Appendix L

Building Modeling Guidelines

Revised October 1, 2010

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 Efficiency Specialty Code (OEESC). Buildings using this protocol will still need to meet the requirements of the OEESC through one of the three paths allowed by the code: Prescriptive Approach, Simplified Trade-Off Approach, or Whole Building Approach. Energy using systems that the OEESC does not regulate shall be modeled according to standard design practice. Standard design practice assumptions made by the modeler shall be approved by the Program Evaluator.

1.2 Definitions

Code Building: A hypothetical building design based on the Proposed Building. The Code building shall incorporate the standard design features of typical buildings of the same usage and just meet the prescriptive requirements of the OEESC according to guidelines presented in this document. The Code building is used to benchmark the relative energy efficiency of the Proposed Building.

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

Code Energy Use: The annual energy use in millions of Btus (MMBtu) calculated for the Code building.

OEESC: Oregon Energy Efficiency Specialty Code, also known as energy code.

OSSC: Oregon Structural Specialty Code, also known as building code.

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

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

Proposed Energy Use: The annual energy use in millions of Btus (MMBtu) calculated for the Proposed 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 Energy Use - Proposed Energy Use) / Code Energy Use] x 100.
(b) Percent Energy Cost Savings = [(Code Energy Cost - Proposed Energy Cost) / Code Energy Cost] x 100.

1.4 Trade-off 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 building and the Proposed building. Future building components shall meet the prescriptive requirements of the OEESC.

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 building energy use, the Proposed building energy use, and the percent energy savings.
(b) Calculated values for the Code building energy cost, the Proposed building energy cost, and the percent cost 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 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 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;
(e) Part-load performance curves for mechanical equipment;
(f) capacity and efficiency correction curves for mechanical heating and cooling equipment;
(g) air-side economizers with integrated control;
(h) all code building characteristics specified in Section 4, Calculation of Code Energy Cost.

2.1.2 The simulation program shall have the ability to either (1) directly determine the proposed energy use and code energy use or (2) produce hourly reports of energy use by energy source suitable for determining the proposed energy use and code 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 building design.

2.1.4 The simulation program shall be tested according to ASHRAE Standard 140, and the results shall be furnished by the software provider upon request by the Oregon Department of Energy.

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, energy prices recommended by the Oregon Department of Energy shall 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 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 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. All end use components within and associated with the building shall be modeled, including but not limited to, exhaust fans, parking garage ventilation fans, snow melt and freeze protection equipment, facade lighting, swimming pool heaters and pumps, elevators, refrigeration and cooking.

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 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 OEESC Tables 503.2.3(1) through 503.2.3(8), if required by the simulation model.
(c) 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 building design.
(d) 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 building design.
(e) Where no active heating system is planned, none shall be modeled.
(f) 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 OSSC Chapter 12.

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 0.30.
(d) Manual window shading devices such as blinds or shades shall not be modeled. Automatically controlled window shades or blinds may be modeled. Permanent shading devices such as fins, overhangs and light shelves 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 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 OEESC Section 505.5.2 Interior Lighting Power Method and Table 505.5.2(a).
(d) 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 facade lighting).
(e) Credit may be taken for the use of automatic controls for daylight utilization when not required by OEESC Section 505.2.2.3, 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.

(f) 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)	Conference Rooms, Meeting Rooms, Classrooms, Employee break rooms, Copying Rooms, Restrooms, Dressing/Locker Rooms and Offices < 300ft^2	Buildings > 2,000 ft^2	Buildings < 2000ft^2
Programmable timing control	0%	0%	10%
Occupancy sensor	0%	5%	15%
Occupancy sensor and programmable timing control	0%	5%	15%

1. If lighting schedule is adjusted, the code baseline 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 (100%-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.

3.8 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 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.

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

3.10 Further Modeling Limitations and Exceptions

3.10.1 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.

3.10.2 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.

3.11 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 building design.

Exception: Schedules may be allowed to differ between proposed design and code 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.

3.11.1 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.

3.11.2 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.

3.12 Thermal Zones.

3.12.1 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.

3.12.2 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 from an exterior wall. Perimeter spaces shall be those located closer than 15 ft 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 or less from a glazed perimeter wall, except that floor area within 15 ft 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.

3.12.3 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 Energy Use

4.1 Code building Design. The code building design shall be developed based on attributes of the proposed design as described in Section 3, prescriptive requirements of the OEESC, and standard design practice. Code 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 building Envelope. The code 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 building designs. The same shall be true for the areas of roofs, floors, doors, and the exposed perimeters of concrete slabs on grade
in the proposed and code building designs. The following additional requirements shall apply to the modeling of the code 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 OEESC as summarized in Tables 4.1 and 4.2 below. Examples of acceptable Code wall, roof, and exterior floor constructions are shown in Tables 4.3 – 4.6 below.

Exception: 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

Surface Type	U-value[1]
Roofs (attic)	0.027
Roofs (above deck)	0.048
Walls - Above Grade	0.064 (0.051 Group R)[2]
Walls - Below Grade	0.119
Floors - Exterior	0.033

1. U-values are for complete wall assemblies including interior and exterior air layers.
2. Group R, as defined in OSSC.

Table 4.2 Slab on Grade Floors

	Slab Edge Heat Loss F-Value (All Other)	Slab Edge Heat Loss F-Value (Group R)[1]
Heated slab on grade	0.86	0.86
Unheated slab on grade	0.73	0.54

1. Group R, as defined in OSSC.

Table 4.3 Example Code Exterior Walls Construction

Layer	R-Value (All Other)	R-Value (Group R)[2]
Outside Air Layer[1]	0.170	0.170
¾ in. cement plaster	0.150	0.150
5/8 in. plywood	0.770	0.770
Insulation/framing	13.295	17.278
5/8 in. gypsum board	0.560	0.560
Inside Air Layer[1]	0.680	0.680
Total Resistance	15.625	19.608
U-factor	0.064	0.051

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.
2. Group R, as defined in OSSC.

Table 4.4 Example Code Roof Construction

Layer	Insulation Entirely Above Deck[1]
Outside Air Layer[2]	0.17
Built-up roofing	0.33
0.75 in. plywood	0.93
Insulation/framing	18.23
5/8" gypsum board	0.56
Inside Air Layer[2]	0.61
Total Resistance	20.83
U-factor	0.48

1. See OEESC for attic construction requirements.
2. 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 Below Grade Wall Construction

Layer	R-Value
8 in. heavyweight concrete, sand & gravel	0.53
Insulation/framing	6.633
5/8" in. gypsum board	0.56
Inside air film[1]	0.68
Total Resistance	8.403
U-factor	0.119

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 Exterior Floor Construction

Layer	R-Value
Outside Air Layer[1]	0.17
Insulation/framing	27.053
0.75 in. plywood	0.93
Carpet and pad	1.23
Inside air film[1]	0.92
Total Resistance	30.303
U-Factor	0.033

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 proposed 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.
Window area shall be equal to that in the proposed design or 30% of gross exterior wall area, whichever is smaller. If the window area of the proposed design is greater than 30% 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 30% window to wall ratio.

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

Table 4.7 Thermal Performance of Code Baseline Vertical Fenestration (30% Maximum of Above-Grade Wall)

	U-Value[1]	**SHGC**[2]
Framing materials other than metal		
	0.35	0.40
Metal framing with or without thermal break		
Curtain Wall/storefront	0.45	0.40
Entrance door	0.80	0.40
All other	0.46	0.40
Skylights (3% maximum of roof)	0.60	0.40

1. U-value is for overall fenestration performance including effects of frames, not Center of Glass U-value.
2. Solar Heat Gain 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.

4.2.4.4 Skylight Area. Skylight area shall equal that in the proposed design or 3% of gross exterior roof area, whichever is smaller. If the skylight area of the proposed design is greater than 3% 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 3% skylight to wall ratio.

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

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

4.2.4.7 Door Thermal Performance. For swinging doors, U value will be 0.70, for roll-up or sliding doors, the U value will be 0.50.

4.2.5 Roof Albedo. All roof surfaces shall be modeled with a reflectivity of 0.30.

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

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

4.3.1 Code Baseline HVAC System Type and Description. HVAC systems in the code building design shall be based on usage, number of floors, conditioned floor area, and heating source as specified in Table 4.8 and shall conform with the system descriptions in Table 4.9.

Table 4.8 Code 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 system type, use the predominant condition to determine the system type for the entire building.

Exceptions:

(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 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, 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 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.
(d) For laboratory spaces with a minimum of 5,000 cfm of exhaust, use system types 5 or 7 serving only those spaces.
(e) Where no heating system is planned for the proposed building, no heating system should be modeled in the code building.
(f) Where no cooling system is planned for the proposed building, no cooling system may be modeled in the code building.

Exception: Cooling may be modeled in the code building for zones of the building where the following requirements are met.

1. Peak cooling load in the code 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 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 4.9 Code 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[3]	-------------
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 > 8,000 CFM shall be single zone VAV – see Section 4.3.3.12
2. Hybrid system has fossil fuel or purchased central hot water coil and electric reheat.
3. Water cooled chiller systems where total installed heat rejection capacity exceeds 6,000,000 Btu/h shall use System 5 – See Section 4.3.3.9 for heat rejection requirements.

4.3.1.1 District or Campus Thermal Energy. For systems using district hot water, steam, or chilled water, two options are available based on LEED Version 2 “Treatment of District or Campus Thermal Energy”. The Code building must meet OEESC requirements. Proposed buildings 50,000 square feet or less must use Option 1. The Option 1 method uses purchased hot water, steam, or chilled water with costs based on actual utility rates. Proposed buildings over 50,000 square feet may choose Option 2 if the District Thermal System provides more than 20% of the building’s annual energy use.

Option 2 credit will be based on energy consumption, not energy costs. Only savings attributable to Energy Efficiency are allowed. No more than 5% savings may be attributed to the district plant efficiencies.

4.3.2 General Code HVAC System Requirements. HVAC Systems in the code building design shall conform to 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 building design shall be modeled at the minimum efficiency levels, both part load and full load, in accordance with OEESC Section 503. 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 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 building design by more than 50. If unmet load hours in the proposed design exceed the unmet load hours in the code 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 building design shall be based on a cooling supply-air-to-room-air temperature difference of 20°F 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 or the required ventilation air or make up air, whichever is greater. If return or relief fans are specified in the proposed design, the code building shall also be modeled with fans serving the same functions and sized for the baseline system supply fan air less the minimum outdoor air, or 90% of the supply fan air quantity, whichever is larger. For systems serving laboratory spaces, code building design shall be based on a cooling supply-air-to-room-air temperature difference of 17°F 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 building designs.

Exceptions:

(a) When demand controlled ventilation is not required by OSSC Section 1203.2.12 but is included in the proposed design, ventilation may be varied to match actual occupancy, but peak ventilation rates shall remain the same.

(b) When designing systems in accordance with ASHRAE Standard 62.1 Section 6.2 Ventilation Rate Procedure, reduced ventilation airflow rates may be calculated for each HVAC zone in the Proposed design with a zone air distribution effectiveness (Ez) > 1.0 as defined by Table 6.2 in ASHRAE Standard 62.1. Code ventilation airflow rates in those zones shall be calculated using the Proposed design Ventilation Rate Procedure calculation with the following change only. Zone air distribution effectiveness shall be changed to (Ez) = 1.0 in each zone having a zone air distribution effectiveness (Ez) > 1.0. The Proposed design and Code design Ventilation Rate Procedure calculations, as described in ASHRAE Standard 62.1, shall be submitted to the Program Evaluator to claim credit for this exception.

(c) If the minimum outdoor air intake flow in the Proposed design is provided in excess of the amount required by the rating authority, then the Code building design shall be modeled to reflect that required by the rating authority and will be less than the Proposed design.

4.3.2.7 Air Economizers. Code building systems shall have integrated outdoor air economizers, available for cooling anytime the outdoor dry bulb temperature is less than 70 °F.

Exceptions:

(a) Economizers shall not be used for systems 1, 2, 3, and 4 with cooling capacities less than 54,000 Btu/h. This exception may only be taken for equipment up to the first 240,000 Btu/h of a buildings cooling capacity, as allowed by OEESC Section 503.3.1.

(b) Systems that include air cleaning to meet the requirements of ASHRAE Standard 62 Section 6.1.2. 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 building design.

(c) Systems serving only residential spaces and hotel or motel guest rooms.

4.3.2.8. System Fan Power. System Fan electrical power for supply, return exhaust and relief shall be calculated using the following formulas:

For Systems 1 and 2,

$P_{fan} = 0.2409$ W/CFM

For Systems 3 through 7,

$P_{fan} =$ bhp x 746 / Fan motor efficiency

Where

P_{fan} = electric power to fan motor (watts) and

bhp = brake horsepower of baseline fan motor
Constant Volume (Systems 3 & 4) = CFM x 0.00094 + A
Variable Volume (Systems 5, 6, & 7) = CFM x 0.0013 + A

Where A is calculated according to OEESC Table 503.2.10.1(2) using the pressure drop adjustment from the proposed building design and the design flow rate of the baseline building system. Do not include pressure drop adjustments for heat recovery devices that are not required in the baseline building system by 4.3.2.11

Fan motor efficiency = the efficiency from Table 4.10 for the next motor size greater than the bhp.

CFM_S = the baseline system maximum design supply fan airflow rate in cfm

Table 4.10 Fan Motor Efficiency[1]

Motor Horsepower	Nominal Efficiency
1	82.5
1.5 to 2	84.0
3-5	87.5
7.5 to 10	89.5
15 to 20	91.0
25 to 30	92.4
40 to 50	93.0
60	93.6
75	94.1
100 to 125	94.5
150 and over	95.0

1. Nominal efficiencies in accordance with NEMA Standard MG1 for enclosed motors at 1800 RPM

4.3.2.8.1 The calculated system fan power shall be distributed to supply, return, exhaust, and relief fans in the same proportion as the proposed design.

4.3.2.9 Exhaust Air Heat Recovery. Individual fan systems that have both a design supply air capacity of 5,000 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 energy recovery system. The energy recovery system shall provide a change in the enthalpy of the outdoor air supply of 50 percent or more of the difference between the outdoor air and return air at design conditions. Provision shall be made to bypass or control the energy recovery system to permit cooling with outdoor air where cooling with outdoor air is required. Where a single room or space is supplied by multiple units, the aggregate supply (CFM) of those units shall be used in applying this requirement.

Exception: See OEESC Section 503.2.6

4.3.2.10 Kitchen hoods. Kitchen hoods with exhaust capacity greater than 5,000 CFM are required to be modeled with variable flow, See OEESC Section 503.2.5.2

4.3.2.11 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 °F deadband (separation between cooling and heating setpoints), the deadband in the code building shall be increased to 5°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 HVAC systems shall conform with provisions in this section where applicable to the specified code system types as indicated in section headings.

4.3.3.1 Heat Pumps (Systems 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.

4.3.3.2 Type and Number of Boilers (Systems 1, 5 & 7). The boiler plant shall use the same fuel as the proposed design and shall be forced draft, except as noted under Section 4.3.1.1, District Thermal System. The code building design boiler plant shall be modeled as having a single boiler if the code 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 (Systems 1, 5 & 7). Hot water design supply temperature shall be modeled at 180°F and 130°F 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, 150°F @ 50°F and above, and ramped linearly between 180°F and 150°F at temperatures between 20°F and 50°F.

4.3.3.4 Hot Water Pumps (Systems 1, 5, & 7). The code building design pump power shall be 19 W/gpm [equal to a pump operating against a 60 foot 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 5 horsepower, pumps should be modeled as constant speed, riding the pump curve. For heating water systems with 300,000 Btu/h heating capacity and pumping energy of 5 horsepower or greater, user shall model variable speed pumps.

4.3.3.4.1 Hot Water pumps. The pump power for systems using District hot water shall be 14 W/gpm.

4.3.3.4.2 Heating Water Pump Control. Heating water pump operation shall be locked out whenever outside air temperatures are 70°F and above.

4.3.3.5 Type and Number of Chillers (Systems 5 & 6). Electric chillers shall be used in the code building design regardless of the cooling energy source except as noted under Section 4.3.1.1, District Thermal System. The code 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

Chiller Cooling Capacity	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 (Systems 5, 6, & 7). Chilled water design supply temperature shall be modeled at 44°F and 56°F 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 (Systems 5, 6, & 7). Chilled water systems shall be modeled as constant flow primary/variable flow secondary systems. The code 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 5 horsepower, pumps should be modeled as constant speed, with secondary pump riding the pump curve. For chilled water systems with 300,000 Btu/h cooling capacity and pumping energy of 5 horsepower or greater, user shall model secondary pump as a variable speed pump.

4.3.3.7.1 Chilled-water pumps. The pump power for systems using District chilled water shall be 16 W/gpm.

4.3.3.7.2 Cooling Water Pump Control. Cooling water pump operation shall be locked out whenever outside air temperatures are 55°F and below.

4.3.3.8 Heat Rejection (Systems 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 OEESC Table 503.2.3(7).

If chiller type as determined by Table 4.11 is water cooled, the heat rejection device shall be an axial fan cooling tower having fans with the capability to operate at two-thirds of full speed or less. Condenser water design supply temperature shall be 85°F or 10°F approach to design wet bulb temperature, whichever is lower, with a design temperature rise of 10°F. The tower shall be controlled to maintain a 70°F leaving water temperature where weather permits, floating up to leaving water temperature at design conditions. The code building design pump power shall be 19 W/gpm. Open cooling towers configured with multiple condenser water pumps shall be modeled so that all cells can be run in parallel with a turndown flow that is the larger of (1) the flow produced by the smallest pump or (2) 50 percent of the design flow for the cell.

4.3.3.9 Heat Recovery for reheat and service water heating where total installed heat rejection capacity of water cooled chillers exceeds 6,000,000 Btu/h the baseline system shall recover 30% of the peak heat rejection load at design conditions for preheat of service hot water systems or reheat design.

4.3.3.10 Supply Air Temperature Reset (Systems 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 7°F temperature difference under minimum load conditions.

4.3.3.11 VAV Minimum Flow (Systems 5, 6, & 7). VAV systems shall be modeled assuming a variable speed drive. Minimum volume setpoints for VAV reheat boxes shall be 20% 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 5,000 CFM of exhaust shall reduce the exhaust and makeup air volume during unoccupied periods to the largest of 50% of design values, the minimum outdoor air flow rate, or the airflow rate required to comply with the OSSC.

4.3.3.12 Large Volume Single Zone VAV (Sys. 3 & 4 > 8,000 CFM). Fan systems with supply airflow > 8,000 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 building design shall use the same energy source as the corresponding system in the proposed design and shall conform to the following conditions:

(a) Where a complete service hot water system exists, the code 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 OEESC Table 504.2.

(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 in OEESC Table 504.2 shall be assumed and modeled identically in the proposed and code 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 building system shall use separate systems meeting the minimum efficiency requirements applicable to each system individually.

4.5 Interior Lighting. Lighting power in the code building design shall be determined in accordance with either OEESC Section 505.5.2 Tenant Space Method and Table 505.5.2(a) or OEESC Section 505.5.2.1 Space-by-Space Method and Table 505.5.2(b).

4.5.1 Egress lighting. Egress lighting shall be modeled to shut off during unoccupied periods.
Exception: Building exits as defined in OSSC Section 1002.

4.5.2 Automatic lighting controls shall be modeled in the Code building design as detailed in OEESC Section 505.2.2.2.

4.6 Exterior Lighting. Lighting power in the code building design shall be determined in accordance with OEESC Section 505.6.

4.6.1 Exterior Lighting Controls. See requirements of OEESC Section 505.2.4

4.7 Other Systems. Other systems, such as motors not covered by the OEESC, 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.