FINAL DRAFT Briefing Document (12-May-2008)

IBPSA/LEED Canada TAG Joint Task Force
LEED Energy Modeling Assessment (EMA)

Executive Summary

With Natural Resource Canada's (NRCan's) launch of EcoEnergy for Buildings, incentives previously provided under the Commercial Building Incentive Program (CBIP) have been discontinued. Although NRCan continues to provide verification services under the EcoEnergy initiative, with the demise of CBIP, the need for the CaGBC to provide for independent energy performance compliance review services for LEED submissions is increasing. Hence, this briefing document provides guidelines for submission requirements and for conducting building energy simulation reviews in support of LEED Canada certification for Energy & Atmosphere Prerequisite 2 (EAp2) and Credit 1 (EAc1). In terms of implementation, the guidelines and recommendations presented herein will be used as follows:

- The guidelines pertaining to submission requirements are meant to clarify the building energy simulation submission process for building energy modelers currently working on LEED Canada-NC projects. These can be implemented immediately for all LEED Canada-NC projects not yet submitted for certification review; and
- The guidance and recommendations pertaining to conducting building energy simulation reviews will be evaluated by the CaGBC during upcoming reviews and utilized by the LEED Canada Initiative Certification Task Force during the development of the next iteration of LEED Canada-NC.

Submission Requirements

The submission requirements to the CaGBC for its review of EAp2 and EAc1 are very similar to those required by NRCan for CBIP and its present validation services under ecoEnergy. One significant exception is that stamped hard copies of drawings are not necessary and the provision of electronic files is encouraged. The previous CBIP guidelines and checklist are still relevant for

modelers in preparing packages for review. In addition, the Submission Checklist in Attachment A lists the files and submission requirements for EAp2/c1.

In summary, the simulation submission package should include the following key items:

- Signed LEED letter templates for EAp2 and EAc1 (as always);
- Documentation of the energy simulation qualifications of the professional(s) responsible for the preparation and verification of the building energy simulation;
- Narrative that includes a summary building description, listing of efficient characteristics and an overview of the modeling approach;
- Listing of building characteristics that apply to: 1) the Reference case, and 2) the Proposed design (see Attachment C for an example); and
- Supporting simulation files and notes, drawings and specifications (See Attachment A).

Review Process

Once the submission is received, the CaGBC will perform an initial check to see if the above information is readily apparent in the submission. The person administrating the application will forward the submission package to an independent reviewer to perform an initial "screening review." Depending on the results of the screening and/or based on a random audit process, the compliance models may be examined in further detail.

The *screening review* has the objective of quickly assessing if the claimed energy performance savings appear justified or may warrant a more detailed review. The screening is anticipated to only take about 3 – 4 hours in total to complete. The reviewer will initially check over the modeling package to become familiarized with the building and modeling approach. He/She will then apply his/her experience, quick analysis tools (e.g., Web Screening Tool) and communicate with the modeler as necessary to provide an assessment as to the apparent validity of the claimed savings. The screening phase is concluded with a brief letter/email report to the CaGBC administrator providing a relative ranking/grade to indicate if the simulation appears reasonable or if a detailed review is necessary.

If a *detailed review* is deemed necessary and/or the project is selected as part of a random audit process, the energy performance compliance review process will follow the same general approach as has been applied for past CBIP reviews. This includes performing a more detailed assessment of the specific Proposed

and Reference case model results and inputs to verify the validity of the claimed savings.

Note that detailed reviews may entail performing some simulations, which infers that the reviewer would need to be able to run the simulation. Hence, the CaGBC may deem it necessary to charge an additional fee for energy performance software that is not widely used in Canada and/or is relatively expensive to license. It would be difficult for the CaGBC to set pricing at this stage and hence, it is encouraged for submitters who are looking to make submissions using packages other than EE4, DOE2.1e or eQuest to communicate this to the CaGBC prior to embarking on the final compliance modeling for application purposes.

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Task Force Participants

Participants	Organization
Curt Hepting (chair)	EnerSys Analytics Inc.
Jim Clark	NRCan
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Purpose

Define criteria, guidelines and references for conducting building energy simulation reviews in support of achieving LEED Canada Energy & Atmosphere Prerequisite 2 (EAp2) and Credit 1 (EAc1).

Background

Natural Resource Canada (NRCan) recently unveiled their EcoEnergy for Buildings program which discontinued the provision of incentives under the Commercial Building Incentive Program (CBIP). This is significant as it will trigger the use of other simulation programs and approaches other than EE4 and the CBIP protocols for application to LEED Canada. As the CaGBC will be receiving an increasing number of submissions that do not use EE4 energy performance compliance simulations, the CaGBC has a pressing need to establish a credible, efficient and timely approach to LEED Canada-NC energy performance modeling reviews used for EAp2 and EAc1 (and indirectly for EAc2 and EAc5). Their goal is to develop a reliable and cost-effective approach to reviewing LEED Canada-NC applications for EAp2 & EAc1.

Under the EcoEnergy for Buildings program, NRCan has committed to continuing to review EE4 simulations on behalf of LEED Canada. However, with no incentives, there is less attraction to use EE4, except for those simulators who do not want to invest the time and expense required to learn another simulation program and/or how to apply the necessary modeling rules to build an appropriate Reference case model. EcoEnergy for Buildings and EE4 will continue to support those learning simulation (using EE4). The challenge will be to ensure that there will be as few discrepancies as possible in the treatment of energy performance strategies, modeling concepts and reference case treatment between all modeling programs and approaches (CBIP and ASHRAE).

Task Force Objectives

I. Draft certification review protocols and initial guidelines for appropriately and consistently conducting reviews of energy performance compliance models for LEED Canada. At this date, a two-step approach and level-of-effort is under consideration:

   1) initial certification screenings,

   2) detailed audits of EAp2 & EAc1; if earmarked in step 1.

   This task would also entail the identification of submittal requirements to facilitate reviews for both steps.

II. Develop criteria for qualified energy analysts to perform reviews

III. Later: Explore suggested resources and approaches to developing a "resource network" to enhance the review process and make it more efficient. This could include, but would not be limited to compiling a potential list of qualified contractors and resources for existing building performance data (e.g., “benchmarks”).

Approach and Concepts

I. Protocols and Guidelines

A. Process

1. Submission: Submission provided to the CaGBC and checked for completeness by CaGBC administrator before forwarding to review team. Modeling packages to be provided in a consistent format and to include:

   a. Signed LEED letter templates for EAp2 and EAc1 (as always);

b. Documentation of the energy simulation qualifications of the professional(s) responsible for the preparation and verification of the building energy simulation;

c. Narrative including building description, summary of efficient characteristics and overview of modeling approach.

d. Paired listing of building characteristics for Reference vs Proposed (see Attachment C for an example).

e. Same information as stipulated by CBIP except stamped hard copies not necessary. Shop drawings are still necessary, but only for key energy saving equipment related to efficiency strategies highlighted in the narrative (e.g., heat recovery equipment); although, all shop drawings need to be available upon request. See "CBIP Submission Checklist" in Attachment A.

2. Screening: CaGBC administrator to forward submission package to an independent reviewer to perform an initial screening. The independent reviewer will then provide an indication to the CaGBC as to whether a detailed review of the submission is required.

   a. 3-4 hr screening by a qualified independent reviewer, providing web-based or email-based summary as to reasoning for acceptance as is or indication if a further detailed review is warranted.

      i. Recommend that reviewer perform a CBIP Screening Tool analysis of the project based on submitted information, realizing how the limitations and capabilities of the Screening Tool may deviate from the actual design.

      ii. Reviewer to give a ranking or grade for CaGBC to assess relative necessity for escalation to a detailed review, since CaGBC will be restricted on how many can be pushed through for detailed review (based on budgetary and resource constraints).

   b. Support communication between reviewer and modeler, even though it contrasts with CaGBC policy.

3. Detailed Review: Reviews identified by screening

   a. Same general approach as for the screening but in much more detail.

   b. Protocol and cost effectively the same as presently followed for CBIP (but also applied to submissions made with tools other than EE4)

      i. Concern on software and analysis approach expressed (see Software Restrictions and Conditions of Use later)

c. Reviewer to directly communicate with simulator on discrepancies
    i. Avoid involving CaGBC staff
    ii. Adhere to professional courtesy and ethics for peer review

4. General Review Approach: See Reviewer Checklist as a guide for items to verify (Attachment B).
    a. **Summary Review:** Assess claimed energy performance savings and evaluate against summary of characteristics that are highlighted as being better than the respective Reference case (CBIP or ASHRAE ECB). The key here is whether what is described as being energy efficient makes sense for the level of savings claimed.
        i. Check energy results from BEPS reports (or equivalent).
        ii. Review building and systems description.
        iii. Gauge relative efficiency in light of stated energy efficiency measures.
    b. **Characteristics Review:** Review the comparative list of building characteristics for the Proposed versus Reference case to see if 1) the Reference case is described appropriately and 2) if anything stands out as adversely or beneficially benefiting the Proposed case. Consider applying a relative ± percentage ranking next to each item to help gauge relative savings level based on experience.
        i. Refer to "Energy Performance Compliance Modeling Reviewer Checklist" in Attachment B for a listing of characteristics and their relative importance upon energy performance. Focus on aspects that typically make the biggest impact (e.g., heat recovery, condensing boiler, ground-source heat pumps, demand controlled ventilation, etc.)
        ii. Ensure that the Reference case has been described appropriately, thereby providing confidence that the simulator correctly understands how to configure the Reference for CBIP (if not in EE4) or ASHRAE 90.1.
    c. **Model Checks:** Spot check characteristics identified in above step within simulation input/output to verify claimed characteristic setting and see if the influence is apparent.
        i. Check LEED Letter Template to see if claimed savings by end-use and fuel type appear reasonable.
        ii. Look for the BEPS and ES-D reports (or equivalent) for the Proposed and Reference cases to see if results correlate with LEED Letter Template.

iii. See if unmet loads and underheated hours are comparable between the Proposed and Reference, if not adequately addressed as to the reason for any significant disparities.

d. **Analysis Checks:** Consider running a simple archetype model to help verify overall savings and/or savings of key claimed features. A recommendation for this would be to use the Web Screening Tool, but it would depend on what the reviewer has at his/her disposal to help with the analytical verification.

e. **Mandatories Review:** Do *not* actively review but confirm that professional(s) signed and verified that they are met. Only flag items that do not appear to be in compliance if obvious during screening review process.

f. **Communication:** Follow-up on key discrepancies with simulator, if applicable. Reviewers are encouraged to exercise judgment as to the relative significance of possible discrepancies.

g. **Review Report:** For a screening, provide a relative ranking/grade which the CaGBC can use to gauge if a detailed review is necessary. Provide comments as to any key discrepancies and report back to CaGBC on at least:

- ✓ For a screening, provide a clear recommendation for further action recommended to the CaGBC: pending, audit, denied, credit achievement anticipated.
- ✓ Comment on technical validity, highlighting relative performance of project and analysis approach
- ✓ Comment on areas of concern, as applicable
- ✓ Comment on quality of submission, with some examples
- ✓ For a detailed review, clearly indicate the verified performance level and EAp2/c1 indicators (e.g., percent energy savings, EAc1 points). Past CBIP reviews provide good examples of a detailed verification report, although the simulation output attachments are likely unnecessary.

5. Appeal Process

   a. CaGBC already has a process in place, including the provision of an extra fee that may be all/partially refunded depending on the outcome.

   b. Jury of peers / technical advisory group would handle (see later under Resources)

6. Process Recommendation: Recommend that automated web-based system should be established to facilitate process.

7. Concerns: The following concerns were identified by the task force in relation to the review process.
   a. The currently acceptable path of hiring an independent assessor to review submissions may introduce bias into the review process as firms may enter into agreements with selected, favoured contractors. Some potential means of addressing this concern are that either:

      i. The currently acceptable path of hiring an independent assessor to review submissions should be phased out;

      OR

      ii. Since there is general agreement that reviews should be facilitated through the CaGBC process to provide an independent arms-length review, the CaGBC should facilitate the random assignment of assessors. The CaGBC could facilitate the random assignment of assessors using a "lottery service" (which could technically be automated via a web-based capability) to assign assessors at any stage after a project has been registered. In such a scenario, fees and scope of services would be negotiated between the assessor and submitting firm, but the assessor could be retained throughout the entire review process (if he/she is still available by the time the LEED submission is made). This arrangement might even be encouraged by the CaGBC as it would shift all direct review expenses to the submitter, although this would need to be balanced against the prospect of it resulting in a lack of reviewers available for other submissions. In this scenario, the CaGBC should still conduct an initial screening of the independent review.

   b. Technical advisory group / jury of peers becoming overwhelmed with interpretation requests (CIRs) and being able to respond in a timely manner.

      i. Reviewers to first communicate with simulator to work through possible discrepancies and issues, thereby heading off the need for many CIRs

      ii. Encourage CIR to be submitted jointly from reviewer and simulator so that both views are presented and worked through (which could result in an acceptable decision); reviewer should make it the responsibility of the simulator to draft up CIR (i.e., do most of the work).

iii. Advice for providing modeling not a mandate for the CaGBC; need to keep "how to model" external to the CaGBC.

c. Possible concern over providing intellectual property regarding unique simulation techniques and tools (e.g., DOE2 functions) to other simulators.

i. Analytical methodologies must be transparent to adequately conduct a review, particularly for unique approaches where such tools would be applied (e.g., this is a key reason EE Wizard submissions are not recognized for EAc1).

ii. Intellectual property does not need to be divulged if the submitter can adequately explain and/or demonstrate the validity of results from the implemented technique/tool to the satisfaction of the reviewer. That is, the technique would have to stand up to "first principles" of engineering/physics.

If he/she cannot adequately convey the methodology, then it is possible that credit will not be fully recognized. However, it is hard to envision a case where this would be significant enough to cause a considerable change in the overall assessment results (e.g., more than 2 EAc1 points). But if so, the submitter can appeal the decision.

iii. CaGBC and IBPSA encourage simulation and technology transfer but do not expect companies to give away intellectual property.

iv. CaGBC requires a confidentiality agreement for reviewers.

B. Software Restrictions and/or Conditions of Use

1. Capabilities already generally defined by LEED. More specifically, ASHRAE 90.1-2004 Section 11.2 on Simulation General Requirements provides specific guidance as to software requirements and capabilities.

2. Cost is an issue (e.g., IES and TAS are relatively expensive versus EE4, DOE2. eQuest, EnergyPlus), which would be a significant barrier for independent review.

a. Requirement to provide for transparency and ability to investigate model in detail for verification purposes; hence, reviewers need to be provided with the option of running a simulation if desired, which is hampered if a he/she has to make a relatively expensive investment without being adequately compensated.

b. The CaGBC may deem it necessary to charge an additional fee for energy performance software that is not widely used in Canada and/or is relatively expensive to license. Setting pricing at this stage is problematic and would vary on the circumstances as well as the pool of independent reviewers available who have the capability to run a specific simulation program. Hence, the CaGBC would likely need to hear from potential applicants as what is likely to enfold before setting and/or advising on any additional costs (beyond the $1700 fee). Licensing issues and a thorough understanding of the capabilities of proprietary modeling packages are also key concerns that would require critical review and consideration in allowing submissions using certain modeling packages.

3. Corrections and clarifications

   a. How to address for CBIP and EE4.

      i. Somewhat unique compared to other software and approaches since the vast majority of LEED submissions have used EE4 and many likely will continue to do so. Further, the "modeling rules" are more clearly defined with CBIP path, but several are incorrect and/or inconsistent (e.g., CBIP/EE4 version changes with GSHP Reference case). In either case, if a modeler has used EE4 and/or followed the "CBIP – EE4 Modeling Guide" in good faith, then he/she should not be penalized if either does or indicates something that is incorrect.

      ii. Advisory group role oversight should be combined with the CBIP TC. However, the reviewer and modeler should correspond first and foremost to work out discrepancies.

      iii. LEED allows credit for things CBIP does not. This needs to be reconciled to provide consistency between CBIP and LEED in order for NRCan's role as reviewer to be of full value.

   b. How to address for non-EE4 software.

      i. Should be consistent with CBIP protocols, wherever possible

      ii. Ideally advisory group would fulfill role of making interpretations for compliance modeling approaches. But the reviewer and simulator are encouraged to work out discrepancies together, with the reviewer reporting on decisions for possible future reference.

C. Guidelines and Resources

1. Jury of peers / technical advisory group for energy should be established.
   a. Formulated for main purpose of ruling on credit interpretation requests (CIRs) associated to energy performance simulation; responding to appeals would hopefully be relatively seldom.
   b. Desirable to have NRCan involved with the aim to communicate and coordinate on acceptable simulation methodologies and approaches.

2. CBIP Guide
   a. Do not apply as an absolute (i.e., as the "law"), but apply as a guideline that should be adhered to unless good reason is provided otherwise. Reviewers should be aware that the Guide is incorrect and/or incomplete in some cases.
   b. Resolving inaccuracies in the Modeling Guide would ideally be facilitated by the technical advisory group in cooperation with NRCan.
   c. Specific to EE4, although concepts can apply to modeling approach in general, as indicated by LEED Canada-NC Reference Guide.

3. MNECB/EE4 Help – provides rules for modeling following CBIP procedures
   a. Out-of-date, but ~98% applicable still. Check if NRCan would be open to updating.

4. Clarifications & Consistency (has been a problem in the past with CBIP)
   a. Network coordinated with technical advisory group and reviewers (e.g., web-based bulletin board) for posting and resolving atypical issues and approaches would be desirable.
      i. Electronic database and/or bulletin board of posted reviewer reports for accessing decisions on how to acceptably approach various simulation issues would be ideal (e.g., representing DCV, reference case for hybrid GSHP/boiler, radiant heating/cooling)
   b. CBIP Technical Committee
      i. Needs to be coordinated with technical advisory group
      ii. To be useful, must be coordinated with overall simulation compliance methodology (e.g., ASHRAE 90.1 ECB)
      iii. Must apply beyond EE4.

II. Reviewer Qualifications

A. Necessary Resources

1. Available qualified people to handle anticipated number of submissions

   a. Given about 5,000 new building starts per year (NRCan), CaGBC's stated goal of '100,000 green buildings by 2012" must assume that most applications will be other than for new construction (NC).

   b. Assuming that a quarter of the new buildings will require simulation review, this equates to a need for the equivalent of about 2.5 people per year dedicated to only screenings of NC projects. As few professionals will likely want to dedicate their careers to only doing reviews, a need for at least 25 qualified "screeners" would be in order (assuming an average 10% dedication rate).

   c. If a third of the above are tagged for detailed reviews, this equates to a need for the equivalent of about 7.5 people per year dedicated to only reviews of NC projects. As few professionals will likely want to dedicate their careers to only doing reviews, a need for roughly 70 qualified reviewers would be in order (assuming an average 10% dedication rate). This is unlikely given the present state of the industry and hence, the screening review process must be opened up to professionals who may not be experts in energy modeling but at least have a good understanding in building science and energy performance concepts.

B. Required Experience (keep in mind resource requirements)

1. Differentiate for screening versus detailed review?

   a. Arguments provide for having screeners with higher qualifications than for reviewers and vice versa. But based on short supply in market, this will have to be compromised to allow for less experienced screeners. While this may initially prove frustrating to seasoned simulators who make submissions, it should help educate and expand understanding of building energy dynamics and concepts in Canada.

2. Experience

   a. Must have a good understanding of mechanical systems concepts/design.

   b. Must have familiarity with CBIP and/or ASHRAE 90.1 ECB energy performance path and their respective requirements.

c. Call of qualifications should ask for how many projects completed and type of projects. This would include type of buildings and efficiency measures analyzed, mechanical system types, and LEED projects with CBIP and/or ASHRAE approaches.

d. Call for qualifications should ask for direct years of simulation experience.

e. LEED AP

3. Software used

a. Call of qualifications should ask for simulation tools, relative experience with each and capacity to execute runs with each software (some may have past experience with a software, such as IES or TAS, but not longer have access due to licensing and cost).

b. Understanding of native description code (e.g., BDL) preferred.

4. Desire expressed to see if reviewers are willing to train and work with others as part of call for qualifications (i.e., mentoring).

5. Will likely need to have an initial call for qualifications, with the expectation to have another call for qualifications as the need and market grows.

C. Concerns

1. How to encourage qualified simulators to participate

a. Concern as to whether enough of a willing market and capable market exists to fill need.

b. To secure the participation of the design and simulation communities, a clear business opportunity must be identified. The market will need to be expanded following on the analysis presented in the assessment for “Necessary Resources”.

2. Consistency and Expectations

a. Reviewer should make few, if any changes to models. Simulator should be responsible for making all changes. Concentration on specific requests and fast correspondence turn-around between reviewers and simulators will be required.

b. Recognition of various measures not clearly defined in guidelines or directly provided by simulation software; correspondence between reviewer and simulator should address most situations.

3. Reviewers appropriately appreciating the significance of various model characteristics.

   a. Realizing and understanding how certain inaccuracies can have negligible impacts on the compliance modeling.

4. CaGBC may need to contract out reviews, but this could limit access to qualified reviewers. Network concept may be preferable to assemble review teams based on nature of project. In either case, a CaGBC liaison would need to manage and coordinate, with moderation by an experienced simulator.

MNECB+CBIP/ASHRAE 90.1-1999 Submission Checklist

The items listed below are requirements for your energy performance compliance modeling submission, and must be included in your submission package. It is recommended that items be presented in binders/folders with numbered tabs. Use the appropriate column to indicate the location of each item within the submission.

Were ecoEnergy design assistance services used for the purpose of the simulation or verification? Yes ___ No ___

Item Required (see attached instructions for details)			Location in Submission	Initial or Audit Level Submission	For CaGBC Use
1	Submission Checklist			Initial	
2	Submission Overview, including energy efficiency measures and listing of Proposed and Reference case model characteristics.			Initial	
3	Compliance Report (e.g., EAc1 Letter Template or equivalent)			Initial	
4	Explanation of Errors and Warnings, including assessment of unmet load hours			Initial	
5	Outdoor Air Calculation Spreadsheet/Justification			Initial	
6	Relevant Calculations and Notes			Initial	
7	Calculations for Renewable Energies (if applicable)			Initial	
8	Mechanical Zoning Diagram			Initial	
9	Electronic Simulation Files	EE4-CBIP (and associated simulation files)		Initial	
				Initial	
10	Final Drawings	A		Initial	
		M		Initial	
		E		Initial	
		R		Initial	
11	Principle Building Systems (include shop drawings for key energy saving equipment)	Heat Recovery Ventilation		Audit	
		Space Heating and Cooling Equipment		Audit	
		Boilers		Audit	
		Heat Pumps		Audit	
		Air Handling Units		Audit	
		Pumps		Audit	
		Chillers		Audit	
		Cooling Towers		Audit	
		Unit Heaters		Audit	
		Other, Specify:_____		Audit	
		Service Hot Water Heating Equipment		Audit	
		Envelope Construction		Audit	
		Window and Glazing Thermal Performance		Audit	
		Panelized Wall Systems, Curtain Wall Systems		Audit	
		Interior Lighting		Audit	
		Refrigeration Systems		Audit	
		Display Cases[1]		Audit	
		Walk-in Freezers/Coolers		Audit	
		Controls for Display Case & Walk-in Coolers/Freezers		Audit	
		Compressors		Audit	
		Heat Recovery Coils		Audit	
		Mechanical Subcooling		Audit	
		Floating Head Pressure		Audit	
		Renewable Energy Features (if applicable)		Audit	
		Special Energy Conserving Features (if applicable)		Audit	
12	Architectural/Mechanical/Electrical/Refrigeration Specifications			Initial	
13	Energy Prices			Initial	

Energy Performance Compliance Modeling Reviewer Checklist

The following is meant as a guide for reviewers in verifying analyses and simulations submitted for LEED EA Prerequisite 2 and EA Credit 1. Note that any inconsistencies in items marked with a High designation will immediately flag the simulation for detailed review.

OVERALL – Initial check, also should be reviewed again in detailed review

High	1	**Review Simulation** and run, if possible • Check result reported by software – Energy End-Use report (e.g. BEPS) reports in Proposed and Reference building, and determine whether results are reasonable • Check errors or warning reported by software. • Check comparative listing of building characteristics between the Proposed and Reference **Comments:** **Outstanding**:
High	2	Check building **floor and surface areas** (e.g., Summary Compliance Report for EE4, LV-B, LV-D for DOE2-based software). Ensure areas are consistent for both proposed and reference, keeping in mind limit on window area (MNECB path). **Comments:** **Outstanding**:
Med-High	3	**Zoning:** Are assigned zones and the space functions (defining default schedules, receptacle loads etc.) consistent with modeling guide (orientation, core versus perimeter, same schedule)? This is somewhat subject to a modeler's judgment, but look for obvious errors that would affect the relative energy performance between the Proposed and Reference cases. **Comments:** **Outstanding:**
High	4	Compare Proposed vs. Reference Energy End-Use results against expectations for EEMs implemented **Comments:** **Outstanding:**
Med	5	Check that **weather file** used is an acceptable standard weather year for the site. Check that design day temperatures are ASHRAE or building code values for the site. **Comments:** **Outstanding:**
Med	6	Compare space and zone characteristics between Reference and Proposed (e.g., LV-B and SV-A in DOE2-based software), such as for lighting loads, air flows, minimum air flows, heating/cooling capacities. **Comments:** **Outstanding:**
High Med Low/ High	7	Check large equipment parameters – heating, cooling, equipment curves. Review large equipment proposed **plant** inputs against submitted drawings and specs (Special attention to modulating and/or staged equipment, reference building sizing rules for equipment with significant part-load implications, efficiencies)

	Proposed	**Reference**
• Boiler: • Heat Pumps: • DWH: (Of greater importance in MURBs, Hospitals) **Comments:** **Outstanding:**		

	8 Review major (largest 2-3) proposed **system** inputs against drawings and specs. Review major (largest 2-3) reference **system** inputs against drawings and specs. (Special attention paid to the reference building system having been selected and defined appropriately, consistent outside air levels, appropriate fan curves, minimum flows and efficiencies,) Below is only a sample list, more or less may need to be spot checked.	**Proposed**	**Reference**
High Med/ Low High Low High Med-Low Med-High	• System type: • Htg/Clg Cap.: Most important in non-modulating (single stage) equipment • Efficiencies: • Econo. type: • Heat Recovery Effectiveness: • Supply Fan Power: • Control strategies: **Comments:** **Outstanding**:		
High	**9** Check inputs affecting minimum **outdoor air**. Check that total outdoor air rate for each system is correct and is the same for both reference and proposed (MNECB path, also check for over ventilation). Under the 90.1 path check the critical zone calculation and OAF fraction calculation. **Comments:** **Outstanding**:		
Med	**10** Check major envelope **assemblies**. Give special attention to framing. Check major envelope **assemblies**. Give special attention to framing. (ensure reference building R-values are properly assigned)	**Proposed**	**Reference**
	Comments: **Outstanding**:		
Med-High (dep. on % glass)	**11** Check proposed **window** performance values and percent glazing. Check reference **window** performance values and percent glazing. (ensure reference building performance are properly assigned, under MNECB SHGC for reference and proposed should be either the same, or reference building should be set to 0.64) **Comments:** **Outstanding**:		
Med	**12** Spot check proposed lighting power densities. Spot check reference lighting power allowance. (ensure reference building LPDs are properly assigned.)	**Proposed**	**Reference**
	Comments: **Outstanding**:		

MANDATORIES (MNECB or ASHRAE) – Initial check, also should be reviewed again in detailed review

	1 Spot check mandatories MNECB (Complete check list should be included) however typically overlooked items by designers are: • In high glass ratio buildings, maximum average U-values for opaque components • Insulation values for hot water (both space heating and service) piping • flow control for multi-boiler installations • shower auto-shutoff for gang showers • Vestibules (subject to interpretation of "regularly used" entrances) • Excessive penetrations though envelope insulation layer • Independent electric meters for MURBs (MNECB route) • Pool cover requirements • Duct work in unconditioned spaces or outside – insulated properly. MNECB Table 5.2.2.5. • slab insulation (MNECB 3.2.3.3 particularly radiant slabs) • Others? ASHRAE • Vestibules • Optimum start controls (6.2.3.2.3) • Shut off damper controls (6.2.3.2.4) • Automatic ventilation controls for high occupancy areas (6.2.3.9) • Light switches for individual spaces • Pool cover requirements • Automated lighting control requirements (9.2.1.1, 9.2.1.2) • Reference to include exhaust air heat recovery (or equivalents) for fume hoods, kitchen exhaust and larger exhaust (ASHRAE 6.5.6) • heat recovery requirement for MUA >5000 cfm, 70% outdoor air • Others… **Comments:** **Outstanding**:

MECHANICAL – Detailed Review

	1 Review all proposed **plant** inputs against submitted drawings and specs Review all reference **plant** inputs against submitted drawings and specs (special attention to modulating and/or staged equipment, sizing-are reference building sizing rules followed-and of course efficiencies)		
		Proposed	**Reference**
	• DWH: • Boiler: • Chiller: • Clg Twr: • Heat Pump: • Pumps: **Comments:** **Outstanding**:		
	2 Review all proposed **system** inputs against drawings and specs. Review all reference **system** inputs against drawings and specs. (special attention paid the reference building system having been selected and defined appropriately, that the proposed building matches drawings and specification.)		

		Proposed	**Reference**
	• System type: • Htg/Clg Cap.: • Efficiencies: • SAT: • Econo. type: • Heat Recovery Effec.: • Supply Fan Power: • Exhaust/Return Fan: • Humidifier: • Control strategies: **Comments:** **Outstanding**:		
	3 Check that all zones have correct **principal heating source. (EE4 specific)** **Comments:** **Outstanding**:		
	4 Check that all **zones** have correct mechanical inputs.		
		Proposed	**Reference**
	• DCV: • Htg/Clg Capacities: • Airflows: • Fan Power: **Comments:** **Outstanding**:		
	5 Check for process air conditioning – exhaust flows, heating, cooling, etc. These should not be included for EE4/LEED Canada. **Comments:** **Outstanding**:		
	5 Check whether **schedules** are properly selected and are the same for both reference and proposed (note EE4 workaround for DVC allows different schedules). **Comments:** **Outstanding**:		
	6 Check inputs affecting minimum **outdoor air**. Check that total outdoor air rate for each system is correct and is the same for both reference and proposed (MNECB path, also check for over ventilation). Under the 90.1 path check the critical zone calculation and OAF fraction calculation. **Comments:** **Outstanding**:		
	7 Check inputs related to **domestic hot water** peak flows. Check that they are the same for both proposed and reference, if the proposed is less verify demand control measures exist in specifications/drawings. **Comments:** **Outstanding**:		
	8 Check space inputs related to **exhaust fans**. **Comments:** **Outstanding**:		

ARCHITECTURAL – Detailed Review

	1	Check building **floor area** in Summary Compliance Report (EE4 Specific, LV-? For other DOE2 based software). Ensure areas are the same for both proposed and reference. **Comments:** **Outstanding**:
	2	Check all proposed envelope **assemblies**. Give special attention to framing. Check all reference envelope **assemblies**. Give special attention to framing. (ensure reference building R-values are properly assigned) **Comments:** **Outstanding**:
	3	Check all proposed **window** performance values. Check all reference **window** performance values. (ensure reference building performance are properly assigned, under MNECB SHGC for reference and proposed should be either the same, or reference building should be set to 0.64) **Comments:** **Outstanding**:

	Proposed	**Reference**

ELECTRICAL – Detailed Review

	1	Spot check proposed lighting **fixture powers space LPDs.** Spot check reference lighting **fixture powers space LPDs.** (ensure reference building LPDs are properly assigned. **Comments:** **Outstanding**:
	2	Check for any daylighting or occupancy controls in proposed building. Reference building should not have any daylighting or occupancy controls. If ASHRAE route then some spaces (e.g. classrooms) MUST occupancy sensors. Also if ASHRAE route daylight credit can only be taken if model performs daylight calculations. **Comments:** **Outstanding**:

	Proposed	**Reference**

OTHER ISSUES

	1	**Comments:** **Outstanding**:
	2	**Comments:** **Outstanding**:
	3	**Comments:** **Outstanding**:

Sample Modeling Description and Characteristics Report

[Building Name]
[Simulator]

The following list of building characteristics provides a side-by-side comparison of the building characteristics for the Proposed Design versus the [MNECB+CBIP | ASHRAE 90.1-1999 ECB] Reference. In summary, the following are the key design characteristics which provide for superior energy performance as compared to the Reference Case:

- Exterior wall R-value nearly 80% higher than the Reference
- Roof R-value about 40% higher than the Reference
- Overall window conduction about 16% lower than the Reference
- Overall lighting load about 40% lower than the Reference, including credit for occupancy and daylighting controls
- In-floor radiant heating
- Variable-speed control of main air handling unit, providing for air delivery below minimum 0.4 cfm/sf level of Reference
- Heat wheel exhaust air heat recovery at 72.9% effectiveness
- Sea-water source heat pump system providing heating at a seasonal efficiency of COP-3.9 and cooling at over EER-26.
- Sea-water source heat pump system providing service water heating at a seasonal efficiency of COP-4.0.
- Low-flow faucets and showerheads providing 73% lower service water load than for the Reference.

Table 1. Summary of Models

Reference Case (MNECB - Region C)	Proposed Design
Modeling Software: Proposed design completed in DOE2.1e (release Ec133), using EE4 to set up about 95% of the initial Proposed Design. EE4 used exclusively for the Reference Case. **Schedules:** Schedules are identical between the Reference and Proposed Design cases, using MNECB default schedule 'A', which is fairly representative of what is expected for small office type of use. **Space Use Classification:** By space function **Principal Heating Source:** Per MNECB CS, "heat pump" is the principal heating source. **Conditioned Floor Area:** 10837 sf (1007 m^2)	
Building Envelope	
Exterior Walls • From Table 3.3.1.1.A MNECB, Opaque exterior walls at R_o-7 (fossil or heat pump heating).	*Exterior Walls* • R_o-13 (RSI-2.3) for wood stud walls with 3" rigid polystyrene insulation with Z-girts. • R_o-18 (RSI-3.1) for concrete block walls with 3" rigid polystyrene insulation.
Roof • From Table 3.3.1.1.A MNECB, Type III roof	*Roof* • Ro-16.9 (RSI-3.0) for metal roof type and with 3"

at R_o-12.1 (fossil or heat pump heating).	polyiso insulation, mostly with Z-girt thermal bridging.
Glazing • Window area same as for proposed design, up to a fenestration-to-wall ratio (FWR) limit of 0.40, including skylights in calculation of FWR. • From Table 3.3.1.2 MNECB, windows at U_o = U_o-0.56 for fixed windows and U_o-0.60 for operable[1]. • From 5.3.5.5, CS, window shading coefficient set to be same as proposed, instead of set at 0.74 as allowed by the MNECB to weigh benefit of beneficial solar gains versus comfort issues. • From 5.3.5.5, CS, window shading coefficient is adjusted by 80% derating for internal shading, dirt, etc. • No overhangs or fins; self-shading same as for proposed (although EE4 does not provide for).	***Glazing*** • Glazing at 21.7% of vertical wall area • Windows input at overall U-value of 0.45 for a mix of $^2/_3{}^{rds}$ fixed and $^1/_3{}^{rd}$ operable windows with thermally broken aluminum framing (determined using FramePlus). Garage door window at – double glazing in non-thermally broken aluminum frames at Uo = 0.70. • SHGC at 0.50 for clear low-e windows including frames; garage door windows at 0.51. • Overhangs not included for same reasons as for setting shading coefficient same in reference and proposed; that is, overhangs provide for comfort but shows an inappropriate penalty because building is not cooled.
Infiltration • From 5.3.5.9 CS, background infiltration rate of 0.05 cfm/ft^2 of gross wall area, applied 24 hours/day to exterior zones.	***Infiltration*** • Same as for Reference. Note that EE4 erroneously doesn't apply infiltration to unconditioned spaces, which I have corrected.
Lighting	
• Lighting density based on function of zone. Average lighting density is 1.45 W/sf (15.6 W/m^2).	• Average adjusted space lighting density at 0.87 W/sf (9.3 W/m^2), including credit for occupancy sensors and daylighting controls.
Appliances and Plug Loads	
• Equipment density based on function of zone. Average daily peak diversified equipment density from MNECB defaults is 0.32 W/sf (3.5 W/m^2). • Additional diversified process loads added to server and electrical rooms.	• Must be same as Reference. • Process loads same as Reference.
HVAC Equipment.	
System • For multiple zone system (effectively defined by source of ventilation), central VAV with reheat modeled as baseboards. • Single zone systems with constant volume systems	***System*** • AHU-1: Variable volume central air handler serving induction diffusers (except for meeting and boardrooms), with terminal in-floor radiant heating. • Remaining systems not served by AHU-1 as constant volume single zone systems.
Supply and Ventilation Air • Supply air for AHU-1 sized by EE4 at just over 4600 cfm (2200 l/s) based on taking the larger of (1) the outside air requirements or (2) minimum required 0.4	***Supply and Ventilation Air*** • Supply air flow for AHU-1 at nearly 5900 cfm (2800 l/s) overall. • Minimum supply air rate at 60% of peak supply. • Minimum outside air (O/A) at ASHRAE 62 levels,

[1] Note that EE4 has never properly set the window U-value and does not match intended value in DOE2, but the discrepancy is consistent between Reference and Proposed.

cfm/sf. • Minimum flow rate set at 0.4 cfm/sf after final sizing completed. • Minimum design outside air level same as for proposed. • For multiple zone systems without hydronic cooling (AHU-1), 3.0" for supply and 0.6" for return. Single zone with DX or without cooling (FCU-2), 1.3" for supply and no return; with hydronic cooling (FCU-3), 2.0" for supply and 0.6" for return. • For multiple zone systems without hydronic cooling, 45% for supply efficiency and 25% for return efficiency. Single zone with DX or without cooling, 40% for supply (no return); with hydronic cooling, 50% for supply and 25% for return. • For VAV, use of the appropriate type of fan curve. • No exhaust air heat reclaim.	controlled at 100% of supply (although FCU-1 served by AHU-1 technically may provide for some minor amount of mixed air in simulation). • Fan power at 3.8 kW, based on performance specs (shop drawings) for main AHU-1 and mechanical schedules for remaining fan coils and unit heaters. • Variable speed drive on AHU-1. • Exhaust air heat recovery at 72.9% overall effectiveness for heat wheel, including adjustment for amount of exhaust returned to AHU-1 (see notes).
Control • Heating setpoint at MNECB defaults of 22° / 18°C for zones served by radiant heating[2] (AHU-1); setpoints and schedule same as proposed for remaining zones. • Cooling setpoints, setback temperatures, and schedules same as proposed design. • Enthalpy economizer for mechanically cooled zone. • OA scheduled off to zones that do not require OA during unoccupied periods. • Minimum supply air temperature at 55°F, reset based on warmest zone. • No demand ventilation.	***Control*** • Heating setpoints at 20° / 19°C for zones served by radiant heating (see notes on credit for radiant heating); 22°C / 17°C otherwise, except for core open zone which is allowed to float (indirectly conditioned). • Cooling setpoints: 24°C (MNECB default). • Drybulb economizer in the form of hybrid ventilation tied to DDC control, but is not implemented because of how EE4 inappropriately restricts cooling control of non-mechanically cooled zones. Server zone without economizer control. • OA scheduled off during unoccupied periods. • Minimum supply air temperature at 61°F (16°C), with outside air reset. • No demand controlled ventilation, although CO2 sensors installed, but only to monitor indoor air quality and provide alarms if IAQ is unsatisfactory.
Heating Plant • One electric resistance boiler since proposed has 100% GSHP system. Unfortunately, EE4 does not allow the specification of "heat pump" principal	***Heating Plant*** • Baseline with sea water source heat pumps (SWHPs), with hot water reset[3], a seasonal average COP of 3.87 from Water Furnace specs. • Temperature drop of 7.2°C

[2] Not surprisingly, when a more typical setback schedule is introduced, many of the zones are underheated for more the 100 hours because of having inadequate capacity to handle the pick-up load. As this is not the case for the actual proposed design with a more constant temperature profile, the reference baseboard capacities are modified as necessary to provide for MNECB-compliant requirements of having <100 under-heated hours in any zone (which ends up conservative compared to proposed design since the reference still has more under-heated hours).

[3] Hot water reset outside of EE4 using DOE2 since it directly provides this capability.

heating source in the zone *and* allow for use of an electric resistance boiler. Hence, the reference had to be modified manually in DOE2. • Temperature drop through the hot water loop of 29°F. • Constant flow hot water circulation. • Hot water circulation same as proposed (40 ft. is default).	• Constant flow hot water circulation • Hot water circulation at 285 kPa head overall, including sea water heat rejection pumping[4].
Cooling • Central reciprocating chiller at COP 3.8 for hydronic cooling.Temperature rise of 5.6°C. • Circulation head same as proposed. • Constant flow chilled water circulation. • Two cell cooling tower with 85°F – 95°F temperature rise, and a constant speed fan with cycling control and 5.9 hp/1000 MBH. Constant speed tower pump at 60 ft head and combined efficiency of 70%. • Mechanical cooling scheduled off same as for proposed design[5].	***Cooling*** • Cooling at 26.4 EER from sea water-to-water heat pumps. • Temperature rise of 2°C. • Circulation head at 0 feet since pumping from same pumps as for heating (and already accounted for). • Constant flow chilled water circulation. • Only server room mechanically cooled (FCU-3).
Domestic Hot Water (DHW)	
• Since proposed is all electric, then electric resistance. • Load same as Proposed.	• Service water heating provided from sea water source heat pump (WW-5) at COP of 4.0. • Load set corresponding to MNECB defaults, reduced with 0.5 gpm faucets and 1.5 gpm shower (per shop drawings).
Utility Rates	
• Electricity rate same as Proposed.	• Electricity Rates set at BC Hydro 1220 tariff of 6.8 ¢/kWh.

[4] DOE2 requires that all pumps be represented using a single equivalent set of pump characteristics.
[5] Note that EE4 does not provide for this, but can be specifically represented in DOE2.

Simulation Assumptions and Notes

Simulation Cases:

[_____]-Pro.* - Energy performance simulation files for Proposed Design

[_____]-Ref.* - Energy performance simulation files for CBIP Reference Case

SIMULATION NOTES AND ENERGY MANAGEMENT OPTIONS

Roof Air Space: High ceiling is open and exposed to entire first floor and open centre core and the load is effectively …

Radiant Heating Credit: From the LEED Reference Guide, credit for radiant heating may be provided if "HVAC systems are controlled based on …

Exhaust Heat Recovery Effectiveness is applied in DOE2 for central (non-zonal) systems using DOE2's heat recovery capability. This adjusts for …