Energy Trust of Oregon New Buildings Program

# 2019 Energy Code Technical Guidelines

# Contents



DISCLAIMER

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

# Section 1 Introduction

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 strategies may be eligible for cash incentives and technical assistance.

These Technical Guidelines describe the technical requirements that projects must meet to qualify for Energy Trust incentives through the Whole Building and Path to Net Zero Application or Special Measure Incentive Application. Program offerings, incentives, and requirements are subject to change and availability; please ensure that you are referencing versions of Program documents currently in effect.

Energy Trust makes cash incentives available for the installation of building systems that are more energy efficient than those installed to meet minimum Oregon energy code requirements and efficiency standards. Energy efficient strategies are typically related to the envelope, mechanical, electrical, domestic hot water, lighting, and building control systems.

## 1.1 Oregon Code Requirements

Effective October 2019, the Oregon Building Codes Division adopted the 2019 Oregon Zero Energy Ready Commercial Code (OZERCC); the commercial energy provisions are based on the ASHRAE Standard 90.1-2016. Projects permitting under the 2019 OZERCC should follow Energy Trust's program requirements outlined in this document.

Energy Trust requires that projects that are permitting under the 2014 Oregon energy code submit the Program's required documents and forms for projects permitted under the 2014 Oregon Energy Efficiency Specialty Code and to follow the Program's Technical Guidelines v2016.1-160222 available on the Energy Trust website.

The Building Codes Division has also reported the intent to update the Oregon Structural Specialty Code energy provisions to ASHRAE 90.1-2019 effective October 1, 2020. Projects that anticipate permitting under the 2020 energy code and are seeking Energy Trust's assistance should contact our Program, as these Technical Guidelines are currently applicable only to projects permitted under the 2019 OZERCC.

# Section 2 Whole Building 2019 Projects

For projects pursuing Energy Trust's Whole Building and Path to Net Zero incentives, whole building energy modeling is required. Those wishing to participate should refer to the Form 520WB-2019 (Whole Building and Path to Net Zero) to apply. For all projects pursuing whole building modeling, technical requirements include:

- Established target Energy Use Intensity (EUI) appropriate for the building's proposed design, as described in Section 2.1
    - Projects must commit to achieving at least 5% energy savings over a code-minimum building
    - Path to Net Zero projects must commit to a target EUI in alignment with the 2030 Challenge, as described below
- Submission of a whole building energy model, as described in Section 2.2
    - Supporting documents are described in Section 2.5
    - Energy simulation documentation is described in Section 2.5.1

## 2.1 Target Setting

For projects pursuing Whole Building and Path to Net Zero incentives, an EUI target must be established for the proposed design. EUI is expressed as energy per square foot per year and is calculated by dividing the total energy consumed by the building in one year (measured in kBtu) by the total gross floor area of the building. Note that this is site EUI, not source EUI.

For Whole Building projects, projects are required to commit to achieve at least 5% savings better than code. Project teams are encouraged to use the Architecture 2030 ZERO Code Energy Calculator to generate a code building's estimated energy consumption. For estimating purposes, the "Prescriptive" pathway option may be used when completing the calculator; note that the calculator does provide estimated building energy consumption by end use that may be hidden by default (and can be viewed by clicking "Estimated Building Energy Consumption").

For Path to Net Zero projects, the target setting approach aligns with American Institute of Architects' (AIA) 2030 Challenge. Classification of a project as Path to Net Zero requires establishing an EUI target that uses 80% less fossil fuel energy than the national average by building type. For these projects the Architecture 2030 Zero Tool is used for determining a reference building EUI and a Path to Net Zero target EUI. Targets may be met by implementing innovative sustainable design strategies, generating on-site renewable energy, and/or purchasing (20% maximum) off-site renewable energy (evidence of the purchased renewable energy must be provided prior to incentive payment).

## 2.2 Energy Simulation Requirements

For projects pursuing Energy Trust's Whole Building and Path to Net Zero incentives, whole building energy modeling is required. The applicant must provide energy models for the proposed design and baseline scenarios that are compliant with the Performance Rating Method outlined in Normative Appendix G of the ASHRAE 90.1-2016 Standard. As per ASHRAE 90.1 2016 Section G2, proposed and baseline building performance shall be calculated using the following:

- The same simulation program
- The same weather data

- The same energy rates

The simulation program shall be computer-based program for the analysis of energy consumption in buildings (such as, but not limited to, DOE-2, BLAST, or EnergyPlus).

### 2.2.1 Unregulated loads

The Performance Rating Method stipulates that unregulated loads be modeled in the baseline the same as the proposed design. However, the Program will allow for incentives for savings above standard practice for unregulated loads, as addressed in Section 2.6 below.

Projects may submit additional spreadsheet or manual calculations only for energy efficiency strategies 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. Where there are multiple designs, materials, or devices that the simulation program cannot model, each shall be calculated separately, and exceptional savings determined for each. Interactive effects between calculated strategies and modeled strategies must be accurately accounted. The total exceptional savings shall not constitute more than half of the difference between the baseline building performance and the proposed building performance, per ASHRAE 90.1-2016, Section G2.5.

### 2.2.2 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 to validate 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 accurately accounted.

### 2.2.3 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.

## 2.3 Energy Simulation Software Selection

Refer to ASHRAE 90.1-2016, Section G2, for simulation software requirements. Energy Trust will accept energy models developed with software that is compliant with ASHRAE Standard 140 and has the ability to explicitly model all of the following:

- 8,760 hours per year
- Hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation, defined separately for each day of the week and holidays
- Thermal mass effects
- Ten or more thermal zones

- Part-load performance curves for mechanical equipment
- Capacity and efficiency correction curves for mechanical heating and mechanical cooling equipment
- Air economizers with integrated control
- Baseline building design characteristics as specified in ASHRAE 90.1-2016, Section G3

## 2.4 Energy Modeling Reminders

Analysts should use this section as a reference for basic adjustments that should be made and variables that should be verified in all energy models.

- **Miscellaneous equipment loads**: Modeling assumptions may underestimate the equipment load of the building. Since equipment loads are required to be the same in both the baseline and proposed models, this will cause the savings as a percentage of energy use to be overestimated. Additionally, because the equipment gives off heat that increases the cooling load, mechanical efficiency savings may be underestimated.
    - The energy analyst should ask the owner and design team about planned equipment and plug loads in the facility in order to accurately estimate equipment loads and simulate building energy consumption.
- **Building operating hours**: Energy analysts sometimes under- or overestimate 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?
    - Are there off-season uses that need to be considered (ex. summer events at schools)?
- **Simulation software defaults**: Default input variables available in simulation software should be checked by the analyst to determine if they are appropriate for the energy models. Examples include, but are not limited to, the following:
    - Fan and equipment part-load performance curves – ensure that the selected performance curves are appropriate to the equipment being modeled
    - Sizing ratios – ASHRAE 90.1-2016, Section G3.1.2.2 stipulates the baseline cooling sizing ratio to be 1.15 and the heating sizing ratio to be 1.25; HVAC system fan sizing ratios should be set to 1.0 in the baseline model
    - Building unoccupied heating and cooling – check how the heating and cooling systems are simulated to be operating during unoccupied hours; for actual building usage 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 loop operation – a demand-based operation is usually more appropriate than a standby mode (continuous operation) for actual building usage as it allows cooling or heating to enable when there is a demand
    - Fan energy and cooling efficiency in packaged equipment – some simulation software intends for the packaged cooling equipment efficiency input to be determined without including supply fan electric energy consumption; check how the software being used intends for packaged equipment fan energy and cooling efficiency to be entered

## 2.5 Required Documentation

Project owners seeking Energy Trust incentives using the Whole Building and Path to Net Zero – Whole Building Installation Incentive Application must submit the following along with the application form:

- All energy simulation models in accordance with Sections 2.2-2.4 and Section 2.6 of this document
- Supplemental files as applicable demonstrating derivation of modeled inputs (for example, spreadsheet file showing how lighting power density was computed, spreadsheet file showing how modeled miscellaneous loads were calculated, etc.)
- Exceptional calculation files (as applicable)
    - Spreadsheet files used to perform the calculations, performed on a time-step basis consistent with the simulation program used (Excel format spreadsheet files)
    - Step-by-step documentation of the exceptional calculation method performed, detailed enough to reproduce the results
    - A sensitivity analysis of energy consumption when each of the input parameters is varied from half to double the value assumed
    - The performance rating calculated with and without the exceptional calculation method
- Completed **Energy Modeling Summary Workbook**
- Supporting equipment documentation:
    - Mechanical drawings and equipment schedules (.pdf format)
    - Lighting fixture plans and schedules (.pdf format)
    - Electrical drawings and equipment schedules (.pdf format)
    - Plumbing drawings and equipment schedules (.pdf format)
    - Architectural drawings, including floor plan(s), elevations, and envelope cross sections as needed (.pdf format)
    - Schematic diagram and equipment schedule for any renewable generation systems not included in the above (.pdf format)
    - Site plan(s) showing adjacent structures and terrain 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 energy models. 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 energy models is currently available in the market.
    - Schematic diagram showing the mechanical operation and/or layout of any specialty process (e.g. pool heat recovery system with dehumidification). These diagrams must be included for systems that are not considered commonly used/installed or may not be easily understood using a written description. (.pdf format)

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

### 2.5.1 Energy Model Files

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. Documentation that does not meet Energy Trust's sufficiency requirements, in its sole discretion, for calculating Program savings will not be accepted for incentive application purposes.

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

- For DOE-2 based models:
    - Input Files
        - Input file (.inp)
        - Project file (.pd2)
        - Parametric run files, if applicable (.prd)
        - Weather file
        - Any external files referenced by the input file (ex. custom library file)
    - Output Files
        - Simulation output file (.sim)
- For IES VE models:
    - Cabinet archive file (.cab) (please ensure the version is included in the filename, ex. [VE2019]), containing:
        - Simulation files (.asp)
        - Loads files (.clg and .htg)
        - Results files (.aps)
- For EnergyPlus and EnergyPlus-based models:
    - Inputs
        - Input file (.idf)
        - Weather file (.epw)
    - Outputs
        - Annual Building Utility Performance Summary
        - Summary showing unmet load hours
        - Equipment Summary
        - System Summary
        - Envelope Summary
- For TRACE 700 models:
    - Trace archive file (.TAF) (please be sure to include any custom library members when archiving)
    - Weather file
    - Output files (Energy cost budget/PRM summary, energy consumption summary reports, and others as needed)
- For all other simulation programs, sufficient documentation of the simulation inputs and outputs must be provided, including the modeling files themselves. The Program reserves the right to request any additional documentation that may be needed to perform a comprehensive review of the simulations.

Program staff will execute the modeling files to review and verify that:

- the baseline inputs are in accordance with ASHRAE 90.1-2016 Appendix G,
- the proposed inputs are substantiated by the received supporting documentation, and

- the energy savings estimates are reasonable.

If inputs or resulting inputs do not appear reasonable, 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 and source of the energy savings as well as confirm that the estimated savings are eligible for Energy Trust incentive funding. Final determination of whether savings are eligible for Program incentives rests with Energy Trust.

## 2.6 Unregulated Savings

There are sources of unregulated energy use that are not addressed by the ASHRAE 90.1-2016 standard, including, but not limited to:

- Equipment plugged into receptacles such as computers, printers, coffee makers, refrigerators ("plug" loads)
- Grills, ovens, fryers, and other cooking equipment
- Compressed air systems in manufacturing and warehouse facilities
- Specialized equipment in laboratories, hospitals, and manufacturing plants
- Refrigeration equipment and controls in grocery stores and refrigerated warehouses

For these unregulated loads, the Performance Rating Method outlined in Appendix G of ASHRAE 90.1-2016 stipulates that the baseline building performance be modeled the same as the proposed design. However, incentives are eligible through the Program for energy savings over a standard practice baseline for these loads. To estimate savings from unregulated loads, the applicant must submit a separate energy model with the applicable unregulated load(s) set to a standard practice baseline value. In such situations, three energy models must be provided to the program:

- Proposed model reflecting the proposed design
- 90.1-Baseline model per ASHRAE 90.1-2016 Appendix G in all aspects, including with the unregulated loads equal to those in the proposed design
- Program-Baseline model per ASHRAE 90.1-2016 Appendix G in all aspects, except that unregulated loads reflect standard practice

Where there is no clear code requirement for a specific modeling parameter, the analyst should reflect on what common design practice would dictate. The energy analyst is encouraged to contact the Program to discuss the baseline selection and assumptions for any unregulated loads in question.

Standard practice baseline assumptions for refrigeration and grocery are provided in the following table, categorized into three different store types: convenience stores (5,000 – 35,000 sq.ft), grocery stores (35,000 – 50,000 sq.ft), and supermarkets (50,000 – 150,000 sq.ft).

*Table 1 Standard Practice Baseline for Refrigeration and Grocery*

| | System Characteristic | Baseline Assumption | Application |
|---|---|---|---|
| **Refrigeration System** | System configuration | Single stage parallel systems | Grocery and supermarket |
| | Refrigerant | R-448A or CO2 | |
| | Subcooling | Mechanical subcooling | |
| | 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 65 Btu/h/Watt at 10°F TD (standard practice) | |
| | Condenser control | SCT floating following ambient dry bulb temperature with VFD fan control | |
| | Minimum condensing temperature | 70°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 | ECM | Convenient store, grocery, supermarket |
| | Display case lights | LED | 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 RH | Grocery, supermarket |
| | Evaporator coil TD (walk-ins, coolers, and freezers) | TD of 10°F | Convenient store, grocery, supermarket |

# Section 3 Special Measures

Projects not submitting the Energy Trust Whole Building and Path to Net Zero incentive application but that are proposing to use energy efficient equipment that exceeds code requirements may apply for Special Measure incentives. Special Measures may consist of specialized equipment that does not warrant a full energy model or cannot be designated as standard equipment, as found on the Program's Form 520S. The Program may provide technical support to calculate energy saving estimates for these measures. For projects that are submitting energy calculations, requirements include the following:

- Projects must be tested for cost-effectiveness, as described in Section 3.1.
- Calculations must meet the requirements for spreadsheet and manual calculations in Section 3.2.

## 3.1 Benefit-to-Cost Ratio Test

Special Measures must pass the Total Resource Cost benefit cost ratio (TRC) test using the **Cost-Effectiveness Calculator (CEC)**, which can be found in the **Savings Summary Worksheet**. Instructions are included in the worksheet.

Each measure must have a TRC of at least 1 in order to be eligible for Program incentives. It is beneficial for other quantifiable non-energy cost savings or added value resulting from the measure, such as reduced maintenance or inventory and water savings. An explanation and supporting documentation regarding such non-energy cost savings must be provided to the Program.

## 3.2 Spreadsheet and Manual Calculations

Projects may submit spreadsheet or manual calculations for measures that are enrolled as a Special Measure. 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 energy recovery measures, 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 also clearly identify the specific details (e.g., equipment and motor efficiencies, operating schedules, fan speed percentages) for each measure and the corresponding baseline information used in the energy consumption calculations. The expected utility service provider and corresponding rate schedule must also be clearly identified, and these values should be used in the energy cost savings calculations for each measure.

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

- A list of all assumptions, constants, performance values, and equations
- Interactions between measures should be accounted for in the calculations
- Documentation to identify and substantiate the assumptions and basis for all usage and weighting factors
- Clear documentation for proprietary, analyst generated, and/or manufacturer licensed spreadsheets/calculation tools. All formulas, assumptions, and corresponding cell references shall be clearly identified. Documentation provided must give the Program reviewer a clear and

logical progression of the results obtained from such calculation tools. User interface input and output data sheets are not acceptable substitutes for calculation documentation in lieu of the above requirements.

- All electronic spreadsheet calculations for each measure, “unlocked” (i.e., please do not submit PDFs of spreadsheet calculations)
- All manual calculations for each measure

To help expedite the review process, it is recommended that for spreadsheet calculations each measure be provided on no more than one spreadsheet file (multiple worksheets are permitted). Multiple measures may be included in one spreadsheet using multiple worksheets so long as each sheet clearly identifies the corresponding measure (may be beneficial when analyzing multiple measures that have interactive effects).

# Appendix A Program Utility Savings Methodology

## Introduction

This Appendix A describes the method by which Energy Trust New Buildings Program calculates utility savings. Energy Trust Program savings are determined from the submitted 2004 Appendix G-compliant baseline model (Baseline model) and proposed whole building model (Proposed model). There are two main steps in the overall process:

1) The whole building energy use for a 90.1-2016 Appendix G-compliant baseline building is derived from the 2004 baseline model results using end use energy ratios (described below), and
2) a Program Baseline is determined from the whole building kWh and therm consumption values found in step 1 by adjusting the end-use fuel ratio to represent a fuel mix consistent with the proposed building. This is done so that fuel switching is not incentivized.

Project information and model energy consumption results shall be submitted via the Energy Modeling Summary Workbook (EMSW). Calculations for the above two steps are embedded within the EMSW.

## Why Baseline and Energy Savings are Not Derived from Appendix G Cost Compliance Methodology

The Building Performance Factors presented in ASHRAE 90.1-2016 Table 4.2.1.1 were derived by PNNL as explained in PNNL-25202 per the following equation:

$$BPF_{Year\ X} = (\sum \frac{Prototype\ Building\ Regulated\ Energy\ Cost_{Year\ X}}{Prototype\ Building\ Regulated\ Energy\ Cost_{2004}})/N_p \quad \text{(Eq. 1)}$$

where:

| | | |
|---|---|---|
| Prototype Building Regulated Energy Cost $_{year\ x}$ | = | The portion of annual energy cost due to regulated energy use from the PNNL prototype buildings for a given building prototype, climate zone, and edition of Standard 90.1. |
| Prototype Building Regulated Energy Cost $_{2004}$ | = | The portion of annual energy cost due to regulated energy use from the PNNL prototype buildings for a given building prototype, climate zone, and the 2004 edition of Standard 90.1. |
| $N_p$ | = | Number of prototype buildings of a particular building type (example, for Office building type $N_p$ is three: Small Office, Medium Office, and Large Office) |

The overall ASHRAE-2016 Appendix G cost compliance methodology has Eq. 1 built in as a basis for determining code compliance on a whole-building cost basis which is not appropriate for determining a code baseline or energy savings. Attempting to apply BPFs to determine a code baseline whole building energy use would necessitate assuming energy cost differences from 2004 to 2016 are equivalent to whole building energy consumption differences over the same period which will not always be accurate.

Another reason the Appendix G method cannot be adapted to determine energy savings is that energy end use reductions between the 2004 and 2016 PNNL prototype models – which are used to calculate BPF – are not even across all end uses. Service hot water and building heating energy are a primary example of this: SHW end use energy remains essentially constant between 2004 and 2016 models while building heating energy use has changed dramatically in the same period. The calculated BPF values, which are central to the Appendix G cost compliance methodology, cannot be disaggregated by fuel type or end use, therefore, the method presented below is used to determine energy savings.

## Program Utility Savings Methodology

To address the issues described above, this methodology relies on ratios between the 2004 and 2016 PNNL prototype model results for each energy end use calculated on a kBtu/sqft basis. The end use ratios are determined from the PNNL prototype models that were used to calculate Appendix G BPFs; the ratio calculations maintain the same building type groupings as used for the BPF determinations (e.g., multifamily end use ratios are an average of the High-rise and Mid-rise Apartment prototype results). The PNNL summary spreadsheet '2016EndUseTables_04_04_2019.xlsx' is used as a basis for calculation of the final ratios shown below in Table 2 for CZ4C and in Table 3 for CZ5B.

The following elaborates on the two steps mentioned in the introduction. All calculations are embedded in the EMSW.

1. Determine a 90.1-2016 Appendix G-compliant baseline: The 90.1-2016 baseline site energy is calculated by multiplying each end use of the project's baseline model by the appropriate ratio from either Table 2 or Table 3. Note that ratios for unregulated uses are always 1.0. End uses are then summed to determine the regulated and unregulated components for kWh and therm consumption.

2. Determine the Program baseline: To ensure fuel switching is not incentivized, the regulated results from the 90.1-2016 Appendix G-compliant baseline in step 1 are adjusted to match the regulated fuel mix of the proposed design at the end-use level. This is accomplished by only adjusting the consumption of each of the following regulated end-uses to match the fuel mix of the proposed design for that end-use: Space Heating, Domestic Hot Water Heating, and Cooling. These are end-uses where a fuel switch could occur from the Appendix G baseline.

3. Finally, savings are determined by subtracting the project's proposed model energy consumption from the values determined in step 2.

*Table 2: End Use Ratios for CZ4C*

| End Use | PNNL End Use | End Use Ratios | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Multifamily | Healthcare/Hospital | Hotel/Motel | Office | Restaurant | Retail | School | Warehouse | All Other |
| Space Heating (Regulated) | Heat | 0.55 | 0.44 | 0.26 | 0.39 | 0.80 | 0.58 | 0.67 | 0.71 | 0.55 |
| Cooling (Regulated) | Humidify<br>Cool | 0.78 | 0.55 | 0.82 | 0.48 | 0.49 | 0.55 | 0.43 | 0.39 | 0.56 |
| Ventilation (Regulated) | Fans | 0.84 | 0.64 | 0.60 | 0.79 | 0.41 | 0.50 | 0.40 | 0.71 | 0.61 |
| Water Heating (Regulated) | SHW | 1.00 | 0.93 | 1.00 | 0.98 | 1.00 | 0.95 | 0.99 | 0.97 | 0.98 |
| Lighting (Regulated) | Light.Int | 0.75 | 0.78 | 0.58 | 0.55 | 0.34 | 0.67 | 0.30 | 0.37 | 0.54 |
| Lighting (Unregulated) | - | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Pumps (Regulated) | Pumps | 0.85 | 0.49 | 0.69 | 0.82 | 1.00 | 1.00 | 1.08 | 1.00 | 0.87 |
| Heat Rejection (Regulated) | Ht.Rej | 0.63 | 0.70 | 1.00 | 0.78 | 1.00 | 1.00 | 1.00 | 1.00 | 0.89 |
| Supplemental Heat Pump (Regulated) | Heat | 0.55 | 0.44 | 0.26 | 0.39 | 0.80 | 0.58 | 0.67 | 0.71 | 0.55 |
| Exterior Usage (Regulated) | Light.Ext | 0.45 | 0.42 | 0.53 | 0.27 | 0.32 | 0.33 | 0.31 | 0.46 | 0.39 |
| Plug and Process Load (Unregulated) | Cook<br>Equip<br>Data.Ctr | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Elevator/ Misc. Energy (Regulated) | Elevator<br>Ht.Rcvy<br>Txfmr | 0.89 | 0.90 | 0.83 | 0.85 | 1.00 | 1.00 | 0.43 | 1.00 | 0.86 |
| Misc. Energy (Unregulated) | Cook<br>Data.Ctr<br>Equip | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Refrigeration (Regulated) | Refrig | 1.00 | 0.89 | 0.91 | 1.00 | 0.77 | 1.00 | 0.83 | 1.00 | 0.92 |
| Refrigeration (Unregulated) | - | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

*Table 3: End Use Ratios for CZ5B*

| End Use | PNNL End Use | End Use Ratios | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Multifamily | Healthcare/ Hospital | Hotel/ Motel | Office | Restaurant | Retail | School | Warehouse | All Other |
| Space Heating (Regulated) | Heat | 0.56 | 0.48 | 0.23 | 0.42 | 0.86 | 0.65 | 0.71 | 0.62 | 0.57 |
| Cooling (Regulated) | Humidify<br>Cool | 0.74 | 0.49 | 0.75 | 0.53 | 0.54 | 0.51 | 0.48 | 0.30 | 0.54 |
| Ventilation (Regulated) | Fans | 0.81 | 0.64 | 0.69 | 0.79 | 0.37 | 0.51 | 0.44 | 0.65 | 0.61 |
| Water Heating (Regulated) | SHW | 1.00 | 0.94 | 1.00 | 0.98 | 1.00 | 0.95 | 0.99 | 0.97 | 0.98 |
| Lighting (Regulated) | Light.Int | 0.75 | 0.78 | 0.58 | 0.54 | 0.33 | 0.66 | 0.29 | 0.40 | 0.54 |
| Lighting (Unregulated) | - | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Pumps (Regulated) | Pumps | 0.85 | 0.61 | 0.66 | 0.81 | 1.00 | 1.00 | 0.65 | 1.00 | 0.82 |
| Heat Rejection (Regulated) | Ht.Rej | 0.62 | 0.65 | 1.00 | 0.79 | 1.00 | 1.00 | 1.00 | 1.00 | 0.88 |
| Supplemental Heat Pump (Regulated) | Heat | 0.56 | 0.48 | 0.23 | 0.42 | 0.86 | 0.65 | 0.71 | 0.62 | 0.57 |
| Exterior Usage (Regulated) | Light.Ext | 0.45 | 0.42 | 0.53 | 0.26 | 0.32 | 0.33 | 0.31 | 0.46 | 0.39 |
| Plug and Process Load (Unregulated) | Cook<br>Equip<br>Data.Ctr | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Elevator/ Misc. Energy (Regulated) | Elevator<br>Ht.Rcvy<br>Txfmr | 0.89 | 0.90 | 3.47 | 0.85 | 1.00 | 1.00 | 0.43 | 1.00 | 1.19 |
| Misc. Energy (Unregulated) | Cook<br>Data.Ctr<br>Equip | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Refrigeration (Regulated) | Refrig | 1.00 | 0.89 | 0.90 | 1.00 | 0.78 | 1.00 | 0.83 | 1.00 | 0.92 |
| Refrigeration (Unregulated) | - | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |