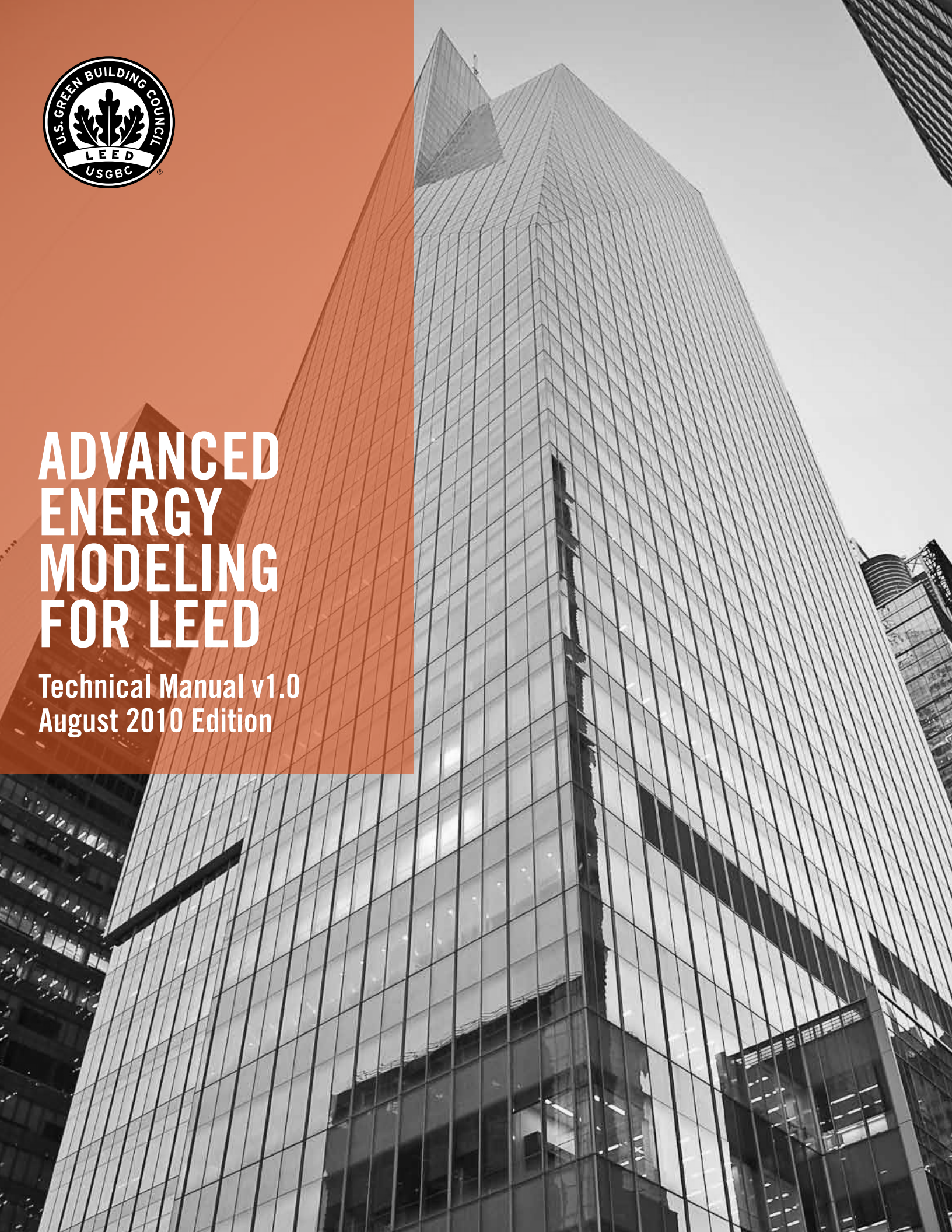

ADVANCED ENERGY MODELING FOR LEED

Technical Manual v1.0
August 2010 Edition

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Equivalency to ASHRAE 90.1–2004

Title 24–2005 is deemed to be directly equivalent to ASHRAE 90.1–2004 by USGBC for projects in California for the purpose of certification of EA Prerequisite 2 and EA Credits 1, 2, and 6. Projects within California may still elect to use ASHRAE 90.1–2004 instead of Title 24–2005. However, once the Title 24 or ASHRAE path is chosen, it must be used consistently for the prerequisite and credits listed above. Projects do not need to provide justification or support of Title 24–2005 equivalence when applying for LEED-NCv2.2, LEED-CSv2.0, or LEED for Schools certification.

2.2 Energy Modeling Requirements

The methodology described in ASHRAE 90.1–2004 (Appendix G), California Title 24–2005, and Oregon Energy Code 2005 involves the generation of two energy models—one representing a baseline minimum-standard building and the other representing the proposed building with all its designed energy enhancements.

Table 2.1 summarizes the three referenced standards' modeling requirements for typical projects. . Since project-specific information may vary, project teams should refer to the referenced standard for all applicable details and modeling requirements. LEED-CS and LEED for Schools are identical to LEED-NC except as noted in this table.

Table 2.1. Comparison of Modeling Requirements for ASHRAE 90.1-2004, California Title 24, and Oregon Energy Code

ASHRAE 90.1–2004		Oregon Energy Code 2005		California Title 24–2005	
Baseline Case	**Proposed Case**	**Baseline Case**	**Proposed Case**	**Baseline Case**	**Proposed Case**
Schedule of Operation					
Same as proposed design. Exception: Schedule may differ from proposed design if proposed design is implementing some nonstandard efficiency measures.	Use actual operating schedule. Exception: Schedules can be modified to model nonstandard efficiency measures such as lighting controls, natural ventilation, demand control ventilation, or service water heating load reductions. When differing schedule is modeled for demand control ventilation in proposed case, baseline case should be modeled with ASHRAE 62.1–2004 minimum values.	Same as ASHRAE 90.1–2004.	Same as ASHRAE 90.1–2004.	Same as proposed design. Automatically modeled in compliance mode.	Default Title 24 schedules used for heating, cooling, fans, lighting, receptacle loads, etc.
Orientation					
Simulations with 4 orientations are required (0º, 90º, 180º, and 270º). Self-shading is ignored in baseline model.	Model building orientation as designed.	Same as proposed design. Simulations of 4 orientations are not required.	Same as ASHRAE 90.1–2004.	Same as proposed design. Automatically modeled in compliance mode. Simulations of 4 orientations are not required.	Model building orientation as designed.

2.3.3 California Title 24 Qualified Simulation Software

California's current state-approved energy compliance software programs for use with the Title 24 standards are EnergyPro and eQuest Compliance Module (D2comply 3.6, the DOE-2.2 component contained within eQUEST 3.6 to perform Title 24 compliance analysis). These programs can automatically generate the energy budget for the standard design and calculate the energy use of the proposed design after the proposed design inputs are complete.

2.4 Key Output Reports

Information from the energy simulation software output reports is used to complete the LEED submittal template and calculate energy savings for EA Credit 1. This section highlights some of the keythe output report parameters critical to the quality control process for credit compliance. The summary output reports include information necessary for verification of the modeling results reported on the LEED submittal template.

NOTE: *Typically, the summary output reports contain information on energy use by end use, energy cost, and unmet load hours for both the baseline and the design case energy models.*

2.4.1 DOE-2 Simulation Software Key Output Reports

All of the DOE-2 based simulation software programs generate the following reports: Building Energy Performance Report (BEPS), Building Utility Performance Report (BEPU), and Energy Cost Summary Report (ES-D). They are the most important output files provided as supplemental documentation for EA Credit 1 applications.

The BEPS and BEPU reports (Figure 2-1) summarize building energy performance in terms of end use by fuel type, total use by fuel type and the energy use intensity. The reports also display the percentage of hours that any system zone is outside of throttling range and the percentage of hours that any plant load is not satisfied. The difference between the two reports is that the BEPS report summarizes the energy use in the units of MBtu (million Btu), while the BEPU report presents the energy use in the units of Therms and kWh.

The ES-D report (Figure 2-2) summarizes the energy use and energy cost by utility type, provides the virtual energy rate for each utility type, and reports the project's total energy cost. Since EA Credit 1 points are based on energy cost savings, the ES-D reports for the Baseline and Proposed buildings are the reports used to calculate the savings percentage and points achieved.

Highlights in Figure 2.1 correspond to the following:

1. BEPS and BEPU reports are building-level reports. The BEPS report includes only energy drawn or supplied across the building boundary—that is, energy provided by generators or photovoltaics is not included in the BEPS report unless it "flows" through a utility meter (i.e., is supplied back to the utility grid). Strictly, the BEPS report does not report energy used within the building; rather, it reports energy "imported" into or "exported" from the building.

2. The weather file should be for the correct location. If the weather file for the exact location is not available, an alternative file for the closest available location is typically considered appropriate. If the selected weather file is not from the closest available location—for example, because of altitude differences or a microclimate—an explanation for the selection is required.

3. The energy types shown are those specified with the ELEC-METER, FUEL-METER, STEAM-METER, and CHW-METER commands in PLANT.

4. See whether the site Energy Use Intensity (EUI) is reasonable for the building type and climate. The Commercial Buildings Energy Consumption Survey (CBECS) database and the EnergyStar Target Finder database can be used for this purpose.

5. Check here for unmet load hours, defined as hours when one or more zones are out of the throttling range. The denominator used for this calculation is 8,760 unless the total run hours for the longest-operating air handler is reported (SS-R report). If this value is provided along with the SS-R DOE-2 output for that system, then that value may be used in place of 8,760. When 8,760 hours is used as the denominator,

the percentage reported here should be less than 3.4%, because the annual unmet load hours should not exceed 300. The number of unmet load hours for the proposed design case should not exceed the number of unmet load hours for the baseline case by more than 50. That is, Proposed Case Unmet Load Hours <= Baseline Case Unmet Load Hours + 50.

Highlights from Figure 2.2 correspond to the following:

1. The ES-D report is also a building-level report.
2. Confirm that the virtual energy rates are reasonable.
3. See whether the energy cost per unit floor area is reasonable for the building type and climate (see number 4 under Figure 2.1).

Figure 2-1. Sample BEPS and BEPU Reports from eQuest[2]

```
EA Credit Guidance Manual Sample Project                    DOE-2.2-45k   6/01/2009   14:30:47  BDL RUN  2
REPORT- BEPS Building Energy Performance (1)                WEATHER FILE- Seattle   WA TMY2 (2)
-------------------------------------------------------------------------------------------------------------

                    LIGHTS  TASK LIGHTS  MISC EQUIP  SPACE HEATING  SPACE COOLING  HEAT REJECT  PUMPS & AUX  VENT FANS  REFRIG DISPLAY  HT PUMP SUPPLEM  DOMEST HOT WTR  EXT USAGE   TOTAL
                    -------  ----------  ----------  -------------  -------------  -----------  -----------  ---------  --------------  ---------------  --------------  ---------  --------
EM1  ELECTRICITY (3)
     MBTU             0.0         0.0       315.4            0.0           54.3          0.0          7.3       66.2             0.0              0.0             0.0        0.0     679.3
FM1  NATURAL-GAS
     MBTU             0.0         0.0         0.0          194.4            0.0          0.0          0.0        0.0             0.0              0.0            40.6        0.0     235.1
                    -------  ----------  ----------  -------------  -------------  -----------  -----------  ---------  --------------  ---------------  --------------  ---------  --------
     MBTU           236.0         0.0       315.4          194.4           54.3          0.0          7.3       66.2             0.0              0.0            40.6        0.0     914.4

TOTAL SITE ENERGY        914.39 MBTU     36.6 KBTU/SQFT-YR GROSS-AREA     36.6 KBTU/SQFT-YR NET-AREA (4)
TOTAL SOURCE ENERGY     2273.04 MBTU     90.9 KBTU/SQFT-YR GROSS-AREA     90.9 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  0.0 (5)
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.0

NOTE:  ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.
```

```
EA Credit Guidance Manual Sample Project                    DOE-2.2-45k   6/01/2009   14:30:47  BDL RUN  2
REPORT- BEPU Building Utility Performance                   WEATHER FILE- Seattle   WA TMY2
-------------------------------------------------------------------------------------------------------------

                    LIGHTS  TASK LIGHTS  MISC EQUIP  SPACE HEATING  SPACE COOLING  HEAT REJECT  PUMPS & AUX  VENT FANS  REFRIG DISPLAY  HT PUMP SUPPLEM  DOMEST HOT WTR  EXT USAGE   TOTAL
                    -------  ----------  ----------  -------------  -------------  -----------  -----------  ---------  --------------  ---------------  --------------  ---------  --------
EM1  ELECTRICITY (3)
     KWH              6[illegible].         0.       92425.            0.          18924.          0.          2145.      19393.           0.               0.              0.         0.   199042.
FM1  NATURAL-GAS
     THERM            0.          0.          0.         1944.            0.          0.           0.           0.         0.              0.             406.              0.      2351.

TOTAL ELECTRICITY     199042. KWH       7.962 KWH     /SQFT-YR GROSS-AREA     7.962 KWH     /SQFT-YR NET-AREA (4)
TOTAL NATURAL-GAS       2351. THERM     0.094 THERM   /SQFT-YR GROSS-AREA     0.094 THERM   /SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  0.0 (5)
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.0

NOTE:  ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.
```

2 Based on DOE-2.2 Reports and Modeling Quality Control Concepts, available at: http://doe2.com/download/eQUEST/DOE22Reports-and-QC_2001-06-07.zip

Table 2.2. Summary of Major EA Credit 1 CIRs, through June 26, 2009. (continued)

Topic	Rating System and CIR date	Summary	Description
HVAC system (continued)			
Baseline HVAC system serving high process load spaces	NCv2.2 3/23/2007	Clarifies use of exception to G3.1.1 to document baseline and achieve greater energy savings from single-zone systems in high process load areas.	CIR allows projects to demonstrate substantial energy savings for well-designed HVAC system serving high process load spaces based on following exception to G3.1.1: "Any space that has high occupancy or process loads including peak thermal loads that differ by at least 10 Btu/h-sq. ft. shall be modeled with packaged single zone system per Exception to G3.1.1."
HVAC systems controlled by occupancy sensors	NCv2.2 8/13/2007	Clarifies how to document energy savings from HVAC systems controlled by occupancy sensors.	ASHRAE 90.1–2004, Appendix G, Table 3.2, defines default power adjustment percentages for automatic lighting controls. Although this table is not intended to address other systems controlled by occupancy sensors, CIR clarifies that it is acceptable to use 10% power adjustment indicated in table for buildings larger than 5,000 sf for all systems controlled by occupancy sensors. Alternatively, if published, credible data demonstrate energy savings for equipment controlled by occupancy sensors, then demonstrated values may be used, as long as study is referenced or (preferably) provided. In this case, Exceptional Calculation Method should be used, consistent with CIR dated 6/7/2001.
Hospitals and laboratory baseline HVAC system	NCv2.2 8/16/2007	Clarifies how baseline HVAC systems may be modeled for spaces with pressurization and air change requirements.	Pressurization and air change requirements of health care facilities fall under Exception (c) of G3.1.1, which indicates that packaged single-zone systems (System 3 or 4) may be used as baseline system. Ruling acknowledges that, without reheat, single-zone, constant-volume system is unable to meet temperature and humidity control requirements typical for hospitals and laboratories. It requires that project teams follow Appendix G and model these spaces with pressurization control requirements with packaged single-zone systems in baseline building. Humidity control requirements should be modeled same as in proposed building, even if that requires modeling reheat with that system type.
	NCv2.2 8/16/2007, 8/13/2007, 3/4/2008	Allows health care and laboratory projects to apply Appendix AC and ASHRAE 90.1–2007, Appendix G 3.1.2.9, to document baseline fan power.	Rulings acknowledge that fan power is not adequately addressed by ASHRAE 90.1–2004 for health care and laboratory applications. Appendix G, Section 3.1.2.9, in ASHRAE 90.1–2004 does not give credit for air pressure drops associated with cooling coils, preheat coils, multiple filter stages, air blenders, extensive sound attenuation, humidifiers, and exhaust bio-safety cabinets that may be used in health care facilities and laboratories and contribute to excessive fan energy. To avoid penalizing such facilities, rulings allow laboratory and hospital projects to use Addendum AC and apply changes to Appendix G, Section 3.1.2.9, that are published in 2007 version of standard. Addendum AC adds pressure drop credits for fan systems that include evaporative cooling, sound attenuation, ducted returns, filtration, and return or exhaust airflow control devices. These credits are in Table 6.5.3.1.1B of this addendum. In addition, rulings clarify that projects may not use Labs21 "Laboratory Modeling Guidelines using ASHRAE 90.1–2004 Appendix G" as compliance path for modeling laboratories.
Fume hoods	NCv2.2 8/13/2007	Allows use of ASHRAE 90.1–2004, Addendum AC, and ASHRAE 90.1–2007, Appendix G, to demonstrate savings from laboratory exhaust systems.	Addendum AC modifies fan power allowance in Section 6 of ASHRAE standard and includes exemption for fans exhausting air from fume hoods. When these fans are exempted, allowed horsepower for entire system must be reduced by adjustment factor contained in addendum.

Table 2.2. Summary of Major EA Credit 1 CIRs, through June 26, 2009. (continued)

Topic	Rating System and CIR date	Summary	Description
HVAC system (continued)			
Natural ventilation	NCv2.2 3/22/2007	Describes requirements for documenting energy savings from natural ventilation.	Submittals for natural ventilation savings will be evaluated on case-by-case basis and should include following information: • Detailed project description; • Clear identification of areas taking credit for natural ventilation; • Detailed description or references that document modeling algorithms and/or methodology for natural ventilation portion of energy model; • All thermostat, fan, infiltration, and other appropriate schedules for naturally ventilated areas; • Documentation to demonstrate that range of unmet load hours is similar for both proposed and baseline buildings, to ensure that savings are not claimed for hours outside control parameters; • Documentation to demonstrate that theoperational schedule for natural ventilation system aligns with anticipated occupants' behavior and • Exceptional calculations to document manual control features (for case-by-case review).
Lighting system			
Manual lighting controls	NCv2.2 10/23/2007	Prohibits inclusion of manual lighting controls in energy savings calculations.	As indicated in Table G3.1.6 of ASHRAE 90.1–2004, only automated lighting controls are eligible for energy savings credit. CIR confirms that use of manual master switch, such as manual master switch control in each apartment to turn off lights and to control HVAC system in response to occupancy, does not qualify for credit under EA Credit 1. Manual controls are not eligible for energy savings.
Automatic lighting controls	NCv2.2 10/24/2008	Clarifies use of the Exceptional Calculation Method to document higher savings from automatic lighting controls.	For automatic lighting controls, ASHRAE 90.1–2004, Appendix G, Table G3.2, Power Adjustment Percentages for Automatic Lighting Controls, defines default percentages of savings that can be claimed. CIR clarifies that project teams are allowed to claim greater savings for use of automatic lighting controls than default savings percentage, based on statement in ASHRAE 90.1–2004, Table G3.1.4, Baseline Building Performance, indicating that nonstandard efficiency measures, such as lighting controls, can be modeled by modifying schedules, provided revised schedules have approval of rating authority (USGBC in this case). CIR requires that schedule change and energy savings be modeled and submitted as Exceptional Calculation Method with documentation that supports proposed lighting schedule.
Lighting in multilevel residential buildings	NCv2.2 3/23/2007	Describes specific requirements for modeling lighting in multilevel residential buildings.	All common areas and support areas, including circulation, lounges, and lobbies, should be included in lighting power density calculations and modeled in both proposed design and baseline cases. All hard-wired lighting in living units that is shown on building plans must be considered process energy and modeled identically in baseline and proposed building simulations as shown in plans. Credit may be taken for efficient hard-wired lighting in living units using the Exceptional Calculation Methodology.

3.2.3 Output-Input Consistency Checklist

The last step for verifying the accuracy of the energy savings is to check for consistency between outputs and inputs. Table 3.3 is a checklist for reviewing the consistency of energy modeling outputs and inputs and provides calculation methods and rules of thumb to predict rough order-of-magnitude results. It can assist with quality assurance on projects using ASHRAE 90.1–2004, California Title 24, and the Oregon Energy Code.

Table 3.1. Input QC Checklist

Topic	Check	ASHRAE 90.1–2004 common errors	Resources
General information			
Simulation program	Verify that approved energy simulation software has been used.	• Using unqualified simulation software, e.g. using Energy-10 for buildings with more than 2 thermal zones or larger than 10,000 sf.	ASHRAE 90.1–2004, Appendix G, Section G 2.2
Weather file and climate zone	Verify that correct weather file and climate zone have been used.	• n/a	n/a
Referenced standard	Verify that approved referenced standard has been used.	• Using referenced standard other than ASHRAE 90.1–2004 for project not located in California or Oregon.	n/a
New construction percentage	Verify reported percentage of new construction consistent with LEED Online project summary.	• Reporting different percentages on submittal template and LEED Online.	n/a
Target finder score	Confirm that Target Finder Score is provided. If not provided, check Table 1.2 of EA Credit 1 submittal template to verify project's primary occupancy.	• Not providing Target Finder Score even though project has Target Finder standard occupancy type.	Target Finder Web site
Space summary			
Building floor area	Verify that building floor area is consistent with other credits. Verify conditioned area with IEQ Prerequisite 1. Consider ± 10% variance to account for built-up area.	• Building floor area is inconsistent with other credits.	n/a
Building envelope			
Existing building	Verify baseline energy modeling approach for existing building renovation.	• Baseline building shell of existing construction is not modeled as it exists prior to any revisions.	ASHRAE 90.1–2004, Table G3.1, Section 5(f)
Opaque assemblies	Verify that opaque envelope input reflects correct assembly construction and U-values.	• Incorrect envelope constructions are modeled in baseline building (e.g., exterior walls not modeled with lightweight, steel-framed assemblies).	ASHRAE 90.1–2004, Table G3.1, Section 5(b)
Fenestration	Verify that fenestration area modeled for baseline meets referenced standard requirements.	• Baseline vertical fenestration exceeds 40% of gross above-grade wall.	ASHRAE 90.1–2004, Table G3.1, Section 5(c)
	Verify that Baseline and Proposed design U-values reflect assembly U-values.	• Proposed design uses center-of-glass U-values rather than whole window assembly U-values (including frame). • Baseline building adds frame conductance to prescriptive Baseline assembly U-values. • Not applying Ufixed for all windows in baseline. • Addendum A or ASHRAE 90.1–2007, Appendix G, is not used, but Baseline case windows are not modeled uniformly.	
	Verify that Solar Heat Gain Coefficient (SHGC) input is correct for baseline.	• Using SHGCnorth for north windows in Baseline.	
Shading devices	Verify that proposed design includes correct type of shading devices.	• Proposed design models manually controlled shading devices, such as blinds.	ASHRAE 90.1–2004, Table G3.1, Section 5, Exception (d)
	Verify that baseline building includes no shading devices	• Baseline building includes shading devices.	

APPENDIX A.
ASHRAE 90.1–2004 ADDENDA

The ASHRAE 90.1–2004, Appendix G, addenda that affect achievement of EA Credit 1 are listed and described in Table A.1. As previously noted, a project team that elects to apply requirements in an addendum must apply the entire addendum to all other relevant credits in the LEED submittal. In addition, the USGBC CIR dated 4/23/2008 allows the use of ASHRAE 90.1–2007, Appendix G, which includes all ASHRAE 90.1–2004 addenda and other modifications, in place of ASHRAE 90.1–2004, Appendix G, if the energy simulation follows the language of 2007 Appendix G in its entirety.

Table A.1. ASHRAE 90.1–2004, Appendix G Addenda

Appendix G section	Topic	Description	Addendum text
G2.2.4	Simulation program	Addendum a adds new section, G2.2.4, to G2.2 regarding requirements on simulation program.	"The simulation program shall be tested according to ANSI/ASHRAE Standard 140 and the results shall be furnished by the software provider."
G3.1.1	Baseline HVAC system type and description	Addendum U adds requirements to G3.1.1 for modeling Baseline HVAC systems.	"For systems 1, 2, 3, and 4, each thermal block shall be modeled with its own HVAC system. For systems 5, 6, 7, and 8, each floor shall be modeled with a separate HVAC system. Floors with identical thermal blocks can be grouped for modeling purposes."
Table G3.1, Section 1	Proposed model	Addendum a clarifies how to document installed system's power demand and operating schedules for Section G3.1.1 when simulation program doesn't specifically model them.	"Where the simulation program does not specifically model the functionality of the installed system, spreadsheets or other documentation of the assumptions shall be used to generate the power demand and operating schedule of the systems."
Table G3.1 Section 4	Schedules	Addendum ag narrows scope of fans to meet requirements for HVAC fan schedules.	"Schedules for HVAC fans that provide outdoor air for ventilation shall run continuously whenever spaces are occupied and shall be cycled on and off to meet heating and cooling loads during unoccupied hours."
Table G3.1 Section 5	Building envelope: exceptions	Addendum a adds detailed requirements on modeling techniques for uninsulated envelope assemblies in Section G3.1.5. Section G3.1.5 requires that all components of building envelope in proposed design shall be modeled as shown on architectural drawings or as-built for existing building envelope. However, uninsulated assemblies are permitted to differ from architectural drawings.	"(a) All uninsulated assemblies (e.g., projecting balconies, perimeter edges of intermediate floor stabs, concrete floor beams over parking garages, roof parapet) shall be separately modeled using either of the following techniques: 1. Separate model of each of these assemblies within the energy simulation model 2. Separate calculation of the U-factor for each of these assemblies. The U-factors of these assemblies are then averaged with larger adjacent surface using an area-weighted average method. This average U-factor is modeled within the energy simulation model."
Table G3.1 Section 5	Building envelope: baseline building performance	Addendum a modifies requirements on distribution of vertical fenestration in Baseline model.	"(c) Vertical Fenestration. Vertical fenestration … shall be distributed on each face of the building in the same proportion as in the Proposed Design."
Table G3.1 Section 6	Lighting: proposed building performance	Addendum ae requires that loads of lighting systems connected via receptacles be included in simulations.	"For multifamily living units, hotel/motel guest rooms, and other spaces in which lighting systems are connected via receptacles and are not shown or provided for on building plans, assume identical lighting power for the proposed and Baseline building designs in the simulations." (Addendum A deleted the following: "… but exclude these loads when calculating the baseline building performance and proposed building performance.")

APPENDIX D.
EXCEPTIONAL CALCULATION METHODOLOGY

This appendix describes exceptional calculation methodologies that have been submitted by project teams and accepted by USGBC. The actual values may have been tweaked in some cases. The project names and any project-specific information are omitted for confidentiality reasons.

D-1. Natural Ventilation

Savings for natural ventilation should be claimed using Exceptional Calculation Methodology. According to Appendix G, if no cooling system exists, a default cooling system must be assumed and modeled. It must be identical to the system in the baseline building. The proposed system should be modeled as a hybrid, in which cooling is provided by natural ventilation when conditions are acceptable and by the default mechanical cooling system when natural ventilation is inadequate to provide thermal comfort. It is acceptable to use a combination of tools, evaluate indoor and outdoor temperatures, increase infiltration (to approximate natural ventilation), shut down the fans, and turn off the cooling during periods when opening the windows has been determined to meet the cooling load.

Energy Efficiency Measure

The project is close to the ocean and consists of two small buildings, with a total of 8,500 sf, that achieve substantial energy savings by incorporating a natural ventilation strategy. No mechanical heating or cooling is intended for either building, with the exception of a small electrical and server room. The buildings meet the requirements of ASHRAE 62.1–2004, Section 6.8, and CIBSE Applications Manual 10: 2005. Openings include operable windows, through-the-roof ventilators, and vents between interior spaces. Control mechanisms for the natural ventilation openings are manual. A long, tall hallway situated perpendicular to the prevailing winds will collect heated air and exhaust it to the outside. The roof over much of the space is sloped, allowing air to enter on the low side and exit on the high side. In all cases, the buildings are designed to facilitate cross-ventilation, with windows low on the walls for drawing air in, and windows and vents high in opposite walls or on the roof to draw air out. The mean monthly outdoor temperature for the project is greater than 50°F and less than 92.3°F all months of the year, as required under ASHRAE 55–2004, Section 5.3, for naturally ventilated buildings.

Modeling Methodology

EnergyPlus was used to model the building, since the EnergyPlus software can evaluate energy and comfort parameters tied to natural ventilation. The method consists of four models, described in Table D.1.

Table D.1. Energy Model Descriptio

Model		Description	EAc1 LOL Template inputs
Baseline	B	Follows Appendix G	Baseline for Table 1.8.2
Proposed Case without NV	P1	Proposed case model with systems identical to Baseline model; natural ventilation not modeled	Proposed case for Table 1.8.2. and baseline for ECM Section 1.7
Proposed Case: comfort analysis model	P2	Proposed case model with operable windows and vents; NV ON year-round during occupied periods	Analysis model; NV schedule developed based on hourly results of this model (results not listed in EAc1 template)
Proposed Case with NV	P3	Proposed Case for ECM	Proposed Case for ECM Section 1.7

Note: *ECM = Exceptional Calculation Methodology*
NV = natural ventilation