Appendix L

Building Modeling Guidelines

Oregon Building Energy Performance Rating Method

1. General

1.1 Scope. The purpose of this document is to specify the method of determining energy performance of a proposed building for the purpose of demonstrating performance in excess of that required by the Oregon Energy Code (Chapter 13 of the 2004 Oregon Structural Specialty Code.) Buildings using this protocol will still need to meet the requirements of the energy code through one of the three paths allowed by the code; Prescriptive Approach, Simplified Trade-Off Approach, or Whole Building Approach. *Building performance better than code as demonstrated by these rules, does not meet the requirements of the Whole Building Approach.*

1.2 Definitions

Code Baseline Building: A hypothetical building design based on the Proposed Building. The Code Baseline Building shall incorporate the standard design features of typical buildings of the same usage and just meet the prescriptive requirements of the Oregon Energy Code according to guidelines presented in this document. The Code Baseline building is used to benchmark the Proposed Buildings' relative energy efficiency. (For SEED projects, this is also referred to as the "Code Building").

Proposed Building: The building as designed for construction. (For SEED Projects, this is also referred to as the "SEED Building")

Energy Code: Chapter 13 of the current State of Oregon Structural Specialty Code.

Proposed Energy Cost: The annual energy cost in dollars calculated for the proposed building.

Code Baseline Energy Cost: The annual energy cost in dollars for the code baseline building.

Proposed Energy Use: The annual energy use in millions of Btu's (Mmbtu's) calculated for the proposed building.

Code Baseline Energy Use: The annual energy use in millions of Btu's (Mmbtu's) calculated for the code baseline building.

Program Evaluator*:* The organization or agency that adopts or sanctions use of this rating methodology.

SEED Program: The State Energy Efficient Design Program administered by the Oregon Department of Energy, requiring facilities constructed or purchased by Oregon State Agencies to be "models of energy efficiency".

1.3 Savings. Percent energy savings and percent energy cost savings are calculated as follows:

(a) Percent Energy Savings = [(*Code Baseline Energy Use- Design Energy Use*) / *Code Baseline Energy Use*] x 100

(b) Percent Energy Cost Savings = [(*Code Baseline Energy Cost- Proposed Energy Cost*) / *Code Baseline Energy Cost*] x 100.

1.4 Tradeoff Limits. When the proposed modifications apply to less than the whole building, only parameters related to the systems to be modified shall be varied. Parameters relating to unmodified existing conditions or to future building components shall be identical for both the *code baseline building and the proposed building*. Future building components shall meet the prescriptive requirements of the Energy Code. This means that futures systems such as lighting or HVAC that will be installed under a separate building permit (including future tenant improvements) are not eligible for tradeoff. Those systems must be identical in the code baseline and proposed buildings.

1.5 Documentation Requirements. Performance shall be documented, and documentation shall be submitted to the *Program Evaluator.* The information submitted shall include the following:

(a) Calculated values for the *code baseline energy cost*, the *proposed energy cost*, and the percent cost savings.
(b) Calculated values for the *code baseline energy use,* the *proposed energy use*, and the percent energy savings.
(c) A list of the energy-related features that are included in the proposed design and on which the energy performance rating is based. This list shall document all energy features that differ between the models of the proposed building and the code baseline building.
(d) Input and output report(s) from the *simulation program* or compliance software including a breakdown of energy usage by at least the following components: interior and exterior building lights, internal equipment loads, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, fans, and other HVAC equipment (such as pumps). The output reports shall also show the amount of time any loads are not met by the HVAC system for both the *proposed design* and *code baseline building design*. Electronic copies of inputs are required.
(e) An explanation of any error messages noted in the *simulation program* output.

2. Simulation General Requirements

2.1 Simulation Program. The *simulation program* shall be a computer-based program for the analysis of energy consumption in buildings (a program such as, but not limited to, DOE-2, BLAST, or Energy Plus). The *simulation program* shall include calculation methodologies for the building components being modeled. If no *simulation program* is available that adequately models a design, material, or device, see Section 5.

2.1.1 The *simulation program* shall be approved by the *Program Evaluator* and shall, at a minimum, have the ability to explicitly model all of the following:

(a) 8,760 hours per year;

(b) hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation, defined separately for each day of the week and holidays;
(c) thermal mass effects;
(d) 10 or more thermal zones;
(f) capacity and efficiency correction curves for mechanical heating and cooling equipment;
(g) air-side economizers with integrated control;
(h) all *code baseline building* characteristics specified in Section 4, *Calculation of Code Baseline Energy Cost*.
(i) fenestration shading.

2.1.2 The simulation program shall have the ability to either (1) directly determine the *proposed energy use* and *code baseline energy use* or (2) produce hourly reports of energy use by energy source suitable for determining the *proposed energy use* and *code baseline energy use* using a separate calculation engine.

2.1.3 The *simulation program* shall be capable of performing design load calculations to determine required HVAC equipment capacities and air and water flow rates in accordance with generally accepted engineering standards and handbooks (for example, ASHRAE Handbook of Fundamentals) for both the *proposed building* design and *code baseline building* design.

2.2 Climate Data. The *simulation program* shall perform the simulation using hourly values of climate data, such as temperature and humidity from representative climate data, for the site in which the *proposed design* is to be located. For locations where weather data is not available, the designer shall select available weather data that best represents the climate at the construction site. The selected weather data shall be approved by the *Program Evaluator*.

2.3 Energy Rates. Annual energy costs shall be determined using actual rates for purchased energy in effect at the time building construction begins. If actual rates are unavailable, average state energy prices established by the Oregon Department of Energy may be used. Rates from different sources may not be mixed in the same project.

Exception : On-site renewable energy sources or site-recovered energy shall not be considered to be purchased energy and shall not be included in the *proposed energy cost*. Where on-site renewable or site-recovered sources are used, the *code baseline building design* shall be based on the energy source used as the back-up energy source or electricity if no back-up energy source has been specified.

2.4 Performance Calculations. The *proposed energy cost* and *code baseline energy cost* shall be calculated using:

(a) the same *simulation program,*
(b) the same weather data, and
(c) the same energy rates.

3. Calculation of the *Proposed Building Energy Use*

3.1 Proposed Building Model. The simulation model of the *proposed design* shall be consistent with the design documents including proper accounting of fenestration and opaque envelope and areas; lighting power and controls; HVAC system types, sizes, zoning, and controls; and service water heating systems and controls.

3.2 Buildings with Incomplete Energy System Designs. When these modeling guidelines are applied to buildings in which energy-related features have not yet been designed (e.g., a lighting system), those yet-to-be-designed features shall be described in the *proposed design* exactly as they are defined in the *code baseline building design.* Where the space classification for a space is not known, that space shall be categorized as an office space.

3.3 HVAC Systems. The HVAC system type and all related performance parameters, such as equipment capacities and efficiencies, in the *proposed design* shall be determined as follows:

(a) Where a complete HVAC system exists, the model shall reflect the actual system type using actual component capacities and efficiencies.
(b) Where an HVAC system has been designed, the HVAC model shall be consistent with design documents. Mechanical equipment efficiencies shall be adjusted from actual design conditions to the standard rating conditions specified in tables 13 L through 13 R of the Oregon Energy Code, if required by the simulation model.
(d) Where a heating system is planned, but has not yet been designed, the heating system classification shall be assumed to be natural gas, unless none is available at the site, then it shall be electric. The system characteristics shall be identical to the system modeled in the *code baseline building design.*
(e) Where a cooling system is planned, but has not yet been designed, the cooling system characteristics shall be identical to the system modeled in the *code baseline building design.*
(f) Where no active heating system is planned, none shall be modeled.
(g) Where no active cooling system is planned, none shall be modeled.

3.3.1 Ventilation rates shall be modeled as they are shown in the design drawings. They may not be less than required by Chapter 12 of the Oregon Structural Specialty Code.

3.4 Building Envelope. All components of the *building envelope* in the *proposed design* shall be modeled as shown on architectural drawings or as built for existing building envelopes. This includes components separating conditioned space from unconditioned or semi-conditioned space.

Exceptions:
(a) Any envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described, provided that it is similar to an assembly being modeled. If not separately described, the area of an envelope assembly shall be added to the area of the adjacent assembly of that same type with the same orientation and thermal properties.
(b) Exterior surfaces whose azimuth orientation and tilt differ by less than 45 degrees and are otherwise the same may be described as either a single surface or by using multipliers.
(c) For exterior roofs , the roof surface may be modeled with a reflectance of 0.45 if the reflectance of the proposed design roof is greater than 0.70 and its emittance is greater than 0.75. All other roof surfaces shall be modeled with a reflectance of 0.3.

(d) Manual window shading devices such as blinds or shades shall not be modeled. Automatically controlled widow shades or blinds may be modeled. Permanent shading devices such as fins, overhangs and lightshelves may be modeled.

3.5 Interior Partitions. It is not required to model interior partitions. If modeled, interior partitions should be modeled as shown on architectural drawings or as built for existing buildings.

Exceptions:

(a) Interior partitions shall be modeled where they separate thermal zones where design space temperatures are dissimilar.
(b) Interior partitions shall be modeled when required by simulation program for modeling daylighting control schemes.

3.6 Service Hot Water Systems. The service hot water system type and all related performance parameters, such as equipment capacities and efficiencies, in the *proposed design* shall be determined as follows:

(a) Where a complete service hot water system exists, the model shall reflect the actual system type using actual component capacities and efficiencies.
(b) Where a service hot water system has been designed, the service hot water model shall be consistent with design documents.
(c) Where no service hot water system exists or is specified but the building will have service hot water loads, a service hot water system shall be modeled that matches the system in the *code baseline building design* and serves the same hot water loads.
(d) For buildings that will have no service hot water loads, no service hot water heating shall be modeled.

3.7 Lighting. Lighting power in the *proposed design* shall be determined as follows:

(a) Where a complete lighting system exists, the actual lighting power shall be used in the model. Lighting loads should be modeled accurately for each individual zone instead of using an average across all zones.
(b) Where a lighting system has been designed, lighting power shall be consistent with design documents. Lighting loads should be modeled accurately for each individual zone instead of using an average across all zones.
(c) Where no lighting exists or is specified, lighting power shall be determined in accordance with the Section 131.4.1, Tenant Space Power Allowance Method and Table 13G of the Oregon Energy Code.
(e) Lighting system power shall include all lighting system components shown or provided for on the plans (including lamps and ballasts, task and furniture-mounted fixtures, parking garage lighting, and building façade lighting).
(f) Credit may be taken for the use of automatic controls for daylight utilization when not required by Section 1313.3.1.3 of the Oregon Energy Code, but only if their operation is directly modeled in the building simulation.

Exception. Credit may be taken for daylight utilization by modifying lighting schedules if the schedule reduction is determined by a separate daylighting analysis simulation as approved by the Program Evaluator.

(g) Credit may be taken for automatic lighting control devices not required by code, by reducing the lighting power or the lighting schedules for automatically controlled systems for the *proposed design* according to table 3.1.

Table 3.1 - Adjustment Factors for Automatic Lighting Controls[1]

Automatic Control Devices(s)	**(a) Conference Rooms, Meeting Rooms, Classrooms, and Offices < 300ft²**	**(b) Offices Occupancies >2,000ft² Contiguous Space (excluding spaces in (a))**	**(c) Buildings >5,000 ft² (excluding spaces in (a))**	**(d) Buildings <5000ft² (excluding spaces in (a))**
(1) Programmable timing control	0%	0%	0%	10%
(2) Occupancy sensor	0%	5%	5%	15%
(3) Occupancy sensor and programmable timing control	0%	5%	5%	15%

1. If lighting schedule is adjusted, the codebaseline fractional schedule should be multiplied by the adjustment factor. For example, if the hourly lighting schedule indicates 50% of peak connected lighting load and the guidelines allow a 15 % reduction, the hourly adjusted schedule should be:

50% x (1-15%) = 42.5%
Not
50% -15% = 35%

Exception: Reductions different than those prescribed by the above table may be taken when approved by the program evaluator provided credible documentation is supplied.

3.9 Receptacle Loads. Receptacle and process loads, such as those for office and other equipment, shall be estimated based on the building type or space type category and shall be assumed to be identical in the *proposed* and *code baseline building designs*, except as specifically authorized by the Program Evaluator. Receptacle loads should be modeled as accurately as possible for each individual zone instead of using an average across all zones.

Exception. Credit may be taken for automatic receptacle based occupant sensing control systems, by reducing the equipment power or schedules for automatically controlled equipment used for the *proposed design* by 15%. Reductions in excess of 15% may be taken when approved by the Program Evaluator provided credible technical documentation is provided.

3.10 Other Systems. Other systems, such as motors, elevators, and distribution transformers, may be modeled with energy performance as indicated in the design documents.

3.11 Further Modeling Limitations and Exceptions

3.11.1 Limitations to the *Simulation Program*. If the *simulation program* cannot model a component or system included in the *proposed design* explicitly, substitute a thermodynamically similar component model that can approximate the expected performance of the component that cannot be modeled explicitly.

3.11.2 Alterations and Additions. It is acceptable to demonstrate compliance using building models that exclude parts of the existing building provided all of the following conditions are met:

(a) Work to be performed in excluded parts of the building does not include alterations to mechanical systems, lighting systems, or building envelope.
(b) Excluded parts of the building are served by *HVAC systems* that are entirely separate from those serving parts of the building that are included in the building model.
(c) Design space temperature and HVAC system operating set points and schedules, on either side of the boundary between included and excluded parts of the building, are the same.
(d) If a declining block or similar utility rate is being used in the analysis and the excluded and included parts of the building are on the same utility meter, the rate shall reflect the utility block or rate for the building plus the addition.

3.12 Schedules. Schedules capable of modeling hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation shall be used. The schedules shall be as planned for the building, determined by the designer and owner, and consistent with common practice. The program evaluator shall have approval authority over the proposed schedules. Schedules shall be identical for the *proposed design* and *code baseline building design.*

Exception: Schedules may be allowed to differ between *proposed design* and *code baseline building design* with approval of the *Program Evaluator* when necessary to model nonstandard efficiency measures. Measures that may warrant use of different schedules include but are not limited to lighting controls, natural ventilation, demand control ventilation, and measures that reduce service water heating loads.

3.12.1 HVAC Fan Schedules. Schedules for HVAC fans, which shall run continuously whenever spaces are occupied and shall be cycled on and off to meet heating and cooling loads during unoccupied hours.

Exceptions
(a): Where fans in the proposed design do not run continuously, but instead cycle on and off to meet load and required ventilation is not being provided by the fan system, fans should not be simulated to run continuously.
(b): HVAC fans shall remain on during occupied and unoccupied hours in spaces that have health and safety mandated minimum ventilation requirements during unoccupied hours.

3.12.2 HVAC Zone Thermostat Setpoints. The thermostat setpoints shall be as planned for the building, determined by the designer and owner, and consistent with common practice.

3.13 *Thermal Zones.*

3.13.1 *HVAC Zones* Designed. Where *HVAC zones* are defined on HVAC design drawings, each HVAC zone shall be modeled as a separate *thermal block*.

Exception: Different *HVAC zones* may be combined to create a single *thermal block* or identical *thermal blocks* to which multipliers are applied provided all of the following conditions are met:
(a) The space use classification is the same throughout the *thermal block.*
(b) All HVAC zones in the thermal block that are adjacent to glazed exterior walls face the same orientation or their orientations are within 45 degrees of each other.
(c) All of the zones are served by the same *HVAC system* or by the same kind of *HVAC system*.

3.13.2 *HVAC Zones* Not Designed. Where the *HVAC zones* and systems have not yet been designed, *thermal blocks* shall be defined based on similar internal load densities, occupancy, lighting, thermal and space temperature schedules, and in combination with the following guidelines:

(a) separate *thermal blocks* shall be assumed for interior and perimeter spaces. Interior spaces shall be those located greater than 15 ft (5 m) from an exterior wall. Perimeter spaces shall be those located closer than 15 ft (5 m) from an exterior wall.
(b) separate *thermal blocks* shall be assumed for spaces adjacent to glazed exterior walls; a separate zone shall be provided for each orientation, except that orientations which differ by less than 45 degrees may be considered to be the same orientation. Each zone shall include all floor area that is 15 ft (5 m) or less from a glazed perimeter wall, except that floor area within 15 ft (5 m) of glazed perimeter walls having more than one orientation shall be divided proportionately between zones.
(c) separate *thermal blocks* shall be assumed for spaces having floors that are in contact with the ground or exposed to ambient conditions from zones that do not share these features.
(d) separate *thermal blocks* shall be assumed for spaces having exterior ceiling or roof assemblies from zones that do not share these features.

3.13.3 *Thermal Blocks* in Multifamily Residential Buildings. *Residential spaces* shall be modeled using at least one *thermal block* per living unit except that those units facing the same orientations may be combined into one *thermal block*. Corner units and units with roof or floor loads shall only be combined with units sharing these features.

4. Calculation of the *Code Baseline Energy Use*

4.1 Code Baseline Building Design. The *code baseline building design* shall be developed based on attributes of the *proposed design* as described in Section 3, prescriptive requirements of the Oregon Energy Code, and standard design practice. Code Baseline building modeling parameters shall be the same as the proposed building except as described in Section 4 or with approval of the *Program Evaluator*.

4.2 Code Baseline Building Envelope. The *code baseline building design* shall be modeled with the same number of floors and identical conditioned floor area as the *proposed design*. Equivalent dimensions shall be assumed for each exterior envelope component type as in the *proposed design*; i.e., the total gross area of exterior walls shall be the same in the *proposed* and *code baseline building designs.* The same shall be true for the areas of roofs, floors, and doors, and the exposed perimeters of concrete slabs on grade shall also be the same in the *proposed* and *code baseline building designs.* The following additional requirements shall apply to the modeling of the *code baseline building design*:

4.2.1. The azimuth and surface tilt or orientation category of each opaque exterior surface shall be modeled in the same manner as it occurs and is modeled in the *proposed design.*

Exception. If it can be demonstrated to the satisfaction of the *Program Evaluator* that the building orientation is not dictated by site considerations, the proposed building energy use may be generated by simulating the building with its actual orientation and again after rotating the entire building 90, 180, and 270 degrees and averaging the results.

4.2.2. Exterior Opaque Assemblies. Opaque assemblies types shall be lightweight assembly types conforming to the prescriptive requirements of the Oregon Energy Code as summarized in tables 4.1 and 4.2 below. Examples of acceptable Code Baseline wall, roof, and exterior floor constructions are shown in tables 4.3 – 4.6 below.

Exception:
(a) Slab on grade floors and below grade walls which should account for the mass in the Proposed Building floors and below grade walls.

Table 4.1. Walls, Roofs, and Exterior Floors - Zone 1 and Zone 2

Surface Type	***U-value[1] Zone 1***	***U-value[1] Zone 2***
Roofs	0.050	0.050
Walls - Above Grade	0.130	0.090
Walls - Below Grade	0.110	0.110
Floors - Exterior	0.070	0.070

1. U-values are for complete wall assemblies including interior and exterior air layers.

Table 4.2. Slab on Grade Floors, Zone 1 and Zone 2

	Slab edge heat loss - F-value - Zone 1	***Slab edge heat loss - F-value – Zone 2***
Heated slab on grade	0.95[1]	0.90[2]
Unheated slab on grade	0.73[3]	0.73[3]

1. F-factor from ASHRAE 90.1, 1999 Table A-16, based on heated slab with R-7.5 vertical insulation extending 24” down as required by Section 1312.1.2.4 and Table 13D.
2. F-factor from ASHRAE 90.1, 1999 Table A-16, based on heated slab with R-10 vertical insulation extending 24” down as required by Section 1312.1.2.4 and Table 13E.
3. F-factor from ASHRAE 90.1, 1999 Table A-16, based on un-heated slab with no insulation.

Table 4.3. Example Code Baseline Exterior Walls Construction - Zone 1 and Zone 2

Layer	***Climate Zone 1 R-Value***	***Climate Zone 2 R-Value***
Outside Air Layer[1]	0.17	0.17
¾ in. cement plaster	0.15	0.15
5/8 in. plywood	0.77	0.77
Insulation/framing	5.36	8.78
5/8 in. gypsum board	0.56	0.56
Inside Air Layer[1]	0.68	0.68
Total Resistance	7.69	11.11

U-factor	0.130	0.090

1. For most simulation programs (including DOE2), inside and outside air layer is calculated automatically by the program and should not be included in the assembly.

Table 4.4. Example Code Baseline Roof Construction - Zone 1 and Zone 2

Layer	*Climate Zone 1 and Climate Zone 2 R-Value*
Outside Air Layer[1]	0.17
Built-up roofing	0.33
0.75 in. plywood	0.93
Insulation/framing	17.40
5/8" gypsum board	0.56
Inside Air Layer[1]	0.61
Total Resistance	20.00
U-factor	0.050

1. For most simulation programs (including DOE2), inside and outside air layer is calculated automatically by the program and should not be included in the assembly.

Table 4.5. Example Code Baseline Below Grade Wall Construction - Zone 1 and Zone 2

Layer	*Climate Zone 1 and Climate Zone 2 R-Value*
8 in. heavyweight concrete, sand & gravel	0.53
Insulation/framing	7.32
5/8" in. gypsum board	0.56
Inside air film	0.68
Total Resistance	9.09
U-factor	0.110

1. For most simulation programs (including DOE2), inside and outside air layer is calculated automatically by the program and should not be included in the assembly.

Table 4.6. Example Code Baseline Exterior Floor Construction - Zone 1 and Zone 2

Layer	*Climate Zone 1 and Climate Zone 2 R-Value*
Outside Air Layer[1]	0.17
Insulation/framing	11.04
0.75 in. plywood	0.93
Carpet and pad	1.23
Inside air film[1]	0.92
Total Resistance	14.29
U-Factor	0.070

1. For most simulation programs (including DOE2), inside and outside air layer is calculated automatically by the program and should not be included in the assembly.

4.2.3. Interior Walls. Interior walls shall be modeled the same as the p*roposed design.*

4.2.4.Vertical Fenestration. All vertical glazing shall be modeled as fixed and shall be assumed to be flush with the exterior wall and no shading projections are to be modeled.

4.2.4.1 Window Area. Area of code baseline windows shall be as follows.

1. Window Area Zone 1. Window area shall equal to that in the proposed design or 40% of gross exterior wall area, whichever is smaller. If the window area of the proposed design is greater than 40% of the gross exterior wall area, code baseline window area shall be decreased by an identical percentage in all walls in which windows are located to reach the 40% window to wall ratio.

2. Window Area Zone 2. Window area shall equal to that in the proposed design or 33% of gross exterior wall area, whichever is smaller. If the window area of the proposed design is greater than 33% of the gross exterior wall area, code baseline window area shall be decreased by an identical percentage in all walls in which windows are located to reach the 33% window to wall ratio.

4.2.4.2 Window Thermal Performance. Window thermal performance shall be as follows.

Table 4.7. Thermal Performance of Code Baseline Windows

	***U-Value*[1]**	***Shading Coefficient*[2]**
Zone 1, Window to Wall Ratio of 30% or Less	0.54	0.57
Zone 2Window to Wall Ratio of 25 % or Less	0.50	0.57
Zone 1, Window to Wall Ratio of >30%	0.37	0.35
Zone 2Window to Wall Ratio> 25 %	0.37	0.43

1. U-value is for overall window performance including effects of frames.
2. Shading Coefficient is center of glass value.

4.2.4.3 Window Orientation**.** Orientation of each window surface shall be the same as in the *proposed building design*.

4.2.5. Skylights and glazed smoke vents.

4.2.5.1. **Skylight Area**. Skylight area shall equal to that in the proposed design or 6% of gross exterior roof area, whichever is smaller. If the skylight area of the proposed design is greater than 6% of the gross exterior roof area, code baseline skylight area shall be decreased by an identical percentage in all roof components in which skylights are located to reach the 6% skylight to wall ratio.

4.2.5.2. **Skylight Orientation and Tilt**. Skylight orientation and tilt shall be the same as in the *proposed building design*.

4.2.5.3. **Skylight Thermal Performance**. Skylight thermal performance shall be as follows:

Table 4.8. Thermal Performance of Code baseline Skylights in Both Zone 1 and 2.

	***U-Value*[1]**	***Shading Coefficient*[2]**
Zone 1 and Zone 2	1.23	0.47

1. U-value is for overall skylight performance including effects of frames.
2. Shading Coefficient is center of glass value.

4.2.6 Doors. Door area and orientation in the Code Baseline building will be identical to doors entered for the Proposed Building.

4.2.6.1. Door Thermal Performance. For doors with a leaf width of four feet or less, and coiling overhead doors, the code baseline doors will be identical thermal performance to the proposed doors. For other opaque doors, center of glass U-value will be 0.200. For glass doors, code baseline performance will be as described in A.4.1.2.4.1. for windows.

4.2.7. Roof Albedo. All roof surfaces shall be modeled with a reflectivity of 0.3.

4.2.8. Existing Buildings. For existing building envelope components not being modified, the *code baseline building design* shall reflect existing conditions. For existing building envelope components being modified, the *code baseline building design* shall be identical to code baseline *building design requirements* as described in 4.2.

4.3 Code Baseline HVAC Systems. The HVAC system(s) in the *code baseline building design* shall be of the type and description specified in 4.3.1 shall meet the general HVAC system requirements specified in 4.3.2, and shall meet any system-specific requirements in 4.3.3 that are applicable to the *code baseline* HVAC system type(s).

4.3.1 *Code Baseline* HVAC System Type and Description. HVAC systems in the *code baseline building design* shall be based on usage, number of floors, conditioned floor area, and heating source as specified in Table 4.9 and shall conform with the system descriptions in Table 4.10.

Table 4.9 *Code Baseline* HVAC System Types

Heating Source	Residential[1]	Non-Residential & 2 Floors or Less & <40,000 ft^2	Non-Residential & 2 Floors or Less & >=40,000 ft^2	Non-Residential & More than 2 Floors
Fossil Fuel and Purchased Heat[2]	Sys. 1 – PTAC	Sys. 3 – PSZ-AC	Sys. 5 - VAV w/Reheat	
Electric and Other	Sys. 2 – PTHP	Sys. 4 - PSZ-HP	Sys. 6 - VAV w/Reheat	
Hybrid System[3]	Sys. 1 – PTAC	Sys. 3 – PSZ-AC	Sys. 7 – Hybrid VAV w/Reheat	

Notes:

1. Residential building types include dormitory, hotel, motel, and multi-family. Residential space types include guest rooms, living quarters, private living space, and sleeping quarters. Other building and space types are considered non-residential.
2. Where no heating energy source is specified, use the "Fossil Fuel" heating source classification.
3. Hybrid system has fossil fuel or purchased central heating coil and electric reheat.
4. Where attributes make a building eligible for more than one *code baseline* system type, use the predominant condition to determine the system type for the entire building.

Exceptions to 4.3.1:
(a) Use additional system type(s) for non-predominant conditions (i.e., residential/non-residential or heating source) if those conditions apply to more than 20,000 ft^2 of conditioned floor area.
(b) If the *code baseline* HVAC system type is 5, 6 or 7, use separate single-zone systems conforming with the requirements of System 3 or System 4 (depending on building heating source) for any spaces that have occupancy or process loads, humidity requirements, or schedules that differ significantly from the rest of the building. Peak thermal loads that differ by 10 Btu/h or more from the average of other spaces served by the system or schedules that differ by more than 40 equivalent full-load hours per week from other spaces served by the system are considered to differ significantly. Examples where this exception may be applicable include, but are not limited to, computer server rooms, natatoriums, and continually occupied security areas.
(c) If the *code baseline* HVAC system type is 5, 6, or 7, use separate systems conforming with the requirements of System 5, 6, or 7 (depending on building heat source) for any zones having special pressurization relationships, cross-contamination requirements, or code required minimum circulation rates. Examples where this exception may be applicable include, but are not limited to, laboratories, vivariums, operating rooms, and isolation wards.
(d) Where no heating system is planned for the proposed building, no heating system should be modeled in the code baseline.
(e) Where no cooling system is planned for the proposed building, no cooling system may be modeled in the code baseline building.

Exception. Cooling may be modeled in the code baseline building for zones of the building where the following requirements are met.
1. Peak cooling load in the code baseline building is at least 25% greater than the same zone in the proposed building as determined by building model output reports.
2. Cooling thermostat setpoints in the code baseline building are set to the maximum occupied and unoccupied space temperature reached by the zone in the proposed building as determined by building model output reports.

Table 4.10 *Code Baseline* System Descriptions

	System 1 – PTAC	**System 4 - PSZ-HP**	**System 7 – Hybrid VAV w/Reheat**
System Type	**Packaged terminal air conditioner**	**Packaged rooftop heat pump**	**Variable air volume with reheat**
Fan Control	Constant Volume	Constant Volume[1]	VAV
Cooling Type	Direct Expansion	Direct Expansion	Chilled Water
Heating Type	Hot Water Fossil Fuel Boiler	Electric Heat Pump	Hybrid[2]
	System 2 – PTHP	**System 5 - VAV w/Reheat**	**-------------**
System Type	**Packaged terminal heat pump**	**Variable air volume with reheat**	-------------
Fan Control	Constant Volume	VAV	-------------
Cooling Type	Direct Expansion	Chilled Water	-------------
Heating Type	Electric Heat Pump	Hot Water Fossil Fuel Boiler	-------------
	System 3 - PSZ-AC	**System 6 - VAV w/Reheat**	-------------
System Type	**Packaged rooftop air conditioner**	**Variable air volume with reheat**	-------------
Fan Control	Constant Volume[1]	VAV	-------------
Cooling Type	Direct Expansion	Chilled Water	-------------
Heating Type	Fossil Fuel Furnace	Electric Resistance	-------------

1.Systems with supply air flow > 15,000 CFM shall be single zone VAV – see 4.3.3.11
2. Hybrid system has fossil fuel or purchased central hot water coil and electric reheat.

4.3.1.1 Purchased Heat or Chilled Water. For systems using purchased hot water, steam, or chilled water, costs shall be based on actual utility rates, and on-site boilers or chillers shall not be modeled in the *code baseline building design*. `

4.3.2 General *Code Baseline* HVAC System Requirements. HVAC Systems in the *code baseline building design* shall conform with the general provisions in this section.

4.3.2.1 System Assignments. For systems types 1,2,3,and 4, each zone shall be modeled with a dedicated HVAC system. For system types 5, 6 and 7, each floor shall be modeled with a separate HVAC System.

4.3.2.2 Equipment Efficiencies. All HVAC and service water heating equipment in the *code baseline building design* shall be modeled at the minimum efficiency levels, both part load and full load, in accordance with Section 1317 of the Oregon Energy Code. Where efficiency ratings, such as EER and COP, include fan energy, the descriptor shall be broken down into its components so that supply fan energy can be modeled separately.

4.3.2.3 Equipment Capacities. The equipment capacities for the *code baseline building design* shall be based on sizing runs and shall be over-sized by 15% for cooling and 25% for heating; i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs shall be 1.15 for cooling and 1.25 for heating. Unmet load hours for the *proposed design* shall not exceed the number of unmet load hours for the *code baseline building design* by more than 50. If unmet load hours in the *proposed design* exceed the unmet load hours in the *code baseline building* by more than 50, code baseline equipment capacities shall be decreased incrementally until the unmet load hours are within 50.

4.3.2.3.1 Sizing Runs. Weather conditions used in sizing runs to determine *code baseline* equipment capacities may either be based on hourly historical weather files containing typical peak conditions or on design days developed using 99.6% heating design temperatures and 1% dry bulb and 1% wet bulb cooling design temperatures.

4.3.2.3.2 Design Air Flow Rates. System design supply air flow rates for the *code baseline building design* shall be based on a cooling supply-air-to-room-air temperature difference of 20° F (11°C) or the required ventilation air or make up air, whichever is greater. Heating only systems shall be based on a supply-air-to-room-air temperature difference of 30°F (17°C) or the required ventilation air or make up air, whichever is greater. For systems serving laboratory spaces, *code baseline building design* shall be based on a cooling supply-air-to-room-air temperature difference of 17°F (9°C) or the required ventilation air or make up air, whichever is greater.

4.3.2.4 Preheat Coils. If the HVAC system in the *proposed design* has a preheat coil and a preheat coil can be modeled in the *code baseline* system, the *code baseline* system shall be modeled with a preheat coil controlled in the same manner as the *proposed design*.

4.3.2.5 Fan System Operation. Supply fans shall operate continuously whenever spaces are occupied and shall be cycled to meet heating and cooling loads during unoccupied hours.

4.3.2.6 Ventilation. Minimum outdoor air ventilation rates shall be the same for the *proposed* and *code baseline building designs.*

Exception: When demand controlled ventilation is not required by Section 1203.2.12 of the Oregon Structural Specialty code but is included in the *proposed design*, ventilation may be varied to match actual occupancy, but peak ventilation rates shall remain the same.

4.3.2.7 Economizers. *Code Baseline building* systems shall have integrated outdoor air economizers, available for cooling anytime the outdoor drybulb temperature is less than 70 deg.F.

Exceptions.

(a) Economizers shall not be used for systems 1, 2, 3, and 4 with cooling capacities less than 54,000 Btu/hr. This exception may only be taken for equipment up to the first 20 Tons of a buildings cooling capacity, as allowed by Section 1317.3 of the Oregon Energy Code.
(b) Systems that include air cleaning to meet the requirements of 6.1.2 of *ASHRAE Standard 62*. This exception shall only be used if the system in the *proposed design* does not use an economizer. If the exception is used, an economizer shall not be included in the *code baseline building design*.
(c) Systems serving only residential spaces and hotel or motel guest rooms.

4.3.2.8 Supply Fan Power. Supply fan electrical power shall be calculated using the following formulas:

For constant volume fan systems : P_{fan} = 0.8226 W/CFM
For variable volume Fan Systems : P_{fan} = * 1.1236 W/CFM
For system types 1 and 2: P_{fan} = 0.2409 W/CFM
where:
P_{fan} = electric power to fan motor (watts)
CFM = design supply flow rate.

Exception If a system in the proposed building contains air filtration with pressure drops in excess of 1” w.c. when filters are clean or heat recovery, the allowable fan system power for the code baseline system may be increased using the following pressure credit:

Pressure Credit (Watts) = Filtration Pressure Credit (Watts) + Heat Recovery Filtration Credit (Watts)

Filtration Pressure Credit (Watts) = CFM_{filter} * (SP_{filter} -1) / 2.77

CFM_{filter} = supply air volume of system with air filtration system in excess of 1” w.c..
SP_{filter} = air pressure drop of the filtering system when filters are clean, in w.g.

Heat Recovery Pressure Credit (Watts) = CFM_{HR} * SP_{HR} / 2.77

CFM_{HR} = supply air volume of system with heat recovery
SP_{HR} = air pressure drop of the heat recovery coils in w.g.

4.3.2.9 Return Fans. Return fans should not be modeled.

4.3.2.10 Exhaust Fans. Exhaust fans should not be modeled.

Exception. Exhaust fans serving unconditioned spaces shall be modeled with the fan energy consumption equal to the proposed building.

4.3.2.11 Exhaust Air Heat Recovery. Individual fan systems that have both a design supply air capacity of 10,000 CFM or greater and have a minimum outside air supply of 70% or greater of the design supply air quantity, shall be modeled with a heat recovery system. The heat recovery system shall be capable of increasing the outside air supply temperature at design heating conditions by 20°F in Climate Zone 1 and 30°F in Climate Zone 2. The system shall be

modeled to bypass or control the heat-recovery system to permit air economizer operation, where applicable.
Exceptions: If any of these exceptions apply, exhaust air energy recovery shall not be included in the *code baseline building design.*

(a) Systems serving spaces which are not cooled and which are heated to less than 55°F.
(b) Systems exhausting toxic, flammable, paint exhaust, corrosive fumes, or dust.
(c) Systems serving type 1 kitchen exhaust hoods.
(d) Where more than 60 percent of the outdoor heating energy is provided from site-recovered or site solar energy.
(e) Systems that only provide cooling.

4.3.2.12 HVAC Zone Thermostat Setpoints. Zone temperature setpoints shall be the same as in the *proposed building.*
Exception: If zones in the *proposed building* have setpoints with less than 5 deg. F. deadband (separation between cooling and heating setpoints), the deadband in the *code baseline* shall be increased to 5 deg. F. by decreasing the heating setpoint and increasing the cooling setpoint by equal amounts. Zones with special occupancy, special usage or code requirements where deadband controls are not appropriate (such as process applications and areas of hospitals normally used by patients), shall leave the deadband the same as in the *proposed building.*

4.3.3 System-Specific *Code Baseline* HVAC System Requirements. *Code* *Baseline* HVAC systems shall conform with provisions in this section where applicable to the specified *code baseline* system types as indicated in section headings.

4.3.3.1 Heat Pumps (Sys. 2 & 4). Electric air-source heat pumps shall be modeled with electric auxiliary heat. The systems shall be controlled with multi-stage space thermostats and an outdoor air thermostat wired to energize auxiliary heat only on the last thermostat stage and when outside air temperature is less than 40°F (4°C).

4.3.3.2 Type and Number of Boilers (Sys. 1, 5 & 7). The boiler plant shall use the same fuel as the *proposed design* and shall be natural draft, except as noted under 4.3.1.1, Purchased Heat. The *code baseline building design* boiler plant shall be modeled as having a single boiler if the *code baseline building design* plant serves a conditioned floor area of 15,000 ft^2 or less, and as having two equally sized boilers for plants serving more than 15,000 ft^2. Boilers shall be staged as required by the load. Lead boiler shall run until its capacity is reached and lag boiler will pickup remaining load.

4.3.3.3 Hot Water Supply Temperature (Sys. 1, 5, & 7). Hot water design supply temperature shall be modeled at 180°F (82°C) and 140°F (54°C) design return temperature. Hot water supply temperature shall be reset based on outside dry-bulb temperature using the following schedule: 180°F @ 20°F and below, 140°F @ 60°F and above, and ramped linearly between 180°F and 140°F at temperatures between 20°F and 60°F.

4.3.3.4 Hot Water Pumps (Sys. 1, 5, & 7). The *code baseline building design* pump power shall be 19 W/gpm [*equal to a pump operating against a 60 foot (18m) head, 60% combined impeller and motor efficiency*]. The pumping system shall be modeled as primary only, with continuous variable flow. For heating water with pumping energy less than 10 brake horsepower, pumps should be modeled as constant speed, riding the pump curve. For heating water systems with pumping energy of 10 brake horsepower or greater, user shall model variable speed pumps.

4.3.3.5 Type and Number of Chillers (Sys. 5 & 6). Electric chillers shall be used in the *code baseline building design* regardless of the cooling energy source except as noted under 4.3.1.1, Purchased Chilled Water. The *code baseline building design's* chiller plant shall be modeled with chillers having the number and type as indicated in Table 4.11 as a function of building peak cooling load.

Table 4.11 Type and Number of Chillers

Building Size	Number and Type of Chiller(s)
≤ 200 Tons	1 air cooled screw chiller
>200 Tons ≤ 300 Tons	1 water cooled screw chiller
> 300 Tons ≤ 800 Tons	2 water cooled screw chillers sized equally
≥ 800 Tons	2 water cooled centrifugal chillers minimum with chillers added so that no chiller is larger than 800 tons (2813 kW), all sized equally

4.3.3.6 Chilled Water (Sys. 5, 6, & 7). Chilled water design supply temperature shall be modeled at 44°F (6.7°C) and 56°F (13°C) design return temperature. Chilled water supply temperature shall be reset based on outside dry-bulb temperature using the following schedule: 44°F @ 80°F and above, 54°F @ 60°F and below, and ramped linearly between 44°F and 54°F at temperatures between 80°F and 60°F.

4.3.3.7 Chilled Water Pumps (Sys. 5, 6, & 7). Chilled water systems shall be modeled as constant flow primary/variable flow secondary systems. The *code baseline building design* pump power shall be 22 W/gpm, [equal to a pump operating against a 70 foot head, 60% combined motor and impeller efficiency]. For chilled water systems with pumping energy less than 10 brake horsepower, pumps should be modeled as constant speed, with secondary pump riding the pump curve. For chilled water systems with pumping energy of 10 brake horsepower or greater, user shall model secondary pump as a variable speed pump.

4.3.3.8 Heat Rejection (Sys. 5 & 6). If chiller type as determined by Table 4.11 is air cooled, the heat rejection device shall be an integral air cooled condenser with an overall efficiency of the chiller condenser combination as determined by Table 13-O.

If chiller type as determined by Table 4.11 is water cooled, The heat rejection device shall be a centrifugal fan cooling tower with 2-speed fans. Condenser water design supply temperature shall be 85°F (29°C) or 10°F (5.6°C) approach to design wet bulb temperature, whichever is lower, with a design temperature rise of 10°F (5.6°C). The tower shall be controlled to maintain a 70°F (21°C) leaving water temperature where weather permits, floating up to leaving water temperature at design conditions. The *code baseline building design* pump power shall be 19 W/gpm (301 kW/1000 L/s) Each chiller shall be modeled with separate condenser water and chilled water pumps interlocked to operate with the associated chiller.

4.3.3.9 Supply Air Temperature Reset(Sys. 5, 6, &7). Supply air temperature shall be reset based on zone demand from the design temperature difference (discussed in Section 4.3.2.3.2) to a 5°F (3°C) temperature difference under minimum load conditions.

4.3.3.10 VAV Minimum Flow (Sys. 5,6,&7). VAV systems shall be modeled assuming a variable speed drive. Minimum volume setpoints for VAV reheat boxes shall be equal to 0.4 cfm/ft2 (2.15 L/s·m2) of floor area, 30% of the design supply flow rate, or equivalent to the minimum ventilation rate, whichever is greatest.

Exception: Systems serving laboratory spaces with a minimum of 5000 cfm of exhaust shall be controlled as constant volume during occupied hours and to reduce the exhaust and makeup air volume to 50% of design values during unoccupied periods.

4.3.3.11 Large Volume Single Zone VAV (Sys. 3&4 >15,000 CFM). Fan systems with supply airflow > 15,000 CFM shall be modeled as variable flow systems, assuming a variable speed drive. System shall be controlled to reduce airflow based on space heating or cooling demand down to a minimum of 60% or the minimum ventilation air required, whichever is greater.

Exception: Systems where the function of the supply air is for purposes other than temperature control, such as maintaining specific humidity levels or supplying an exhaust system shall be modeled as constant volume.

4.4 *Code Baseline* Service Hot Water Systems. The service hot water system in the *code baseline building design* shall use the same energy source as the corresponding system in the *proposed design* and shall conform with the following conditions:

(a) Where a complete service hot water system exists, the *code baseline building design* shall reflect the actual system type using actual component capacities and efficiencies.
(b) Where a new service hot water system has been specified, the equipment shall match the minimum efficiency requirements in Table 13N of the Oregon Energy Code.
(c) Where the energy source is electricity, the heating method shall be electrical resistance.
(d) Where no service hot water system exists or has been specified but the building will have service hot water loads, a service water system(s) using electrical resistance heat and matching minimum efficiency requirements of Table 13N of the Oregon Energy Code shall be assumed and modeled identically in the *proposed* and *code baseline building designs*.
(e) For buildings that will have no service hot water loads, no service hot water heating shall be modeled.
(f) Where a combined system has been specified to meet both space heating and service water heating loads, the *code baseline building system* shall use separate systems meeting the minimum efficiency requirements applicable to each system individually.

4.5 Lighting. Lighting power in the *code baseline building design* shall be determined in accordance with either Section 1313.4.1 Tenant Space Method and Table 13G or Section 1313.4.2 Space-by-Space Method and Table 13H of the Oregon Energy Code. No automatic lighting controls (e.g., programmable controls or automatic controls for daylight utilization) shall be modeled in the *code baseline building design*, as the lighting schedules used are understood to reflect the mandatory control requirements in the code.

4.6 Other Systems. Other systems, such as motors not covered by the Oregon Energy Code, and miscellaneous loads shall be modeled as identical to those in the *proposed design*. Distribution transformers shall be modeled as identical to those in the proposed design.

Exception: These systems may be modeled differently than in the *proposed design* when approved by the Program Evaluator.

5. Exceptional Calculation Methods: Where no *simulation program* is available that adequately models a design, material, or device, the *Program Evaluator* may approve an exceptional calculation method to demonstrate above-code performance using this method. Applications for approval of an exceptional method shall include documentation of the calculations performed and theoretical and/or empirical information supporting the accuracy of the method.