Building Performance Evaluation Guide

Version 1.8

Prepared by

Center for Energy and Environment

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1. Schematic Design & Design Development Phase Requirements

Whole building energy simulation shall be used to determine the basis for the designed energy performance (kBtu/SF/Yr) and carbon emissions (lbs of CO2/SF/Yr) reported for projects included in the Minnesota Sustainable Building 2030 (SB 2030) program. Building simulation outputs of energy usage for each utility shall be entered into the B3 Guidelines Tracking Tool. Document predicted and actual energy use by type to determine the Design Energy Use (kBtu/SF/Yr) and Design Carbon Emissions (lbs of CO2/SF/Yr) for the project at each stage. Information about the design strategies and simulation assumptions used to determine the proposed building performance must also be entered into the Building Strategy Checklist and uploaded. While detailed building simulation development in the early design stages will provide for greater accuracy in preliminary estimates of energy performance, the detailed modeling and documentation submission requirements outlined in section 2 (below) are not required until the construction documents phase. The whole-building energy simulation during the schematic design and design development phases is generally expected to be less detailed to cost-effectively provide flexibility in evaluating the relative impact of a wide variety of design alternatives while giving a preliminary indication of the design's energy performance relative to its SB 2030 energy standard. Tracking tool entry of estimated energy use by fuel and an end use energy breakdown are the only simulation documentation requirements for the early design stages (as noted in the B3 Guidelines Tracking Tool).

2. Construction Documents Phase Requirements

Whole building energy simulation shall be used to determine the design energy performance inputs for *Document predicted and actual energy use by type* (Guideline E1D in Version 2.2 of the B3 Guidelines), which calculates the Design Energy Use and Design Carbon Emissions energy use intensity (kBtu/SF/Yr) and carbon emissions (lbs of CO2/SF/Yr) reported for projects included in the Minnesota Sustainable Building 2030 (SB 2030) program. Adherence to the technical and documentation requirements in this Section 2 is needed for reporting and certification during the construction documents phase. The use of whole building simulation provides a design team with great flexibility in taking credit for a variety of approaches to improve energy performance because the interactive effects of multiple energy design features on building performance are evaluated as accurately as possible. Both key simulation results, entered directly into the energy end-use by type table, and detailed documentation of the design and simulation must be uploaded into the project tracking tool in *Document predicted and actual energy use by type*.

2.1. Building Simulation Basic Requirements.

For the purposes of SB 2030 construction document phase compliance documentation, hourly building simulations shall be performed using one of the following software packages with weather data from a nearby location: eQUEST, TRACE 700, Hourly

Analysis Program, IES-VE or any DOE2.1E or DOE2.2 based simulation software that meets the requirements of Section 2.2 in ASHRAE Standard 90.1 2010 Appendix G. [1]

Simulations shall be according to the proposed design requirements in Appendix G of ASHRAE Standard 90.1 (2010 or later) for *Proposed Building Performance* and the rules outlined below—with the rules below superseding Appendix G of ASHRAE Standard 90.1 wherever the two are in conflict. Note that the only portions of Appendix G that apply to *Proposed Building Performance* (and SB 2030 simulations) are Sections G1 through G3.1.1.3.4, G3.1.2.5, G3.1.2.6, G3.1.3.6, G3.1.3.15, and the left-hand column (i.e. the *Proposed Building Performance* column) of table G3.1.

Final simulations shall not have more than 300 unmet load hours, except where it can clearly be shown that the inaccuracy introduced by the unmet load hours is small enough that it could not make the difference between the project meeting or not meeting the SB 2030 energy standard.

2.2 Exterior Lighting

Exterior lighting that is powered through the building's utility meter shall be included in the simulation model (and Energy Standard determination). Parking garages should also have their floor area included as a "Building" in the Energy Standard Tool (E1C4) while surface parking lots should have their area included in the "Parking Illuminated Area" within the "Building Characteristics" area of the Energy Standard Tool inputs.

2.3 District Energy Systems

Simulated energy use shall be assigned to the SB 2030 project consistent with the measurement and allocation of energy use outlined in the SB 2030 metering requirements, which are documented in the Metering Requirements document. For example, a building served by a district chilled water system shall have the cooling portion of energy use represented in terms of chilled water provide (e.g. ton-hours) instead of electric use of the chiller. This is true for both the energy simulation output documentation and in the entry of "Energy Performance Indicators" in E1D1. This reporting of energy use in terms of district system load vs plant fuel input must also be consistent between the design energy use indicators entries (E1D1) and the Energy Standard Tool inputs (E1C3).

2.4 Simulation Inputs

2.4.1 *Matching with Energy Standard Tool Inputs.* Simulation inputs that correspond to inputs used in setting a project's standard within the SB 2030 Energy Standards Tool (e.g. space square footages, outdoor air ventilation rates, occupant densities,

[1] For design teams wishing to use an alternative software package that is widely recognized as having equivalent capabilities (e.g. approved for federal tax credit calculations [current list available at http://www1.eere.energy.gov/buildings/qualified_software.html]), contact SB 2030 program staff ahead of time for case by case consideration.

thermostat setpoints, plug loads, process loads, sensible heat gains, latent heat gains, schedules, parking lot lit area, etc.) shall match the Energy Standards Tool inputs used to determine the project's final design-stage energy standard. Exceptions to this will only be allowed where one of the following conditions apply AND are noted on the submission:

A) A specific energy saving design feature is modeled through such input changes and supplemental documentation justifies the appropriateness of the input modifications; or
B) A simulation program default is used that is expected to yield the same or higher energy use.

2.4.2. *Matching with Design Documents.* Simulation inputs shall accurately represent the actual building design as documented by the construction documents per Table G3.1 of Appendix G of ASHRAE Standard 90.1 2010. This includes, but is not limited to: building and space geometry, orientation, areas of spaces, thermal zoning, envelope component characteristics, lighting power, fenestration areas (multiple windows with the same glass type and orientation within the same space may be combined), HVAC zoning, HVAC system type, HVAC system efficiencies, HVAC controls, etc. Where actual component rating data is not available for a specific item, its performance shall be modeled to match the most relevant performance requirements for that component in ASHRAE Standard 90.1 2010 (or simulation software default values when performance data is unknown and not governed by ASHRAE Standard 90.1 2010).

2.4.3. *Simulation Program Default Values.* Simulation program default values may be used (in place of actual component rating data for the specified equipment) where the default values are expected to lead to simulated energy use that is at least as high as what would result from the use of actual design values or when actual performance data is unknown and not governed by ASHRAE Standard 90.1 2010. Common examples of the use of default values (or pick-list only inputs) are expected to include automatically calculated HVAC unit fan power at design conditions and window performance. Note that default *performance curves* (e.g. normalized part-load efficiency curves) will be accepted.

2.4.4. *Lighting Fixture Power.* Lighting connected wattage shall be based on representative manufacturers' published ratings (for the lamp and ballast combination specified) whenever possible. Alternatively, Xcel Energy's latest Lighting Efficiency Input Wattage Guide may be used to estimate fixture wattage (dated 11/2013 at the time of this document's release).

2.5 Documentation of Simulation Model

Documentation of simulation must be submitted to describe and document the building energy simulation model that is submitted for final design review by the SB 2030 program. General requirements for documentation are listed in 2.5.1, and specific direction for pre-approved simulation software packages is outlined in 2.5.2.

2.5.1 *General Requirements for Documentation*

2.5.1.1. *Geometry & Zoning Documentation.* Geometry and Zoning must be documented by simulation model input reports, output reports or screen shots that show the following:

A) Roof area
B) Wall area by direction
C) Window area by direction
D) Floor area and exterior exposures by zone
E) The location and orientation of shades and/or adjacent obstructions (e.g. buildings) that are included in the simulation model

To facilitate review, optional visual representation of the modeled building orientation, exterior, and zoning is desirable. This could be in the form of software screen shots, software reports and/or marked up floor plans and elevations.

2.5.1.2. *Envelope Components.* Envelope component thermal properties must be documented by simulation model input reports, output reports or screen shots that show the following that apply to the building:

A) Window performance parameters in the form they are input into the simulation program (e.g. glass U-value, shading coefficient, frame type and width)
B) Roof assembly U-value
C) Exterior wall assembly U-value
D) Exterior floor assembly thermal performance (U-value, C-factor, F-factor or appropriate value for assembly type)
E) underground assembly thermal performance (U-value, C-factor, F-factor or appropriate value for assembly type)
F) The following optional additional documentation is desirable to facilitate review.
    1. For projects with multiple window types marked up elevation and window type pages of the plans
    2. Note source of window performance values

2.5.1.3. *Modeled Spaces.* The information listed below shall be documented for each space/zone within the simulation model. Documentation can be in the form of multiple reports, as long as there are consistent space/zone names or some other way for the reviewer to determine all of the following for each space.

A) Square footage
B) Space type indicator, such as naming convention or list of space types by zone
C) Floor level(s) or other space multipliers
D) Exterior envelope exposure areas (i.e. wall, roof and windows areas and types)
E) Maximum occupancy (# or square footage per occupant)

F) Maximum outdoor air (or outdoor air per person plus any minimum outdoor air per square foot)
G) Total connected lighting power and lighting connected Watts per square foot
H) Plug and process load Watts per square foot
I) Schedule names, average occupied temperatures when heated/cooled (note if not cooled or heated) and average percentage of maximum for: occupancy, lighting, and plug/process loads.
J) The following optional additional documentation is desirable to facilitate review.
    1. Cross-references between the simulation model spaces and corresponding space(s) in CDs (e.g. a table or hand written notes on either the floor plans or visual model per 2.5.1),
    2. Table showing the summing up of square footages by space type (consistent with the Energy Standards Tool input).

2.5.1.4. *Mechanical Equipment.* Document the applicable information from the list below for each HVAC system and plant.

A) Documentation of model spaces/zones served by each HVAC system
B) Documentation of HVAC systems and secondary systems (e.g. baseboard heating) served by each central plant.
C) Heating and/or cooling efficiency as input into the simulation model (e.g. EIR in eQUEST)
D) Supply and outdoor air flows
E) Thermostat (or water temperature) schedule name(s) and setpoints for occupied and unoccupied periods.
F) Fan/pump operating schedule name and percent on-time for an average weekday and weekend day.
G) For central plants, design water flow and pressure.
H) The following optional additional documentation is desirable to facilitate review.
    1. Clear statement of fan/pump power modeling basis (e.g. manufacturer's cut sheet, or simulation program default for a high efficiency motor with the design's static pressure), with clear documentation of simulation inputs used.
    2. Cross-reference between individual HVAC/central plant systems in the model and corresponding HVAC/central plant units in CDs in the form of a table or hand-written notes on floor plans.

2.5.1.5 *Domestic Water Heating.* Indicate the key performance parameters for the domestic water heating equipment and loads in the form that they are input into the simulation program (e.g. HIR, UA, peak gpm, temperature rise and hourly load schedule in eQUEST).

2.5.1.6. *Hourly Schedules*. Provide documentation of the schedules used for: occupancy, lighting, plug loads, process loads, temperature controls, fan control, domestic hot water load, and any other key input schedule.

2.5.1.7. *Additional Notes.* Submit additional notes or documentation as needed to clearly outline the simulation modeling assumptions—especially regarding the incorporation of key energy design features that are not explicit inputs into the simulation model.

2.5.1.8. *End-Use Breakdown by Fuel.* Submit an output report(s) that shows the simulation model's results of key energy end-uses for each fuel type (consistent with the input of energy end-use by fuel type in the tracking tool.

2.5.1.9. *Summary of Unmet Load Hours.* Provide summary reports showing that number of unmet load hours. If the number of unmet load hours exceeds 300 provide a narrative describing the circumstances and why in the modelers opinion that will not have a substantial effect on the overall building energy consumption.

2.5.2. *Simulation Input and/or Output File(s)*. Submittal of electronic text, SIM or PDF version of key simulation input and/or output files and other documentation as listed below satisfy the requirements of 2.5.1.

2.5.2.1 *DOE2 Based Software.* The output reports listed below shall be considered adequate documentation for DOE2 based software simulations (and these may simply be included as part of a larger output file that includes additional reports). Note that the full .INP file may be substituted for the output reports noted with an asterisks. The Parm files are also desired as optional additional documentation when available. **For project using eQUEST, submitting the simulation and output file is the simplest option for providing adequate documentation.**

A) Space type indicator for each zone in model per 2.5.1.3.B (not an output report)
B) BEPS—Building Energy Performance
C) BEPU—Building Utility Performance
D) ES-D—Energy Cost Summary
E) ES-E—Summary of Utility Rate (for all utility rates)
F) LS-C—Building Peak Load Components
G) LS-D—Building Monthly Load Summary
H) LV-A—General Project Parameters*
I) LV-B—Summary of Spaces
J) LV-C—Details of Spaces (for all spaces)*
K) LV-D—Details of Exterior Surfaces (for all surfaces)*
L) LV-G—Details of Schedules*
M) PS-A—Plant Energy Utilization
N) PS-B—Utility and Fuel Use Summary
O) PS-C—Equipment Loads and Energy Use
P) PS-E—Energy Use Summary (for all meters)
Q) PV-A—Plant Design Parameters

R) SS-A—Systems Loads Summary (for all systems)
S) SS-C—System Load Hours (for all systems)
T) SS-D—Building HVAC Load Summary
U) SV-A—System Design Parameters (for all systems)

2.5.2.2 *TRACE 700 Software*. The reports listed below shall be considered adequate documentation for TRACE 700 based software simulations (and these may simply be included as part of larger files that include additional reports).

A) The following ENTERED VALUES and SYSTEM CHECKSUMS reports:
   a. Walls by Direction
   b. Room by Room
   c. Room Assignments
   d. System Entered Values
B) The following Library Members (except sections where no members used):
   a. Floor - Construction Types
   b. Roof – Construction Types
   c. Wall – Construction Types
   d. Glass Types
   e. Adjacent Building - Shading
   f. Overhand - Shading
   g. Schedules
   h. Lights
   i. Misc. Loads
   j. People
   k. Ventilation
   l. Heating Equipment
   m. Cooling Equipment
   n. Misc. Equipment
   o. Fans
   p. Heat Recovery
C) The following VIEW RESULTS reports:
   a. Energy Consumption Summary
   b. Energy Cost Budget / PRM Summary
   c. Monthly Energy Consumption
   d. Building Temperature Profiles
   e. Room Checksums
   f. System Checksums

2.5.2.3 *Hourly Analysis Program (HAP) Software.* **Submitting the simulation file is the simplest option for providing adequate documentation.** Alternatively, the reports listed below shall be considered adequate documentation for Hourly Analysis Program based software simulations (and these may simply be included as part of larger files that include additional reports).

A) The following Input Reports:

a. Spaces
b. Systems
c. Plants
d. Buildings
e. Project Libraries: Schedules, Walls, Roofs, Windows, Doors, Chillers(if any), Cooling Towers(if any), and Boilers(if any)

B) Air System Simulation Report including:
   a. Unmet Load report
   b. Zone Temperature Report

C) Plant Simulation Report including:
   a. Unmet Load Report

D) Building Simulation Report including:
   a. Energy Budget by System Component
   b. Energy Budget by Energy Source
   c. Monthly Energy Use by Component

E) System Design Reports including:
   a. System Sizing Summary
   b. Ventilation Sizing Summary

F) Plant Design Reports including:
   a. Cooling Sizing Summary
   b. Heating Sizing Summary

2.5.2.4 *IES-VE Software*. The reports listed below shall generally be considered adequate documentation for IES-VE based software simulations (and these may simply be included as part of larger files that include additional reports). **Providing the project's archive file will tend to speed up the review process and reduce the need for reviewer questions.**

A) A model report from ModelIT application showing at least the following:
   a. Thermal Template Data
   b. Constructions
   c. Surface Areas
   d. Floor areas
   e. Orientation
   f. Profiles
   g. Internal Gains

B) The following reports generated through the PRM Navigator:
   a. Complete BRM Reports showing energy end usage by space types & total equipment energy usage
   b. BEPS
   c. BUP
   d. All other detailed simulation reports generated through the PRM Navigator

C) A text format (.txt) version of the .pdb file showing profile (schedule) input data [open in NotePad and SaveAs .txt]:

D) The following exports (to Excel) from VistaPro:
    a. Hourly lighting gain, people gain, miscellaneous gain, and HVAC airflow
    b. Peak individual energy consumption for each fan, pump, chiller, boiler, etc.
    c. Hourly energy consumption for each fan, pump, chiller, boiler, etc.
E) Images of the 3D model using ModelViewer2 and Apache to graphically show:
    a. Zoning room data (areas, etc.)
    b. The assignment of constructions
    c. Shading devices and/or adjacent obstructions (e.g. buildings)

2.6 Documentation of Design

In order to allow confirmation that the simulation model accurately represents the actual building design, the following excerpts from the construction documents shall be submitted at the time of application for final design certification in electronic form (PDF preferred) and/or hard copy:

From Architectural & General Pages & Specifications

A) Site Plan Showing Building Orientation and any obstructions (e.g. other buildings) included in the simulation model
B) Floor Plans for Each Level
C) Elevations for Each Exterior Building Face
D) Location, Size and Performance of All Exterior Windows, Doors & Architectural Glass (include documentation of NFRC certified ratings if not in specifications-- window type and performance [rated assembly NFRC U-value, SHGC, and visible transmittance]), and detail for any shading devices included in the simulation
E) Sections, Details and Specifications as Needed to Show Exterior Wall, Roof and Floor Constructions and Insulation Levels Plans and Specifications.
F) If the project is taking credit for energy efficient equipment, plans and specifications showing Appliance/Equipment Locations, Counts, Sizes, and Performance Levels.

From Mechanical Pages & Specifications

A) Plans Showing Locations, Areas Served and System Design for all HVAC Equipment
B) Plans Showing Water Heating Equipment Locations and System Design
C) Plans Showing All Fuel and Thermal Meters
D) Mechanical Schedules Showing Summary Information for All HVAC and Water Heating Equipment
E) Mechanical Specifications and Submittals as Needed to Document Key Energy Performance Parameters Not Noted in Schedules (e.g. fan and pump power draw)

From Electrical Pages & Specifications

A) Plans Showing Lighting Fixture Locations and Control Circuiting for Each Space
B) Plans Showing All Electric Meters
C) Lighting Fixture Schedule
D) Where Lighting Fixture Power is Not Based on Xcel Energy's Input Wattage Guide, Provide Manufacturers' Published Data Showing Fixture Input Power
E) Specs for Lighting Fixtures, Lamps, Ballasts and Controls
F) Any Drawings, Schedules & Specifications with Information on Motors

2.7 Documentation Submission and Inquiries.

The documentation of simulation input and results noted in Sections 2.1 – 2.6 and related questions shall be submitted to the SB 2030 program via the program's on-line project tracking system. Note that the SB 2030 project reviewers may have clarifying questions for the project team during the review process. Those questions will be submitted in writing to the design team and should be responded to in writing. Inquiries related to these requirements shall be directed to Patrick Smith at SB 2030@b3mn.org or 612-626-9709.