UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Residential Environmental Assessment Program (REAP) 3.0

Energy Modeling Guidelines

Amy Ferguson

University of British Columbia

APPP 506

Themes: Buildings, Energy

31 Dec, 2016

APPP506

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Amy Ferguson
Student Number: [redacted]

20-Dec-16

Revised April 27, 2017

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Executive Summary

This report was undertaken for UBC Campus and Community Planning (Sustainability and Engineering) to support the review and revision of the Residential Energy Assessment Program (REAP). The purpose of this study is to develop recommendations to improve modeling guidelines to support the energy targets and modelling requirements in REAP 3.0 for multi-use residential buildings (MURBs).

In order to accomplish this task a review of modeling guidelines was conducted, REAP 3.0 submissions were reviewed, and six energy modelers were interviewed to improve the understanding of other approaches to guidelines, to monitor current applications and to gain insights from local modeling expertise. The following modeling guidelines were reviewed: UBC Modeling Guidelines, City of Vancouver Draft Modeling Guidelines, BC Hydro's New Construction Program's Energy Modeling Guidelines, Guidance for Energy Modeling Compliance Documentation in LEED Canada, COMNET Modeling Guidelines, and ENERGY STAR Multifamily High Rise Program Simulation Guidelines Version 1.0 Revision 03. Combining aspects from the different guidelines could be beneficial in creating a more robust guideline document. Some noted aspects to incorporate include a list of common errors, clarification on submission process, and standardized documentation. Six current REAP 3.0 energy modeling reports were reviewed and it was noted that some parameters are calculated differently, reporting templates differ, and there is no easy data access or comparison between buildings. A number of common themes were identified from the interviews. Energy modelers noted that the UBC Guidelines are clear and straightforward, that UBC Guidelines should be software neutral, that there should be clarity on what to report, and that merging UBC guidelines with CoV draft guidelines would improve UBC's guidelines. It was also noted that the CoV guidelines are still in draft form so there are gaps and needed clarifications.

From the review of guidelines, current submissions and interviews, eight primary recommendations were developed. These include keeping the UBC checklist, using existing energy modeling guidelines as a basis for updates, adopting different standards to existing guidelines if needed, clarifying when specific items need to be submitted, developing a standardized reporting template, clarifying mandatory credits, increasing the stringency of some of the credits, and making guidelines software neutral.

Purpose

The University of British Columbia (UBC) needs robust modeling guidelines to support the energy targets and modelling requirements in Residential Energy Assessment Program (REAP) 3.0. The purpose of this project is to improve energy modeling guidelines for UBC's REAP 3.0 for multi-use residential buildings (MURBs).

This project is being undertaken for UBC Campus and Community Planning (Sustainability and Engineering) with Ralph Wells as the project mentor.

Data and Methods

A review of modeling guidelines will be conducted for this project using resources such as:

- Online resources
- Texts
- Policies
- Journals
- Reports
- Supplementary material from mentor

In addition to the review of modeling guidelines other information will be gathered for this project including:

- Energy modeling reports from UBC buildings
- Draft guidelines

Information will be collected using the following methods:

- Online research
- Energy modeler interviews
- Reviewing energy modeling reports

After information and data is collected it will be consolidated. The data will be evaluated using a variety of techniques some of which may include table displays and written form. Based on the findings recommendations will be proposed. The collected findings and recommendations will be communicated in the final deliverable.

Confidentiality

This project is not confidential, however information specific to UBC buildings is regarded as confidential and the identities of the energy modelers interviewed along with interview transcripts will also remain in confidence.

Background

Increasing greenhouse gas (GHG) emissions from fossil fuel consumption are causing serious impacts on the planet. The Intergovernmental Panel on Climate Change (IPCC) reported that "the last three decades have been successively warmer at the Earth's surface than any preceding decade since 1850." As such, it has become critical to reduce energy consumption. According to StatsCan the residential sector consumed between 1200-1400 PJ of energy per year during 2005-2009. This accounts for roughly 16-17% of all the energy usage in Canada (Statistics Canada, 2011).

GHGs are known to cause climate change. Residential energy usage is responsible for approximately 15% of Canada's GHG emissions (Zhang, 2004). In the latest report, AR5, the IPCC stresses the importance of GHG mitigation stating with high confidence that "without mitigation efforts beyond those in place today… warming by the 21st century will lead to high to very high risk of severe, widespread and irreversible impacts globally."

The building code drives the efficiency of buildings and their energy use. The update of the code in British Columbia to its current standards provided an energy savings of approximately 10-15% and GHG reductions of approximately 16% when compared to the previously instated code (Frappé-Sénéclauze, 2015). Further tightening the code could allow for even more energy savings and GHG reductions.

Policy Review

REAP 3.0

REAP 3.0 is a green building rating system on UBC's Point Gray campus developed by UBC that is employed for residential developments on campus. UBC buildings are required to meet the REAP 3.0 requirements in addition to British Columbia Building Code (BCBC) requirements. The rating system is organized similar to the Leadership in Energy and Environmental Design (LEED) rating system. REAP 3.0 is divided into the seven following categories: Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR), Indoor Environmental Quality (IEQ), Construction (CON), and Innovation and Design Process (ID). Each of these categories has mandatory credits and optional credits. The amount of points received from the credits in each section determines the REAP rating which ranges from Gold (45 – 60 points) to Platinum Plus (101 – 134 points). REAP 3.0 also implements building energy targets.

City of Vancouver

According to the renewable city strategy by 2030 new buildings are required to use 100% renewable energy (City of Vancouver, 2015). The City of Vancouver (CoV) approved the Zero Emissions Building Plan on July 13, 2016. This implements goals for Vancouver regarding new buildings. The plan focuses initial action on greenhouse gas (GHG) reduction in new residential buildings. Vancouver requires all buildings constructed from 2020 to be carbon neutral in operations (City of Vancouver, 2015). Additional actions in the Zero Emissions Building Plan are summarized below:

1. Limits: GHG and thermal energy demand;
2. Leadership: New City-owned buildings aim to achieve zero emissions;
3. Catalyst Tools: support private sector leadership;
4. Capacity Building: invest in tools to develop & share knowledge and to remove barriers (City of Vancouver, 2015).

Building Act and BCBC

The Building Act (BA) is a legislation that was passed in the spring of 2015. Currently it applies to all areas of British Columbia (BC) "except the City of Vancouver and federal lands and reserves." The BA empowers the BCBC. It also removes the ability for local governments to create bylaws that establish standards for buildings.

In September 2015, the Energy Efficiency Working Group (EEWG) convened to develop recommendations to "allow local governments to require consistent building energy efficiency requirements that go beyond the BCBC" (BSSB, 2016). The EEWG developed "a long-term policy road map for improved energy efficiency performance for buildings" (BSSB, 2016). They developed a set of criteria for a tiered stretch code which provided guidance for the new Building Act. The new Building Act will take away local governments' (cities and municipalities) ability to set building standards, including energy in January 2018 and the sole regulation for buildings will be the BCBC. The new Building Act will also implement a 'Step Code' that provides tiered energy targets that local governments can adopt.

In order to achieve compliance according to the BCBC for Part 3 buildings the National Energy Code for Buildings (NECB) 2011 or American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 2010 must be followed. Part 3 buildings, are defined by the BCBC as "large complex buildings." MURBs being studied at the University of British Columbia fall under the category of Part 3 buildings.

When following NECB 2011 or ASHRAE 90.1 2010 for Part 3 buildings (Section 10.2 in the BCBC) there are 3 main pathways. These pathways are a prescriptive path, a tradeoff path, or a performance path. A prescriptive pathway outlines the exact criteria for the building to follow. The second pathway is the tradeoff path. Trade-off compliance allows buildings to have requirements that are lower than prescriptive requirements by having other requirements exceed the prescriptive requirements within the same section, acting as a trade-off. The performance pathway involves energy modeling.

With the development of new plans, strategies, and acts there is a large potential for advancement in the green building market. Designers will be obligated to provide modelling to verify that the new regulations are being met. Modeled buildings often do not reflect their proposed modeled energy and can in some cases be less energy efficient. There is also a wide range of reported values and techniques used for modeling. This emphasizes the importance of developing guidelines for energy modeling.

Energy Modeling Overview

According to REAP 3.0 all buildings must meet a maximum energy usage intensity (EUI) of 160 kWh/m^2/yr. This is a mandatory credit in the EA section of REAP 3.0 and requires the use of energy modeling. There are also three voluntary energy credits that require the use of energy modeling. Currently UBC has the UBC Energy Modeling Guidelines that:

- "Highlight common modelling simplifications/errors that may lead to inaccurate modelling results;
- Provide a recommended approach to addressing those simplifications/errors;
- Provide a level playing field for energy modelling, helping ensure industry-accepted energy modelling approaches are followed;
- Create improved accountability to help ensure that the proposed model reflects the intended building design" (Halsall Associates).

NECB 2011

For compliance with NECB 2011's performance path the annual energy consumption of the proposed building must not exceed the annual energy consumption of the reference building. The reference building is a baseline building that the proposed building is compared to. The NECB 2011 standard outlines many requirements of the baseline building. Energy consumption is modeled in the proposed building. Performance path can be used only when the construction techniques or the components of the proposed building are more energy efficient than the prescriptive requirements.

ASHRAE 90.1 2010

For compliance with ASHRAE 90.1 2010's performance pathway called the Energy Cost Budget (ECB) all mandatory provisions in the standard must be met in addition to the requirements of ECB. Compliance is then achieved when the design energy cost does not exceed the energy cost budget and when the energy efficiency levels meet or exceed the levels used to calculate the design energy cost. The ECB method uses software to model proposed building energy use by fuel type and end use. ASHRAE 90.1 2010 terms the baseline building as a "budget building" while NECB refers to a "reference building." These are terms, although different, have the same meaning. ASHRAE 90.1 2010 also states that simulation programs must be computer based for the analysis of energy consumption however a particular software is not specified in ASHREA 90.1 2010 or in NECB 2011. This leaves the decision up to the modeler.

There is a wide variety of building energy models (BEMs) in use today. They offer differences in interface interaction, inputs, outputs, and usability. This creates a complex web of choices for building modelers.

Energy Modeling Guideline Review

In order to understand what exists for North American modeling guidelines a review of modeling guidelines was undertaken. Harvard was reviewed for energy modeling guidelines but no formal document was found. Five energy modeling guidelines were identified in Canada and one outside of Canada. Other areas were explored with little to no success. The five Canadian guidelines are UBC Modeling Guidelines, CoV Modeling Guidelines, BC Hydro's new Construction Modeling Guidelines, Guidance for Energy Modelling Compliance Documentation in LEED Canada, and ENERGY STAR Multifamily High Rise (MFHR). The other North American guideline is COMNET modeling guidelines. A high-level tabular comparison for these guidelines is provided in Appendix I.

UBC Modeling Guidelines

The UBC modeling guidelines are broken into six main components:

- Building Envelope
- Central Plant Equipment
- HVAC Systems
- Lighting
- General
- Building Specific

Each component is broken into sub-sections that outline common errors or oversimplifications and recommendations to avoid modeling mistakes. In addition to the modeling guidelines document there is also a modeling checklist.

Building Envelope

In the building envelope section three main common errors are highlighted. The first check is to "verify that the above-grade wall and roof inputs reflect the construction assemblies and U-values." Common errors include:

1. "On a typical project, up to 20 different wall and/or roof assemblies can be included in a given design. Defining multiple assemblies can be time consuming and in most cases, for the purpose of whole building energy simulation, several similar-performing assemblies can be represented by a single type without compromising accuracy.
2. Thermal bridging of steel or wood framing is not accounted for correctly.
3. Spandrel panels are modelled using insulation values provided by the manufacturer."

The second is to "verify that the proposed window U-values and solar heat gain coefficients (SHGC) reflect the correct assembly thermal performance." Common errors for this include using the centre-of-glass thermal properties and "depending on the number of different window assemblies, the number of window assemblies is reduced."

The third is balconies. Often balconies are ignored in the model but they need to be taken into account.

Central Plant Equipment

The central plant equipment section outlines boiler parameters such as boiler type, efficiency and size must reflect the equipment schedule/cut sheet and design conditions. Commonly proposed errors include incorrect thermal efficiency, heating capacity or number of boilers, or "thermal efficiency of condensing boilers is not defined at operating conditions."

This applies for chiller parameters. Common errors include incorrect COP, cooling output or number of chillers, or COPT and output are not defined at ARI 550/590 test conditions.

Again pump parameters must also reflect the equipment schedule/cut sheet and non-HVAC pumps such as a sum or storm or sanitary pumps are included in the model.

Service hot water loads must account for all fixtures commonly fixtures. Often janitor sinks are not included.

Lastly in this section is district energy systems (DES) and combined heat and power (CHP). The guidelines outlines that the "methodology described in the LEED Canada Supplemental Guidance for DES and CHP systems is implemented properly."

HVAC Systems

The first sub-section of HVAC Systems is fan power. Fan power includes motor efficiency but often the fan brake horsepower (BHP) is entered as the fan power which is incorrect.

The second sub-section is ventilation heat recovery. In this section often “heat recovery effectiveness is not adjusted when a make-up air unit equipped with heat recovery provides only a portion of the ventilation air to an air handling unit or in cases where the exhaust air does not match the supply air or when some of the outdoor air bypasses the heat recovery device” so it should be verified “that heat recovery effectiveness calculation accounts for differing supply and exhaust airflows.”

The third sub-section is outdoor air rates. Here the modeler must “verify that outdoor air rates for the proposed systems match the actual design,” “that the proposed building ventilation rate does not exceed the ventilation rates defined by ASHRAE 62.1 (or superseding standard) by more than 20%,” and that “if the proposed design exceeds the reference standard by more than 20%, the baseline ventilation rate is set to the minimum rate in the referenced standard (without the 20% allowance).” Common errors and oversimplifications include the modelled outdoor airflows for the proposed design does not match the design outdoor airflows on a system level and “the reference and proposed buildings are modelled with the same ventilation rates, even though the proposed building exceeds the ASHRAE 62.1 (or equivalent code) allowance by 20%.”

The fourth sub-section is demand and control ventilation (DCV). Here it is outlined that it is important for modelers to “verify that the DCV has been modelled according to the methodology described in the LEED Canada 2009 supplemental guidance for energy modelling.” A common error is that the “simulator has reduced the fan schedule to account for DCV.”

The last sub-section is outdoor air economizer energy modelling. Modelers must verify that the modelling of the outdoor air economizer reflects the actual design. A common oversimplification is when “the maximum outdoor air ratio is set to 1.00 when a make-up air unit delivers fresh air to air handling units.”

Lighting

The first sub-section is daylighting and automatic lighting controls. Here it must be verified that the daylight and occupancy sensors have been modelled in accordance with Section 8.1.1 of the EE4 Modelling Guide. The control fraction is set to 1.0 when daylighting or occupancy sensors control only a fraction of the lighting fixtures within a zone, so this must be taken into account.

The second sub-section is lighting systems. Here it must be verified that “the ballast power is included in the power of lighting systems.” Common errors and oversimplifications include that “the lighting power density only accounts for the light bulb and excludes the ballast power.”

General

Under the general component is the sub-section energy rates. Here the modeler must “provide a description of utility rates used in the model.” “Utility rates can have a significant impact on the overall energy cost saving.”

Building Specific

For residential buildings, it needs to be verified "that the energy consumption from appliances is included in the simulation." Commonly "only the MNECB default plug loads are included for residential building" and the energy consumed from appliances is omitted but this is incorrect.

Checklist

In addition to the written guidelines a REAP modeling checklist is also available for modelers to use. The checklist outlines the same above sections as mentioned above but in an Excel spreadsheet.

City of Vancouver Modeling Guidelines

The CoV has drafted energy modeling guidelines in order to "clarity on energy modeling inputs for the purposes of showing compliance with the ZEN Buildings Policy." For a tabulated version of these guidelines reference Appendix II. The draft modeling guidelines are broken into 5 sections:

- Introduction
- Standardized assumptions
- Calculating envelope heat loss
- Passively cooled buildings
- References and resources

Introduction

The introduction covers definitions, acceptable energy modeling software, the weather file that is to be used, and unmet hours in the energy simulation. Annual hours must be limited to 100 hours or less with the following exception; annual cooling unmet hours are allowed provided that the cooling capacity has been purposively undersized.

Standardized Assumptions

In the second section, standardized assumptions are listed. These include schedules, internal and DHW loads, other loads, infiltration, ventilation, and terminal units and exhausts fans. The standardized numerical assumptions for MURBs include schedules, suite information, and ventilation rates. These are included in Appendix II.

Other loads include elevators which should be modeled by using the expected electrical drawing of each elevator. Frequency of use is based on building type and size. All other process loads are to be included in the energy model.

Infiltration is modeled as a function of wind from the weather file. The equation is included in the guidelines. Reduced air leakage rates can be modeled if the project teams commits to achieving a minimum air leakage rate which will be confirmed by mandatory air tightness testing.

Ventilation rates are modeled as per design; however, MURBs designed to ASHRAE 62-2000 make-up air quantities cannot be modeled "lower than that required by Table 2: Outdoor Air Requirements for Ventilation 2.3 Residential Facilities of ASHRAE 62-2001."

Terminal equipment fans must be modeled according to design. "Modelers must ensure that minimum flow rates and control sequences of VAV terminals and Fan Powered Boxes are modeled according to the design, and if not available at the time of modeling, according to expected operation based on maintaining ventilation and other air change requirements as appropriate."

Calculating Envelope Heat Loss

The third section includes opaque assemblies and fenestration and doors. Opaque assemblies outline the approaches that may be used to determine the overall opaque U-value. This sub-section also outlines the elements that should and should not be included for the calculation for overall thermal transmittance of opaque building assemblies. Similarly the fenestration and doors sub-section outlines limitations in determining fenestration U-factors.

Passively Cooled Buildings

To model buildings that do not incorporate mechanical cooling the guidelines state, "it must be demonstrated that interior temperatures of occupied spaces do not exceed the 80% acceptability limits for naturally conditioned spaces, as outlined in ASHRAE 55-2010 Section 5.3, for more than 20 hours per year for any zone." Additional measures such as solar shading "shall be validated through engineering calculations (i.e. computer modeling or similar). Calculations must be based on annual weather data using the weather file described above."

BC Hydro's New Construction Program's Energy Modelling Guideline

In March of 2016 BC Hydro published "New Construction Program's Energy Modelling Guideline" to "assist in the design and construction of new high performance and energy efficient public/institutional, commercial, and multi-unit residential buildings in B.C." In the guidelines BC Hydro outlined 3 main sections:

- Project baseline
- Energy modelling study submission requirements
- Other modelling requirements

Project Baseline

The project baseline must be agreed upon before work begins. The baseline is to be calculated by:

- Applicable legislation or by-laws - any applicable building code energy requirements
- ASHRAE 90.1 2010, or
- NECB 2011
- BC Hydro's New Construction Baseline Table for HVAC Systems (Appendix A)
- Special cases to be reviewed by the BC Hydro program team

Energy Modelling Study Submission Requirements

The energy modeling study submission requirements includes Energy Study Proposal, Energy Study Report, Post-Tender Energy Study Report Update (if applicable), and Lighting Calculator. As of May 1, 2015 the program required the submission of the Energy Modelling Study Proposal and Report Workbook with the purpose:

- "To standardize energy study reporting format.
- To show required information and inputs needed from consultants for the technical review in the proposal and study approval process.
- To minimize duplication in documenting and submitting information for review phases (proposal and study reviews)."

The Report Workbook is a Microsoft Excel workbook composed of 13 worksheets. The first stage is the energy study proposal. In this stage the workbook is submitted along with the project application and consultant's proposal. Only the proposal worksheet is completed. This does not include technical details but is used for BC Hydro's program engineer to review the proposed modelling study scope and cost.

The second stage, energy study report, is when the study inputs worksheet is completed for the workbook. Modelling inputs from the proposal stage may change and this worksheet allows those changes to be captured. After the study inputs are entered and the LCC analysis and summary worksheets will automatically update. Modelers must add in energy cost measures (ECM) details for the cost consultant. Additional building systems or modelling process details not captured in the spreadsheets must be added to the bottom of the workbook with their calculations and details.

The post-tender energy report study update is only required if the building design or size has been significantly altered after the approval of the "pre-tender study report." In this case the workbook must be updated and resubmitted to the program for review.

The last requirement is the lighting calculator. The lighting calculator must be completed by an electrical consultant based on the final or as-built design. Lighting drawings and luminaire specs must be submitted as well.

Other Modelling Requirements

Other modelling requirements include:

- Windows to Wall Ratio (WWR)
    - 40% of gross above-grade wall area when compared to the baseline building
- Building Envelope Thermal Bridging and Effective Building Envelope Opaque U-Values
    - The baseline building U-values (that account for interface details) must also be determined
    - BC Hydro presented a methodology for determining this in the report "Accounting for Thermal Bridging at Interface Details – A Methodology for De-Rating Prescriptive Opaque Envelope Requirements in Energy Codes"
- Mechanical Ventilation
    - modeled the same as the proposed design ventilation rates up to 50% higher than BCBC requirements
- Natural Ventilation (with passive cooling)
- Service Water Heating

- Plug Loads
  - Electric load tables provided in guidelines
- Lighting Power Densities and Schedules
  - Lighting hours provided in Appendix
- Modeling of lighting controls
- Elevators
  - Motor load table provided in guidelines
- Indoor Temperature Set Points
- Minimum Equipment Efficiencies
- Air to Water Heat Pumps
- Baseline Model Central Heat Pump Type and Sizing
- Radiant Heating/Cooling Systems with Displacement Ventilation
- Under Floor Air Distribution (UFAD) and Thermal Displacement Ventilation
- Infiltration
- Baseline Fan Power Calculation

Additionally an air-cooled heat pump supplement performance table is included in the appendices.

Guidance for Energy Modelling Compliance Documentation in LEED Canada

Leadership of Energy and Environmental Design (LEED) is a rating system for green buildings. It is divided into 8 main sections: Innovation & Design Process (ID), Location & Linkages (LL), Sustainable Sites (SS), Water Efficiency (WE), Energy & Atmosphere (EA), Materials & Resources (MR), Indoor Environmental Quality (EQ), and Awareness & Education (AE). The range of points that a building receives determines its rating. A certified building has 45-59 points. A Silver building is 60-74 points. Gold is 75-89 points and lastly, platinum is 90-136 points. Each of the sections had prerequisites or mandatory measures and optional measures. The total number of points available is 136. The majority of points are from the EA section, totaling 38 points.

The purpose of the "Guidance for Energy Modelling Compliance Document in LEED Canada" is to standardize energy modeling compliance documentation used in the Canada LEED Rating Systems. The document is segmented into Part One and Part Two. Part One includes information typically included in energy modelling reports created for LEED. It is intended for use by energy modelers Part 2 "provides details of what sections are typically included in third party energy modelling review reports. For the purpose of this report only Part One will be examined. Part One is divided into 11 sections.

Part One

The first section in Part One, Front End, describes the information that should be included. This includes building name, project number, energy modeler contact information, and relevant signatures.

The second section, Proposed Building Energy Simulation Overview, requires general information about the project (location, use, occupancy, floor area, storeys), software and weather file used, simulated building floor area summary of key ECMs, modeling method for lighting (space or building), a description of schedules, declaration of all applicable NECB or ASHRAE 90.1 mandatory requirements/provisions that have been met or that are not applicable to the design, and the Credit Interpretation Request (CIR) number if guidance from CIRs have been applied.

The third section, Proposed Building Simulation Details requires details for the plant, HVAC Secondary Systems, Zoning, Envelope description and thermal performance, lighting, any use of "model workarounds" where simulation software was unable to accurately model a component of the building

The fourth section is Baseline Building Generation. In this section details described in section 1.3 must be applied to the baseline building. Any differences in overall ventilation between the proposed and baseline must in accordance with *LEED Canada 2009 Supplementary Energy Modelling Guidelines*. A description of the baseline plant and system equipment and steps taken to the size the baseline building must be included. Additionally a description and justification for any atypical LPD not covered under ASHRAE 90.1 or NECB must be included.

Section 5 is the District Energy System Details section. This section requires the inclusion of description and calculations for connected DE systems.

Section 6 is Renewable Energy System Details. This is only required for projects connected to renewable energy systems. Here these systems must be described. If any additional calculations are needed to estimate the amount of energy produced an explanation of why must be included.

Section 7 is Additional Calculations. If additional calculations are used in their energy simulation or energy performance calculations details and calculations must be included.

Section 8, Utility Rates, includes a description of utility rates and rate structure used in the baseline buildings and the proposed energy simulations. For non-traditional fuels additional details are available in "Guidance for Non-Traditional Fuels in LEED Canada"

Section 9, Warnings, Errors, Troubleshooting includes an "explanation of major errors reported by the simulation software, and an assessment of unmet heating and/or cooling load hours."

Section 10 details Building Energy Simulation Results. This includes signed letters, summary of energy consumption by month or annual end uses for the proposed and baseline buildings.

Lastly, Section 11 outlines the typically appendices to be included. The typical appendices mentioned are:

- "Zoning diagrams
- Supporting documentation for utility rates.
- Supporting documentation for major HVAC, and lighting equipment, and envelope components.
- Signed mandatory requirements/provisions checklists (MNECB or ASHRAE).
- Outdoor air calculation spreadsheets.

- Calculations for model work-arounds, exceptional calculations, process energy savings, renewable
- Energy systems, district energy systems, etc.
    - Supporting documentation for final energy model:
- issued-for-construction drawings along with shop drawings of modelled system components,
- or as-built drawings; and
- specifications for building systems being modelled, along with controls sequence of operation."

COMNET Modeling Guidelines

COMNET, a quality assurance program for energy modelers, has developed a set of modeling guidelines. The purpose of these guidelines is to provide a "detailed reference and modeling guide for using the performance rating method in Appendix G of Standard 90.1-2016." COMNET's modeling guidelines are broken out into the following sections:

- 2.1 General Requirements for Data from the User
- 2.2 Thermal Blocks, HVAC Zones and Space Functions
- 2.3 Unmet Load Hours
- 2.4 Calculation Procedures
- 2.5 HVAC Capacity Requirements and Sizing
- 2.6 Ventilation Requirements

In section 2.1 the guidelines state that all building descriptors must be stated by the modeler. Building descriptors provide information about the baseline and the proposed buildings. Descriptors include building envelope descriptions, thermal blocks, HVAC system map, and onsite power generation. In this section the space use must also be stated. Part 3 of the guidelines describes the descriptors is further detail and outlines the rules that apply to the descriptor for the proposed and baseline buildings.

Section 2.2 provides guidance on how to define thermal blocks. This section provides guidance on number of thermal blocks, space use classification, envelope load, HVAC zones, and plenums. As for specific numerical values, this section states "Combined lighting, receptacle, and process equipment power densities that differ by no more than 2.0 W/ft^2 or a factor of two may be considered similar."

Section 2.3 defines unmet load hours. This section provides a list of common verifications for reasons for unmet loads.

Section 2.4 describes the 15 step calculation procedure for tax deductions and green building rating. "Sizing calculations are performed for the baseline building and heating equipment is oversized by 25% and cooling equipment by 15%."

Section 2.5 HVAC capacity guidelines are stated in order to ensure that the unmet load hours are not exceeded. Both space loads and systems loads must be met.

Section 2.6, the last section in Part 2, directs the modeler to ASHRAE 62.1 for ventilation requirements.

There are no specific numerical parameters other than the unmet hours, and sizing calculation percentages mentioned above.

ENERGY STAR MFRH Program Simulation Guidelines Version 1.0, Revision 03

The ENERGY STAR guidelines are specific to multifamily buildings. The purpose of this document is to "be used by ENERGY STAR Multifamily High Rise (MFHR) participants and energy modelers to calculate the *Performance Rating* of the *Proposed Design* for each building participating in the program." It is a supplement to the methodology described in ASHRAE 90.1 2007 or 2010. ENERGY STAR MFRH is divided into the following main sections and appendices:

- Definitions
- Scope
- Objectives
- Modeling Guidelines
- Appendix A: References Standards and Data Sources
- Appendix B: Description of Performance Path Calculator

Under Modeling Guidelines, the standard is broken into the following sections:

- 3.1 General Approach
- 3.2 Performance Rating and Documentation Requirements
- 3.3 Simulation Program
- 3.4 Building Envelope: Opaque Assemblies
- 3.5 Building Envelope: Vertical Fenestration
- 3.6 Lighting
- 3.7 Thermal Blocks
- 3.8 HVAC
- 3.9 Domestic (Service) Hot Water Systems
- 3.10 Receptacles and other plug loads
- 3.11 Elevator Loads
- 3.12 Ventilation and Infiltration
- 3.13 HVAC Distribution Losses
- 3.14 Fan Motor Energy
- 3.15 Pumps
- 3.16 Energy Rates

These modeling guidelines cover the above topics in deal and reference ASHRAE 90.1 when more detail is needed.

REAP 3.0 Submission Reviews

After reviewing literature on modeling guidelines REAP 3.0 submissions were reviewed in order to determine commonly reported parameters. Appendix III shows the parameters reported in the REAP 3.0 submissions for the six current REAP 3.0 buildings.

While reviewing the reports the following was also noted:

- Some parameters are calculated differently
- There are different reporting templates

- There is no easy data access or comparison

Energy Modeler Interviews

After reviewing UBC's REAP 3.0 energy modeling reports, energy modelers were interviewed to gain insight from people who are familiar with the energy modeling process and using energy modeling guidelines. Appendix IV includes the list of formal questions that were posed to the modelers. Additionally, Appendix V includes a transcript of the interviews. Common themes arouse from the interviews (see Table 1 below). Check marks indicate that the item was mentioned by the energy modeler.

Table 1: Common Occurring Items in Energy Modeler (EM) Interviews

Items mentioned by EMs	**EM 1**	**EM 2**	**EM 3**	**EM 4**	**EM 5**	**EM 6**
UBC Guidelines are clear and straightforward	✓	✓		✓	✓	✓
UBC Guidelines should be software neutral		✓			✓	
There should be clarity on what to report			✓			✓
Merging with CoV draft guidelines would improve UBC's guidelines	✓	✓	✓	✓	✓	

Although many of the energy modelers were in favour of harmonizing REAP 3.0 with the CoV guidelines, one modeler warned against this stating that the CoV guidelines are currently in development stage and there are still many gaps and needed clarifications. The modeler recommended using ASHRAE as a reference.

Recommendations

Based on the findings from the review of modeling guidelines, REAP 3.0 submission review, and the energy modeler interviews the following primary recommendations were developed: These aspects from include a list of common errors, standardized assumptions, clarification on submission process, and standardized documentation

1. **Keep the UBC Energy Modeling Checklist as a part of the new guidelines**. This recommendation was based on the feedback from the modelers. Many indicated that they found this checklist useful and for this reason it is recommended that the checklist remain a part of REAP.

2. **Expand UBC's guidelines by using existing guidelines as a basis for updated guidelines.** This recommendation helps to ensure efficiency. The inclusion of a list of common errors in the UBC guidelines was unique to the reviewed modeling guidelines and was considered helpful by the majority of the interviewed modelers so it should not be eliminated. Instead it should be expanded upon using existing guidelines which would avoid the unnecessary task of creating of new guidelines from scratch.

3. **Adopt different standards from existing guideline if needed.** This recommendation corresponds with recommendation 2. If an existing guideline is used the targets and energy measures can be altered but the wording can remain the same or similar in order to be efficient, concise, and precise. For example the ENERGY STAR MFRH Program has guidelines specific to MURBs and as mentioned by an interviewed modeler, ASHRAE's Appendix G has a very comprehensive set of modeling guidelines as well.

4. **Develop standardized reporting template.** This recommendation ensures that the buildings are reporting the measures that UBC is interested in tracking and the spreadsheet allows for the data to be easily complied and compared. This recommendation is based on the review of BC Hydro's New Construction Program's Energy Modelling Guidelines and CoV Modeling Guidelines. The template should include the following:
    a. Standard inputs
    b. Standard outputs
    c. Excel Spreadsheet for reporting so data can be easily accessed
        i. Possible worksheets include: inputs, REAP 3.0 checklist, and outputs

5. **Clarify when and what should be included during stages of submission.** This will promote clarity in the REAP compliance process. This recommendation is based off of the review of the Guidance for Energy Modeling Documentation in LEED Canada guidelines.

6. **Clarify some of the mandatory credits**. Again, this will promote clarity in the REAP compliance process. One specific item mentioned by a modeler was to:
    a. Clarify wording regarding minimum exterior wall insulation of R-15.6

7. **Consider increasing stringency of some of the EA credits.** This recommendation will encourage better energy performance in REAP buildings. This was also mentioned by a modeler during the interview process. These could include:
    a. M4: Energy Efficient Windows
    b. Mandatory Gold EA EUI

8. **Change wording in UBC Energy Modeling Guidelines to allow for appropriate software other than eQUEST and FramePlus Online to be used for modeling.** This recommendation was mentioned by many of the interviews modelers and would allow the use of more up to date software.

Conclusion

Although energy modeling guidelines and best practices are fairly new, guidelines for energy modeling do exist. UBC should use these guidelines as a foundation or reference them within its own guideline document along with adopting the above recommendations.

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APPENDICES

Appendix I – Review of Modeling Guidelines Tabular Comparison

	UBC	CoV	BC Hydro	LEED	COMNET	ENERGY STAR
Main Purpose	Outline common errors or oversimplifications and recommendations to avoid modeling mistakes	Clarity on energy modeling inputs for the purposes of showing compliance with the ZEN Buildings Policy	Assist in the design and construction of new high performance and energy efficient public/institutional, commercial, and multi-unit residential buildings in B.C	Standardize energy modeling compliance documentation used in the Canada LEED Rating Systems	Provide a detailed reference and modeling guide for using the performance rating method in Appendix G of Standard 90.1-2016	Outline methodology for calculating a Performance Rating for multifamily buildings in EPA's ENERGY STAR Multifamily High Rise Program
Main Sections	• Building Envelope • Central Plant Equipment • HVAC Systems • Lighting • General • Building Specific	• Introduction • Standardized Assumptions • Calculating Envelope Heating Loss • Passively Cooled Buildings	• Project Baseline • Energy Modelling Study Submission Requirements • Other Modeling Requirements	Under Part One: • Front End • Proposed Building Energy Simulation Overview • Proposed Building Simulation Details • Baseline Building Generation • District Energy System Details • Renewable Energy System Details • Additional Calculations • Utility Rates	Under General Modeling Procedures: • 2.1 General Requirements for Data from the User • 2.2 Thermal Blocks, HVAC Zones and Space Functions • 2.3 Unmet Load Hours • 2.4 Calculation Procedures • 2.5 HVAC Capacity Requirements and Sizing • 2.6 Ventilation Requirements	Under Modeling Guidelines: • 3.1 General Approach • 3.2 Performance Rating and Documentation Requirements • 3.3 Simulation Program • 3.4 Building Envelope: Opaque Assemblies • 3.5 Building Envelope: Vertical Fenestration • 3.6 Lighting • 3.7 Thermal Blocks

				• Warnings, Errors, Troubleshooting • Building Energy Simulation Results • Appendices		• 3.8 HVAC • 3.9 Domestic (Service) Hot Water Systems • 3.10 Receptacles and other plug loads • 3.11 Elevator Loads • 3.12 Ventilation and Infiltration • 3.13 HVAC Distribution Losses • 3.14 Fan Motor Energy • 3.15 Pumps • 3.16 Energy Rates
Numeric Parameters	No	Yes	No	No	No	Yes

Appendix II – CoV Parameters

Schedules	Suites	Table A-8.4.3.2(1)G of NECB 2011
	Corridors and Parkade Lighting	8760 Full Load Hours
	Stairwells, Mechanical / Electrical Rooms, Other Spaces	According to modeler's judgement based on actual intended use
	Parkade Fan Schedule	4 hours / day
	Suite Exhaust Fans	2 hours/day
Internal and DHW Loads	Occupancy	2 people for the 1st bedroom, 1 additional person for each bedroom thereafter
	Plug Loads	5 W/m^2. If there are gas-fired cooking appliances, then 1 W/m^2 shall be assigned to gas and 4 W/m^2 shall be assigned to electricity
	Lighting	5 W/m^2, unless a complete suite lighting design is provided as part of the contract documents for the project
	DHW	0.0013 L/s/person (0.021 gpm/person) of peak flow
Infiltration	Infiltration Equation SI	Infil (m^3/s) = 0.00025 $m^3/s/m^2$ x (0.224 x Wind Speed), Wind Speed is measured in m/s
	Infiltration Equation IP	Infil (cfm) = 0.05 cfm/ft^2 x (0.224 x Wind Speed), Wind Speed is measured in mph
Ventilation	MURB projects designing to ASHRAE 62-2001	Make-up air quantities for the suites cannot be modeled lower than that required by Table 2: Outdoor Air Requirements for Ventilation 2.3 Residential Facilities of ASHRAE 62-2001 (i.e. 0.35 ACH but not less than 7.1 L/s/person (15 cfm/person), based on 2 occupants for the first bedroom and 1 additional occupant for each additional bedroom)

Appendix III – REAP 3.0 Reported Energy Modeling Inputs

	Lot E	**Site B**	**Virtuoso**	**Lots 27-29**	**Eton**
Reported By	Stantec	Williams Engineering	Williams Engineering	Stantec	Morrison Hershfield
Climate Zone	Y	N	N	Y	Y
Building Area - Storeys	Y - N	Y - Y	Y - Y	Y - N	Y - N
Building Type	Y	N	N	Y	Y
Operating Hours	Y	N	N	Y	Y
Occupancy	Y	Y (Peak)	Y (Peak)	Y	Y
Plug Loads	N – broken in sub-sections	N	N	N – broken in sub-sections	Y
Outdoor Air/Infiltration	Y	Y	Y	Y	Y
Wall R-Value - Above Grade - Below Grade	Y - Y - Y	Y - N - N	Y - N - N	Y - Y - Y	Y - N - N
Roof R-Value	Y	Y	Y	Y	Y
Window U-Value	Y	Y	Y	Y	Y
Window Area %	Y	Y	Y	Y	Y
External Shading	Y	N	N	Y	N
Interior Lighting (LPD) - Controls	Y - Y	Y - Y	Y - Y	Y - Y	Y - Y
Exterior Lighting	Y			Y	Y
Equipment Load	Y	Y (Appliance)	Y (Appliance)	Y	N
Elevator Load	Y	N	N	Y	N
HVAC Systems	N	Y	Y	N	Y
Indoor Design and Temperature Schedules	Y	Y	Y	Y	N
Humidity	Y	Y	Y	Y	N
Heating - Type - Efficiency - Water Loop	N - N - N - N	Y - Y - Y - N	Y - Y - Y - N	Y - N - N - N	Y - Y - Y - Y
Heat Recovery	Y	Y	Y	Y	N
Cooling - Type - Speed - Efficiency	Y - Y - Y - N	Y - Y - N - Y	Y - Y - N - Y	Y - N - N - N	Y - Y - Y - N
Pump Head	N	N	N		Y
DHW	Y	Y	Y	Y	Y

- Type - Efficiency	- Y - N	- Y - Y	- Y - Y	- Y - N	- N - N
Fan - Power - Control - Operation	Y - Y - Y - Y	Y - Y - Y - N	Y - Y - Y - N	Y - Y - Y - Y	Y - Y - N - N

Appendix IV – Energy Modeler Interview Questions

Interview Questions

1. Do you have any specific feedback on individual topics in the REAP 3.0 Energy Modelling Guideline Checklist?
2. Do you have any other comments on REAP 3.0 Energy Modelling Guidelines?
3. Do you have any specific feedback on individual mandatory EA credits for REAP 3.0 or modeling of?
4. Do you have any other comments on REAP 3.0 mandatory EA credits?

We are considering harmonizing UBC REAP guidelines with CoV guidelines.

1. Do you have any specific feedback on the parameters or guidelines provided in the CoV table?
2. Do you have any other comments on CoV guidelines?
3. Do you have any comments on harmonizing REAP 3.0 guidelines with CoV guidelines?

4. Do you see any major gaps or omissions not covered by REAP 3.0 or CoV guidelines?

Optional Question:

1. Do you have any additional default parameters that should be considered? Some example parameters are provided in the UBC architype tab in the spreadsheet that was previously emailed.