Energy Trust of Oregon
New Buildings Program

Technical Guidelines

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DISCLAIMER

These Technical Guidelines are intended solely for use in connection with participation in Energy Trust of Oregon, Inc.'s (Energy Trust) New Buildings program (Program) and for the purpose of evaluating potential Program incentives. Program participants are responsible for their own independent verification of the application and relevance of these Technical Guidelines to their projects. While Energy Trust may provide funding for Program incentives, Energy Trust is not supervising any work performed for a Program participant, nor is Energy Trust responsible in any way for adherence to these Technical Guidelines or proper completion of that work or proper performance of any measure analyzed or implemented. **Participant assumes the risk of any loss or damage(s) that Participant may suffer in connection with reliance or analysis under these Technical Guidelines or ultimate installation of any identified measures.**

Energy Trust of Oregon's New Buildings program (Program) provides assistance to project owners, architects, engineers, contractors and others involved in commercial and industrial new construction and major renovation projects. Projects designed to include the installation of energy efficiency measures may be eligible for cash incentives and technical assistance.

These **Technical Guidelines** describe the technical requirements that projects submitting custom savings calculations using a **Modeled Savings or Special Measure Incentive Application** must meet to qualify for Energy Trust incentives. Program offerings, incentives and requirements are subject to change and availability; please ensure that you are referencing versions of Program documents currently in effect.

Energy Trust makes cash incentives available for the installation of building systems that are more energy efficient than those installed to meet minimum Oregon energy code requirements/standards in the same type building with similar occupancy. Any measure that contributes to reducing the overall energy consumption of the proposed design over that of a baseline building can be considered an energy efficiency measure (EEM) for analysis purposes. These items are typically related to the envelope, mechanical, electrical, lighting, and building controls systems. Energy Trust does not guarantee any particular energy or cost savings results from Program participation or measure installations.

The project owner's energy analyst will estimate first-year annual electric and gas savings of the EEMs through an energy model or other energy analysis, as described in these **Technical Guidelines**. The energy analyst will identify EEMs that pass the Program's **Cost-Effectiveness Calculator** test (see Section 2.3) and that have a simple payback period greater than one year for recommendation to the project design team. The analyst will submit the analysis to the Program for review in the form of an **Energy Analysis Report**. By its submittal of the analysis to the Program, the analyst represents that it has the authority to submit the analysis on behalf of project owner and that the analysis is truthful and accurate to the best of its knowledge and has been performed in accordance with these **Technical Guidelines**.

An **Energy Analysis Report Template** and **Savings Summary Worksheet** are available on the Energy Trust website at energytrust.org/business.

1.1 OREGON CODE REQUIREMENTS

Effective July 2014, the Oregon Building Codes Division adopted the 2014 Oregon Energy Efficiency Specialty Code (OEESC) to regulate the design and construction of buildings for the effective use of energy. We understand that during a phase-in period, from July 1, 2014 to September 30, 2014, building officials allowed the use of either the 2014 or the 2010 code. The code changes impact the available Energy Trust incentives that a project may receive; however, the changes did not impact these **Technical Guidelines** and other Program requirements. In instances where a project is exempt from Oregon code compliance or no code requirement is specified, the Program will accept common industry practice or relevant ASHRAE standards to establish the baseline.

1.2 MODELED SAVINGS (2010 AND 2014 CODE PROJECTS)

For enrolled 2010 and 2014 code projects seeking **Modeled Savings** incentives, the Program requires building energy simulation models. An **Energy Analysis Report** and **Savings Summary Worksheet** are also required (see Section 5).

Building energy simulation requirements include:

- Projects must use acceptable baseline system mapping, selection and assumptions as described in Section 2.2.
- EEMs must be modeled and tested for cost-effectiveness, as described in Section 2.3.
- Interactive effects between EEMs must be accounted for in the analysis as described in Section 2.4.
- Documentation requirements for energy simulations are described in Section 5.1.2.

1.3 SPECIAL MEASURES

For projects proposing to use energy efficient equipment that exceeds code requirements but does not qualify under one of the Program's standard equipment offerings, the Special Measure offering may be used. Special Measures may consist of specialized equipment that does not warrant a full energy model or cannot be designated as standard equipment. The Program may provide technical support to calculate energy saving estimates for these measures. For projects that are submitting energy calculations, requirements include the following:

- Projects must be tested for cost-effectiveness, as described in Section 2.3.
- Calculations must meet the requirements for spreadsheet and manual calculations in Section 3.

2.1 ENERGY SIMULATION PROGRAM SELECTION

Since there are limitations in the accuracy of modeling some EEMs with building energy simulation software, it is up to the energy consultant to choose an energy simulation program that is appropriate for the anticipated EEMs.

If the selected energy simulation program cannot explicitly model an EEM, the analyst may utilize a thermodynamically similar component model that can approximate the expected performance. For example, CFD modeling is effective at optimizing natural ventilation openings, quantifying airflow rates and predicting temperatures in the space. Such information is useful in creating informed input variables for energy simulation software. Analysts may utilize industry accepted methodologies when deficiencies in the model will not accurately calculate savings.

For projects approved for early design (also called design performance or simple box) modeling through Technical Assistance for Path to Net Zero, energy models must be completed prior to completion of the Schematic Design and must be capable of analyzing building orientation, building form, window to wall ratio, and/or mechanical systems.

2.2 BASELINE MODEL SELECTION, ADJUSTMENTS AND SYSTEM MAPPING

2.2.1 SEED Appendix L

Projects participating in the State Energy Efficiency Design (SEED) program, that are also participating in this Energy Trust of Oregon New Buildings program, will model the baseline and proposed facility per the SEED program requirements, which currently refer to the SEED Appendix L Building Modeling Guidelines - Revised October 1, 2010. See Section 4 for additional information on how Energy Trust of Oregon New Buildings reviews SEED project analysis for the purpose of determining Energy Trust incentive eligibility.

The Program requires that all other projects seeking Energy Trust **Modeled Savings or Special Measures** incentives model the baseline and proposed facility using the attached **Appendix A**, which are a slightly modified version of the SEED Appendix L created by the Program to incorporate some specific Energy Trust of Oregon New Buildings program technical requirements based on standard design practice and OEESC requirements.

In all cases the baseline must meet the minimum requirements of the Oregon energy code under which the project is permitted.

SEED Appendix L does not define all Oregon code requirements but focuses instead on the significant energy modeling parameters needed to define typical building energy systems. Thus, code requirements not highlighted in **Appendix A** still need to be accounted for by the energy analyst. Energy systems not regulated by the Oregon code must be modeled according to standard design practice (see Section 2.2.2 for examples). When common design practice is more stringent than a particular energy code requirement, the common design practice should take precedence. Standard design practice assumptions made by the modeler will be reviewed by the Program technical reviewers. For Program purposes, determination of standard practice has proven to be particularly important in specialty applications such as: data centers, central plants, swimming pools, hospitals, laboratories, arenas and industrial applications.

2.2.2 Baseline Modeling Adjustments

While the defined baseline requirements outlined in **Appendix A** are applicable to most buildings and systems, there are some instances in which the baseline assumptions appear to be inappropriate or unrealistic, or may limit the project's potential energy savings. The energy analyst is encouraged to contact the Program to discuss the baseline system selection and assumptions. During the model review, the Program may request that the analyst choose an alternative baseline HVAC system type that best represents industry standard practice.

When there is no clear code requirement for a specific modeling parameter, the analyst should reflect on what common design practice would dictate. When common design practice is more stringent than a particular energy code requirement, the common design practice should take precedence.

Appendix B documents acceptable baseline and general modeling assumptions for the equipment, scenarios or building types identified in Table 2-1.

Table 2-1: Project specific baseline assumptions noted in Appendix B

System or Equipment Type	Building Type
Waterside economizers	Grocery Stores
Condenser water reset strategies	Hospitals
Existing facility loads	Light Industrial Applications
Loads and redundancy	

For projects or systems that are unclear or that need further interpretation, the analyst should contact the Program.

For projects participating in the data center offering, please see **Appendix C** for requirements.

2.2.3 Avoiding Fuel Switching

Energy Trust cannot provide financial incentives for measures for converting or replacing electric or gas equipment to another fuel[1]. For new construction projects, the baseline system and proposed system being modeled must use the same fuel types, though not necessarily the same system types. Similarly, individual measures must be compared against baselines with the same fuel (e.g., electric-to-electric, gas-to-gas). Analysts modeling hybrid systems should select hybrid baseline systems as specified in Table 4.8 and 4.9 of **Appendix A**. Below are several examples of appropriate and inappropriate baseline selections for Program purposes. Additional detailed information on system specific fuel switching issues (e.g. pool dehumidification systems) is also provided in **Appendix B**.

Acceptable baseline selection:

- A VAV system with electric reheat has an electric heat source; therefore, the baseline model should be a VAV system with fan powered boxes with electric resistance.
- A water-source heat pump system with a supplemental boiler is a hybrid system; therefore, the baseline system must also utilize electric and gas heating sources, such as VAV systems with gas heating at the air handling unit and electric reheat.

[1] See Fuel Switching Policy Memo at http://energytrust.org/library/policies/4.03.000.pdf

- A VRF system combined with a DOAS with a gas furnace utilizes electricity for cooling and zonal heating, and gas for central heating. Therefore, an appropriate baseline system would be a VAV system with electric reheat and a gas boiler or furnace at the air handling unit.

Unacceptable or ineligible fuel system mapping:

- A building is modeled with air handling units with hot water coils served by a gas boiler in the baseline. The proposed design utilizes a more efficient envelope, thus minimizing the heating load significantly such that the system type is switched to packaged RTU's with small electric heating coils. In this case, the fuel has been switched from gas (baseline) to electric (proposed) and therefore would not be eligible for incentives for the switch in heating system.
- A packaged single zone system with a waste-oil heater has a waste-oil heat source. Regardless of the baseline fuel source, this system would not be eligible for incentives because there will always be a switch in fuel types from electric or gas to waste-oil when comparing the baseline and proposed models.

2.3 COST-EFFECTIVENESS REQUIREMENTS AND MEASURE DEFINITION

All measures must be analyzed individually to quantify energy savings for cost-effectiveness screening unless noted in the sections below. The following sections describe the cost-effectiveness tests and instances in which multiple energy efficient options may be defined as a single measure for cost-effectiveness testing.

2.3.1 Benefit-to-Cost Ratio Test

Efficiency measures must pass a benefit-cost ratio test using the **Cost-Effectiveness Calculator (CEC)**, which can be found in the **Savings Summary Worksheet**. Instructions on how to use the worksheet are included in the worksheet.

Each measure must have a combined societal benefit cost ratio (BCR) of at least 1 in order to be eligible for Program incentives. It is beneficial for the societal test to include other quantifiable non-energy cost savings or added value resulting from the measure, such as reduced maintenance or inventory, water savings, improved market value, improved marketability, etc. An explanation and supporting documentation regarding such non-energy cost savings must be included in the appendix of the **Energy Analysis Report**.

Typically, the sum of individual measure savings is greater than the actual achievable savings because of interactive effects between measures. When the savings values for the individual measures do not sum to the final interactive model savings, the values are pro-rated using a weighted average. Adjustment of the individual measure savings values are automatically performed in the **Savings Summary Worksheet**. The adjusted values are used in the BCR evaluation.

An approximation of the value of a single measure when acting in concert with all other measures is made by normalizing the individual values such that they sum to the interactive total by:

$IM_{CEC} = (IM)*(Int)/(\sum IM)$

Where:

IM_{CEC} = Individual measure value to be used in the CEC
IM = Individual measure value returned from model
Int = Total interactive combined case of all measures
$\sum IM$ = Total of individual measure values returned from model

2.3.2 Generally Recognized as Cost Effective Measures

Prequalified energy measures have been defined in Table 2-2. These are measures prequalified as likely to meet Energy Trust cost effectiveness criteria. In order to evaluate uptake and track incremental costs for use in the Energy Trust of Oregon New Buildings Program, these generally cost effective measures must be evaluated for project-level savings and incremental costs using the guidelines in this document. However, these prequalified measures are eligible to apply for and receive incentives regardless of such additional cost effectiveness analysis.

Table 2-2: Prequalified Measures

	Proposed Baseline Measure	**Prequalified Measure Efficiency or Size Limit**
Lighting and Lighting Controls	Interior Lighting - Reduced LPD Optimize fixture layout, spacing and orientation and efficient fixture selection	10 - 60% better than code
	Occupancy Sensors (exceeding code requirements)	Connected load > 300 W
	Egress lighting scheduled off during unoccupied periods	exceeding code
	Daylighting - exceeding code requirements: continuous or stepped dimming, on/off, or bi-level	Connected load > 300 W
Service Hot Water	Condensing tank hot water heaters	Efficiency > 94% AND only for the following building types: lodging, restaurant, laundry, and residential
	Low Flow Fixtures	Showerheads < 1.75 GPM Showerwands < 1.5 GPM Bath aerators < 0.5 GPM Kitchen aerators < 1.5 GPM
HVAC Equipment	Condensing Furnaces	AFUE > 91%
	Condensing Unit Heaters	Thermal Efficiency > 92%
	Hot Water Condensing Gas Boiler	AFUE > 94%
Fan and Delivery Systems	Specify efficient fans	Fans with mechanical efficiency > 70%
	VFDs on Supply Fan	exceeding code

2.3.3 Defining the Efficiency Measures

In some cases multiple efficiency options may be combined for cost-effectiveness screening, instead of being screened individually. Each of these cases is described in the following sections. For all measures that are defined based on these interactions, the participant must clearly demonstrate that these interactions are present.

2.3.3.1 Positive Energy Savings Interaction

Defining a group of efficiency options as a single measure is allowed when the measures have strong positive energy savings interaction (i.e., they save more together). In other words:

Combined Measure Savings		Individual Measure Savings
(A+B)	>	A+B

Example: Installing light shelves or other architectural features can enhance daylight harvesting, which allows for greater savings to be achieved by the installation of daylighting controls. Since these strategies enhance the savings achieved by each other, the light shelves and automatic daylighting controls may be analyzed as a single daylighting measure.

2.3.3.2 Negative Cost Interactions

Combining measures is allowed if the systems can be purchased, constructed or installed at a lower cost together than if they were individually installed[2], as shown in the following equation:

Combined Measure Cost		Individual Measure Cost
(A+B)	<	A+B

Example: Significant increases in building envelope performance may allow for a substantial reduction in the required heating/cooling capacity of an efficient HVAC system, reducing the cost of the mechanical equipment. In this situation, the increased envelope performance and efficient HVAC system may be analyzed as a single space conditioning measure.

2.3.3.3 Functionality Interactions

Combining measures may also be allowed if one or more of the systems would not be able function properly if the other systems were not implemented.

Example: A radiant heating and cooling system may only be able to adequately condition a space if high-performance glazing were installed that significantly decreased the space's heat loss/gain through the windows. Since one system is necessary for the other to properly function, the radiant system and high-performance glazing may be analyzed as a single space conditioning measure.

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[2] Minor volume discounts (i.e. a reduction in cooling load from 10 tons to 9.5 tons) do not meet the requirements for bundling, as there must be a reason why the cost is significantly lower- enough that the less cost-effective measure might pass.

2.4 MODELING INTERACTIVE EFFECTS

When measures are evaluated individually for cost-effectiveness, the interactions between the measures are not captured.

It is likely that the algebraic sum of the energy savings of the measures calculated individually will not equal the total energy savings calculated from the interactive model. Since the interactive model incorporates the interactive effects of all the EEMs, the Program considers it the most accurate method for calculating the whole building energy savings.

The **Savings Summary Worksheet** will automatically adjust the savings for each measure using a weighted average approach such that the summation of the individual energy savings will not exceed the savings of the interactive model. These weighted energy savings are used in the cost-effectiveness screening. See 2.3.1 for more details on the weighted average methodology. Incremental costs for the measures are not modified by the spreadsheet.

2.4.1 Interactions between Standard and Modeled Savings Measures

Projects that are also applying for Program incentives for measures other than those identified for **Modeled Savings** must incorporate those measures into both the baseline and proposed models. For example, a Modeled Savings project that is applying for Standard measure incentives should incorporate the performance requirements and characteristics of those Standard measures in both the baseline and proposed models, rather than using the corresponding minimum code requirements in the baseline model.

2.4.2 Interactions between Modeled Measures

The Program accepts the following three approaches for energy simulation modeling used by an energy analyst to determine a measure's estimated energy savings. Regardless of the modeling approach used, an interactive model must be created to quantify the overall savings and the interactive savings must be indicated in the **Savings Summary Worksheet**.

<u>Subtractive baseline:</u> The as-designed building is run with all measures included. One measure is removed and the model is rerun. That measure is put back into the model and another is removed and the model is run again. This is done until all measures have been evaluated. The difference between the total interactive run values and the values determined when the measure is removed is considered the individual measure’s contribution. A code baseline model is also required to determine the final interactive energy savings.

This is viewed as the most conservative approach for ascertaining the savings associated with individual measures.

<u>Incremental or rolling baseline:</u> The measures to be included in the design are consecutively added to the baseline model with a run made for each measure to estimate the effect of that measure. It is possible that the sum of the individual savings will not equal the total for the interactive model. Care should be taken in the ordering of measures; those that are most likely to be implemented and most likely to be cost effective should be added first.

This is a more expensive approach. If a measure is removed or modified the model will have to be rebuilt from the point where that element was changed in the model. It is less conservative than the subtractive approach in measuring the effect of individual measures due to the fact that they are not tested against the background of the rest of the measures.

Individual approach: The measures are tested one at a time in isolation against the baseline. Selected measures are included in a final, interactive model. This is considered the least conservative approach to estimating the effect of individual measures in the final building design.

2.5 ENERGY MODELING BEST PRACTICES

This section describes modeling best practices for different systems and scenarios. Analysts should use this section as a reference for some basic adjustments that should be made and variables that should be checked in all energy models.

- **Equipment loads**: Modeling assumptions may underestimate the equipment load of the building. Since equipment loads are required to be the same in both the baseline and proposed models, this will cause the savings as a percentage of energy use to be overestimated. Additionally, because the equipment gives off heat that increases the cooling load, mechanical efficiency savings may be underestimated. The energy analyst should ask the owner and design team about planned equipment and plug loads in the facility in order to accurately estimate equipment loads and simulate building energy consumption.
- **eQUEST Quality Control Reporting tool**: Analysts are encouraged to utilize the new Quality Control Reporting tool within eQUEST (located in the "Tools" menu) that checks a model's EUI against national CBECS data. In addition there are several additional built-in checks and features that flag any unusual inputs or outputs associated with heating loads, cooling loads, unusual operating hours, lighting or miscellaneous loads, fan operation, etc.
- **Examination of building operating hours**: Energy analysts sometimes under- or over-estimate energy savings due to using incorrect building operating hours in the energy models. The energy analyst should ask the owner and design team about planned building operations outside of normal occupied hours. For example:
    - Does the owner have a flexible schedule policy that allows employees to arrive early or stay late?
    - What weekend work activity will occur?
- **eQUEST wizard defaults**: There are several eQUEST wizard input variables that need to be overridden on most energy models. **Appendix D** highlights several default values that should be reviewed by the energy analyst.
- **Available resources**: Analysts are encouraged to reference energy modeling resources that are publicly available. A list of some known resources is detailed in **Appendix E** for informational purposes.

Projects may submit spreadsheet or manual calculations only for measures that cannot be accurately represented by an energy model or for measures that are enrolled as a Special Measure. Analysts should contact the Program to determine if a measure can be analyzed using a spreadsheet or manual calculation. Interactive effects between these measures and modeled measures must be accounted for.

Spreadsheet or manual calculations must be performed in a manner that is clear and concise and uses industry accepted methodologies. All assumptions, constants, and equations used in the calculations must be clearly identified. Weather dependent measures, such as outside air economizer measure, should be modeled using an hourly or bin-based approach utilizing relevant data from the closest weather station so that site specific operating conditions are captured in the savings estimate.

The analyst must determine the energy savings of each EEM by subtracting the proposed annual energy consumption from the annual energy consumption of the corresponding baseline. The baseline for each EEM must meet the requirements described in these **Technical Guidelines** (see Section 2).

The analyst must also clearly identify the specific details (e.g. equipment and motor efficiencies, operating schedules, fan speed percentages) for each EEM and the corresponding baseline information used in the energy consumption calculations. The expected utility service provider and corresponding rate schedule must also be clearly identified, and these values should be used in the energy cost savings calculations for each measure.

If spreadsheet and/or manual calculations are used for a project, all of the following information must be included:

- A list of all assumptions, constants, performance values, and equations
- Interactions between measures should be accounted for in the calculations
- Documentation to identify and substantiate the assumptions and basis for all usage and weighting factors
- Clear documentation for proprietary, analyst generated, and/or manufacturer licensed spreadsheets/calculation tools. All formulas, assumptions and corresponding cell references shall be clearly identified. Documentation provided must give the Program reviewer a clear and logical progression of the results obtained from such calculation tools. User interface input and output data sheets are not acceptable substitutes for calculation documentation in lieu of the above requirements.
- All electronic spreadsheet calculations for each EEM, “unlocked”(i.e. please do not submit PDFs of spreadsheet calculations)
- All manual calculations for each EEM

To help expedite the review process, it is recommended that for spreadsheet calculations each EEM be provided on no more than one spreadsheet file (multiple worksheets are permitted). Multiple EEMs may be included in one spreadsheet using multiple worksheets as long as each sheet clearly identifies the corresponding EEM.

Section 4 State Energy Efficiency Design (SEED) Program Projects

SEED program participants may be eligible for Energy Trust incentives if the building is served by PGE, Pacific Power, NW Natural, or Cascade Natural Gas.

For projects participating in the SEED program, the SEED Appendix L Building Modeling Guidelines Revised October 1, 2010 document may be followed. Baseline EEMs identified and considered cost effective by the SEED program may be combined as a single bundled EEM in the supporting energy analysis and cost-effectiveness calculations submitted to the Program. The energy savings and incremental cost data for each of the analyzed EEMs will be used in the Program's cost-effectiveness calculations.

Where a comprehensive energy analysis report has been prepared for a SEED program project, the Program will allow that report to be submitted in lieu of the **Energy Analysis Report** mentioned in Section 5.1.1 below. However, the Program requires supporting calculations and documentation and a completed **Savings Summary Worksheet** to be submitted along with the comprehensive SEED energy analysis report.

SEED projects must identify the estimated annual electrical energy, natural gas energy, and energy cost savings between the code compliant building and the SEED building. Often SEED energy analysis reports tabulate savings results in terms of MMBtu. When using the **Savings Summary Worksheet** SEED projects should clearly identify the electrical, natural gas, and energy cost savings as follows:

For Baseline EEMs:

- Provide the total bundled measure annual electrical (kWh), natural gas (therm), and energy cost savings
- Provide the total interactive bundled measure incremental cost
- The measure life for the bundled baseline EEMs must be 17.7 years

The Program recognizes that SEED does not require cost effective analysis for the baseline EEMs and that costs for these measures may not be readily available and will require additional efforts by the analyst. However, the Program requires that the bundled package be screened for cost effectiveness.

For Analyzed EEMs:

- Provide the total annual electrical (kWh), natural gas (therm), and energy cost savings for each EEM
- Provide the incremental cost for each EEM
- The measure lives for each measure must be those established by Energy Trust in the **Savings Summary Worksheet** when applicable; in the event of conflict between the **Savings Summary Worksheet** measure lives and the SEED measure lives, the **Savings Summary Worksheet** measure lives shall be used.

Finally, the Energy Trust incentives will be based upon the total interaction between SEED baseline EEMs and additional individual analyzed EEMs that meet the Energy Trust of Oregon New Buildings program’s payback and benefit-cost ratio criteria.

Project owners seeking Energy Trust incentives using the **Modeled Savings Incentive Application (Form 520MS)** for 2010 and 2014 code projects must submit the following along with the application form:

- Completed **Energy Analysis Report** (.pdf format); a template is available at energytrust.org/business/
    - Baseline and proposed construction details, see Table 5-1
- Completed **Savings Summary Worksheet**, available at http://energytrust.org/commercial/incentives/construction-renovation-improvements/custom/modeled-savings
- All EEM energy savings calculations and energy simulation models
- Supporting equipment documentation:
    - Mechanical drawings and equipment schedules (.pdf format)
    - Lighting fixture plans and schedules (.pdf format)
    - Architectural floor plan(s) and elevations as needed (.pdf format)
    - Floor plan(s) identifying the various zones if necessary (.pdf format)
    - Equipment product information sheets indicating efficiencies, performance values, and specifications for proposed equipment used in the calculations. It is not required that the product information sheets submitted be "approved" submittal sheets. The purpose of these sheets is to provide manufacturer documentation and substantiation that the proposed equipment with the performance ratings and specifications used in the calculations is currently available in the market.
    - Schematic diagram showing the mechanical operation and/or layout of the EEM process (e.g. pool heat recovery system with dehumidification). These diagrams must be included for EEM systems that are not considered commonly used/installed or may not be easily understood using a written description. Include these diagrams in the Appendix section of the **Energy Analysis Report**, not as a separate document.
    - Documentation showing the incremental cost basis for the respective EEMs. The incremental cost is the difference in project cost between a proposed EEM and a code baseline design. This is to be provided through cost estimates/documentation signed by the project analyst, project engineer, and/or third party estimator. The baseline measure and cost, as well as the cost of the proposed EEM must be clearly defined. This information will be used to determine the cost effectiveness of a given EEM.

Please note: the Program reserves the right to ask for additional documentation during the review process.

Table 5-1 – Baseline and Proposed Construction Details

EXAMPLE

Construction Details	Actual Design	Oregon Energy Code Chapter-13/ SEED Appendix L
Total Conditioned Area (ft^2)		Same
No. of Floors		Same
Building Orientation		
Wall Construction		Used "Assembly Maximum" Value
Wall R-Value		R-13+R-3.8 ci
Roof Construction		Entirely Above Deck-"Assembly Maximum"
Roof R-Value		20 ci
Roof Color Reflectivity		0.30
Floor Construction R-value		Floor R-7.5 for 24 in below (Heated Slab on Grade)
Percent Glazing Area by Façade		Same
Glazing U-value		0.55
Glazing SHGC		0.40
Glazing Transmittance		N/A
Plant Details		
Heating System Type		Natural Draft Boiler
Heating System Efficiency		80%
HW Pump Rated Horsepower (HP)		Used 19 Watts/gpm calc from Appendix G
HW Pumping Controls		Variable Speed Pumping (Primary Only)
HW Supply/Delta T (F)		HWS=180F and HWR=130F
HW Temperature Controls		HW Reset: 180F @ 20F OAT, 150F @ 50F OAT
Cooling System Type		
Packaged Cooling EER - Including Fan Energy		9.0
Packaged Cooling EER - Not Including Fan Energy		10.49
Chilled Water Pumps Size (HP, Head, Flow)		N/A
Chilled Water Pumping Arrangement (CV, VFD)		N/A
Condenser Water Pumps Size (HP, Head, Flow)		N/A
Condenser Water Pumping Arrangement (CV, VFD)		N/A
Cooling Tower Size (Fan HP, airflow, tonnage)		N/A
Cooling Tower Controls (approach, CWST, CV, VFD)		N/A
DHW System		Same
Miscellaneous Loads (not effected by HVAC)		
Parking Lot Lighting (W/ft^2)		0.15
Stadium Lighting		
Mechanical Room (s) Lighting		
Exhaust Fans		
Internal Loads		
Lighting Power Density (W/ft^2)		Courthouse 1.2
Daylighting Controls		None
Lighting Controls		Schedule Control
Equip / Plug Load Density (W/ft^2)		Office 1.34 (ACM Manual N2.2) Office 0.75 (ASHRAE 90.1 User's Manual)
Occupancy Density		Same
HVAC		
System Type		
Total System Airflow		SAT to Zone T 20F Difference
Economizer Control		75F Lockout
Design OSA Ratio		Same
Minimum Zone Flow Ratio (CFM/SF)		0.4
Cooling Setpoint– Daytime/Night (F)		
Heating Setpoint– Daytime/Night (F)		
SA Temp Controls		SAT Reset Based on 5F Min.
Operating Schedules/Controls		
Occupancy		Same
Lighting		Same
Office Equipment		Same
Heating Setpoints		Same
Cooling Setpoints		Same
Infiltration		Same
HVAC Fans		Same
DHW		Same
Chiller Schedule		Same
Boiler Schedule		Same

5.1.1 Energy Analysis Report

The analyst will include the results of the energy analysis performed in accordance with these **Technical Guidelines** in a comprehensive **Energy Analysis Report**. The report must be written such that it can effectively communicate to the building owner:

- Baseline building and system description
- EEM descriptions, how they will operate and yield energy savings over a code equivalent building/system
- The estimated savings, costs and simple payback period of each EEM

Exception: Where a comprehensive energy analysis report has been prepared for a SEED project, the Program will allow that report to be submitted in lieu of the **Energy Analysis Report** mentioned in this section. However, the Program requires that analyst submit the completed **Savings Summary Worksheet** with the comprehensive SEED energy analysis report.

The **Energy Analysis Report** must contain the following sections and discussion. See the **Energy Analysis Report Template** for specific requirements for each section.

- EEM Savings Overview
- Building and System Description
- Summary of Energy Efficiency Measures
- Economic Summary
- Summary of EEM Costs
- Appendix

The Program will review the completed **Energy Analysis Report**, along with the submitted supporting calculations and documentation, to verify the estimated savings and incentives calculated for each EEM.

5.1.2 Energy Simulation Model

Energy simulation models must be submitted in electronic form. If proprietary software tools are used to justify energy savings and cannot be unlocked, supporting documentation must be submitted to clearly explain the methodology used to derive the resulting energy savings estimates to the Program's satisfaction.

The following information must be provided on projects that use energy simulation modeling:

- For DOE-2 based models:
    - Input Files
        - Input file (.inp)
        - Project file (.pd2)
        - Parametric run files, if applicable (.prd)
        - Weather file

    - Output Files
        - Simulation output file (.sim)
- For Trace models, the following input and output reports are requested:
    - Trace Inputs:
        - Project Information (Basic Project Information)
        - Room Information (Room Areas, People and Lighting Densities, Temp space Set-points, Ventilation and airflow info)
        - System Information (Airside system information, cooling and heating supply temps, control schemes like supply temp reset, fan information)
        - Room Assignment Tree (Which rooms are assigned to what system)
        - Plant Information (Equipment types and efficiencies, chilled and hot water resets)
        - Economic Information (Costs, study life, tax rates, inflation rates, first costs, maintenance costs)
        - Library Members (All the libraries that were used in the file would come from here; for example, wall construction, people and lighting schedules, equipment information, utility rates)
        - Walls by Direction (Areas of walls, glass area and U-factors, overhangs, and shading)
        - Weather file used in model run
    - Trace Outputs:
        - Monthly Energy Consumption (Total Monthly Electric and Gas Consumption)
        - Equipment Energy Consumption (Total Monthly Electric and Gas Consumption of each piece of equipment, including lighting and misc. loads)
        - Economic Summary (Total costs comparisons)
- Energy Plus
    - Inputs
        - .IDF for all measure runs
        - .EPW for the weather file used
    - Outputs
        - Annual Building Utility Performance Summary
        - Summary showing unmet load hours
        - Equipment Summary
        - System Summary
        - Envelope Summary
- For all other simulation programs, sufficient documentation of the simulation inputs and outputs must be provided, including the modeling files themselves. The Program reserves the right to request any additional documentation that may be needed to perform a comprehensive review of the simulations.

Program staff will execute the modeling files to review and verify that the baseline inputs meet the baseline requirements described in these **Technical Guidelines** and energy savings estimates are reasonable. If the inputs or resulting estimates do not appear to meet Program requirements, the Program may require a revised analysis or request additional information. Energy Trust's review is for Program purposes only, so we can clearly understand the scope of the project, proposed EEMs, and source of the energy savings and confirm whether or not proposed EEMs appear to be eligible for Energy Trust incentive funding. Final determination of whether EEMs are eligible for Program incentives rests with Energy Trust.

Appendix A

See attached document: Modeling Guidelines based on SEED Appendix L - Revised October 1, 2010, as Modified by Energy Trust of Oregon New Buildings Program, v. January 2016.

(Not intended for SEED program purposes, this document has been modified and is intended solely for use with the Energy Trust of Oregon New Buildings program)

Appendix B

Project or System Specific Baseline Assumptions
Below is a list of measure interpretations that have been made. Note that the categories listed below are organized by system type or characteristic and project type.

System Size or Type

Condenser water reset strategies. Condenser water reset strategies for larger central plants are eligible for incentives, provided the baseline chilled water plant incorporates a minimum level reset down to 70°F, per **Appendix A**. Additionally, a cooling tower fan energy penalty must be accounted for in the proposed model. Condenser water reset modeled below 60°F needs to be supported by chiller manufacturer selection data run for site conditions and anticipated chiller part load.

Existing facility loads. If a new central plant is designed to offset the heating and cooling load from an existing plant during the non-peak operating conditions when the new plant has excess capacity, energy savings may be credited for the load displaced from the existing plant to the more efficient plant. However, sufficient documentation must be provided with the energy model and savings calculations validating what capacity, including hours of expected load, is available from the new plant to transfer load and what load demand in the existing plant operation is displaceable. Any piping or pumping constraints between the two systems should be considered. Existing plant auxiliary energy uses that continue to operate to support the transfer of energy from the new plant need to be accounted for.

Loads and redundancy. Modeled loads should represent the maximum heating and cooling capacity, excluding redundancy or undocumented future expansion loads. Additionally, central plants are often built to initially serve a new load, but there may be plans to tie future expansions into the plant. Energy savings may only be captured for the known connected load of the plant, as documented by design and construction documents and load calculations. If sufficient documentation is not available at the time of the plant design and construction, the Program may de-rate the savings to account for this uncertainty.

Building Types:

Refrigeration systems for grocery applications. Refrigeration systems for grocery projects are not regulated by OEESC, and there is minimal guidance in SEED Appendix L or ASHRAE Appendix G on appropriate baseline assumptions for a new construction grocery project. Therefore, industry standard practice should be used as the baseline in combination with refrigeration requirements noted in the Federal Energy Independence and Securities Act (EISA) 2007. These minimum industry standards and Federal baseline assumptions have been collected and are illustrated in the Table B-1 below. All grocery projects modeling or estimating energy savings through calculations should incorporate these assumptions into the baseline model or calculations. Other general building baseline assumptions not indicated in the table below (i.e. insulation requirements, lighting power density allowances, HVAC equipment type and efficiency) must comply with OEESC and these **Technical Guidelines**, including **Appendix A**.

Refrigeration systems for grocery applications are categorized in the table below into three different store types: convenient stores (5,000 - 35,000 sq.ft), grocery stores (35,000 – 50,000 sq.ft) and supermarkets (50,000 – 150,000 sq.ft).

Table B-1: Baseline Assumptions for Refrigeration and Grocery

<table>
<tr><th></th><th>System Characteristic</th><th>Baseline Assumption</th><th>Application</th></tr>
<tr><td rowspan="12">Refrigeration System</td><td>System configuration</td><td>Single stage parallel systems</td><td rowspan="11">Grocery and supermarket</td></tr>
<tr><td>Refrigerant</td><td>R-404a</td></tr>
<tr><td>Subcooling</td><td>None</td></tr>
<tr><td>Ambient</td><td>For air-cooled systems; 2009 ASHRAE Handbook Fundamentals, Chap.28, 1% dbt</td></tr>
<tr><td>Condensing</td><td>Air-cooled condenser</td></tr>
<tr><td>Condenser design conditions</td><td>The normal baseline simulation at standard conditions is 10˚F and 15˚F above design ambient condensing temperature for LT & MT system, respectively</td></tr>
<tr><td>Condenser efficiency</td><td>Specific condenser efficiency of 53 Btu/h/Watt at 10˚F TD (standard practice)</td></tr>
<tr><td>Condenser control</td><td>Fixed setpoint using condenser fan cycling based on discharge pressure</td></tr>
<tr><td>Minimum condensing temperature</td><td>85˚F</td></tr>
<tr><td>Compressor control</td><td>Electronic sequencing</td></tr>
<tr><td>Heat reclaim off of refrigeration system</td><td>Heat reclaim for service hot water</td></tr>
<tr><td>Supermarket</td></tr>
<tr><td rowspan="5">Cases and walk-ins</td><td>Case and walk-in fan motors</td><td>Shaded pole in display cases; ECM’s in walk-in evaporator coil</td><td>Convenient store, grocery, supermarket</td></tr>
<tr><td>Display case lights</td><td>Standard efficiency fixtures (typically T8)</td><td>Convenient store, grocery, supermarket</td></tr>
<tr><td>Defrost controls</td><td>Electric (low temp), time-off (medium temp)</td><td>Convenient store, grocery, supermarket</td></tr>
<tr><td>Anti-sweat heater control (LT reach-in cases)</td><td>Modulated based on relative humidity</td><td>Grocery, supermarket</td></tr>
<tr><td>Evaporator coil TD (walk-ins, coolers, and freezers)</td><td>TD of 10˚F</td><td>Convenient store, grocery, supermarket</td></tr>
</table>

Hospital HVAC Systems. SEED Appendix L or ASHRAE 90.1 Appendix G would assign hospitals a VAV system for the main air handler. Often the actual design of hospitals is constant volume reheat for the main air handling unit because the minimum required airflow (air-change-rate) is high and applying VAV terminal units to modulate zone airflow would result in very little turn down. Hospital constant volume systems have high filtration requirements and large duct distribution systems which results in large static pressure requirements. In some designs constant volume terminal units are added to regulate air pressure and airflow between different zones of the hospital. These terminal units add additional pressure. Hospitals that are designed with constant volume systems should also model constant volume systems with the addition of allowed fan pressure credits in the baseline, as follows:

- **Zone Isolation - Special Temperature and Humidity Requirements or High Air Exchange Rates:** Specialty zones (surgery suites, labs, contagious isolation, imaging rooms, etc.) within the hospital should have separate dedicated HVAC units modeled as constant volume in both the baseline and proposed models. This example highlights a scenario in which it makes sense to deviate from the SEED Appendix L and select a baseline typical of the industry.

- **Zone Isolation - Schedule Differences:** Hospitals are very diverse and have many different occupancies and functional use areas. These areas often have different operating schedules, i.e. hospital patient rooms 24/7 vs. medical clinic offices that close at night. Code requires spaces that have different occupancy schedules be served by different HVAC systems or that the HVAC system be zoned in a manner which isolates (airflow and temperature control) unoccupied areas from occupied areas.

Light Industrial Systems. SEED Appendix L or ASHRAE 90.1 Appendix G would dictate that the baseline for a light industrial space > 45,000 sq.ft. would be a VAV system. In practice, it is common for these spaces to be constant volume (CV) because there is a continuous internal process load or heat gain, regardless of time of year or outdoor air temperature. Modeling a VAV system in the baseline would result in inflated baseline energy consumption, because the system is never able to turn down and static pressure of a VAV system is higher when compared to a CV system. In this scenario, it would make sense to deviate from the baseline based on the actual operating conditions.

Appendix C

See attached document: Data Center Offering - Technical Specifications.

Appendix D

eQuest Wizard defaults

There are currently several eQUEST wizard input variables that should be checked by the analyst to determine if they are appropriate for the energy models.

- <u>eQUEST fan and equipment part load performance curves:</u> The VAV with VFD fan speed control part load performance curve is known to understate energy use. This default curve should be changed to a forward curve fan with discharge damper. The same issue relates to various equipment part load performance curves.

- <u>Heating and cooling sizing ratios</u>: The eQUEST wizard default sizing ratio is 1.0, but should be adjusted to comply with **Appendix A** for the baseline model (i.e. heating sizing ratio is 1.25 and cooling sizing ratio is 1.15)

- <u>HVAC system fan sizing ratio</u>: The default value for system sizing is 1.15, but should be adjusted to 1.0 for the code baseline model.

- <u>Building unoccupied heating and cooling:</u> The default command 'Stay Off" disables heating and cooling during unoccupied hours. This under reports modeled energy use. This input should be changed to 'Cycle on Any' to simulate actual building energy use, as fans and equipment often cycle on at night (particularly in the winter) to maintain the night set-back temperature setpoints.

- <u>Chilled water and hot water loops</u>: By default, chilled water and hot water loops controls run in 'standby' mode, meaning that the chillers / boilers run continuously year round, so they're available if needed. Often energy use associated with the chiller is inappropriately estimated during non-cooling months (i.e. November – February) as a result of this default. 'Demand' is usually a more appropriate option than 'standby' as it only allows cooling or heating to enable when there is a demand.

- <u>Fan energy in packaged equipment</u>: Fan energy in eQUEST is over stated in packaged equipment because eQUEST adds fan energy within packaged equipment (i.e. it's included in the equipment EER) AND fan energy based on the fan inputs for each piece of equipment, thus double counting the fan energy (and possibly fan energy savings) for a given system. To account for actual fan energy in the building, the equipment energy input ratio (EIR) should be overstated so that the overall EIR, calculated from the EIR and fan energy consumption values found in output report SV-A, represents the efficiency of the code baseline or proposed design equipment.

- <u>VAV systems:</u> Baseline VAV systems should be modeled such that one VAV system may serve the entire building with the following zoning restrictions:
    - Zones with thermal loads or schedules that vary from the rest of the building need to be excluded from the VAV system
    - Cooling and Heating temperature setpoints (terminal unit control deadband) as defined by owners design intent
    - eQUEST default terminal unit reheat temperature raise = 0. The actual VAV terminal unit design temperature raise should be entered by the analyst

Appendix E

Energy Modeling Resources*

ASHRAE/IESNA Standard 90.1: http://www.ashrae.org

DOE-2 and eQUEST resources: www.doe2.com/

Contrasting the Capabilities of Building Energy Performance Simulation Programs:
http://www.eere.energy.gov/buildings/tools_directory

IBPSA (the International Building Performance Simulation Association): http://www.ibpsa.org

onebuilding.org Discussion Group: http://www.onebuilding.org

YahooGroups EnergyPlus_Support: http://groups.yahoo.com/group/EnergyPlus_Support/

Simulation Research Group: http://simulationresearch.lbl.gov

Design Brief: Building Simulation: http://www.energydesignresources.com/resource/21/

Healthcare Modeling Procedures – 2009 Savings By Design:
http://www.pge.com/includes/docs/word_xls/mybusiness/energysavingsrebates/incentivesbyindustry/healthcare/2009_SBDH_Procedures.doc

HVAC Simulation Guidelines: http://energydesignresources.com/resources/publications/design-guidelines/design-guidelines-hvac-simulation-guidelines.aspx

State-of-the-Art Review: Whole Building, Building Envelope, and HVAC Component and System Simulation and Design Tools: http://web.stanford.edu/group/narratives/classes/08-09/CEE215/ReferenceLibrary/BIM%20and%20Building%20Simulation%20Research/Whole%20Building%20Simulation%20Review.pdf

Modeling of Ventilation Air Heat Recovery and Its Impact in High-Performance Green Buildings:
http://www.ibpsa.us/publications/modeling-ventilation-air-heat-recovery-and-its-impact-high-performance-green-buildings

Energy-Models Forum: http://energy-models.com/

**These resources are provided for information only. Energy Trust has no control over the nature, content or availability of any site listed. The inclusion of any links above does not imply a recommendation or endorsement of any views expressed within them.*

(Not intended for SEED program purposes, this document has been modified and is intended solely for use with Energy Trust of Oregon New Buildings program)

Modeling Guidelines*

based on

Appendix L

Building Modeling

Guidelines,

revised October 1, 2010

***Modified by and for**

Energy Trust of Oregon New Buildings program

use only

v. January 2016

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 Btu (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 Btu (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 and OMSC Chapter 4.

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 Device(s)	Conference Rooms, Meeting Rooms, Classrooms, Employee break rooms, Copying Rooms, Restrooms, Dressing/Locker Rooms and Offices < 300ft²	All Other Spaces
Occupancy sensor	0%	≤ 25%
Occupancy sensor and daylighting controls	0%	≤ 35%

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 OEESC.

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		
Fixed: including 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.

4.2.4.2.1 Code Baseline Thermal Performance. Non-metal frame windows have very low market share in commercial buildings, even though they have higher performance compared to metal frame windows. Projects utilizing non-metal frames in the building may model metal framed windows in the baseline model, i.e. U-value = 0.45 for 2010 and 2014 code projects.

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 Fuel / Building Type	Fossil Fuel and Purchased Heat[2]	Electric and Other	Hybrid Systems[3]
Residential	Sys 1 - PTAC	Sys 2 - PTHP	Sys 1 - PTAC
Non-Residential & 3 floors or fewer & < 25,000 ft^2	Sys 3 – PSZ-AC	Sys 4 – PSZ-HP	Sys 3 – PSZ-AC
Non-Residential & 4-5 floors & < 25,000 ft^2 OR 5 floors or fewer and 25,000 ft^2 - 150,000 ft^2	Sys 8 – Packaged VAV w/Reheat	Sys 9 – Packaged VAV w/PFP Boxes	Sys 10 – Packaged Hybrid VAV
Non-Residential & more than 5 floors or > 150,000 ft^2	Sys 5 – VAV w/Reheat	Sys 6 – VAV w/Reheat	Sys 7 – Hybrid VAV w/Reheat
Retail & 1 to 2 floors	Sys 3 – PSZ-AC	Sys 4 – PSZ-HP	Sys 3 – PSZ-AC
Heated-only Storage	Sys 11 – Heating & Ventilation	Sys 12 – Heating & Ventilation	Sys 11 – Heating & Ventilation

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, 7, 8, 9 or 10 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, 7, 8, 9 or 10, use separate systems conforming with the requirements of System 5, 6, 7, 8, 9 or 10 (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 No.	System Type	Fan Control	Cooling Type	Heating Type
Sys 1 – PTAC	Packaged Terminal Air Conditioner	Constant Volume	Direct Expansion	Hot Water Fossil Fuel Boiler
Sys 2 – PTHP	Packaged Terminal Heat Pump	Constant Volume	Direct Expansion	Electric Heat Pump
Sys 3 – PSZ-AC	Packaged Rooftop Air Conditioner	Constant Volume[1]	Direct Expansion	Fossil Fuel Furnace
Sys 4 – PSZ-HP	Packaged Rooftop Heat Pump	Constant Volume[1]	Direct Expansion	Electric Heat Pump
Sys 5 – VAV w/Reheat	Variable Air Volume with Reheat	Variable Volume	Chilled Water[2]	Hot Water Fossil Fuel Boiler
Sys 6 – VAV w/Reheat	Variable Air Volume with Reheat	Variable Volume	Chilled Water	Electric Resistance
Sys 7 – Hybrid VAV w/Reheat	Variable Air Volume with Reheat	Variable Volume	Chilled Water	Fossil Fuel Central Boiler & Electric Reheat
Sys 8 – Packaged VAV w/Reheat	Packaged Rooftop VAV with Reheat	Variable Volume	Direct Expansion	Hot Water Fossil Fuel Boiler
Sys 9 – Packaged VAV w/PFP Boxes	Packaged Rooftop VAV with parallel fan power boxes and reheat	Variable Volume	Direct Expansion	Electric Resistance
Sys 10 – Packaged Hybrid VAV	Packaged Rooftop VAV with Reheat	Variable Volume	Direct Expansion	Fossil Fuel Central Boiler & Electric Reheat

Sys 11 – Heating & Ventilation	Warm air furnace, gas fired	Constant Volume	None	Fossil Fuel Furnace
Sys 12 – Heating & Ventilation	Warm air furnace, electric	Constant Volume	None	Electric Resistance

1. Systems with cooling capacity greater than or equal to 110,000 Btu/h shall have supply fans controlled by variable speed drives – see Section 4.3.3.12
2. 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, 4, 11 and 12 each thermal block shall be modeled with a dedicated HVAC system. For system types 5, 6, 7, 8, 9 and 10 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 OEESC Section 503.2.5.1 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 **Economizers.** Code building systems shall have supply air economizers on each cooling system and shall be capable of operating at 100% outside air, even if additional mechanical cooling is required to meet the cooling load of the building. Economizer change-over temperature should be held fixed in both the proposed and code baseline unless HVAC equipment changes from Simple to Complex.

4.3.2.7.1 **Economizers for Simple HVAC Systems and Equipment.** Code baseline building systems with packaged equipment with DX coils[1] should be available for cooling anytime the outdoor drybulb temperature is less than 60°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.

4.3.2.7.2 **Economizers for Complex HVAC Systems and Equipment.** Code baseline building systems with cooling coils should be available for cooling anytime the outdoor drybulb temperature is less than the return air temperature.

Exceptions:
(a) Systems that are using water economizers capable of providing 100 percent of the expected system cooling load at outside air temperatures of 50F dry bulb / 45F wet bulb and below.

(b) Economizers shall not be used for systems 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 503.4.1.

[1] Packaged DX cooling equipment has internal control to prevent simultaneous economizer cooling and compressor cooling to prevent coil freezing at low load conditions.

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, 8, 9 & 10) = 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

4.3.2.9.1 Heat Recovery for Dedicated Outside Air Systems (DOAS) with Distributed Heating and Cooling Units. Code allows for two methods of providing ventilation air in distributed heating and cooling systems:

- Ventilation air can be introduced locally through a direct outside air duct. This method is often less expensive (less duct work), but limits the potential for heat recovery.
- A central ventilation system can be used; however, if the ventilation rate is larger than 5,000 CFM, 2010 and 2014 Oregon energy code would require heat recovery.

Projects pursuing distributed heating and cooling systems with centrally ducted ventilation may model the baseline with no heat recovery, provided the total ventilation air is less than 12,000 CFM.

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. Unoccupied temperature set points shall be simulated in the model with a minimum of 10˚F setback from the occupied setpoint. For example, a zone with an occupied heating set point of 70˚F would have an unoccupied heating setpoint of 60˚F.

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, 8 & 10). 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 capacity is less than 2.0 MMBtu or serves a conditioned floor area less than 66,500 sq.ft. If the boiler plant is larger than 2.0MMBtu or if the boiler plant serves more than 66,500 sq.ft. of conditioned space, the plant shall be modeled as having two equally sized boilers. Boilers shall be staged as required by the load. Lead boiler shall run until its capacity is reached and lag boiler will pick up remaining load.

4.3.3.3 Hot Water Supply Temperature (Systems 1, 5, 7, 8 & 10). 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, 8 & 10). The code building design pump power shall be a pump operating against a head pressure equal to the proposed design. The code building total pump efficiency (impeller and motor) shall meet the minimum efficiency requirements noted in Table 4.11 below.

Table 4.11[2]: Minimum allowable pump efficiency	
Pump flow (GPM)	Minimum combined impeller and motor efficiency (%)
100	55%
200	60%
350	65%
500	70%
1000	75%
2000	80%

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 a pumping energy of 5 horsepower or greater, the user shall model variable speed pumps. Additionally, two-way valves shall be modeled for variable pumping systems, while constant volume systems should use three-way valves in the loop.

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, & 7). 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 4.12 as a function of building peak cooling load.

2 Pump head and flow cannot be realistically estimated for a wide range of building types and sizes; however, the pump and motor efficiency can be estimated for a range of flow conditions.

Table 4.12 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 variable primary pumping systems. The code building design pump power shall be a pump operating at a head pressure equal to the proposed design. 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 pumping energy of 5 horsepower or greater, the user shall model variable speed pumps. The code building total pump efficiency (impeller and motor) shall meet the minimum efficiency requirements noted in Table 4.11(above).

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, & 7). If chiller type as determined by Table 4.12 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 4.12 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 a pump operating against a head pressure equal to the proposed design. The code building total pump efficiency (impeller and motor) shall meet the minimum efficiency requirements noted in Table 4.11. 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 40% of the design supply flow rate, or equivalent to the minimum ventilation rate, whichever is greatest.

Exception: Systems serving laboratory spaces with a less than 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 OEESC.

4.3.3.12 Large Volume Fan Systems.

4.3.3.12.1. Fan systems with supply airflow > 8,000 CFM and without direct expansion cooling coils that serve single zones 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.

4.3.3.12.2. All air-conditioning equipment and air handling units with direct expansion cooling and a cooling capacity at AHRI conditions greater than or equal to 110,000 Btu/h that serve single zones shall be modeled as variable flow systems, assuming a variable speed drive. At cooling demands of less than or equal to 50%, supply fan controls shall reduce airflow to no greater than the larger of the following:

1. Two-thirds of the full fan speed, or
2. The volume of outdoor air required to meet the minimum ventilation air requirements.

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 Chapter 2.

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.

Energy Trust of Oregon
New Buildings Program

Technical Guidelines – Appendix C:

Data Center Offering Technical Specifications

August 2016

Appendix C

Energy Trust is currently making a data center offering available to address the specific needs of data centers participating in its New Buildings program (Program). The Program is currently offering incentives for improved energy efficiency of HVAC measures and power distribution systems as well as for increased efficiency of the IT equipment. Potential energy efficiency measures include, but are not limited to, the following:

- Efficient IT and networking equipment
- High efficiency UPS
- High efficiency DX cooling
- Optimized chilled water plant
- Low pressure drop design
- Alternative HVAC systems (i.e. evaporative cooling, extended economizer operation)
- High efficiency lighting and controls

This Appendix C document is specific to the Program's data center offering and describes Program requirements and technical guidelines that vary from, or are in addition to, the main **Technical Guidelines**. All **Technical Guidelines** requirements apply to submitted data center projects, subject to the following. If a specific requirement listed in the **Technical Guidelines** differs from a requirement in this Appendix C, then the Appendix C requirement applies. If you have any questions about the Program's applicable technical requirements for a potential data center project, contact a Program representative.

C.1 DATA CENTER OFFERING

Data center projects can apply for incentives through the **Special Measure Incentive Application (Form 520SM)** or the **Data Center Multi-Incentive Application (520DC)**. Please refer to these forms for specific requirements.

C.1.1 Special Measures

Data centers whose size and efficiency goals do not require full energy modeling, particularly smaller, localized data centers and server rooms and closets located within another building type, can apply for incentives through the **Special Measure Incentive Application (Form 520SM)**. The Program has tools to assist project owners with calculating the energy savings from high efficiency UPS units, rectifiers and transformers.

C.1.2 High Performance Data Center Offering

Data center project owners who choose to use whole building modeling to optimize energy performance and calculate estimated energy savings can apply for incentives through the **Data Center Multi-Incentive Application (520DC)**. Before submitting **Form 520DC**, the project owner should meet with an Energy Trust representative in a "Project Planning Meeting" to determine whether the project will pursue the Program's High Performance data center path or if use of the Special Measures and calculators is appropriate. The Data Center Multi-Incentive Application allows projects to apply for the following incentive offerings:

- Early Design Assistance – helps offset the cost of holding a collaborative project team meeting to discuss energy-related topics with the entire project team (see **Form 520DC** for required discussion topics).

- Technical Assistance – used for energy modeling or other technical activities undertaken to aid in design decisions that lead to increased energy performance. Eligible activities include whole building modeling (using energy simulation software) or developing comprehensive spreadsheet calculations, CFD analysis, or additional studies that support energy-related decisions.
- Construction Document Review Meeting – held to ensure the project continues to meet energy performance targets. Project must submit construction documents and agenda prior to meeting.
- Modeled Savings Incentives – available for energy efficiency savings resulting from installation of qualifying energy measures. Measures must exceed applicable Oregon Energy Efficiency Specialty Code and other baseline requirements set by the Program and must pass the Program's cost effectiveness requirements.

C.1.4 Multiple Use Projects

Contact the Program to determine eligibility for projects with multiple space types that include data centers, for example an office building with a data center. Eligibility will be based on the portion of the building energy use attributed to the data center, whether mechanical systems are separate or inter-related, and data center efficiency goals (i.e. Special Measures versus High Performance Data Center path).

C.2 ENERGY MODELING AND MODELED SAVINGS INCENTIVES

C.2.1 Energy Modeling vs. Spreadsheet Calculations

While project owners may elect to complete a whole building energy model for many reasons, many data center measures may also be calculated using spreadsheet models. This is due to the continuous operation of a data center and high process loads and low weather-related loads. Please contact the Program with any questions about the best approach for calculating energy savings.

C.2.2 Analysis Documentation Requirements

Project owners seeking Energy Trust Technical Assistance incentives using the **Multi-Incentive Application: Data Centers (Form 520DC)**, must submit the requirements listed on that form in Section 4 - Modeled Savings: Steps to Participate. See Section 5 – Energy Analysis Documentation of these **Technical Guidelines** for additional details on supporting documentation. Please note: the Program reserves the right to ask for additional documentation during the review process.

C.3 BASELINE DEVELOPMENT

C.3.1 System Selection

Data centers are process-intensive spaces which do not fit within the system mapping guidelines in **Modeling Guidelines based on Appendix L Building Modeling Guidelines** included in the Program **Technical Guidelines**. The size of the data center, the design load, the proposed system type and other design factors, as well as what is considered standard design practice, influence the baseline selection. Therefore, the Program works individually with data center project owners to establish a site-specific baseline HVAC system baseline. **Baseline system selection will be discussed during the Project Planning Meeting.**

The following describes several characteristics that are used in determining the appropriate baseline system.

Size of Data Center

In general, the size of the data center will have an impact on the type of system selected for the baseline. For smaller data centers, typically those with a cooling load of less than 300 tons (3,600,000 Btu/h), the prevalent system type consists of DX CRAC units placed on the data center floor. For larger data centers, the typical baseline system would consist of a chilled water system (typically a water-cooled chiller with cooling tower) serving CRAH units located on the data center floor. Specifics on the baseline design parameters for these systems can be found in Table C-1.

Economization

The 2014 Oregon Energy Efficiency Specialty Code (OEESC) requires the use of economizers on simple and complex HVAC systems for most data centers, as per §503.3.1 and 503.4.1. Air economizers are required that are capable of operating at 100% of outside air, even if additional mechanical cooling is required (integrated economizer operation). Exceptions are limited to cooling equipment less than 54,000 Btu/h total cooling capacity (total of all units shall not exceed 240,000 Btu/h), cooling equipment serving new computer rooms in an existing building (up to 240,000 Btu/h of new equipment) or cooling equipment serving an existing server room in an existing building (up to 600,000 Btu/h of new equipment) data centers. Additionally, for complex HVAC systems, an exception to this requirement allows the air economizer to be replaced with a water economizer system capable of cooling air by direct and/or indirect evaporation and providing 100% of the expected systems cooling load at outside air temperatures of 45°F dry bulb and 40°F wet bulb and below.

In general, projects with an air economizer in the proposed system will have an air economizer in the baseline and projects with a water economizer will require a water economizer in the baseline, unless economization is not required by code.

C.3.2 Other Baseline Criteria

Table C-1 also includes detailed information on specific modeling requirements for parameters outside the HVAC system, including but not limited to airflow requirements, lighting, and power distribution equipment efficiencies.

C.3.3 Assumptions on Data Center Loads

Another important factor in determining energy saving estimates for data center projects is estimation of the operating IT load. While the data center cooling load for the baseline case is assumed to be equal to the proposed case for HVAC-related measures, it typically is not 100% of the design capacity of the cooling system serving the data center. The Program uses a total IT load equal to 50% of the design load for the average load expected for the **first two years** of the data center operation. Projects may demonstrate that lower or higher baseline load percentages should be used. Supporting documentation will generally be required for these exceptions. **Please contact the Program for additional details.**

Table C-1: Data Center Baseline Assumptions

Acronym	CRAC-DX	CRAH-WC	
Baseline System Type	CRAC or AHU, DX Air- Cooled	CRAH, Water-Cooled Chiller	Notes / Basis / References (See 'Baseline References' tab)
Envelope	2014 OEESC / Technical Guidelines	2014 OEESC / Technical Guidelines	OEESC = Oregon Energy Efficiency Specialty Code, 7/1/2014
Plant			
Cooling System Type	Unitary DX	Chiller, Cooling Tower	
DX / Chiller EER/IEER (ILPV)	2014 OEESC - Table 503.2.3(9)	2014 OEESC - Table 503.2.3(7)	See Table 503.2.3(9) for minimum efficiency requirements for air conditioners and condensing units serving computer rooms and Table 503.2.3(7) for efficiency requirements for water-cooled chillers.
Plant Sizing		Plant shall be sized to satisfy 115% of the design plant cooling load	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016 (page 43)
Coil Sizing	Sized to provide 120% of design load at 0.5% design dry-bulb temperature and the corresponding web-bulb temperature	Sized to provide 120% of design load at 0.5% design dry-bulb temperature and the corresponding web-bulb temperature	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016 (page 40)
Chilled Water Pump Energy	-	Pump operates at head pressure equal to proposed design, meeting minimum efficiency requirements in "Pump Efficiency" tab.	Energy Trust of Oregon New Building Program: Technical Guidelines v2016.1
Chilled Water Pump Design Flow	-	1.2 GPM/ton of chiller capacity (20F deltaT across evaporator)	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Chilled Water Pumping Arrangement	-	Primary: VFD (flow may not decrease to less than 30% of design)	Energy Trust of Oregon New Building Program: Technical Guidelines v2016.1
Condenser Water Pump Energy	-	Pump operates at head pressure equal to proposed design, meeting minimum efficiency requirements in "Pump Efficiency" tab.	Energy Trust of Oregon New Building Program: Technical Guidelines v2016.1
Condenser Water Pump Design Flow	-	2 GPM/ton of chiller capacity (12F deltaT across condenser)	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Condenser Water Pumping Arrangement	-	Constant Volume	Energy Trust of Oregon New Building Program: Technical Guidelines v2016.1
Condenser Water Design Temperatures	-	CWS: Lesser of 85F OR design WB + 10F CWR: CWS + 10F	Energy Trust of Oregon New Building Program: Technical Guidelines v2016.1 2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Cooling Tower Fan Energy (gpm/hp)	-	2014 OEESC - Table 503.2.3(8)	Includes spray pump energy as well for closed-circuit cooling towers.
Cooling Tower Controls	-	VFD	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Condenser Water Supply, Temperature Control	-	70F as weather permits, floating up to design temp	Energy Trust of Oregon New Building Program: Technical Guidelines v2016.1
Chilled Water Supply Setpoint (See Cooling Tower for CW temps)	-	50F	

Table C-1 (continued)

Acronym	CRAC-DX	CRAH-WC	
Baseline System Type	CRAC or AHU, DX Air- Cooled	CRAH, Water-Cooled Chiller	Notes / Basis / References (See 'Baseline References' tab)
Airside			
Economizer	Air Side: EXCEPT for these systems: 1. Units < 54,000 Btu/h, up to the greater of 20 tons OR 10% of total cooling per building 2. New system, existing server room, ≤ 50 tons 3. New system, new server room, existing building, ≤ 20 tons	Air Side: Full Air Side below SAT plus Integrated cooling for OSA temperatures between the SAT and RAT OR Water Side: Cooling Tower/Heat Exchanger to provide 100% capacity at 45/40F DB/WB	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Economizer Control	Full Air Side below SAT plus Integrated cooling from SAT to RAT OSA Differential dry bulb economizer control	Full Air Side below SAT plus Integrated cooling from SAT to RAT OSA Differential dry bulb economizer control	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Supply/Return Air Temperature	SAT: ≥ 60°F RAT: SAT + 20°F	SAT: ≥ 60°F RAT: SAT + 20°F	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Supply Fan Efficiency Metric	0.49 W/CFM (0.39 W/CFM if no economizer present)	0.39 W/CFM	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Supply Airflow Sizing	120% of design cooling load	120% of design cooling load	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Fan Control Based on Total System CFM	Variable Volume (CV if less than 5 tons of design load)	Variable Volume	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Supply Fan Power vs Flow Performance Curve	$PLR = a + b * FanRatio + c * FanRatio^2 + d * FanRatio^3$ where a = 0.027827882 b = 0.026583195 c = -0.0870687 d = 1.03091975	$PLR = a + b * FanRatio + c * FanRatio^2 + d * FanRatio^3$ where a = 0.027827882 b = 0.026583195 c = -0.0870687 d = 1.03091975	*PLR* = Ratio of fan power at part load conditions to full load fan power (limited to a minimum of 10%) *FanRatio* = Ratio of CFM at part load to CFM at full load 2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Supply Airflow Reset	Linear reset from 100% design airflow at 100% cooling load to 50% design airflow at 50% cooling load.	Linear reset from 100% design airflow at 100% cooling load to 50% design airflow at 50% cooling load.	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Supply Air Temperature Reset	Linear reset from 60F at 50% cooling load to 80F at 0% cooling load.	Linear reset from 60F at 50% cooling load to 80F at 0% cooling load.	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Hot/Cold Aisle Containment	Required if IT Load > 175 kW and design HVAC load > 5 tons	Required if IT Load > 175 kW	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Humidification Type	Same as Proposed	Same as Proposed	Requirements of 2014 OEESC, Section 503.2.4.9 Humidity Control shall be met.
Dehumidification	Cooling coil, no reheat	Cooling coil, no reheat	
Ventilation	0.08 CFM / SF	0.08 CFM / SF	ASHRAE 62.1-2007, Table 6.1, Misc. Spaces, Computer
System Controls	Shall maintain temperature and humidity requirements and prevent simultaneous heating and cooling by multiple units	Shall maintain temperature and humidity requirements and prevent simultaneous heating and cooling by multiple units	2014 Oregon Energy Efficiency Specialty Code

Table C-1 (continued)

Acronym	CRAC-DX	CRAH-WC	
Baseline System Type	CRAC or AHU, DX Air- Cooled	CRAH, Water-Cooled Chiller	Notes / Basis / References (See 'Baseline References' tab)
Internal Loads			
Lighting Power Density (W/ft^2)	0.95 in server room	0.95 in server room	2014 Oregon Energy Efficiency Specialty Code, Space-by-Space Method for Data Center
Lighting Controls	Same as proposed	Same as proposed	
Daylighting Controls	2014 OEESC	2014 OEESC	
Occupancy Density	Same as proposed	Same as proposed	
IT/Power Distribution			
Server **/** UPS Load	50% of design IT load for first TWO years of operation	50% of design IT load for first TWO years of operation	(provide supporting documentation for variations)
UPS Efficiency	(See 'UPS Efficiency' and "Rectifier Efficiency" tab) UPS type same as proposed	(See 'UPS Efficiency' and "Rectifier Efficiency" tab) UPS type same as proposed	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016 ENERGY STAR UPS and Rectifier Specifications
Power Distribution Unit Efficiency	See "PDU_TXFMR Efficiency" tab.	See "PDU_TXFMR Efficiency" tab.	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Building Transformer Efficiency	See "PDU_TXFMR Efficiency" tab.	See "PDU_TXFMR Efficiency" tab.	2016 PG&E Data Center Baseline and Measurement and Verification (M&V) Guidelines, February 2016
Server Power Supply Efficiency	At 115V: 85% @ 20% Loading; 88% @ 50% Loading, 85% @ 100% Loading At 230V: 87% @ 20% Loading; 90% @ 50% Loading; 87% @ 100% Loading	At 115V: 85% @ 20% Loading; 88% @ 50% Loading, 85% @ 100% Loading At 230V: 87% @ 20% Loading; 90% @ 50% Loading; 87% @ 100% Loading	Meets the 80 Plus Silver standard