Energy Modeling Guidelines

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Introduction

This document serves to describe the workflow required when using energy modeling to receive cost-sharing benefits and financial incentives provided by the BED Energy Services department.

Fossil Fuel and Energy Consumption Reductions

To mitigate climate change, energy efficiency utilities like Burlington Electric (BED) can provide financial incentives to projects seeking to achieve both *fossil fuel* and *electricity* consumption reductions. Projects may receive incentives for both fuel switching activities, as well as improved performance over baseline equipment**. Please speak with a BED Energy Services staff member to learn more about fuel switching and energy efficiency measures and how a project might qualify for both types of incentive.**

Background

The purpose of the energy modeling process is to identify and quantify energy usage of a building design in order to prioritize potential fuel switching and energy efficiency measures as well as provide summary estimates of measure costs and savings. It is BED's goal to provide customers with in-depth recommendations that can guide building owners, developers, and their consulting professionals toward the most energy efficient, environmentally sustainable, and cost-effective design choices and equipment selections.

Energy models are useful tools for capturing not only the individual efficiency measures (such as lighting, HVAC, building automation and control system measures), but also their synergistic effects. Often this 'greater than the sum of their parts' result enables BED to document the full extent of the potential energy savings of highly efficient designs, and thus maximize the amount of incentive funding that we can offer to our customers.

Design

Contact BED as early as possible to discuss energy modeling approach and baseline system type. Invite BED to participate in design reviews to provide recommendations for energy conservation and maximum financial incentives.

Construction

Invite BED to work collaboratively with energy modeler to adjust modeling parameters as needed and to revise model to reflect actual construction. BED will update rebate estimates based on updated energy model results.

Post-Occupancy

Allow BED to help resolve functional performance deficiencies. BED monitors energy consumption and demand to determine if usage aligns with initial energy model estimates, and helps project teams determine whether model calibration is required.

Incremental Cost Information

It is required by the Vermont State Department of Public Service that Burlington Electric (and Efficiency Vermont) provide incremental cost information for higher-performance building systems and components included as part of energy efficiency measures which receive rebates. It is necessary for project teams to provide BED with *summary* financial information for scopes of work related to the installation of energy-efficient technologies.

These financial documents can usually be gathered by the general contractor or construction manager for the project. Subcontractors can redact markups and provide only grand totals if that is preferred. These invoice documents will only be used in *aggregate*, for maintenance of the database of energy efficiency measures that is submitted to the Department of Public Service. The cost information contained within contractor invoices will not be published or stored publicly, and will only be retained for the purposes of measurement and verification of energy savings.

Required Invoices

The financial incentive amount will be limited to the total incremental cost of the energy-efficient design. The incremental cost for the project shall be calculated using actual costs paid for energy efficient systems. The financial incentive amount paid to the customer cannot exceed the incremental cost of the energy efficiency measures of the project.

The list of necessary invoices for high-performance buildings expected to achieve some level of LEED certification usually includes:

System	*Materials*	*Labor*
HVAC systems such as high-efficiency air handling units, rooftop units, energy recovery units, ground source heat pumps and loop heat exchanger systems	Include only materials costs for equipment and associated components	
LED lighting and networked lighting controls, including light fixtures, wall switches, and all networking and communications components such as gateways and controllers	Include materials costs for light fixtures and control devices	Include labor costs for configuration of lighting control sequences such as high level trim, initial light levels, and vacancy sensing
Building envelope systems (for buildings with insulation R-values substantially exceeding code)	Include only materials costs for superinsulation	
Building automation systems (for buildings with unique sequences of operation designed to maximize energy savings)	Include only materials costs for additional hardware required for highly energy saving sequences of operation	Include only labor costs for programming required for highly energy saving sequences of operation

Energy Modeling Scope of Work

Building owners and developers may undertake other initiatives that require energy modeling, such as LEED certification. Therefore, the scope of work described in this guide can be integrated into other building energy modeling endeavors to create an all-encompassing scope that satisfies the needs of all parties while ensuring customers have an optimal opportunity for cost-sharing benefits and financial incentives.

Baseline Energy Model

The baseline energy model created for LEED certification may be compliant with the baseline model requirements of the BED energy modeling program. The proposed system for the building determines the appropriate baseline system. Page 6 describes baseline HVAC system selection in more detail. **Please contact BED early in the design phase to discuss baseline system selection.**

Accepted Energy Modeling Software

The use of contemporary energy modeling software capable of accurately analyzing modern building systems and components is fundamental and required for measurement & verification (M&V) of energy savings. The M&V process corroborates estimated savings from reputable programs, but cannot evaluate cottage software in order for energy efficiency utilities such as BED to continue to provide financial incentives.

If the proposed building usage is expected to vary hourly, daily, seasonally, (etc.), the software must be capable of accepting inputs and producing outputs for HOURLY variations in occupancy, lighting power, miscellaneous equipment power, thermostat setpoints, HVAC system operation, and envelope and usage characteristics. Inputs shall be capable of being defined separately for each day of the week and holidays.

Building and equipment definitions must accurately represent both baseline and proposed construction details (such as insulating assemblies, fenestration assemblies, infiltration rates), and equipment performance (such as EER/COP, motor efficiencies, and performance curves), in order to produce reasonably accurate estimates of expected energy use.

Pre-approved software listed on the Department of Energy's Office of Energy Efficiency and Renewable Energy website for qualified software for commercial building tax deductions is typically accepted by BED for energy modeling scopes of work as part of the Energy Services department's programs:

https://energy.gov/eere/buildings/qualified-software-calculating-commercial-building-tax-deductions

Use of any modeling software must be pre-approved by BED. **Please call BED if you have any questions about the eligibility of a software program.**

Exceptional Calculation Methods

Exceptional Calculation Methods are defined as analysis methods used when there is no software available that can directly model the building's systems. If modeling software readily exists that allows direct modeling of the technology, BED may request that the model be completed in that platform.

All exceptional calculation methods must be reviewed and pre-approved by BED for the project to receive financial incentives.

Exceptional Calculation Methods are broken down into three categories:

- Modeling Unconventional Equipment or Operation Within Modeling Software
    - Some energy modeling programs allow custom code inputs to simulate specialized equipment or sequences of operation within the simulation. An example of a software supporting this functionality is EnergyPlus' Energy Management System.
    - *BED must review and pre-approve methods for simulation of unconventional systems to ensure savings calculations can be corroborated.*

- Modeling Conventional Components in an Unconventional Way
    - Modeling software development usually follows HVAC system innovations, which means that energy modeling professionals are often left without a direct way to model equipment that is available in the marketplace before a new version of software is released. In these situations, often modelers develop creative ways to approximate operation of new technologies within energy modeling software.
    - *BED will accept these methods ONLY if there is no other freely available software for calculation OR if such software has been available for less than one year.*

- Post-Processing Calculations
    - After the simulation is completed inside modeling software, summary calculations are often completed in a spreadsheet.
    - *BED will accept these calculations if formulas are explicit, assumptions are defined, and sources of assumptions are cited.*

Post-Occupancy Calibration

A building's energy model may make a number of early assumptions about various equipment loads and operating hours which may need to be adjusted once the building is occupied. Energy models should be calibrated after the building becomes occupied, if early assumptions have significantly changed, or if actual energy usage deviates >5% from estimated energy consumption reported by the energy model.

Some common reasons for deviations include changes in the following parameters between the proposed building model and the actual building:

- Occupancy rates
- Occupied schedules
- Equipment run hours
- Equipment loads
- Air tightness

See section 3.2 of the following Modeling Requirements document for more details.

Modeling Requirements

The requirements for baseline and proposed model submissions are specified below. The workflow may require the completion of up to two baseline models and one proposed model.

1. Baseline Model

The modeling process will always require at a minimum one baseline model. However, green building standards, fuel switching measures, and energy efficiency measures have different requirements for baseline characteristics in order to calculate financial incentives. Projects may submit one or more measures that may be participating in each individual incentive program or a project may explore both fuel switching and energy efficiency measures. **Please contact BED to discuss the baseline modeling approach to optimize workflow of the project team.**

1.1. Energy Efficiency Measures

Results from energy models allow BED to offer incentives to the project for implementing electricity efficiency strategies within the design. Modeling for energy efficiency measures may require the development of a second baseline model. For more information about modeling baseline HVAC system selections for energy efficiency measures, see section 2.1, Baseline Building Model HVAC System Selection, below.

1.2. Fuel Switching Measures

Under the Tier 3 program, BED has the opportunity to provide financial incentives to projects for reducing fossil fuel use by switching to cleaner fuels. This is considered a 'fuel switch' and must be modeled accordingly in order to qualify for incentives. For more information about modeling baseline HVAC system selections for fuel switching measures, see section 2.1, Baseline Building Model HVAC System Selection, below.

Note: In certain situations, the model for Tier 3 measures may be sufficient for the project's baseline model for energy efficiency measures. BED will consult with the modeling professional about specific requirements on a case-by-case basis.

2. Baseline Building Performance

The performance rating method shall generally follow guidelines as set forth in ASHRAE 90.1, 2013, Appendix G, with the following caveat, per Vermont CBES 2015, sections C103.3.1 & C103.3.2:

> **The baseline model shall comply with minimum performance as defined by the Vermont Commercial and Residential Building Energy Standards (CBES & RBES) current active version when; plans and specifications have been reviewed for code compliance OR within 180 days after adoption of a new standard. Where ASHRAE 90.1 Appendix G references minimum requirements listed in sections 5 through 9, the equivalent minimum requirement of the appropriate energy standard shall be used.**

2.1. Baseline Building Model HVAC System Selection

In some scenarios, Appendix G does not reflect the Vermont construction market, and the Vermont Department of Public Service requires that efficiency utilities measure energy savings per a baseline system that is *relevant* to the proposed building system type.

In lieu of using Appendix G Tables G3.1.1A for baseline model HVAC system selection, follow the suggested guidelines below. **Please contact BED to discuss your specific project on a case-by-case basis.**

- Electric resistance heat is not allowed under CBES.
    - Where the ASHRAE baseline system calls for use of electric resistance heat, an alternative path must be chosen for the baseline HVAC systems.
- Baseline system selections should be performed as follows:
    - *Fuel Switching Measures*
      For fuel switching (Tier 3) incentives, the baseline building HVAC system shall be selected from the Fossil Fuel, Fossil/Electric Hybrid and Purchased Heat column in ASHRAE 90.1 Appendix G Tables G3.1.1A.
    - *Energy Efficiency Measures*
      This baseline would typically be a modified version of the proposed building model, altered to reflect code-minimum equipment efficiencies and control strategies, aligning with the minimum allowable efficiencies per CBES.
        - **Please consult with BED regarding the appropriate baseline HVAC system selection for EVERY project, especially when projects have a multitude of possible hybrid HVAC systems.**

Building Type	Typical Baseline HVAC System Selection
Residential	System 1 – PTAC
Nonresidential and 3 Floors or Less and <25,000 ft2	System 3 – PSZ-AC
Nonresidential and 4 or 5 Floors and <25,000 ft2 OR 5 Floors or Less and 25,000 ft2 to 150,000 ft2	System 5 – Packaged VAV with Reheat
Nonresidential and More than 5 Floors or >150,000 ft2	System 7 – VAV with Reheat
Heated Only Storage	System 9 – Heating and Ventilation

2.2. Baseline Building Envelope for Existing Buildings

For existing buildings, the baseline model's building envelope shall be existing conditions *unless* specific systems or components are required to be upgraded to comply with the latest version of CBES or RBES.

2.3. Input & Output Reporting

Reports summarizing model inputs and outputs shall present all information in a clear and concise format in conventional engineering units.

Hourly electrical output in kW and kWh is required for BED to facilitate energy model calibration to the constructed building's actual consumption and demand and to accommodate impact assessment of ISO New England peak.

3. Energy Modeling Process and Deliverables

3.1. Phase 1: Design Analysis

The Design Analysis phase allows all stakeholders to review the model inputs, outputs, and assumptions, and allows BED to offer the initial incentive estimate. When the building is occupied, BED will provide the first 50% on the estimated incentive from the Phase 1 model. The workflow for the Design Analysis phase is described below.

1. **Workflow:**

    a. **Stakeholders meeting**: *In-person or online, less than 2 hours.* The purpose of this meeting is to bring the energy modeling professional, architect, engineers, owner, and representatives of BED together to review the modeling approach, calculations, and input variables to be used. This collaborative setting allows all parties to confirm that the model is the best possible representation of the design and intended use of the space.

    b. **Model Creation**:
        i. One baseline model is required, at a minimum, completed following guidelines in Section 2 above.
            1. If applicable, Tier 3 baseline model.
            2. Energy Efficiency Analysis baseline model (if not developed as part of Tier 3 measures).
        ii. One proposed model is required.
        iii. If only one proposed model is provided, this model should be updated to reflect 100% construction drawings to accurately represent the intended design for the project.

    c. **Modeling Documentation and Reporting:**
        i. Develop model input report to include:
            1. Envelope constructions descriptions
            2. Envelope performance characteristics descriptions
            3. Central equipment performance specifications
            4. Terminal equipment performance specifications
            5. Thermal zone setpoints/schedules
            6. Lighting system LPD and control description
            7. Plug/process load variables/schedules
        ii. Develop energy use output reports to include data that will assist customers and Burlington Electric with validating the accuracy of the model in post-occupancy phase:

1. Hourly and monthly electrical consumption for disaggregated energy use types such as:
    a. HVAC, lighting, plug loads, elevators, process loads
2. Facility hourly electrical demand

iii. Delivery of report:

1. Report should be submitted with all relevant details as described above, as well as a brief executive summary narrative that describes the energy performance of the proposed design, in less than two pages. A narrative complements the results of the energy model and highlights the significant performance differences between the baseline and proposed buildings. Within each of the following use types; Cooling, Heating, Fans, Ventilation, Lighting, Plug/Process, and any miscellaneous use type – describe the components and strategies causal to the energy use reduction. Quantify any cumulative effects where multiple efficiency measures interact, and how each component part affects the total energy reduction in the specific use type.
2. The report appendix should contain model files, renderings, analysis tool results, component information, and supporting documentation, as is feasible.
3. The modeling professional is encouraged to include any other pertinent information that that could be useful to BED, the building owner/developer, or the design team.
4. Submit to BED, a copy of all model input files for the project. Files shall be executable by the pre-approved project energy modeling software program(s). These files are for measurement and verification purposes only, and will be kept confidential. BED can enter into a non-disclosure agreement if the energy modeler so desires. Any agreement to provide executable files to any party other than BED, shall be directly negotiated between the energy modeler and the other party.

d. **Post-report meeting:** *In-person or online, less than 2 hours.* The purpose of this meeting shall be to bring together the BED representative, owner's representative, and energy modeler to discuss the report and model results. This meeting shall be scheduled after the report is issued.

3.2. Phase 2: Calibration

The Calibration phase offers the energy modeling professional the opportunity to update the model assumptions and inputs with any modifications made during construction, and allows BED to offer the final incentive. Upon completion of this process the owner /developer will receive the second incentive payment. This payment may be adjusted based on the results of the Phase 2 calibration process. The workflow for the Calibration phase is described below.

1. **Workflow**:

   a. **Calibration Assessment:**
      i. BED will determine if a calibration process is warranted.
      ii. After approximately 1 year of continuous building operation, utility data for actual building energy demand and consumption will be used to verify the accuracy of the model. If the utility data significantly deviates from model outputs (>5%), a calibration process shall be undertaken.
      iii. The calibration process shall consider any physical or operational changes from the original proposed design. This may necessitate changes to the baseline, proposed, or both models. This may include changes to:
         1. Occupancy rates
         2. Occupied schedules
         3. Equipment run hours
         4. Equipment loads
         5. Air tightness
      iv. Some customers may wish to have consultants estimate the cost for the calibration process early in the project, so the funds can be held in contingency. The energy modeler could have a fair idea of the probability of significant deviations based on the building type and use cases, and may be able to estimate the time required based on the changes most likely to occur.
      v. Since the scope of work cannot be definitively known until after the year of typical operation has transpired, *the final additional cost for the calibration process should be negotiated with the pertinent project team members at that time*.

   a. **Calibration Meeting:** *In-person or online, less than 2 hours.* The purpose of this meeting is to bring together BED, the owner's representative, and the energy modeling professional to gather information and review changes to the design during construction (2 hours maximum time commitment).
   b. If calibration is determined to be necessary as a result of the calibration meeting, the energy modeling professional will develop a cost estimate for the expanded scope of work.
   c. Upon customer acceptance of the proposal, the baseline(s) and/or proposed models are to be modified by the energy modeler as required to reflect actual construction and occupancy.
   d. The modeling exercise will be considered complete when:
      i. The proposed model's energy demand and use estimates are within 5% of demand and consumption data from electric meter data.
      ii. An updated modeling report is provided with output in the same format as delivered in Phase 1, including a brief description of all changes made to original model input that impacted the calibrated model's results, in less than two pages.
      iii. Report appendix is updated with revised files that were delivered at the conclusion of Phase 1 that were modified as part of the calibration process.