1.1.2	N/A

- Control through mixed-air-temperature-only not allowed (except for single-zone systems)
- Capable and configured to require high-limit shut-off

Table 6.5.1.1.3 High-Limit Shutoff *Control* Settings for *Air Economizers*[b]

Control Type	Allowed Only in Climate Zone at Listed *Set Point*	Required High-Limit *Set Points* (Economizer Off when): Equation	Description
Fixed dry-bulb temperature	0B, 1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	$T_{OA} > 75°F$	*Outdoor air* temperature exceeds 75°F
	5A, 6A	$T_{OA} > 70°F$	*Outdoor air* temperature exceeds 70°F
	0A, 1A, 2A, 3A, 4A,	$T_{OA} > 65°F$	*Outdoor air* temperature exceeds 65°F
Differential dry-bulb temperature	0B, 1B, 2B, 3B, 3C, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	$T_{OA} > T_{RA}$	*Outdoor air* temperature exceeds return air temperature
Fixed enthalpy with *fixed* dry-bulb temperature	All	$h_{OA} > 28$ Btu/lb[a] or $T_{OA} > 75°F$	*Outdoor air* enthalpy exceeds 28 Btu/lb[a] of dry air[a] or *outdoor air* temperature exceeds 75°F
Differential enthalpy with *fixed* dry-bulb temperature	All	$h_{OA} > h_{RA}$ or $T_{OA} > 75°F$	*Outdoor air* enthalpy exceeds return air enthalpy or *outdoor air* temperature exceeds 75°F

a. At altitudes substantially different than sea level, the *fixed* enthalpy limit shall be set to the enthalpy value at 75°F and 50% rh. As an example, at approximately 6000 ft elevation, the *fixed* enthalpy limit is approximately 30.7 Btu/lb.
b. Devices with selectable rather than adjustable *set points* shall be capable of being set to within 2°F and 2 Btu/lb of the *set point* listed.

- Sensor calibration and accuracy requirements

OREGON DEPARTMENT OF ENERGY

Fluid Economizers – Capacity and Control

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.1.2	503.4.1

- Fluid economizer systems capable of providing up to 100% of the expected system cooling load at:
  - General requirement: 50F dry bulb / 45F wet bulb OAT
  - Computer rooms with water-cooled economizers: 30F dry bulb / 25F wet bulb OAT
  - Computer rooms with air-cooled economizers: 25F dry bulb (4C) or 20 dry bulb (5B)
  - Systems with dehumidification limitations: 45F dry bulb / 40F wet bulb OAT

- New maximum hydronic pressure drop requirements for fluid economizers
  - Maximum 15’ pressure drop through coils/HX or secondary loop so that economizer coil pressure drop is not seen by the loop in normal (non-economizing) mode

Integrated Economizer Control

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.1.3	N/A

- Economizer interlocked with mechanical cooling to provide partial cooling even when some mechanical cooling is required.
- Units with economizers must also have:
  - Interlocking to limit OA damper closing for frost protection until leaving air temperature is less than 45F
  - > 65,000 btu/hr units that control the capacity of mechanical cooling based on occupied space temperature shall have minimum 2 stages of cooling
  - All other DX units that control space temperature by modulating airflow to the space shall comply with:

Table 6.5.1.3 DX Cooling Stage Requirements for Modulating Airflow Units

Rating Capacity, Btu/h	Minimum Number of Mechanical Cooling Stages	Minimum Compressor Displacement[a]
≥65,000 and <240,000	3	≤35% of full load
≥240,000	4	≤25% full load

a. For mechanical cooling stage *control* that does not use variable compressor displacement the percent displacement shall be equivalent to the mechanical cooling capacity reduction evaluated at the full load rating conditions for the compressor.

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Economizer Heating, Humidification System Impact

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.1.4, 6.5.1.5	N/A

- Economizer controls and system design shall not increase the building heating energy use during normal operation
  - Exception for zone-level heating for VAV systems

- Systems with hydronic cooling and humidification systems that are designed to maintain a dew point > 35F shall use a fluid economizer, if an economizer is required

OREGON DEPARTMENT OF ENERGY

Simultaneous Heating and Cooling

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.2.1	503.4.5

Zone thermostatic controls to prevent reheating, recooling, mixing, simultaneous heating and cooling to the same zone (but there are a number of exceptions to this to look at and be aware of)

previous limit of reheat, recooled, or mixed in peak heating demand was to 50% of zone peak supply rate

Exceptions to 6.5.2.1

1. Zones for which the volume of air that is reheated, recooled, or mixed is less than the larger of the following:
   a. Twenty percent of the zone design peak supply for *systems* with *DDC* and 30% for other *systems*.
   b. The outdoor airflow rate required to meet the *ventilation* requirements of ASHRAE Standard 62.1 for the zone.
   c. Any higher rate that can be demonstrated, to the satisfaction of the *authority having jurisdiction*, to reduce overall *system* annual *energy* use by offsetting *reheat/recool energy* losses through a reduction in *outdoor air* intake for the *system*.
   d. The airflow rate required to comply with applicable codes or accreditation standards, such as pressure relationships or minimum air change rates.
2. Zones with *DDC* that comply with all of the following:
   a. The airflow rate in *dead band* between heating and cooling does not exceed the larger of the following:
      (1) Twenty percent of the zone design peak supply rate.
      (2) The outdoor airflow rate required to meet the *ventilation* requirements of ASHRAE Standard 62.1 for the zone.
      (3) Any higher rate that can be demonstrated, to the satisfaction of the *authority having jurisdiction*, to reduce overall *system* annual *energy* use by offsetting *reheat/recool energy* losses through a reduction in *outdoor air* intake.
      (4) The airflow rate required to comply with applicable codes or accreditation standards, such as pressure relationships or minimum air change rates.
   b. The airflow rate that is reheated, recooled, or mixed shall be less than 50% of the zone design peak supply rate.
   c. The first stage of heating consists of modulating the zone supply air temperature *set point* up to a maximum *set point* while the airflow is maintained at the *dead band* flow rate.
   d. The second stage of heating consists of modulating the airflow rate from the *dead band* flow rate up to the heating maximum flow rate.
3. Laboratory exhaust *systems* that comply with Section 6.5.7.3.
4. Zones where at least 75% of the *energy* for *reheating* or for providing warm air in mixing *systems* is provided from *site-recovered energy* (including condenser heat) or *site-solar energy*.

OREGON DEPARTMENT OF ENERGY

Supply Air Temperature Reheat Limit

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.2.1.1	N/A

Where reheating is permitted, zones with both supply and return/exhaust air openings > 6 ft above floor shall not supply heating air > 20°F above space temperature

- Applies where reheating is allowed in other parts of the Standard

Exceptions

- Laboratory exhaust systems complying with 6.5.7.3
- During preoccupancy building warm-up and setback

Hydronic System Controls: 2-pipe, 3-pipe Systems

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.2.2.1, 6.5.2.2.1	503.4.3.1, 503.4.3.2

- No changes
- 3-pipe systems that use a common return for HW and CHW still not allowed
- 2-pipe changeover systems that use a common distribution keep same requirements
  - 15F OA deadband between systems
  - Minimum 4 hour operation in each mode before changeover
  - Maximum 30F between heating and cooling supply temperatures at the changeover point

OREGON DEPARTMENT OF ENERGY

Hydronic Heat Pump Systems

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.2.2.3	503.4.3.3

- Continuing requirement for water supply temperature dead band of at least 20F between initiation of heat rejection or heat addition
  - Exception: < 20F deadband if system loop optimization controller is used to determine optimum temperature based on real-time conditions
- Continuing requirement for automatic valve to minimize or bypass flow around cooling towers. If separate loop with HX, circulation pump on cooling tower shut down.

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Dehumidification

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.2.3	N/A

- Where humidity controls are provided, these controls shall prevent reheating, hot/cold mixing, and other simultaneous heating and cooling of the same airstream.
  - Some exceptions:
    - Supply air volume reduction at least 50% before simultaneous heating/cooling takes place
    - Fan cooling units ≤ 65,000 btu/hr that will unload to 50% capacity before simultaneous heating/cooling takes place
    - Individual mechanical cooling unit has design cooling capacity of ≤ 40,000 btu/hr
    - Systems serving spaces with specific process humidity levels where building includes site-recovered or site solar energy source that provides energy equal to ≥ 75% of annual energy for reheating or providing war air in mixing systems (exception does NOT apply to computer rooms)
    - 90% of reheat or re-cool annual energy is recovered or solar
    - Systems where heat added to airstream is result of use of desiccant system and 75% of heat added by desiccant system is removed by a heat exchanger (either before or after desiccant system with energy recovery)

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Humidification

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.2.4	N/A

- Automatic valve to shut off preheat in humidifiers with preheating jackets mounted in the airstream
- Insulate dispersion tube hot surfaces in airstreams of ducts or AHUs ≥ R-0.5
  - Except where mechanical cooling, including economizer operation, doesn't occur simultaneously with humidification

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Pre-heat Coils, Ventilation Air Heating Control

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.2.5, 6.5.2.6	N/A

- Preheat coils required to have controls to stop heat output when mechanical cooling (including economizing) is occurring
- Units that provide ventilation air to multiple zones (like DOAS) and operate in conjunction with zone heating/cooling shall not use heating or heat recovery to warm supply air greater than 60F when majority of building zones require cooling

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Fan System Power Limitation

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.3.1.1, 6.5.3.1.2	503.2.10.1, 503.2.10.2

- Still applies to systems with total fan system motor nameplate hp > 5
- Same Fan Power Limitation equation

Table 6.5.3.1-1 Fan Power Limitation[a]

	Limit	Constant Volume	Variable Volume
Option 1: Fan *system* motor nameplate hp	Allowable *motor nameplate hp*	$hp \le cfm_S \times 0.0011$	$hp \le cfm_S \times 0.0015$
Option 2: Fan *system* bhp	Allowable fan *system* bhp	$bhp \le cfm_S \times 0.00094 + A$	$bhp \le cfm_S \times 0.0013 + A$

  - Pressure drop adjustments:
    - Credits mostly the same (change for ERV credit)
    - New deductions required for systems without central cooling, heating, or with central electric resistance heat
- Still requirement to select fan motor no larger than the first available motor size greater than the bhp, with indication of bhp on design documents
  - Same exceptions as before, plus **new exception for fans with nameplate < 1 hp**

OREGON DEPARTMENT OF ENERGY

Fan Efficiency

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.3.1.3	N/A

- Fans shall have a fan efficiency grade (FEG) of 67 or higher
- Total efficiency of the fan at design point of operation shall be within 15 percentage points of the maximum total efficiency of the fan
- Number of exceptions
  - Individual fans ≤ 5hp that are not part of a group operating as functional equivalent of a single fan
  - Multiple fans in series or parallel (fan arrays) that have combined nameplate ≤ 5hp
  - Fans that are part of equipment
  - Powered wall/roof ventilators
  - Fans outside the scope of the applicable standard AMCA 205
  - Emergency applications

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Fan Control

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.3.2.1	503.2.10.3

New

- Required to vary fan speed as a function of load for:
  - DX: units ≥ **65,000 btu/hr**, for any fan size
  - CHW/Evap: Required for any capacity and ≥ $^{1}/_{4}$ **hp** fans
- If DX/CHW unit capacity is controlled based on space T, minimum 2 stages
- If units control space temperature by modulating airflow to the space, reduce, shall have modulating airflow
- Low speed required during low-cooling, ventilation operation
- Exceptions: < 1 hp, CHW, and if not used for ventilation and cycles with load, also exceptions to accommodate minimum ventilation

Previous

- Required to vary fan speed (2-speed or VFD) for:
  - DX: single zone units with capacity ≥ **110,000 btu/hr**
    - Reduce to 66% airflow
  - Without DX: fan sysems > 8,000 cfm
    - Reduce to 60% airflow
- VAV fan ≥ 10 hp control with VFD

Temperature Control	Typical Zones	Minimum fan speed	Fan power at min speed	Fan control
Space T by modulating airflow	Multiple	≤ 50%	≤ 30%	Modulating
Capacity based on room T	Single	≤ 66%	≤ 40%	Two-speed, Multi-speed or Modulating

VAV Static Pressure Sensor Location

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.3.2.2	N/A

- Required to locate static pressure sensors such that the setpoint is ≤ 1.2” wg, with accommodation for major duct splits
  - Exception: systems with VAV setpoint re-set

VAV Setpoint Reset

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.3.2.3	503.4.2

New

- Static pressure reset required for systems with total power > 5 hp (if DDC and individual zones reporting to central panel) based on zone requiring the most pressure
- Clarification for control requirements and requirement for alarms for zones that excessively drive reset logic **(faulty zones)**

Previous

- Static pressure reset required for systems with total power > 10 hp (if DDC and individual zones reporting to central panel) based on zone requiring the most pressure

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ENERGY

Return / Relief Fan Control

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.3.2.4	N/A

- Control relief air rate based on direct or indirect (i.e., airflow differential) building pressure measurements
- Requires VFD or other device that will result in:
  - Total return/relief system demand of no more than 30% design power at 50% of total airflow
- A couple exceptions for small return/relief and staged relief fans

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Multi-Zone VAV Ventilation Optimization Control

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.3.3	N/A

- Systems with DDC reporting individual zones back to central panel are required to include a means to reduce OA rates below design rates in response to changes in system ventilation efficiency (from 62.1)
- Exceptions
  - VAV systems with zonal transfer fans, dual-duct dual-fan VAV systems, and systems with fan-powered terminal units
  - Systems where design exhaust is > 70% of total design OA rate

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Parallel-Flow Fan-Powered VAV

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.3.4	N/A

- Required to have automatic controls configured to:
  - Turn off terminal fan except if needed for heating or ventilation
  - Turn on terminal fan as first stage of heating before heating coil is activated
  - For warm-up or setback heating, either
    - Operate terminal fan and coil without primary air, or
    - Reverse terminal logic and provide heating from the central air handler through primary air

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Supply Air Temperature Reset Controls

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.3.5	503.4.5.3

- Basically the same existing requirement to reset supply air temperature in response to building loads or outside air temperature
- Change from minimum reset of **35% to 25%** of difference between design SAT and design room air temperature
- Same exceptions for:
  - Systems that prevent reheating, recooling, or mixing of heated and cooled supply air
  - Systems with 75% of annual reheat energy from recovered or solar energy

OREGON DEPARTMENT OF ENERGY

Fractional Horsepower Fan Motors

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.3.6	503.2.10.4

- Requirement for fans with $^{1}/_{12} \leq$ horsepower < 1 motors to be ECM or have a minimum motor efficiency of 70%
- Also required to have means to adjust motor speed for either balancing or remote control (belt-driven fans may use sheave-adjustment for balancing)
- Exceptions
  - Motors in airstream that operating only when providing heating
  - Motors installed in space-conditioning equipment
  - Fire-pump electric motors, capacitor-start, capacitor-run, and capacitor-start/induction-run small motors
- Previous similar requirements only applied to series fan-powered terminal unit fans

Ventilation Design

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.3.7	N/A

Requires one of the following for OA ventilation systems:

- Design ventilation limited to 135% of the required minimum OA rate (larger or 62.1, exhaust, or other applicable codes/standards.
- Dampers, ductwork, and controls required to allow the system to supply no more than the required minimum OA rate with a single set-point adjustment
- System includes exhaust air energy recovery in compliance with other parts of 90.1

OREGON DEPARTMENT OF ENERGY

Boiler Turndown

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.4.1	503.4.3

- Boiler systems with a design input larger than 1,000,000 btu/hr required to meet turndown ratio
  - Table 6.5.4.1 Boiler Turndown

Boiler System Design Input, Btu/h	Minimum Turndown Ratio
≥1,000,000 and ≤5,000,000	3 to 1
>5,000,000 and ≤10,000,000	4 to 1
>10,000,000	5 to 1

  - Previous requirements were for a multi-stage or modulating burner for boilers > 500,000 btu/hr

OREGON DEPARTMENT OF ENERGY

Hydronic Variable Flow Systems

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.4.2	503.4.3.4

- HVAC pumping systems with three or more control valves designed to modulate or step open and close as a function of load shall be
  - Designed for variable fluid flow
  - Capable of reducing flow rates to ≤ 25% of design flow rate or equipment minimum
- Individual or parallel pumps serving variable flow systems with a motor hp (or combined parallel hp) at least the power in Table 6.5.4.2 shall have controls and/or devices resulting in pump motor demand ≤ 30% of design wattage at 50% of design water flow
  - For OR climate zones 4C and 5B
    - CHW pumps: ≥ 7.5 hp
    - HW pumps: ≥ 10 hp
  - Control as function of desired flow or differential pressure (with specifications for delta P control, dP setpoint reset, etc.)
- Previous requirements were for either hydronic supply temperature reset OR flow reduction (VFD required if > 5 hp)

OREGON DEPARTMENT OF ENERGY

Hydronic Variable Flow Systems

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.4.2	503.4.3.4

- Exceptions to hydronic variable flow systems control requirements
  - Differential pressure setpoint reset not required when valve position is used to comply with CHW and HW temperature reset controls
  - Variable flow control not required on heating water pumps where more than 50% of annual heat is generated by an electric boiler
  - Variable flow not required for primary pumps in a primary/secondary system
  - Variable flow not required for a coil pump provided for freeze protection
  - Variable flow not required for heat recovery coil runaround loops

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Chiller and Boiler Isolation

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.4.3	503.4.3.5

- Same requirements as before
- If chiller plant has more than one chiller or a boiler plant has more than one boiler, required to shut off all flow to the chiller/boiler when that equipment is shut down
- Chillers piped in series considered as one chiller
- Number of pumps ≥ number of chillers or boilers, and staged on and off with the equipment

CHW and HW Temperature Reset Controls

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.4.4	503.4.3.4

- Same threshold as before (300,000 btu/hr design capacity)
- Previous requirements to reset temperature OR reduce flow. 90.1 has requirements for both.
- Requirement remains to include controls to automatically reset supply water temperatures by representative building loads (return temperature) or OA temperature
- Previous specification for reset by 25% of difference between design supply-to-return temperature no longer applied
- Where DDC is used to control valves, the set point shall be reset based on valve positions until one valve is nearly wide open or setpoint limits of the system equipment or application have been reached
- Exceptions: where CHW supply is already cold (district heating), process temperature requirements, or where valve position is used to comply with other code turndown requirements

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Hydronic Heat Pumps and Water-Cooled Unitary AC

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.4.5	503.4.3.3.3

New

- All hydronic heat pumps and water-cooled unitary AC require a 2-position automatic valve interlocked to shut off flow when the compressor is off (exception: if units use a fluid economizer)
- If hydronic system has total pump power > 5 hp, controls required that result in pump motor demand of no more than 30% design wattage at 50% of flow

Previous

- If hydronic system has total pump power > 10 hp, each hydronic heat pump is required to have an automatic 2-position valve or be served by a dedicated pump with a check valve

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Pipe Sizing

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.4.6	N/A

- Applies to CHW and condenser water piping
- Maximum flow rates shall not exceed the value provided for the given pipe size and operating hours
- Increased maximum values (allowances) for variable flow/variable speed systems
- Exceptions
  - Piping sections not in the critical circuit at design conditions (and not expected to be in critical circuit for more than 30% of operating hours)
  - Other piping systems with same or less total pressure drop than values in table as applied to standard weight steel pipe

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Chilled Water Coil Selection

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.4.7	N/A

- Minimum 15F delta T
- Minimum 57F LWT at design conditions

Exceptions

1. Coils with an air-side pressure drop exceeding 0.70 in. of water when rated at 500 fpm face velocity and dry conditions (no condensation).
2. Individual fan-cooling units with a design supply airflow rate 5000 cfm and less.
3. Constant-air-volume systems.
4. Coils selected at the maximum temperature difference allowed by the chiller.
5. Passive coils (no mechanically supplied airflow).
6. Coils with design entering chilled-water temperatures of 50°F and higher.
7. Coils with design entering air dry-bulb temperatures of 65°F and lower.

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Heat Rejection Equipment – Fan Speed Control

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.5.2	503.4.4

- Fan speed control required for motors (or array of motors) ≥ 5 hp (compared to 7.5 previously)
- Must result in fan motor demand reduction to ≤ 30% of design wattage at 50% design airflow
- Fan speed modulated based on leaving fluid temperature or condensing temperature/pressure of heat rejection device

<u>Exceptions</u>

- Condenser fans serving multiple refrigerant circuits or fluid cooling circuits
- Condenser fans serving flooded condensers

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Heat Rejection Equipment – Tower Flow Turndown

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.5.4	503.4.3.7

- Same requirements for tower flow turndown
- Open cooling towers with multiple condenser water pumps must be designed so that all cells can be run in parallel with flow that is the larger of:
  - Smallest pump flow
  - 50% of the design flow for the cell

OREGON DEPARTMENT OF ENERGY

Energy Recovery

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.6.1	503.2.6

New

- For systems operating < 8000 hours/yr, no requirement
- For systems operating ≥ 8000 hours/yr, based on cfm and OA %. If cfm exceeds value, energy recovery is required

Previous

- Required for systems ≥ 5,000 cfm and ≥ 70% OA

Table 6.5.6.1-2 Exhaust Air *Energy* Recovery Requirements for *Ventilation Systems* Operating Greater than or Equal to 8000 Hours per Year

Climate Zone	% *Outdoor Air* at Full Design Airflow Rate							
	≥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 Airflow Rate, cfm							
3C	NR	NR	NR	NR	NR	NR	NR	NR
0B, 1B, 2B, 3B, 4C, 5C	NR	≥19,500	≥9000	≥5000	≥4000	≥3000	≥1500	≥120
0A, 1A, 2A, 3A, 4B, 5B	≥2500	≥2000	≥1000	≥500	≥140	≥120	≥100	≥80
4A, 5A, 6A, 6B, 7, 8	≥200	≥130	≥100	≥80	≥70	≥60	≥50	≥40

NR—Not required

Energy Recovery

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.6.1	503.2.6

- Result is some cases that would have required ERV before may not in the future, and vice versa
- Recovery system effectiveness ≥ 50%
- Number of exceptions
  - Lab systems meeting 6.5.7.3
  - Systems serving uncooled spaces that are heated to < 60°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

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Heat Recovery for Service Water Heating

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.6.2	503.4.5.4

- Same threshold as before, required when:
  - Heat rejection capacity > 6,000,000 btu/hr AND service water heating load > 1,000,000 btu/hr
  - Previously design reheat was included in the 1,000,000 threshold, but now it only includes service water heating capacity
- New requirement for 24 hours/day operation before requirement applies
- Heat recovery minimum capacity increased from 30% to 60% of peak heat rejection load (if that path is followed)
- New exception for facilities that provide condenser heat recovery for space heat
- Similar exception for when > 60% (previously 25%) of service water heating energy is provided from site-recovered or site solar energy

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Transfer Air

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.7.1	N/A

- Limitations on conditioned supply air to not exceed the greater of:
  - Supply air needed to meet the cooling/heating load
  - Ventilation rate (facility, AHJ, or 62.1)
  - Exhaust flow minus available transfer air
- Intent is to minimize use of supply air to meet exhaust/pressurization requirements. Less supply air leads to less fan energy and heating/cooling of that supply air.
- There are a few case-specific exceptions

Kitchen Exhaust

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.7.2	503.2.5.2

- Mostly the same requirements
- Replacement air introduced directly into the hood cavity of kitchen exhaust hoods shall not exceed 10% of the hood exhaust flow rate
- If total kitchen exhaust > 5000 cfm, then each hood shall comply with the maximum exhaust rate (cfm/linear foot) for that type of hood and equipment
- If total kitchen exhaust > 5000 cfm, then either
    - 50% of replacement air is transfer air that would otherwise be exhausted
    - Demand ventilation on at least 75% of exhaust air (existing requirement)
    - Energy recovery (sensible) of 40% on half of total exhaust

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Laboratory Exhaust

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.7.3	503.2.6

- Laboratory requirements were previously structured in the exceptions to the code ERV requirements. They are now part of their own section.
- Building with laboratory exhaust > 5,000 cfm require at least one of:
  - VAV systems to reduce energy through reduced exhaust/make-up and/or heat recovery to meet performance specifications
  - If specific minimum circulation rates are required, have controls that will reduce to these rates
  - Direct makeup airflow ≥ 75% exhaust flow rate heated no warmer than 2F below room setpoint, cooled to no cooler than 3F above setpoint, no humidification, and no simultaneous heating and cooling for dehumidification

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Radiant Heating

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.8	503.2.11

Unenclosed Spaces

- Same requirement as before
- Radiant heating required when heating unenclosed spaces

Enclosed spaces

- Must conform to other portions of 90.1 (hydronic, VAV system requirements when used on conjunction, etc.)

Hot Gas Bypass

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.9	503.2.12

Maximum allowable hot gas bypass % reduced

New

Rated Capacity	Maximum Hot-Gas Bypass, % of total capacity
≤ 240,000 Btu/hr	15%
> 240,000 Btu/hr	10%

Previous

Rated Capacity	Maximum Hot-Gas Bypass, % of total capacity
≤ 240,000 Btu/hr	50%
> 240,000 Btu/hr	25%

- Applied in systems with stepped or continuous unloading
- Limitation also pertains to chillers
- Hot gas bypass not to be used on constant-volume units

Door Switches

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.5.10	N/A

- 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

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Submittals / Completion

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
6.7	503.2.9

New

- Construction documents shall require that :
  - within 90 days after system acceptance, record drawings and O&M manual delivered to owner
  - All HVAC systems be balanced with generally accepted engineering standards, and air and hydronic systems first balanced to minimize losses and then to meet design flow conditions
  - Written TAB report be provided to owner for zones > 5000 ft^2
  - Buildings > 50,000 ft^2 conditioned area, except warehouses and semiheated spaces, detailed **Cx instructions** for HVAC systems shall be provided by designer in plans and specs
- General requirement for requirements to be on the plans, but building official shall not require copies of any reports or drawings

Previous

- Requirement to provide a means for system balancing
- Requirement to construction documents specify delivery of O&M manual to building owner

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7 – Service Water Heating

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Service Water Heating

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
Chapter 7.4	504

- Requirements for temperature controls for storage temperature adjustment
- Pipe insulation
  - 2014 OEESC: 1” for all recirculating and externally heated piping, 0.5” for first 8 feet of non-recirculating systems
  - ASHRAE 90.1-2016
    - insulation required for recirculating and externally heated piping, first 8 feet of non-recirculating system and branch piping
    - Pipe insulation thickness is dependent on fluid temperature and pipe diameter. Mostly 1” required for most common applications, but could be more for hotter water and larger pipes

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Service Water Heating

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
Chapter 7.4	504

- 90.1 requires automatic controls (via time switch or other) to turn off temperature maintenance during extended periods of non-utilization. 2014 OEESC had similar requirement, but required demand sensing controls and systems < 100,000 btu/hr were exempted
- Similar requirement for heat traps for non-recirculating systems
- Similar requirements for pool heaters on/off, pool covers, and time switch for pool heaters and pumps
- 90.1-2016 does not contain same previous Oregon requirement for indoor pool heat recovery
- 90.1 max temperature to public facility restrooms = 110F (it was 120F in OEESC)

High Capacity Service Water Heating

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
7.5.3	504

- Large service water heating systems with total installed input capacity ≥ 1,000,000 Btu/hr are required to have:
  - Weighted average thermal efficiency ≥ 90%
  - So some units can be non-condensing, but requires some to be condensing

- Exceptions
  - Where 25% of annual service water heating requirement is provided by solar or site-recovered energy
  - Equipment is installed in individual dwelling units
  - Individual gas water heaters with input capacity < 100,000 btu/hr

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Compliance Documentation

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EXECUTIVE ORDER 17-20
COMMERCIAL ENERGY CODE

Code Compliance Form

State of Oregon
Building Codes Division
Better Buildings for Oregon

Part I COMcheck information

Compliance path:
- ❑ **Performance path**
- ❑ **Prescriptive path**

COMcheck (Standard 90.1) results:
- ❑ **Pass**
- ❑ **Fail** *If using the performance path, submit the energy model report with this form

Prepared by or under the supervisions of: ________ **Date:** ________

Part II Projected energy use

Enter the ZERO Code Calculator results for projected energy use.

Estimated building energy consumption: ______ MBtu/yr

Part III Estimated available renewables for the building

Enter the ZERO Code Calculator results for offsets.

Total renewable energy necessary to achieve Net Zero: ______ MBtu/yr

On-site potential PV rated capacity ______ kW

CHECKLIST AND APPLICANT SIGNATURE

COMcheck report and ZERO Code Calculator report must be submitted with this form.

- ❑ **COMcheck report is attached**
- ❑ **Energy model report is attached** (if COMcheck failed)
- ❑ **ZERO Code Calculator report is attached**

SAMPLE

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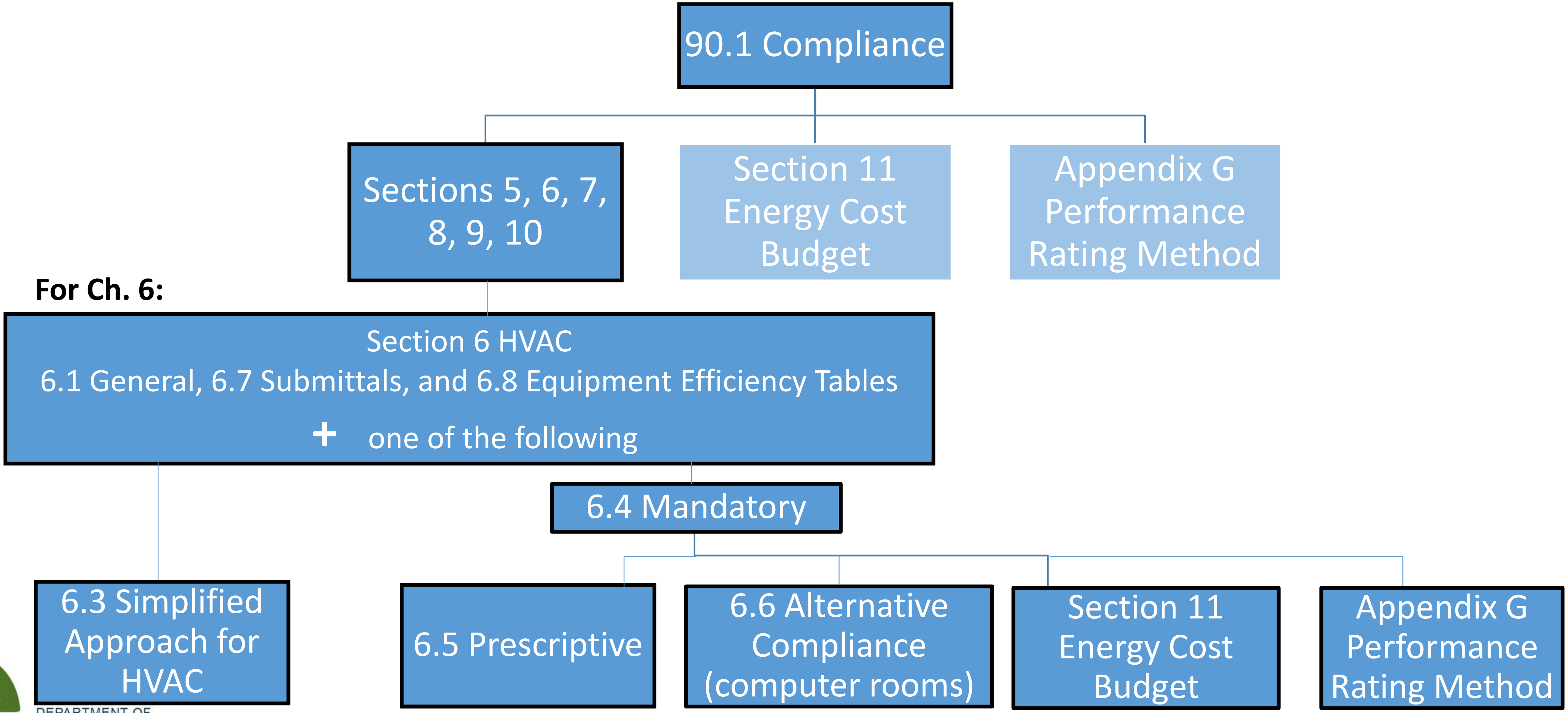
https://zero-code.org/energy-calculator/

CHAPTER 6 HVAC COMPLIANCE PATHS



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Performance Pathways

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
Ch. 11, Appendix G	506

- Previous Oregon code contained Section 506 Whole Building Approach, based on 90.1 Ch. 11 Energy Cost Budget
- 90.1 includes two performance paths for code compliance, Ch.11 and Appendix G
  - Both based on energy simulation
  - Both compare a proposed building design to a baseline building meeting the prescriptive requirements of the code
  - Both compare the annual energy cost ($) of the proposed building to the baseline building

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Performance Pathways

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
Ch. 11, Appendix G	506

- Ch. 11 Energy Cost Budget has been used for code compliance in the past to demonstrate whole-building compliance when prescriptive compliance are not met
  - ECB proposed design impacts the baseline more. Baseline matches the proposed design in many parameters, backed down to code prescriptive values
  - Baseline changes with each code iteration
- Appendix G is widely used already for beyond-code and performance programs like LEED
  - Provides some credit that wouldn't be available for good design choices that are more energy efficient than what is standard practice
  - Fixed baseline to 90.1-2004, but performance index targets change with each code

$$Performance\ Cost\ Index\ (PCI) = \frac{Proposed\ Building\ Performance}{Baseline\ Building\ Performance}$$

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Performance Pathways

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
Appendix G	506

- Appendix G compliance is achieved when:
  Performance Cost Index PCI < Performance Cost Index Target PCI_t
- Performance Cost Targets are specific for each climate zone and building type and consider regulated vs. unregulated (plug) load impact

$$PCI_t = \frac{(BBUEC + (BPF \cdot BBREC))}{BBP}$$

$$Performance\ Cost\ Index\ (PCI) = \frac{Proposed\ Building\ Performance}{Baseline\ Building\ Performance}$$

- New "Building Performance Factors" with each code iteration will ratchet down the PCI_t for compliance
- Appendix G for code compliance and beyond-code programs could lead to efficiencies in model development – one model for multiple purposes – and could encourage market development to automate simulation process for baseline

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Performance Pathways

2019 Oregon / ASHRAE 90.1-2016	2014 OEESC
Appendix G	506

Table 4.2.1.1 ***Building*** **Performance Factor (BPF)**

Building Area Type[a]	Climate Zone																
	0A and 1A	0B and 1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.73	0.73	0.71	0.69	0.74	0.73	0.68	0.78	0.81	0.81	0.76	0.80	0.81	0.76	0.79	0.74	0.80
Healthcare/ hospital	0.64	0.56	0.60	0.56	0.60	0.56	0.54	0.57	0.53	0.55	0.59	0.52	0.55	0.57	0.52	0.56	0.56
Hotel/motel	0.64	0.65	0.62	0.60	0.63	0.65	0.64	0.62	0.64	0.62	0.60	0.61	0.60	0.59	0.61	0.57	0.58
Office	0.58	0.62	0.57	0.62	0.60	0.64	0.54	0.58	0.60	0.58	0.60	0.61	0.58	0.61	0.61	0.57	0.61
Restaurant	0.62	0.62	0.58	0.61	0.60	0.60	0.61	0.58	0.55	0.60	0.62	0.58	0.60	0.63	0.60	0.65	0.68
Retail	0.52	0.58	0.53	0.58	0.54	0.62	0.60	0.55	0.60	0.60	0.55	0.59	0.61	0.55	0.58	0.53	0.53
School	0.46	0.53	0.47	0.53	0.49	0.52	0.50	0.49	0.50	0.49	0.50	0.50	0.50	0.49	0.50	0.47	0.51
Warehouse	0.51	0.52	0.56	0.58	0.57	0.59	0.63	0.58	0.60	0.63	0.60	0.61	0.65	0.66	0.66	0.67	0.67
All others	0.62	0.61	0.55	0.57	0.56	0.61	0.59	0.58	0.57	0.61	0.57	0.57	0.61	0.56	0.56	0.53	0.52

a. In cases where both a general *building* area type and a specific *building* area type are listed, the specific *building* area type shall apply

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THANK YOU

Blake Shelide, PE
Facilities Engineer
blake.shelide@oregon.gov

https://www.oregon.gov/energy/energy-oregon/Pages/Energy-Code.aspx