Energy Trust of Oregon
New Buildings Program

Technical Guidelines

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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.

In 2009, the Oregon legislation (Senate Bill 79) was approved and signed into law which, among other things, directed the Director of the Department of Consumer and Business Services (subject to the approval of appropriate advisory boards) to adopt amendments to the state building code designed to reduce energy use in commercial construction by 15-25% over 2007 code provisions by 2012. Because projects which are permitted under the 2010 code will now have a different baseline than those permitted under the 2007 code, this change has prompted a redesign of our Program offerings. **The Oregon energy code that a project is subject to will determine which application forms a project owner should complete and which incentives will be available from Energy Trust.**

These **Technical Guidelines** describe the technical requirements that projects enrolled in either the **Custom Track** (2007 code projects) or submitting a **Modeled Savings Incentive Application** (2010 code projects) must meet to qualify for Energy Trust incentives.

Under each of the aforementioned Program offerings, 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). These items are typically related to the envelope, mechanical, electrical, lighting, and building controls systems.

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,** Savings Summary Worksheet for 2007 Code, and Savings Summary Worksheet for 2010 Code are available on the Energy Trust website at energytrust.org/business.

1.1 OREGON CODE REQUIREMENTS

Effective July 1, 2010, the Oregon Building Codes Division adopted the 2010 Oregon Energy Efficiency Specialty Code (OEESC) to regulate the design and construction of buildings for the effective use of energy. With this code change, Oregon's energy code, the 2010 OEESC, is now a stand-alone code and takes the place of Chapter 13 in the 2007 Oregon Structural Specialty

Code (OSSC). During a phase-in period, from July 1, 2010 to September 30, 2010, building officials allowed the use of either the 2010 OEESC or Chapter 13 in the 2007 OSSC.

Whether a project is subject to the 2007 or 2010 version of the Oregon energy code will 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 CUSTOM TRACK (2007 CODE PROJECTS)

For enrolled 2007 code projects seeking **Custom Track** incentives**,** the Program does not dictate any specific required analytical approach. Custom spreadsheets, building energy simulation models, manufacturer's calculator tools, and other analyses recognized as standard engineering practice are considered acceptable. The analysis should reflect good engineering practice with a level of effort consistent with the complexity of the EEMs being considered. Regardless of the analytical approach, an **Energy Analysis Report** and **Savings Summary Worksheet for 2007 Code** are required as part of the **Custom Track** (see Section 5).

Spreadsheet and manual calculation requirements are described in Section 3.

Modeling requirements are discussed in the following sections:

- Projects must use acceptable baseline system mapping, selection and assumptions as described in Section 2.2.
- EEMs must be modeled individually and tested for cost-effectiveness unless bundling exceptions are allowable, 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 are described in Section 5.1.2.

1.3 MODELED SAVINGS (2010 CODE PROJECTS)

For enrolled 2010 code projects seeking **Modeled Savings** incentives, the Program requires building energy simulation models. An **Energy Analysis Report** and **Savings Summary Worksheet for 2010 Code** 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 2.22.1.
- EEMs must be modeled individually and tested for cost-effectiveness unless bundling exceptions are allowable, 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.

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 a 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 variable for energy simulation software. Analysts may utilize industry accepted methodologies when deficiencies in the model will not accurately calculate savings.

2.2 BASELINE MODEL SELECTION, ADJUSTMENTS AND SYSTEM MAPPING

2.2.1 SEED Appendix L[1]

The energy analyst must generally model the baseline and proposed facility using Oregon's State Energy Efficiency Design (SEED) program's Building Modeling Guidelines Appendix L[2], regardless of whether or not the facility is participating in the SEED program. Section 2.2.3 describes acceptable deviations from SEED Appendix L that are allowable in Energy Trust's Program. Projects permitting under the 2010 code must reference the revised version of SEED Appendix L, dated October 1, 2010. In all cases the baseline must meet the minimum requirements of the Oregon energy code under which the project is permitted.

2.2.2 Program Changes to SEED Appendix L

For Energy Trust's purposes, the Program has made changes to SEED Appendix L (see Appendix A) based on standard design practice and OEESC requirements.

SEED Appendix L doesn't define all Oregon code requirements, but focuses instead on the significant energy modeling parameters needed to define typical building energy systems. Code requirements not highlighted in SEED Appendix L 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 2.2.3 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. 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.

[1] ASHRAE 90.1-2007 Appendix G is currently being investigated by the Program for adoption into the Technical Guidelines. Projects that wish to reference Appendix G instead of SEED Appendix L should contact the program to determine if any adjustments must be made to the baseline model.

[2] It should be noted that SEED Appendix L was developed from ASHRAE 90.1 Appendix G and contains modifications and enhancements to comply with the intent of the OSSC Chapter 13 (2007 code version) and OEESC Chapter 5 (2010 code version).

2.2.3 Acceptable Deviations from SEED Appendix L or Code

While the defined baseline requirements outlined in SEED Appendix L and OEESC 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.

The following criteria are used by the Program to determine if an energy analyst may deviate from the SEED Appendix L HVAC system mapping or code requirements.

2.2.3.1 HVAC system mapping exceptions

While the defined HVAC mapping process outlined in SEED Appendix L generally works well there are some cases where the assigned baseline HVAC energy system is inappropriate and limits the project's potential energy savings. Common central HVAC systems, such as a variable air volume (VAV) system, generally serve medium to large buildings and can be inefficient because of the reheat energy associated with trying to serve cooling and heating loads with one common air duct. In addition to large reheat loads, the fan energy required to push air through an extensive ducting system is energy intensive.

Distributed HVAC systems consist of many smaller fan units or passive heating and cooling elements located throughout the building that generally serve individual zones. Zone temperature is controlled by applying heating or cooling as needed, removing the risk of simultaneously heating and cooling associated with a VAV system. Below are some examples of typical distributed system types:

- Passive radiant heating and cooling
- Active radiant heating and cooling
- Variable refrigerant flow (VRF) heat pump systems
- Water source heat pump systems

SEED Appendix L defines the baseline HVAC system for 2-story buildings less than 40,000 sq. ft. as a distributed HVAC system with packaged single zone systems. Standard design practice would suggest the baseline system would be a central VAV system. For situations were a VAV system would be a more appropriate baseline, VAV systems may be modeled in the baseline provided that supporting justification for the baseline switch is submitted by the analyst. Below are examples of criteria that may warrant modeling a VAV system in the baseline:

- Building must have cooling;
- Buildings that feasibly would not work well with packaged single zone systems (e.g. if structural constraints require smaller ductwork common to VAV systems, if there are roof space limitations, if there is a large diversity of interior and perimeter zones, etc.);
- Single story buildings must be larger than 20,000 sq. ft.; multistory buildings must be larger than 15,000 sq. ft.;
- Building type must be office. Other building types, such as large education or retail, must provide justification for why a VAV system should be applied in the baseline. No residential or multifamily buildings.

2.2.3.2 *Specific SEED Appendix L exceptions*

Analysts are encouraged to work with the Program to establish an appropriate baseline when the SEED Appendix L baseline is unrealistic. Below are examples of adjustments to Sections of SEED Appendix L that are allowable:

- *Section 3.7- Lighting allowances for automatic lighting controls* limits the reduction in lighting power modeled for daylighting or occupancy controls to 5-10%. An allowance may be taken for projects modeling occupancy and daylighting controls up to a 25% reduction in lighting power, where they are not required by code. This aligns with the Lighting Calculator assumptions used in other Program offerings.

- *Section 4.3.1- Code Baseline HVAC System Type and Description* defines the HVAC system type to be used in the baseline model. The system mapping described in Tables 4.8 and 4.9 may not be appropriate or compatible with the proposed building type. For example a 3-story 20,000 sq.ft. building would be required to model a VAV system with chilled water coils and reheat in the baseline, whereas a VAV system with DX coils may be more typical for that building type and size. Analysts should contact the Program to determine if a different baseline system (e.g. ASHRAE 90.1-2007 Appendix G baseline system mapping) may be used. It is recommended that this be established early in the design process, preferably when the analyst submits a proposed energy analysis plan to the Program.

- *Section 4.3.2.7 Economizers* requires an integrated economizer on code systems anytime the outdoor air temperature is less than 70˚F*.* Code baseline building systems may adjust the baseline model economizer assumptions with the following configuration in an effort to reflect actual economizer operation:
    - Packaged equipment with DX coils[3] – economizer cooling anytime the outdoor drybulb temperature is less than 60°F
    - Equipment with cooling coils – economizer cooling anytime the outdoor drybulb temperature is less than the return air temperature.

  Economizer change over temperature should be held fixed in both the proposed and code baseline unless HVAC equipment changes from packaged DX to cooling coils or vice versa.

2.2.3.3 *Specific code requirement baseline exceptions*

Analysts are encouraged to work with the Program to establish an appropriate baseline when the code baseline assumptions are unrealistic. Below are examples of adjustments to the baseline energy model that are allowable.

- Window U-Value: The code U-value for windows varies based on material type. For example, in the 2010 Oregon code, metal frame windows must have a U-value=0.45, while non-metal (wood, vinyl, or fiberglass) must have a U-value=0.35. Non-metal frame windows have very low market share in commercial buildings, even though they have higher performance compared to metal framed windows. Projects utilizing non-metal in

3 Packaged DX cooling equipment have internal control to prevent simultaneous economizer cooling and compressor cooling to prevent coil freezing at low load conditions.

the frames in the building may model metal framed windows in the baseline model, i.e. U-value=0.45 for 2010 code projects.

- Dedicated Outside Air Systems (DOAS) with Distributed Heating and Cooling Units: Code allows two methods for 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 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.

- Water Cooled vs. Air Cooled Condenser Cooling Systems: The minimum code-required efficiency for a chiller is dependent on the chiller type selected. Projects adopting higher efficiency water cooled systems may model the baseline system as an air cooled chiller for the following system types:
    - Water cooled chillers less than 300 tons
    - Rooftop packaged equipment with chilled water coil served by water cooled chiller vs. RTUs with DX mechanical cooling

2.2.3.4 Project or system-specific baselines

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	
Dehumidification systems for swimming pools and spas	

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.

2.2.4 Avoiding Fuel Switching

Energy Trust cannot provide financial incentives for measures for converting or replacing electric or gas equipment to another fuel[4]. 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 SEED Appendix L. 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 packaged AC units with a gas furnace.

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 unless the baseline is updated to an electric fuel source.
- 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 BUNDLING

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 measures may be bundled together for cost-effectiveness.

2.3.1 Benefit-to-Cost Ratio Test

Individual measures must pass a benefit-cost ratio test using the **Cost-Effectiveness Calculator (CEC)**, which can be found in the **Savings Summary Worksheet for 2007 Code** and the **Savings Summary Worksheet for 2010 Code**. Select the "Instructions" tab for instructions on how to use the worksheet.

Using the **Cost-Effectiveness Calculator** tab, each individual measure (or "bundle" of related measures, as described in Sections 2.3.2 through 2.3.5) must have a benefit cost ratio (BCR) of

[4] See Fuel Switching Policy Memo at energytrust.org/library/policies/4.03.000-P.pdf

at least 1.0 for both societal and utility cost effectiveness tests, as determined by the Program. 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 values for the individual measures do not sum to the final interactive model, 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 Pre-approved Measures for Cost-Effectiveness Screening

Pre-approved energy measures have been defined in Table 2-2. These are measures that have repeatedly proven to be cost effective and don’t require project-specific cost-effectiveness analysis. Measures in this table are measures that are commonly bundled together for SEED projects, measures that have been evaluated as Standard measures, or measures that have proven to be cost-effective in the HVAC and Lighting Calculator tools.

At the energy analyst’s discretion, any of the pre-approved energy measures from this list can be bundled together for cost-effectiveness screening. For each pre-approved measure, an efficiency limit has been set which represents that highest efficiency that was found to be cost-effective. Analysts working on a project with measures exceeding these limits should contact the Program to determine if the measures can be incorporated into the bundle of measures. To utilize the pre-approved measures, the analyst should prepare two baseline models: the code baseline model and the baseline model with the pre-approved measures bundled together. The pre-approved measures must be evaluated for cost-effectiveness as a group, so an incremental cost for the group of measure must be submitted with the project.

Table 2-2: Pre-approved Measures

	Proposed Baseline Measure	Efficiency or Size Limit For Which Measures are Pre-Approved
Envelope	Metal window frame with thermal break	U-value > 0.42
	Wood, vinyl, or fiberglass window frames	U-value > 0.28
	Tinted glazing	SHGC > 0.32
	Skylights- Metal window frame with thermal break	U-value > 0.55
Lighting and Lighting Controls	Interior Lighting - Efficient Design - Reduced LPD Optimize fixture layout, spacing & orientation and efficient fixture selection, (fixture CU)	< 25 % better than code
	Occupancy sensors (exceeding code requirements)	Connected load > 300 watts
	Automated selective switching (timeclock based)	Connected load > 2000 watts
	Automated selective switching (occupancy sensor backed)	Connected load > 1500 watts
	Egress lighting scheduled off during unoccupied periods	exceeding code
	Daylighting (exceeding code requirements) - continuous or stepped dimming	Connected load > 300 watts
	Daylighting (exceeding code requirements) - on/off	
	Daylighting (exceeding code requirements) - bi-level	
Service Water	90%-plus condensing tank hot water heaters	n/a
	Tankless / Instanteous gas water heaters	Energy Factor > 0.82 for unit capacities between 50,000 - 200,000 btu/h
	Low flow fixtures	Showerheads < 2 gpm, Shower wands < 1.5 gpm, Bath aerator < 0.5 gpm, Kitchen aerator < 1.5 gpm
HVAC equipment	Condensing furnaces	Efficiency < 96%
	Cooling-unit efficiency	> or equivalent to CEE Tier 2 efficiency levels
	Air-to air heat pump efficiency	
	Water-source heat pump	> 10% better than Oregon code values
VFD's	Heating water pumps	3 HP pumps only
	Chilled water or condenser water pumps	3 HP pumps only
	Cooling tower fans	3 and 5 HP fans
	HVAC supply or exhaust fans	3, 5 and 7.5 HP fans
Fan and Delivery Systems	Specify efficient fans	Fans with mechanical efficiency < 70%
	Minimize fan compotent and duct distribution pressure losses to reduce overall system brake horsepower	< SEED Appendic L and code limits
	Terminal fan power VAV boxes to reduce perimeter zone reheat	Fan systems > 10,000 CFM
Pumps and Delivery Systems	Increase cooling coil temperature difference	< SEED Appendic L limits
	Increase heating coil temperature difference	< SEED Appendic L limits
Misc.	High Efficient Transformers	Efficiency levels > federal requirements

2.3.3 Individually Analyzed Measures

In general, measures not included in Table 2-2 must be analyzed individually for cost effectiveness. A list of measures requiring individual analysis is available in Appendix D. Analysts are encouraged to use this measure list as a resource during project scoping or early design meetings to identify potential efficiency strategies and measures.

2.3.4 Bundling of Measures

In some cases measures may be bundled together for cost-effectiveness screening, instead of being screened individually. Measure bundling is allowed when the measures have strong positive energy savings interaction (i.e., they save more together) or when the measures can be purchased, constructed and/or installed at significantly lower cost together[5]. In other words:

Bundled Measure Savings or Cost		Individual Measure Savings or Cost
(A+B)	>	A+B

Measures that are interactive or interdependent in these ways should be bundled together. Measure bundling may also be allowed if a measure is not cost-effective alone but is cost-effective with an enhancement, provided that enhancement could not technically work on its own. The following examples highlight some typical cases, but it is expected that bundled measures will vary by project type and building operating characteristics.

- Improved envelope measures that reduce mechanical equipment costs: Envelope measures can be bundled with HVAC measures when envelope improvements are significant enough to allow for a substantial reduction in mechanical equipment size. The reduced mechanical equipment cost savings can be credited towards the added envelope measure costs.

- Architectural daylighting features and lighting control design: Architectural features such as exterior overhangs and fins or interior light shelves may be added to enhance daylight harvesting and create greater lighting savings. These same architectural features have a secondary benefit of blocking direct sunlight and solar heat gain from entering the building. The resulting reduction in cooling load adds additional savings. These effects all stem from the same measure. If the lighting savings are significant enough to allow reduction in mechanical equipment size, the mechanical equipment cost savings can be credited towards the daylight dimming controls and architectural features.

- Data center waterside economizer and hot/cold aisle separation: Hot and cold aisle separation allows warmer supply air temperature to be provided to the servers, thus increasing the number of waterside economizer operating hours. Evaluating these two EEMs as a bundle will typically identify greater energy savings than if these EEMs are assessed individually.

2.3.5 Adjusted Cost-effectiveness Requirements for Emerging Technologies

Energy Trust seeks to encourage promising innovative energy systems and emerging technologies. Some measures which are new to the market have “early adopter” cost premiums which adversely affects measure cost-effectiveness. While these measures may not currently pass the Program’s cost-effectiveness requirements, they may become cost-effective in the near future due to increased field experience or higher sales volume. To encourage the adoption of these measures, Energy Trust may allow non-cost-effective measures according to the following criteria:

- Measures must be on the Emerging Technologies list in Table 2-3.

[5] 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.

- Measures must have a Societal System BCR = 0.80 or greater.
- The final interactive model, including all pre-approved or individually analyzed measures, must have a Utility System BCR and Societal BCR greater than 1.0.

Table 2-3: Emerging technologies that qualify for a relaxed BCR = 0.8

Emerging Technologies
Radiant heating and cooling panels / chilled beams
Radiant heating and/or chilled floors
Evaporatively cooled HVAC units
Dedicated outside air system (DOAS) with heat recovery
Natural ventilation system without hybrid back up system
Heavy massed building without a mechanical refrigerant cooling system
Ground source heat pumps
Low temperature air source heat pumps
Displacement ventilation systems
Energy recovery chillers
Air-to-water heat pumps for waste-heat recovery off of exhaust air (e.g. bathroom exhaust)
Tankless condensing water heaters for space heating in small commercial applications
VAV systems with separate HVAC units for perimeter and core zones to minimize reheat
VAV systems with secondary cooling unit serving high loads to allow aggressive supply air temperature reset

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 affects of all the EEMs, the Program considers it the most accurate method for calculating the whole building energy savings.

The “EEM Inputs” tab of the **Savings Summary Worksheet** will automatically adjust the savings for each measure using a weighed 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, which can be seen in the **Cost-Effectiveness Calculator** tab. 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** (2010 code projects) or **Custom Track** (2007 code projects) 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**.

Subtractive baseline: 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.

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

Incremental or rolling baseline: The measures to be included in the design are consecutively added to the model with a run made for each addition to estimate the effect of the individual 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.

- **Baseline model energy use index (EUI):** Baseline models sometimes have a low EUI, which may indicate incorrect assumptions that result in lower energy savings. Energy analysts are encouraged to check the baseline model EUI against the Commercial

Building Energy Consumption Survey (CBECS) data or Pacific NW Commercial Building Stock Assessment (CBSA) data.

- **Equipment loads**: Modeling assumptions frequently 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 underestimate 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 E* 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 known resources is detailed in *Appendix F*.

2007 code projects may submit spreadsheet or manual calculations instead of an energy model. 2010 code projects may submit spreadsheet or manual calculations only for measures that cannot be accurately represented by an energy model. 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 indentified, 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”
- 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.

4.1 STATE ENERGY EFFICIENCY DESIGN PROGRAM PROJECTS (SEED)

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, 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.

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**; SEED measure lives may not 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 payback and benefit-cost ratio criteria.

Project owners seeking Energy Trust incentives using either the **Custom Track Incentive Workbook (Form 520C)** for 2007 code projects or the **Modeled Savings Incentive Application (Form 520MS)** for 2010 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 for 2007 Code** or **Savings Summary Worksheet for 2010 Code**, available at energytrust.org/business
- 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 or bundle of EEMs.

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

Table 5-1 – Baseline and Proposed Construction Details

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	E	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	X	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	A	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)	M	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	P	
Mechanical Room (s) Lighting		
Exhaust Fans		
Internal Loads		
Lighting Power Density (W/ft^2)		Courthouse 1.2
Daylighting Controls	L	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	E	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

<u>Exception:</u> 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:

- Baseline and proposed building input and output files (i.e. all .inp, .pd2, .prd, .sim files) for DOE-2 based models
- 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)

  - 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)

Program staff will review the modeling files to verify that the baseline inputs meet the baseline requirements described in these **Technical Guidelines** and to confirm that the energy savings estimates are accurate and 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

Program Changes to SEED Appendix L

Program recognized changes to SEED Appendix L are indicated below. Sections are organized in the order of SEED Appendix L sections. Underlined text indicates additions to the existing text. Text that is struck-out indicates removal of existing text.

4.3.2.12 HVAC Zone Thermostat Set points. 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 unoccupied heating set point of 70˚F would have an unoccupied heating setpoint of 60˚F.

4.3.3.2 Type and Number of Boilers (Systems 1, 5 & 7). The boiler plant shall use the same fuel as the proposed design and shall be forced draft, except as noted under Section 4.3.1.1, Purchased Heat. 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~~serves a conditioned floor area of 15,000 ft^2 or less, and 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 pickup remaining load.

4.3.3.4 Hot Water Pumps (Systems 1, 5, & 7). For heating water with pumping energy less than 5 horsepower, pumps should be modeled as constant speed, riding the pump curve. For heating water systems with~~ 300,000 Btu/heating capacity and~~ a pumping energy of 5 horsepower or greater, the user shall model variable primary speed pumps. Additionally, two-way valves shall be modeled for variable pumping systems, while constant volume system should use three-way valves in the loop.

4.3.3.4 Hot Water Pumps: The code building design pump power shall be a pump operating against a head pressure equal to the proposed design. ~~60 foot head pressure and 19 W/gpm [equal to a pump operating against a 60 foot head, 60% combined impeller and motor efficiency].~~ The code building total pump efficiency (impeller and motor) shall meet the minimum efficiency requirements noted in Table A-1 below.

Table A-1[6]: 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%

4.3.3.7 Chilled Water Pumps (Systems 5, 6, & 7). Chilled water systems shall be modeled as variable primary pumping systems ~~as constant flow primary/variable flow secondary systems~~. ~~The code building design pump power shall be 22 W/gpm~~

4.3.3.7 Chilled Water Pumps (Systems 1, 5, & 7). ~~Chilled water systems shall be modeled as constant flow primary/variable flow secondary systems. The code building design pump power shall be 22 W/gpm, [equal to a pump operating against a 70 foot head, 60% combined motor and impeller efficiency].~~ The code building design pump power shall be a pump operating at a head pressure equal to the proposed design ~~against a 70 foot head pressure~~. The code building total pump efficiency (impeller and motor) shall meet the minimum efficiency requirements noted in Table A-1 (above).

4.3.3.8 Heat Rejection (Systems 5 & 6) – pumping requirements. The code building design pump power ~~shall be 19 W/gpm~~ 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 A-1.

4.3.3.11 Proposed 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 equal to 0.4 cfm/ft2 of floor area, 40%[7] ~~20%~~ of the design supply flow rate, or equivalent to the minimum ventilation rate, whichever is greatest.

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

6 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.

7 Code allows the VAV reheat box airflow to increase to 50% of the design supply airflow rate during the heating mode. The referenced 20% airflow rate only applies when zone temperature is floating between heating and cooling setpoint – control deadband. Since simulation programs can't vary minimum airflow rates, an average value of 40% should be assigned. However, other code allowed design criteria may apply to minimum VAV reheat box airflow: 0.4 cfm/ft2 or equivalent to the minimum ventilation rate.

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

Waterside economizers. Per OEESC Section 503.4.1 Exception 2, water side economizers are required for cooling loads that are 10% or more of the total building cooling capacity and not served by air-side economizers. If a water-side economizer is sized to handle additional loads (beyond 10%) and there is additional load on the chiller during water-side economizer operating conditions, energy savings may be captured for incentives. In addition, projects should consider pursuing additional energy measures surrounding waterside economizers, such as optimizing controls or extending the waterside economizer operation beyond the code requirement of a 45˚F ambient wet bulb temperature.

- **Exception 1:** Waterside economizers in data centers in which the entire cooling load is a process load are required by section 503.4.1 Exception 5 of OEESC to provide a water-side economizer sized for that load.

- **Exception 2:** Waterside economizers in buildings or central plants supporting large facilities (hospitals, laboratories, campuses) which serve year round cooling loads of 50 tons or more are required to model waterside economizer performance per 503.4.1 Exception 1 of OEESC. Loads under 50 tons must be served by dedicated unitary cooling equipment. Chiller should be modeled off during winter operation.

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 SEED Appendix L. 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.

Dehumidification for swimming pools or spas. There are two types of systems used to maintain humidity for a swimming pool or spa space: supplying large quantities of relatively dry outside air and exhausting moist air from the pool room (also called push-pull ventilation) or using mechanical cooling for dehumidification. A typical code-compliant system for the Oregon climate, the push-pull ventilation system, is to be used as the baseline system. The wide array of dehumidification configurations and system performance doesn't allow for a prescriptive baseline description. Proposed dehumidification system performance needs to be compared to a baseline push-pull ventilation system with specific details based on system size, as follows:

Baseline for systems greater than 5,000 cfm supply air:

- Variable push-pull ventilation system - outside air volume varies to maintain humidity set point
- Minimum outside air during occupied periods must meet code-required ventilation per the 2010 Oregon Mechanical Specialty Code Table 403.3
- Exhaust air heat recovery system to heat ventilation air with minimum 70% sensible effectiveness of heat exchanger (this number may be revised based on info from coil mfgrs – although Innovent claims 75%; Munters 88%)
- Design supply airflow during occupied periods meets required air changes per hour

Baseline for systems that are less than 5,000 cfm supply air:

- Constant volume push pull ventilation system with constant volume of outside air to maintain humidity setpoint
- Minimum outside air during occupied periods must meet code-required ventilation per the 2010 Oregon Mechanical Specialty Code Table 403.3
- Exhaust air heat recovery system to heat ventilation air with minimum 70% sensible effectiveness of heat exchanger
- Design supply airflow during occupied periods to meet required air changes per hour

The main benefit of installing a dehumidification system is the ability to reduce outside air by using mechanical cooling to remove moisture as opposed to washing the space with larger quantities of OSA. One potential EEM includes using a heat pump dehumidification system with heat recovery for air reheat and pool water heating. In order to meet the code requirements, this system must have the evaporative coil located upstream of the exhaust air stream. A second possible measure is to use a heat pump/evaporative coil after sensible heat recovery in the exhaust air stream to recover additional latent energy.

Fuel switching has also been raised as an issue of concern for pool dehumidification system: A code-compliant pool ventilation system would provide varying quantities of outside air to remove excess moisture in a push-pull system with 70% heat recovery efficiency. Pool loads (space heating and pool water) would typically be served by a gas fuel source. A pool dehumidification system, on the other hand, uses a heat pump (i.e. electric fuel source) to dehumidify return air. Recovered heat from the dehumidification heat pump can be used to reheat the air during the heating season and to heat pool water. However, heating energy provided by a gas fuel source will likely still be required for meeting pool water heating and envelope heating loads. If the dehumidification system is used in a configuration that reduces the gas load below the code compliant baseline system without eliminating gas heating completely, these gas savings would be eligible for incentives.

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 SEED Appendix L.

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

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

Hospital HVAC Systems. SEED Appendix L or ASHRAE 90.1-2007 would assign hospitals a VAV system for the main air handler. Often the actual design of hospitals is a constant volume reheat system 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 follow:

- **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 the 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 manor which isolates (airflow and temperature control) unoccupied areas from occupied areas.

Light Industrial Systems. SEED Appendix L or ASHRAE 90.1-2007 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 line based on the actual operating conditions.

Appendix C

Beginning in 2012, a new data center offering is available to address the specific needs of data centers that participate in the Energy Trust of Oregon New Buildings. 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:

- High efficiency power supplies
- Low power processors
- High efficiency UPS
- High efficiency power distribution (i.e. higher distribution voltage)
- Airflow management (i.e. hot/cold aisle rack configuration, dependent upon baseline)
- High efficiency CRAC/CRAH/AHU unit selection
- High efficiency chillers
- Optimized cooling plant
- Alternative HVAC systems (i.e. evaporative cooling)
- High efficiency lighting and controls

The guidelines in this appendix describe variations from the main guidelines specified in the remainder of this document. It should be noted that, unless superseded by requirements in this section, all requirements included in the **Technical Guidelines** are applicable to data center projects.

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 Calculators and 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 developed calculators and tools to assist project owners with calculating the following special measures:

- Energy-efficient servers
- High-efficiency UPS
- High-efficiency chillers
- High-efficiency power distribution
- Other future measures (high efficiency DX CRAC)

These calculators may also be used in conjunction with the efficient and innovative data center offerings – please contact the Program for more information. Project owners can also apply for additional special measures not covered under the calculators.

C.1.2 Efficient and Innovative Data Center Paths

Data centers 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 must meet with an Energy Trust representative in a Project Planning Meeting so that the Program can determine if your project will be enrolled in the Efficient or Innovative data center path (see below for further information) or if the special measures and calculators will better serve the project.

Both paths offer incentives for early design assistance, technical assistance, and modeled savings; however, different requirements and incentive structures apply. See **Form 520DC** for requirements.

The Innovative path is targeted at projects that pursue an integrated design approach where efficiency opportunities across all energy systems (HVAC, IT, and electrical systems) are considered that may result in significant overall energy savings by reducing the IT load, delivering electrical power efficiently, minimizing airflow requirements and providing efficient cooling systems. Projects in the Innovative path are required to engage with the Program from early design (schematic design stage) through installation and site verification.

C.1.3 Determining Project Eligibility

All newly enrolled data center projects will be required to hold a Project Planning Meeting with a program representative to determine the most appropriate offering path: special measures, Efficient path, or Innovative path. The checklists below will be used by the Program to determine project eligibility for the various offerings.

Special Measure Checklist

✓	Participation in Project Planning Meeting
✓	Efficiency measures can be calculated using Program calculators or other simplified spreadsheet analysis

Efficient Path Checklist

✓	Participation in Project Planning Meeting
✓	Efficiency goals in at least one area of data center design (IT, power distribution, HVAC)
✓	Project warrants a whole building energy model and the proposed measure list includes multiple measures that are not covered by Program calculators

Innovative Path Checklist

✓	Participation in Project Planning Meeting
✓	Commitment to calculable efficiency improvements in **<u>ALL</u>** of the following areas:
	Server efficiency - Energy Star, high efficiency power supplies, etc.

	Power distribution efficiency - high efficiency UPS, PDU, higher voltage delivery, eliminate transformation steps, etc.
	HVAC efficiency - wider environmental operating range, high efficiency HVAC equipment, increased air- or water-side economization, containment, etc.
✓	Aggressive energy efficiency goals – minimum of 20% total energy savings over the baseline system (contact Program staff for additional information)
✓	Rigorous energy modeling (see Section 2.1). List additional analysis planned (computational fluid dynamics, advanced IT analysis, etc.
✓	Project owner's willingness to consider measures with simple payback period of up to 5 years
✓	Integrated design process will be used, including clearly defined design criteria (such as an Owner's Project Requirements document) that discusses environmental conditions, redundancy requirements, utilization rates, etc.
✓	Commissioning plan must include, at a minimum:
	Design review
	Integration of IT and HVAC systems
	Functional testing of HVAC controls and energy-related features
✓	Enrollment during schematic design or earlier
✓	Program invited to participate and provide input during a project design meeting consistent with the Innovative path requirements for early design assistance

C.1.4 Multiple Use Projects

For those projects with multiple space types that include data centers, for example an office building with a data center, please contact the Program to determine the most appropriate enrollment path. Eligibility will be based on 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. calculator and/or special measures versus Efficient or Innovative path).

C.2 ENERGY MODELING AND MODELED SAVINGS INCENTIVES

C.2.1 Energy Modeling vs. Spreadsheet Calculations

While projects may elect to complete a whole building energy model for many reasons, there are several data center measures that may be more easily and as accurately calculated using spreadsheets. This is due to the continuous operation of a data center and high process loads and low weather-related loads. Examples include the measures listed in Section C.1.1, as well as some HVAC systems that may not be easily modeled using eQUEST or other modeling software. 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 Stage 3: Steps to Participate. See Section 5 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 SEED Appendix L or ASHRAE 90.1 – Appendix G. 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 projects 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.

<u>Size of Data Center</u>

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, the prevalent system type consists of DX CRAC units placed on the data center floor. For data centers with overhead air distribution, the system type would consist of DX AHU. 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 (or AHU for overhead air distribution). Specifics on the baseline design parameters for these systems can be found in Table C-1. These parameters are based upon Oregon Energy Code and Sections 1 through 5 of these Guidelines.

<u>Economization</u>

The 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 systems serving new buildings (up to 240,000 Btu/h of new equipment) or existing buildings (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.

Integrated Economizers – Air economizers required in the baseline models should be set up for integrated operation. Set points used for integrated operation will be based on the supply and return temperatures that are dependent on the data center IT density, as shown in Table C-1. The integrated economizer operation should occur at outside temperatures between the supply and return temperatures.

C.3.3 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 (hot/cold aisle configuration versus full hot or cold aisle containment), lighting, and power distribution equipment efficiencies.

C.3.3 Assumptions on Data Center Loads

Another important factor in determining potential energy savings 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 server/UPS load equal to 50% of the equipment nameplate rating for the average load expected for the first two years of the data center operation. This accounts for the fact that servers are not typically loaded to 100%. However, projects may demonstrate that lower or higher baseline load percentages should be used. **Please contact the Program for additional details.**

Table C-1: Data Center Baseline Assumptions

System #	1	2	3	4	Notes / Basis / References (See 'Baseline References' tab)
Acronym	CRAC-DX	CRAC-CW	CRAH-WC	CRAH-AC	
Baseline System Type	CRAC or AHU, DX Air- Cooled	CRAC, DX, Condenser Water	CRAH, Water-Cooled Chiller	CRAH or AHU, Air-Cooled Chiller	
Envelope	2010 OEESC / SEED	2010 OEESC / SEED	2010 OEESC / SEED	2010 OEESC / SEED	OEESC = Oregon Energy Efficiency Specialty Code, 10/1/2010 SEED = State Energy Efficient Design program
Plant					
Cooling System Type	Unitary DX	Unitary DX, Fluid Cooler	Chiller, Cooling Tower	Air-Cooled Chiller	
DX / Chiller EER/IEER (ILPV)	2010 OEESC	2010 OEESC	2010 OEESC	2010 OEESC	Air-cooled chillers - note Code size limits: Max air-cooled system: 299 tons Max air-cooled sub-system: 100 tons for systems ≥300 tons
Chilled Water Pump Energy	-	-	Pump operates at head pressure equal to proposed design, meeting minimum efficiency requirements in "Pump Efficiency" tab.		Technical Guidelines, Appendix A changes to SEED Appendix L requirements
Chilled Water Pumping Arrangement	-	-	Primary: VFD	Primary: VFD	Technical Guidelines, Appendix A changes to SEED Appendix L requirements
Condenser Water Pump Energy	-	Pump operates at head pressure equal to proposed design, meeting minimum efficiency requirements in "Pump Efficiency" tab.		-	Technical Guidelines, Appendix A changes to SEED Appendix L requirements
Condenser Water Pumping Arrangement	-	VFD	CV	-	SEED
Fluid Cooler /Cooling Tower: Condenser Water Design Temperatures	-	CWS: Lesser of 85F OR design WB + 10F CWR: CWS + 10F	CWS: Lesser of 85F OR design WB + 10F CWR: CWS + 10F	-	SEED
Fluid Cooler Fan Energy (W/CFM)	-	2010 OEESC	2010 OEESC	-	
Cooling Tower Fan Energy (W/CFM)	-	2010 OEESC	2010 OEESC	-	
Fluid Cooler / Cooling Tower Controls	-	2-speed fan	2-speed fan	-	SEED
Condenser Water Supply, Temperature Control	-	60F as weather permits, floating up to design temp	65F as weather permits, floating up to design temp	-	CRAC units can operate with CW as low as 60F, adding efficiency.
DX Selection Point	Design Ambient Temp	-	-	Design Ambient Temp	
Chiller Selection Point (See Cooling Tower for CW temps)	-	-	CHWS: 50F CHWR: 60F	CHWS: 50F CHWR: 60F	Keeps cooling coil above dew point, raises chiller efficiency.
DX/Chiller Efficiency Curves ('Surfaces')	Derive using varying ambient temperature with constant cooling load				Getting manufacturer data is challenging, but full-load with variable ambient/condenser water temp is how datacenters operate. To cover this, eQuest can model bi-quadratic efficiency curves well.
Economizer Control - See Section below for SAT/RAT to be used in Air Side Economization	Air Side: Full Air Side below SAT plus Integrated cooling from SAT to RAT OSA EXCEPT for these systems: 1. Units < 54,000 Btu/h: Greater of ≤ 20 tons OR ≤ 10% of total cooling per building 2. New system, existing servers, ≤ 50 tons 3. New system, new servers, existing building, ≤ 20 tons	Water Side: Fluid Cooler to provide 100% capacity at 45/40F DB/WB	Air Side: Full Air Side below SAT plus Integrated cooling from SAT to RAT OSA OR Water Side: Cooling Tower/Heat Exchanger to provide 100% capacity at 45/40F DB/WB	Air Side: Full Air Side below SAT plus Integrated cooling from SAT to RAT OSA OR Water Side: Chiller to provide 100% capacity at 45/40F DB/WB w/o compressors running	Per Code CRAH systems can use either water side or air side economization. Air side is simple - the air handler pulls in OSA directly. Water side varies with chiller type: *CRAH/AHU, water-cooled chiller: heat exchangers allow bypassing chillers so heat is conveyed directly to cooling towers. *CRAH/AHU, air-cooled chiller: custom chillers can provide cooling with internal heat exchangers without using compressors.

Table C-1 (continued)

Fan Energy, Air Temperatures, Hot/Cold Aisle Isolation based on Server Density (W/SF)	**Fan Energy SAT/RAT (F, DB) Aisle Type**				SAT = supply air temperature; RAT = return air temperature Select supply air temperature based on 100% 'design' server load, not 50% load called for under "Server/UPS Load". Energy Efficiency Baselines for Data Centers, PG&E, 11/30/2011
0-100 W/SF	0.651 W/CFM 62 / 70 Hot Aisle/Cold Aisle, Open				Ducted/floor supply
101-220 W/SF	0.663 W/CFM 64 / 74 Hot Aisle/Cold Aisle, Ducted Return				Ducted/floor supply, ducted return
221-400 W/SF	0.675 W/CFM 67 / 82 Hot Aisle/Cold Aisle, Fully Enclosed				
Supply Air Temperature Reset	-	-	7 F	7 F	SEED
Fan Control Based on Total System CFM	Constant Volume (for systems serving process loads only)				Energy Efficiency Baselines for Data Centers, PG&E, 11/30/2011
Humidification Type vs. design cooling capacity	≤ 200 tons: Steam or infrared, 0.33 kWh/lb steam > 200 tons: Adiabatic (Mist, Wetted-Media or Ultrasonic) OR Same as Proposed				Select humidification type based on 100% 'design' server load, not 50% load called for under "Server/UPS Load".
Humidification Management	Prohibit dehumidification at cooling coils during operation of humidifiers				
Dehumidification	Cooling coil, no reheat				
Humidity Control Range (%)	40 - 60				ASHRAE
Ventilation	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				2010 Oregon Energy Efficiency Specialty Code
Internal Loads					
Lighting Power Density (W/ft^2)	0.93 in server room				2010 Oregon Energy Efficiency Specialty Code, Open Office
Lighting Controls	Same as proposed				
Daylighting Controls	Code (2010 OEESC)				
Occupancy Density	Same as proposed				
Server / UPS Load	50% of design IT load expected for first TWO years of operation (provide supporting documentation for variations)				
Server Power Supply Efficiency	87%				This parameter allows for savings from higher efficiency power supplies or DC power supply architecture. 80 Plus Standard (for server efficiency)
Power Distribution Unit Efficiency	See "PDU Efficiency" tab.				
Server CPU Power	Standard efficiency processors				
Building Power System	High/medium voltage (480/208) from primary transformer, passed through UPS system, stepped down at Power Distribution Units within server room to server power supplies.				
UPS Efficiency	(See 'UPS Efficiency' tab) UPS type same as proposed				Baseline UPS type should be the same as the proposed (i.e. baseline cannot be double conversion while proposed is line interactive)
Ancillary spaces (Offices)	Per SEED				
Other parameters not shown	Per SEED, Oregon Specialty Codes				

Appendix D

	Individually analyzed measures	
Envelope	Ceiling/roof insulation Wall insulation Floor/slab insulation Window U-value Window SHGC Skylight U-value	Skylight SHGC Architectural shading and overhangs Air-lock vestibule or revolving doors Other envelope measures
Lighting and Lighting Controls	Interior Lighting: Optimize fixture layout, spacing & orientation and efficient fixture selection, (fixture CU) to achieve LPD reduction > 25% Custom interior lighting controls Exterior Lighting controls	Exterior Lighting: Optimize fixture layout, spacing & orientation and efficient fixture selection, (fixture CU) Custom interior or exterior lighting fixtures (e.g. LED fixtures)
Service Water	Preheat DHW with reclaimed waste heat (i.e. chiller condenser, direct-contact boiler stack economizer, 24/7 computer server room AC unit)	Heat pump water heater Process related reduction in DHW: laundry, kitchen Waste water heat recovery Other DHW measures
HVAC unitary equipmen t	AC unit, air-to-air heat pumps, and water-source heat pump efficiencies when standard track is not used	Radiant heating - infrared over head Other HVAC general/unitary measures
Mechanical System Selection	**Central System** - Advanced VAV (minimize reheat and low pressure delivery) - Cold air (low temperature) distribution - Under Floor Air Distribution (UFAD) - Displacement Ventilation	**Distributed System** - Hydronic radiant heating - Hydronic radiant cooling - Variable refrigerant flow (minisplits with common condenser) - Water loop heat pump system - Four pipe fan coil
Fan Systems and Distribution	Heat recovery (air-to- air, run-around loop, heat wheel) Variable ventilation based on CO2 control Dedicated outside air system (DOAS) Night-flush cooling cycle Evaporatively cooled HVAC units Zone airflow and temperature setback in unoccupied areas of multizone unit through occupancy sensors or schedules	**Minimize VAV reheat** Perimeter and core zoning Perimeter and core zone controls Dual duct distribution and controls Fan power VAV boxes Fan power VAV boxes
Hydronic Design and Pumping	Variable primary pumping with VFD Increase cooling coil temperature difference Increase Heating coil temperature difference Reduce pump head pressure	Time clock and OSA lockout control of heating and cooling pumps
Chilled water	Select efficient kW/ton chillers: 1) centrifugal, 2) screw, 3) reciprocating Select chiller size(s) for efficient sequencing, i.e. low load operation Optimization of chiller sequencing controls Central Heat Pump Water-side free cooling: cooling tower and P&F heat exchanger	Heat recovery chiller Specify more efficient cooling tower to reduce LWT Water-cooled versus air cooled Evaporative-cooled versus air cooled Condenser water reset controls Other cooling measures
Boilers and other heating systesm	Standard (non-condensing) boilers Select boiler size(s) for efficient sequencing, i.e. low load operation Optimization of boiler sequencing controls High turn-down modulating burmer controls Electronic parallel positioning	Improve draft controls, i.e. barometric dampers VFD on combustion air fan Condensing hydronic boiler, design at lower supply/return water temp. i.e 140 F supply and 110 F return water temp. Water-source or ground-source heat pumps
Misc. Systems	Ultra efficient motors in excess of code NEMA primum efficient motor effeciency Efficient elevators and controls **Server and Telecom Rooms** Improved air flow effectivness, reduce bypass factors Air side economizer cooling Water side economizer cooling	**Refrigeration Systems** Select units with high efficiency compressors Increase condensing efficiency and optimize capacity control Install floating-head pressure controls **Appliances** Residential Energy Star Equipment Commercial Energy Star Equipment

Appendix E

eQuest Wizard defaults

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

- eQUEST fan and equipment part load performance curves: 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.

- Heating and cooling sizing ratios: The eQuest wizard default sizing ratio is 1.0, but should be adjusted to comply with SEED Appendix L for the baseline model (i.e. heating sizing ratio is 1.25 and cooling sizing ratio is 1.15)

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

- Building unoccupied heating and cooling: 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.

- Chilled water and hot water loops: 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.

- Fan energy in packaged equipment: 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.

- VAV systems: 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 F

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

Bldg-Sim Discussion Group: http://www.gard.com/ml/bldg-sim.htm

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

Building Simulation User News: http://simulationresearch.lbl.gov/un.html

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

Healthcare Modeling Procedures – 2006 Savings By Design: http://www.energysoft.com/ep/SBDHProcedures.pdf

HVAC Simulation Guidelines: http://www.energydesignresources.com/resource/200/

State-of-the-Art Review: Whole Building, Building Envelope, and HVAC Component and System Simulation and Design Tools: http://www.arti-research.org/research/completed/finalreports/30010.30020-final.pdf

Modeling of Ventilation Air Heat Recovery and Its Impact in High-Performance Green Buildings: http://ceae.colorado.edu/ibpsa/ocs/viewpaper.php?id=27&cf=1

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