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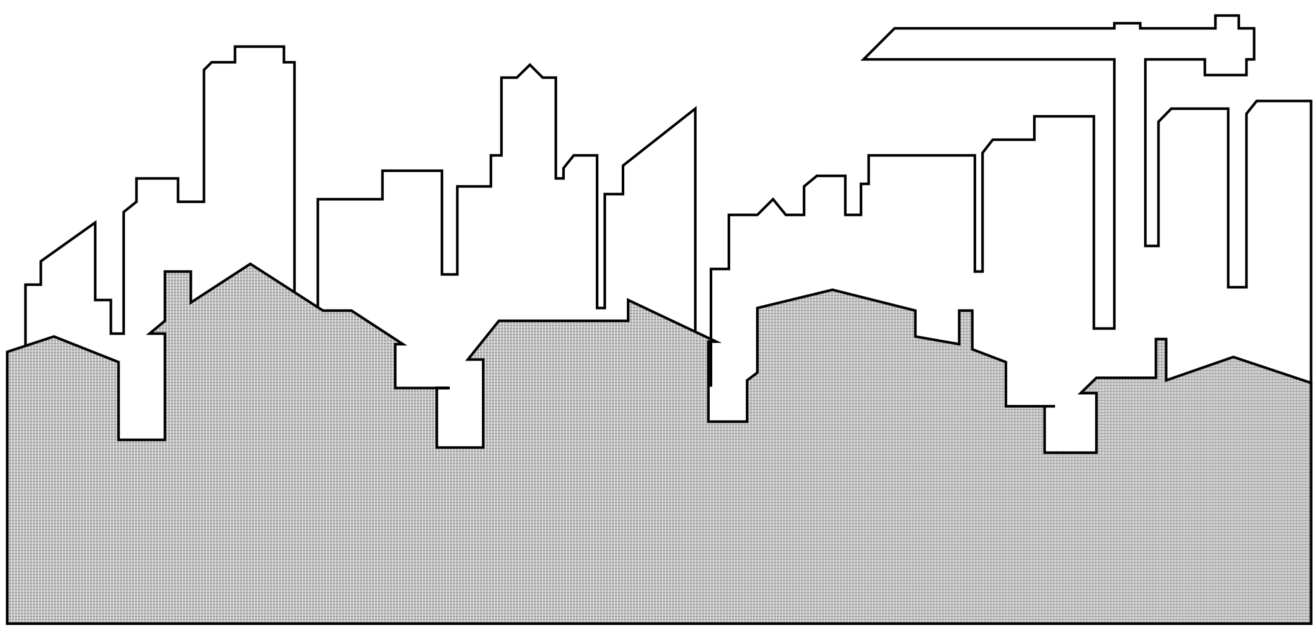
Canadian Commission on
Building and Fire Codes

Performance Compliance for Houses

Specifications for Calculation Procedures
for Demonstrating Compliance to the
Model National Energy Code of Canada for Houses 1997
Using Whole House Performance

March 1999



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Preface

The Model National Energy Code of Canada for Houses (MNECH) 1997 features two types of requirements: mandatory, mostly qualitative, requirements that must be met by all *proposed designs*; and prescriptive, quantitative, requirements for which the MNECH provides three optional paths to show compliance:

1. Prescriptive Compliance
2. Trade-off Compliance
3. Performance Compliance

Prescriptive Compliance

A *proposed design* will comply with the prescriptive requirements of the MNECH if the thermal characteristics relating to space heating [e.g. *effective thermal resistance* of walls, HRV (heat recovery ventilator) efficiency], are equal to or better than the prescriptive requirements provided in Sections 3.3. and 5.3. of the MNECH. This is the simplest compliance path and requires no performance calculation.

Trade-off Compliance

Section 3.4. of the MNECH allows deviation from some of the prescribed envelope requirements, provided that other envelope components compensate so that the net *space heating requirement* is less than or equal to that which would result from the prescriptions. Two methods of envelope trade-off compliance are provided. Subsection 3.4.2. of the MNECH states that compliance can be achieved by showing that the sum of the areas of all above-ground assemblies divided by their respective *effective thermal resistances* is no greater than it would be if all assemblies complied with prescriptions. Subsection 3.4.3. of the MNECH allows compliance to be demonstrated using computer software that evaluates envelope trade-offs using a specified calculation procedure.

Performance Compliance

Performance compliance is an option (described in Part 8 of the MNECH) that permits a *proposed design* to deviate from prescriptive requirements provided that the *proposed design* can be shown, using computer software (*compliance software*), to have an *annual adjusted energy consumption* for space heating no greater than that of a *reference house* that satisfies the prescriptive requirements. The MNECH specifies that software used for this purpose comply with this specification.

This document specifies the various functions that the *compliance software* must be capable of performing in order to assist a user in demonstrating that a *proposed design* complies with the MNECH. The intended audience for this specification is the software development agency that will develop or adapt software and related manuals for this purpose.

Statement of Intent

In general, the purpose of the performance compliance procedure is not to develop an accurate prediction of annual energy use for space heating. Rather, the purpose is to develop fair and consistent evaluations of the effects of deviations (in whatever direction) from MNECH prescriptive requirements. As such, many simplifying assumptions were made to rationalize the modeling exercise without compromising the intent.

Further, a number of occupant practices may result in energy conservation, for example, lowering or setting back thermostats. The performance analysis will not account for these measures. Since the performance path is used to allow deviations from MNECH prescriptive requirements, it was felt that occupant behaviour should not be relied upon to achieve consistent and permanent reductions in building energy consumption. As well, some energy-saving measures depend on the occupant for proper functioning to save energy; for example, insulating shutters for windows, and attached sunspaces that don't incorporate heating systems. It is generally acknowledged that such devices can save energy when used for that purpose, and the MNECH will not discourage their use; nevertheless, it was felt that the overall intent of the MNECH would be compromised if the removal of other, more permanent energy-efficient measures (such as envelope insulation) were to be allowed in favour of occupant-sensitive measures.

In summary, a wide range of characteristics determine the energy efficiency of a building. The MNECH will require some of these to meet prescribed levels of energy efficiency, and will allow some others to be used instead of the prescriptive requirements through the trade-off and performance paths. Beyond these minimum requirements, it is expected that many conservation features not required by the MNECH and not included in the scope of the performance compliance path will continue to be demanded by the consuming public and contribute to the overall energy efficiency of buildings.

Definitions

Words and terms that appear in italics in this document are defined terms intended to have a specific meaning. Terms that are defined in Section 1.4., Definitions, of Chapter 1 of this document shall have the meaning given therein. Terms that are not defined in Section 1.4. shall have the meaning defined in the MNECH.

Words and terms used in this document that are not defined in Section 1.4., Definitions, of Chapter 1 of this document and are not defined under Article 1.1.3.2. of the MNECH shall have the meanings that are commonly assigned to them in the context in which they are used in this document and in the MNECH, taking into account the specialized use of terms within the various trades and professions to which the terminology applies.

Chapter 1
Scope, Function and Definitions

1.1. Scope

1.1.1. Applicable Building Types

This procedure shall apply to all buildings covered by the MNECH.

There are restrictions on the components that may deviate from prescriptive values (see Subsection 1.1.6.).

Multiple dwelling units served by a single, central heating system, or served by individual heating systems, are within the scope. In these cases, the analysis shall apply to individual dwelling units (see Figure 1-2).

Modeling a building containing several dwelling units with independent heating systems as a single building, or choosing an average unit as representative of all units in the building, shall not be allowed.

Each unit that is different for modeling purposes shall comply on its own (applies to, for example, apartments in a small apartment building, or row housing). See Figures 1-1 and 1-2 for clarification.

1.1.2. Window Thermal Characteristics, Orientation and Areas and Passive Solar Designs

Decreasing the *U-value* of windows from prescriptive levels can be used as a compensatory measure for any permitted deviation from the MNECH prescriptive requirements for other components. However, decreasing window area below the prescribed limit cannot be used as a compensatory measure. Increasing window areas above the prescribed limit for houses (20% of floor surface area) is permitted but, in most Canadian climates, will result in the need to take compensatory actions, even if the orientation of windows is predominantly south facing. This is due to the fact that if a total window area larger than the prescribed limit is specified, the extra window area has to perform as well as or better than the wall it is replacing. This is made more difficult than is normally allowed by models because of a built-in allowance for external shading. Thus, several features of good passive solar design might be needed (e.g. judicious window sizing and orientation, higher performance windows, improved use of interior mass) for the full benefits of such a design to be apparent in the performance analysis. It was felt that since the intent of the performance analysis is to allow deviations from MNECH prescriptive requirements (a feature that passive solar designers are not likely to need in many cases), the overall objectives of the MNECH would not be served by making it easy to remove energy-efficient features by simply re-orienting windows.

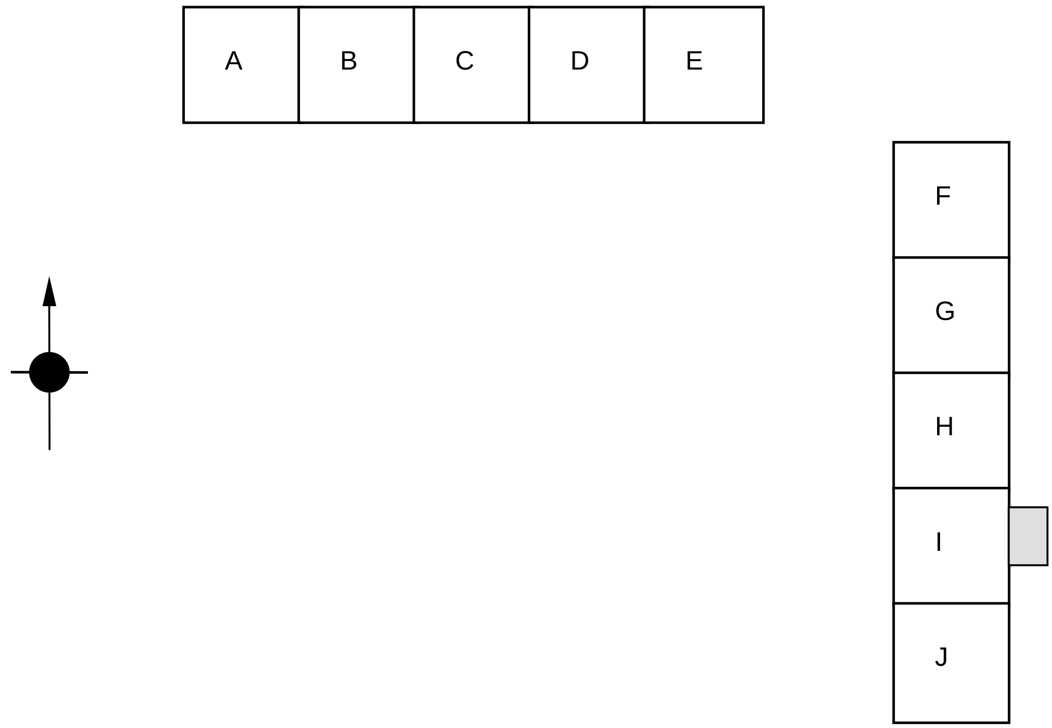

Figure 1-1. Consider 10 row houses identical in construction, differing only in their orientation and the number of row houses next to them, with the exception of house I, which has an attached sunspace. If the glazing of houses A through E faces only north-south, then houses A and E are identical for modeling purposes: they both have three exposed walls (the fact that in house E an exposed wall faces east and in house A it faces west has no impact on the modeling required by the MNECH). House B is not identical to house A since it only has two exposed walls; house B is identical, however, to houses C and D. Therefore only houses A and B need to be modeled to check for compliance for the whole row. Similarly, for row houses F-J where all the glazing faces east-west, houses F and J are identical, as are houses G and H. Note that house G is not identical to house B since the glazing faces in differing directions, and therefore houses G and H would have to be modeled separately from houses B, C and D. However, house I must be modeled separately from all the others since its sunspace makes it unique.

1.1.3. Additions to Existing Buildings

New additions to existing buildings having a total floor surface area greater than 10 m^2 must comply with the MNECH. For modeling purposes, the addition may be considered separately, or in combination with the whole building.

1.1.4. Active Solar Systems

Active solar space heating systems, when suitably modeled, are included in the scope.

1.1.5. National Building Code or Provincial and Territorial Codes

The National Building Code of Canada (NBC) or the appropriate provincial and territorial building codes contain certain minimum standards designed principally to address health and safety concerns. The performance compliance path shall not be used to contravene these minimum standards.

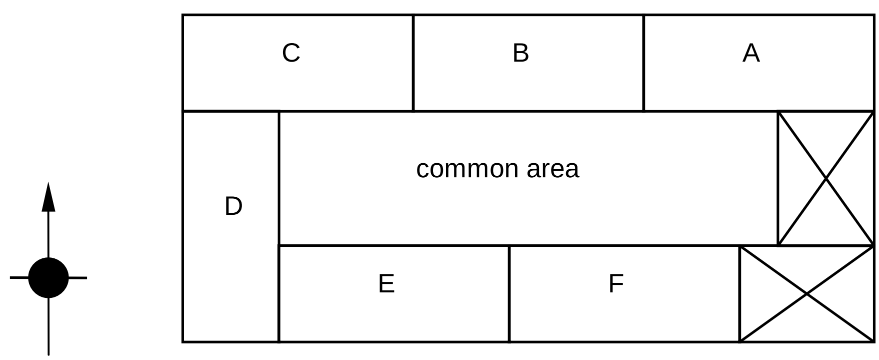

Figure 1-2. Consider six apartments on one floor of a small apartment building. The apartments are identical in floor surface area, but differ in their orientation. They have identical glazed areas, but the glazing is distributed such that there is glazing on each of an apartment's exposed walls. Apartments E and F are identical for modeling purposes: they both have one exposed wall with identical glazing in the same orientation; therefore only one of E and F would have to be modeled separately. Apartment A is not identical to apartment C. They both have two exposed walls, and the same amount of glazing facing north, but apartment A has some glazing facing east, and C has some glazing facing west; therefore both A and C would have to be modeled separately. Apartment B is not identical to A or C because it has only one exposed wall. Neither is apartment B identical to E or F because the orientations are different; therefore B would have to be modeled separately. Apartment D would also have to be modeled separately since it has a different orientation to all the other apartments. The common area is outside the scope of the performance path.

1.1.6. Component Deviations

The performance compliance path is intended to offer greater flexibility to the designer in meeting the energy performance requirements of the MNECH than that offered by either the prescriptive or trade-off path. However, there are still restrictions on which building components can be addressed and how far from the prescriptive values they may vary. The addressable components and their range of variation are detailed in the boxes below.

1.1.6.1. Components That May Deviate from Prescriptive Values

The following components may take on values other than the minimum / maximum values prescribed in the MNECH, which would, in isolation, generally lead to a greater building *space heating requirement*:

1) The *effective thermal resistance* of truss-type attics may be reduced by up to 40%.
2) The *effective thermal resistance* of joist-type roofs may be reduced by up to 25%.
3) The *effective thermal resistance* of walls may be reduced by up to 25%.
4) The *effective thermal resistance* of floors may be reduced by up to 40%.
5) Window Energy Rating may be decreased (or *U-value* may be increased).
6) Window area may be increased beyond 20% of floor surface area. (Note that this may increase or decrease *space heating requirement* depending on climate, window and wall type, etc.)
7) The *effective thermal resistance* of basement walls may be reduced by up to 40%.
8) The *effective thermal resistance* of floors-on-ground may be reduced by up to 40%.
9) HRV may be replaced by a unit of lower efficiency, or removed altogether.
10) Door *U-value* may be increased by up to 40%.

1.1.6.2. Actions That May be Taken to Compensate for Reduced Performance Resulting from Deviations*

The following actions may be taken that would, in isolation, generally lead to a reduction in building *space heating requirement*:

1) The *effective thermal resistance* of attics or roofs may be increased.
2) The *effective thermal resistance* of walls may be increased.
3) The *effective thermal resistance* of floors may be increased.
4) Window Energy Rating may be increased (or *U-value* may be decreased).
5) The *effective thermal resistance* of basements and / or coverage may be increased.
6) Thermal mass may be increased.
7) Window orientation may be changed (credits or penalties only occur for window area greater than 20% of floor surface area).
8) Furnace efficiency may be increased, except in multiple dwelling buildings with a central system.
9) Heat pump efficiency may be increased, except in multiple dwelling buildings with a central system.
10) HRV efficiency may be increased, if serving a single dwelling unit.
11) Active solar space heating system may be used (if it can be suitably modeled).
12) Air tightness may be improved, credit only given for a normalized leakage area below 1 cm^2/m^2, and down to 0.6 cm^2/m^2, normalized leakage area used must be supported by an airtightness test.
13) Door *U-value* may be decreased.
14) The *effective thermal resistance* of walls, roofs and floors with imbedded heating ducts, cables or pipes (i.e. radiant heating within component) may be increased.

*Note to 1.1.6.2.: Different deviations may be applied to individual components of the same kind. For example, the *effective thermal resistance* of one wall may be decreased while another wall *effective thermal resistance* is increased to compensate.

1.1.6.3. Components That May Not be Varied under the Performance Path

The following components may <u>not</u> be varied in order to affect *space heating requirement*:

1) Fan or pump efficiency independent of system efficiency.
2) Service hot water equipment, combination service hot water / space heating equipment and loads.
3) Internal heat gains including: lighting and other electrical loads, and occupants.
4) Thermostat settings.
5) Absorptance of walls, roofs, floors, or opaque portions of doors.
6) Shading of windows or *skylights*.
7) A normalized leakage area of greater than 2 cm^2 / m^2 may not be specified.
8) Furnace or heat pump efficiency in multiple dwelling buildings with a central HVAC system.
9) Reductions in *effective thermal resistance* are not permitted for walls, roofs, and floors containing radiant heating elements.
10) All other parameters that are not specifically identified in the MNECH as being subject to a prescriptive requirement.

1.1.6.4. Components That May be Changed But are Unlikely to Affect Compliance

The following components may be varied by the designer but will have little direct effect on the *space heating requirement* because, for these components, the *reference house* will take on the same values as the *proposed design*:

1) Wall orientation and area.
2) Roof orientation and area.
3) Window and / or *skylight* type, i.e. fixed or operable.
4) Reducing window area below the maximum allowed by the prescriptions.

1.2. Precedence of the MNECH

This document describes the calculation procedure for performance compliance as given in Part 8 of the MNECH and is subject to changes made necessary by revisions to the MNECH. It must be read in conjunction with the relevant requirements of the MNECH, which is a binding document that establishes the rules for performance compliance. Where discrepancies occur between the present document and the MNECH, the MNECH shall govern.

1.3. Function and Structure of this Document

The basic principle of Part 8 of the MNECH is that a *proposed design* may depart from the prescriptive requirements of the code (within specified limits) if it can be shown using *compliance software* that the *annual adjusted energy consumption* of the *proposed design* is less than or equal to an *energy target* that is based on the energy consumption of a similar building that follows the prescriptive requirements.

Chapter 2 of this document describes in more detail the structure and function of the *compliance software* as summarised below. In order to comply with this specification, the *compliance software* must:

- provide a user interface to permit appropriate data for the *proposed design* to be entered;
- check the data input for consistency and to ensure that restrictions are satisfied;
- process user input by adding fixed values and providing defaults so as to create complete input data necessary to simulate the energy performance of the *proposed design*;
- on error, abort the rest of the procedure and generate error messages and diagnostic information for the user;
- calculate the annual consumption of each energy source for the *proposed design*, ensuring that the proper climate data is used for analysis;
- adjust the energy consumption of the *proposed design* using the *energy source adjustment factor* for each source;
- sum the adjusted energy consumption for all sources used in the *proposed design* to obtain the *annual adjusted energy consumption*;
- generate data to define a *reference house*, combining input data for the *proposed design* and the prescriptive requirements of the MNECH;
- calculate the annual consumption of each energy source for the *reference house*, ensuring that the proper climate data is used for analysis;
- adjust the energy consumption for the *reference house* using the *energy source adjustment factor* for each source;
- sum the adjusted energy consumption of the *reference house* for all sources used to obtain the *annual adjusted energy consumption* (the *energy target*);
- compare the *annual adjusted energy consumption* of the *proposed design* to the *energy target* to determine compliance;
- if the *proposed design* complies, then generate compliance reports for submission to the building official;
- if the *proposed design* does not comply then generate a report showing non-compliance and containing information to help the designer determine what design changes are needed to comply; and
- generate diagnostic and information reports.

Chapter 3 describes the user input required by the *compliance software* in order to model the *proposed design* and *reference house.*

Chapter 4 contains requirements for defining the input files of the *proposed design* and *reference house* to allow for successful modeling. This includes defaults and fixed input not covered in the user-defined inputs described in Chapter 3.

Chapter 5 describes the required characteristics of the energy calculation methods used by the *compliance software*.

Chapter 6 describes the steps that need to be performed by the *compliance shell* to process the outputs of the *energy analysis engine* and to produce the *annual adjusted energy consumption* of the *proposed design* and *reference house.*

Chapter 7 describes an outline testing method for *compliance software.*

1.4. Definitions

Words and terms that appear in italics in this document are defined terms intended to have a specific meaning. Terms that are defined in this Section shall have the meaning given below. Terms that are not defined below shall have the meaning defined in the MNECH.

Words and terms used in this document that are not defined in this Section and that are not defined under Article 1.1.3.2. of the MNECH shall have the meanings that are commonly assigned to them in the context in which they are used in this document and in the MNECH, taking into account the specialized use of terms within the various trades and professions to which the terminology applies.

Annual adjusted energy consumption means the sum of the annual consumption of each energy source multiplied by the *energy source adjustment factor*.

$$AAEC = \left(\sum_{t}^{e1} \frac{H_1}{n_1}\right) \bullet ESAF_1 + \left(\sum_{t}^{e2} \frac{H_2}{n_2}\right) \bullet ESAF_2 ....$$

where,

AAEC	=	annual adjusted energy consumption (adjusted MJ/year),
$ESAF_1$, $ESAF_2$…	=	*energy source adjustment factor* for energy source 1, energy source 2...
e1, e2…	=	energy source 1, energy source 2, ...
t	=	time,
H_1 , H_2…	=	heat load at time *t* for energy source 1, energy source 2, … (MJ),
n_1, n_2	=	system efficiency at time *t* for energy source 1, energy source 2…

Authority having jurisdiction means the governmental body responsible for the enforcement of any part of the MNECH or the official or agency designated by that body to exercise such a function.

Compliance shell means a user interface where user inputs are entered and checked, simulation input files are prepared, energy simulation is prompted for both the *proposed design* and the *reference house*, and results displayed and printed out.

Compliance software means a computer program consisting of a *compliance shell* and *energy analysis engine* that is used for testing *proposed design* performance path compliance with the MNECH.

Effective thermal resistance (RSI-value) means the inverse of the *overall thermal transmittance* of the assembly, as defined in the MNECH, including air films and the effect of thermal bridging. For assemblies in contact with the ground, the *effective thermal resistance* excludes the resistance of the ground and of the exterior air film at its surface.

Energy analysis engine means a collection of algorithms that calculate the *space heating requirements* of the *reference house* and the *proposed design* given the input file prepared by the *compliance shell.* The *energy analysis engine* may be newly developed specifically for MNECH compliance, or be adapted from an existing building simulation program.

Energy target means the *annual adjusted energy consumption* of the *reference house.*

Energy source adjustment factor means the factor by which the consumption of a given energy source is multiplied to obtain the *annual adjusted energy consumption* of a building. The factors are based on the relative costs of fuels, region-by-region, at the time of preparation of the MNECH and are found in Appendix D of the MNECH.

Performance compliance report means a record of the information that is input, processed and output by the *compliance software*; intended to accompany an application for a building permit.

Primary energy source means the energy source consumed in greatest quantity by the *principal heating system*. For example, the *primary energy source* for a fuel-assisted heat pump would be electricity.

Principal heating source means the source with the highest *energy source adjustment factor* in Table D-1 of Appendix D of the MNECH that accounts for more than 10% of the required space heating capacity of the *proposed design*. For example, the *principal heating source* for a fuel-assisted heat pump would be "heat pump."

Principal heating system means the *proposed design's* main heating system. For example, the *principal heating system* for a *proposed design* with electric baseboard heaters and a supplementary active solar heating system would be the electric baseboard heaters. Not to be confused with the *principal heating source*.

Proposed design means a building with components differing from the prescribed values in the MNECH that seeks to comply with the MNECH via the performance path.

Reference house means a hypothetical replica of the *proposed building* using the same energy sources for the same functions, having the same general physical dimensions and orientations and having the same environmental requirements, occupancy, climate data, and operations schedules, but made to comply with all applicable prescriptive requirements of the MNECH.

RSI-value (see effective thermal resistance)

Secondary energy source means another energy source consumed by the *principal heating system*. For example, the *secondary energy source* for a fuel-assisted heat pump would be gas.

Space heating requirement means the annual energy required by the heating system(s) in order to deliver enough energy to the space to maintain the setpoint air temperature at the desired value. Equal to the instantaneous heating load divided by the seasonal system efficiency summed over the year.

$$SHR = \sum_{t}^{e1} \frac{H_1}{n_1} + \sum_{t}^{e2} \frac{H_2}{n_2} + \ldots$$

where,

SHR	=	*space heating requirement* (MJ / year).
e1, e2…	=	energy source 1, energy source 2, ...
t	=	time,
H_1, H_2…	=	heat load at time t for energy source 1, energy source 2, … (MJ),
n_1, n_2	=	system efficiency at time t for energy source 1, energy source 2…

Supplementary heating system means a heating system used by the *proposed design* other than the *principal heating system*. For example, the *supplementary heating system* for a *proposed design* with electric baseboard heaters and a supplementary active solar heating system would be the active solar heating system.

U-value means the *overall thermal transmittance* of the assembly, including air films and the effect of thermal bridging. See MNECH for definition of *overall thermal transmittance*.

Chapter 2
Structure and Functions of the Compliance Software

2.1. Structure of Compliance Software

1) The *compliance software* comprises two parts:

a) *Compliance shell*: an interface where user inputs are entered, simulation input files prepared, and results displayed;

b) *Energy analysis engine*: a collection of algorithms that calculate the space heating energy requirements of the *reference house* and the *proposed designs* given the input file prepared by the *compliance shell*.

2.2. Functions of the Compliance Software

1) This section describes in general terms the various *compliance shell* and *energy analysis engine* functions and the order in which they will be carried out.

2.2.1. Prompting the User for Input

1) The *compliance shell* shall prompt the user for all necessary inputs describing the *proposed design*. These inputs are described in Chapter 3. The *compliance shell* shall:

a) ensure that all necessary inputs are provided;

b) ensure inputs obey specified restrictions and are otherwise error free;

c) indicate default values where appropriate;

d) prevent the user from changing fixed inputs.

2.2.2. Input Files for Simulation

2.2.2.1. The Proposed Design Input File

1) The *compliance shell* shall generate a *proposed design* input file for the *energy analysis engine* comprising user inputs (as defined in Chapter 3) and necessary default and fixed inputs (as defined in Chapters 3 and 4).

2.2.2.2. The Reference House Input File

1) The *compliance shell* shall generate a *reference house* input file for the *energy analysis engine* based on user inputs for the *proposed design* (as defined in Chapter 3) and necessary default inputs (as defined in Chapters 3 and 4).

2.2.2.3. Input Conversion

1) The format of input required by the *energy analysis engine* may differ from the format required by the *compliance shell*. In this case, the *compliance shell* shall perform all necessary conversions. The conversion routines shall not in themselves act to change the performance of the *proposed design* compared to the *reference house*.

2.2.2.4. User Access to Inputs

1) The user shall only be able to change input data through the *compliance shell*.

2.2.3. Calculation of the Annual Consumption of Each Energy Source

1) The *energy analysis engine* shall take the prepared input files and, on a command issued from the *compliance shell*, run two simulations over the approved climate year: one for the *reference house* and the second for the *proposed design*. Output to the *compliance shell* shall be the annual consumption of each energy source used for heating the building. The *energy analysis engine* shall be configured to ensure that the restrictions of Article 1.1.6.3 can be observed.

2.2.4. Adjusted Annual Space Heating

1) The *compliance shell* shall apply *energy source adjustment factor*s to the energy requirement of each energy source. The *compliance shell* shall ensure that the restrictions of Article 1.1.6.3 are observed. These adjusted values shall then be summed separately for both the *reference house* and the *proposed design* to produce an *annual adjusted energy consumption* for each building. The *annual adjusted energy consumption* for the *reference house* is termed the *energy target*.

2.2.5. Comparison of Design and Reference House

1) The *compliance shell* shall compare the *annual adjusted energy consumption* for the *proposed design* with the *energy target*. If the *proposed design* consumption is equal to or less than the *energy target* (and all other mandatory requirements of the MNECH are met) then the *proposed design* complies with the MNECH via the performance path.

2.2.6. Performance Compliance Report

1) The *compliance shell* shall prepare a *performance compliance report* (which can be made available in hard-copy) detailing the *proposed design*, the *reference house*, and the simulation results. The information to be included in the *performance compliance report* is shown in Appendix A.

Chapter 3
User Inputs to be Prompted by the Compliance Shell

3.1. General

1) This chapter describes the inputs that the *compliance shell* must request of the user of the *compliance software*.

2) Unless explicitly stated, all inputs shall be entered in accordance with MNECH Section 2.2.

3.2. Division into Thermal Blocks

1) The *proposed design* may be modeled as either a single (thermal) zone or as multiple zones.

2) The majority of this manual, in particular this Chapter, is written assuming that single zone modeling will be adopted.

3) Where multiple zone models are proposed to be used, they shall provide results consistent with approved single zone models. Consistency will be determined according to the procedure outlined in Chapter 7.

3.3. Project Identification and General Inputs

1) The *compliance shell* shall request the following inputs from the user:

a) project name;

b) project location;

c) project owner;

Data needed for reporting purposes and for *compliance shell* to select appropriate weather data and *reference house* prescriptive envelope.

d) "designer" who has the responsibility for certifying that the *performance compliance report* represents a true record of the energy analysis;

e) total occupied heated *floor surface area* [the *floor surface area* may be calculated from the heated volume defined in Clause (g)];

As determined by definition in MNECH Articles 1.1.3.1. and 3.3.1.5. Required for determining the maximum reference window area (20% of floor surface area).

f) number and type of rooms: entries for kitchen, living, dining, utility, bedrooms, bathrooms, basement and other;

Required for determining required ventilation rates in accordance with CAN / CSA-F326-M / NBC 1995, Part 9. HOT-2000[1] uses these room types.

g) heated volume, including:
   i) basement [the heated volume may be calculated from the *floor surface area* defined in Clause (e)]; and
   ii) sunspaces.

For calculation of infiltration rate and minimum ventilation rate.

Even if not heated initially they are typically retrofitted to provide full comfort conditioning.

2) No input is required for unheated spaces.

e.g. corridors in small apartment buildings.

3) The following attached spaces are to be excluded from the analysis:

a) garages;

b) unheated vestibules; and

c) unheated crawl spaces separated from the living area by an insulated floor with an integral air barrier

The user will be allowed to increase the wall thermal resistance by 0.16 $m^2 \cdot °C / W$ for walls between heated and unheated spaces [see Sentence 3.5.1.(3)].

4) *Space heating requirement*s of common areas shall be omitted from the analysis, and where applicable shall comply with the prescriptive requirements of the MNECH.

3.4. Heating Source Classification

1) The *compliance shell* shall request the *principal heating source* from the user.

Required to determine the prescriptive requirements of *reference house*.

3.5. Inputs to Specify the Envelope Components of the Proposed Design

1) Every envelope component that separates the heated space from the outdoors, unheated space, or the ground must be input, as described in this Section.

3.5.1. Above Ground Exterior Walls

Includes portions of the foundation wall that are above ground.

Note that orientation and tilt is not a required input for (opaque) walls since absorptance is set to 0.0. It may, however, be necessary for some software in defining window orientation, i.e. where specific windows are assigned to specific walls.

1) For each wall the *compliance shell* shall request the following input from the user:

a) wall type (log wall / all others);

b) surface area;

c) an input of:
   i) *effective thermal resistance* of the assembly; or
   ii) construction in layers; or
   iii) other input format suitable for the *energy analysis engine* and meeting the requirements of Appendix C of the MNECH.

2) If thermal bridging is not accounted for in the input data, it shall be handled by the *compliance shell* in a manner consistent with the MNECH Subsection 2.2.2.

3) An exterior wall separating an interior heated space from an enclosed unheated (non exterior) space, e.g. an unheated garage, shall have its *effective thermal resistance* increased by 0.16 $m^2 \cdot °C/W$ to account for the extra resistance of the enclosed unheated space (see Figure 3-1 for clarification).

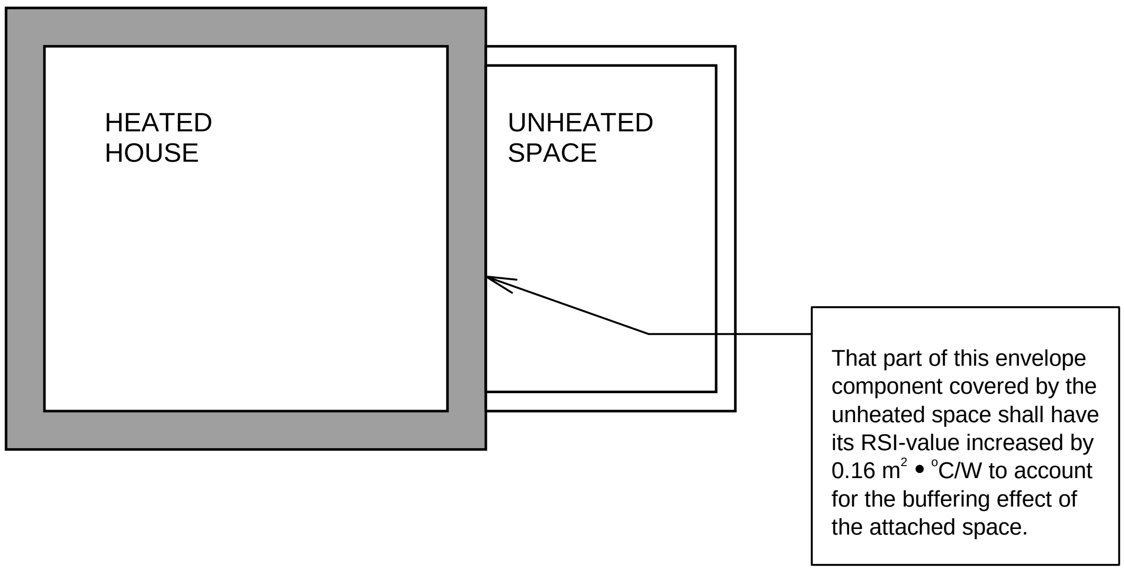

Figure 3-1. Example of the buffering effect of an attached unheated space.

3.5.2. Roofs

1) For each roof, the *compliance shell* shall request the following input from the user:

Note that orientation and tilt is not a required input for (opaque) roofs since absorptance is set to 0.0. It may, however, be necessary for some software in defining *skylight* orientation, i.e. where specific *skylights* are assigned to specific roofs.

a) roof type [Type I (attic type) / Type II (other)],

Required to determine the prescriptive *effective thermal resistance* of the *reference house*.

b) surface area, and

c) an input of:
   i) *effective thermal resistance* of the assembly; or
   ii) construction in layers; or
   iii) other input format suitable for the *energy analysis engine*.

2) If thermal bridging is not accounted for in the input data, it shall be handled by the *compliance shell* in a manner consistent with Subsection 2.2.2. of the MNECH.

3) A roof separating an interior heated space from an enclosed unheated (non-exterior) space, e.g. an unheated, enclosed sundeck, shall have its *effective thermal resistance* increased by 0.16 $m^2 \cdot °C / W$ to account for the extra resistance of the enclosed unheated space (see Figure 3-1 for clarification).

Construction spaces vented to the outdoors, such as attic and roof spaces, are considered exterior spaces and are not subject to this provision.

3.5.3. Exposed Floors

1) For each floor, the *compliance shell* shall request the following input from the user:

a) surface area; and

b) an input of:
   i) assembly *effective thermal resistance*; or
   ii) construction in layers; or
   iii) other input format suitable for the *energy analysis engine*.

2) If thermal bridging is not accounted for in the input data, it shall be handled by the *compliance shell* in a manner consistent with the Subsection 2.2.2. of the MNECH.

3) An exposed floor separating an interior heated space from an enclosed unheated (non-exterior) space, e.g. an unheated garage, shall have its *effective thermal resistance* increased by 0.16 $m^2 \cdot °C/W$ to account for the extra resistance of the enclosed unheated space (see Figure 3-1 for clarification).

3.5.4. Windows and Other Glazed Areas

1) For each window separating heated space from the outdoors, the *compliance shell* shall request the following input from the user:

Includes windows and other glazed surfaces that are inclined 60° or more from the horizontal.

a) window type (fixed or operable with sash / fixed without sash);

Required to determine *reference house* prescriptive energy rating.

b) orientation, specified as the azimuth and tilt (optional) of the surface;

Number of specified orientations is *energy analysis engine* dependent, but azimuth must be defined at least in the four cardinal directions.

Tilt is an optional input depending on *energy analysis engine* capabilities.

c) rough opening area, including frame and sash and construction clearances;

For bay and tilted windows the gross area (not "projected" or wall opening area) will be used for the purposes of calculating heat losses and gains. Further, a single orientation, being that of the host wall, will be used.

d) overall *U-value* accounting for complete window; and

As rated by CSA A440.2.

e) *solar heat gain coefficient* (SHGC), accounting for complete window.

As rated by CSA A440.2.

2) Input for exterior shading devices is not allowed.

Effects are included in a "global" shading coefficient of 0.8 [see Sentence 4.6.4.(6)].

3) Windows and other glazed areas separating an interior heated space from an enclosed unheated (non-exterior) space, e.g. an unheated vestibule, shall have their *effective thermal resistance* increased by 0.16 m^2•°C / W to account for the extra resistance of the enclosed unheated space (see Figure 3-1 for clarification).

4) Windows and other glazed areas separating an interior heated space from an enclosed unheated (non-exterior) space shall have a *solar heat gain coefficient* (SHGC) equal to 0.0.

For example, a door from a heated living area to an unheated sunspace is part of the external envelope but will receive no solar gain.

3.5.5. Skylights

1) For each *skylight*, the *compliance shell* shall request the following input from the user:

Include windows and other glazed surfaces that are inclined less than 60° from the horizontal.

a) orientation, specified as the azimuth and tilt (optional) of the surface;

Number of specified orientations is *energy analysis engine* dependent, but azimuth must be defined at least in the four cardinal directions.

Tilt is an optional input depending on *energy analysis engine* capabilities.

b) rough opening area, including frame and sash and construction clearances;

c) overall *U-value* accounting for complete *skylight*; and

d) *solar heat gain coefficient* (SHGC) accounting for frame and sash.

2) No input shall be requested for specific exterior shading devices.

3.5.6. Walls in Contact with the Ground

1) For each wall in contact with the ground, the *compliance shell* shall request the following input from the user:

a) surface area;

b) surface area above ground;

c) *effective thermal resistance;*

d) average depth of the wall below ground,

e) average depth of the insulation (below ground); and

f) insulation position (interior / exterior / combination).

3.5.7. Floors in Contact with the Ground

1) For each floor in contact with the ground, the *compliance shell* shall request the following input from the user:

a) floor type [Type I (with embedded heating elements) / Type II(other)];

Required to determine the prescriptive *effective thermal resistance* of the *reference house*.

b) surface area;

c) *effective thermal resistance*;

d) depth of the floor below *grade*, or categories from the following table:

Depth, m	Description
0	slab-on-ground
0 < depth ≤ 1	crawl space and shallow basements
> 1	full basement

e) perimeter length of the floor; and

f) width of the insulation from the inside edge of the floor slab.

3.5.8. Doors

1) For each door, excluding sliding patio type doors, the *compliance shell* shall request the following input from the user:

Sliding patio door shall be included in windows and other glazed areas.

a) surface area;

b) overall *U-value* accounting for complete door and frame; and

As rated in conformity with CSA standard A453, “Energy Performance Evaluation of Swinging Doors.”

c) *solar heat gain coefficient* (SHGC), accounting for complete door and frame.

As rated in conformity with CSA standard A453, “Energy Performance Evaluation of Swinging Doors.”

2) Doors between heated and enclosed unheated spaces shall have a *solar heat gain coefficient* (SHGC) equal to 0.0.

For example, a door from a heated living area to an unheated sunspace is part of the external envelope but will receive no solar gain.

3) A door separating an interior heated space from an enclosed unheated (non-exterior) space, e.g. an unheated garage, shall have its *effective thermal resistance* increased by 0.16 $m^2 \cdot °C / W$ to account for the extra resistance of the enclosed unheated space (see Figure 3-1 for clarification).

3.5.9. Airtightness

1) Inputting an airtightness value is optional. If the user chooses to input a value the *compliance shell* shall request the normalized leakage area (cm^2/m^2). The equivalent leakage area (cm^2) may be requested provided the proper provisions are made to calculate the normalized leakage area.

Tests and calculations must be performed in accordance with standard CAN/CGSB-149.10-M.

2) Input values lower than 2.0 cm^2/m^2 must be verified by a blower door test.

3) The *compliance shell* shall not accept any normalized leakage area less than 0.6 cm^2/m^2, or shall replace any such lower values with 0.6 cm^2/m^2.

3.6 Thermal Mass

1) The default value for thermal mass shall be 0.060 $MJ/m^2 \cdot °C$. If the user chooses to input a value, the *compliance shell* may request a thermal mass value ($MJ/m^2 \cdot °C$) or a category from the following table:

Finite difference/element methods might implicitly model thermal mass from the properties of the construction materials.

Where m^2 refers to floor surface area.

Category	Thermal Capacity per floor area, ($MJ/m^2 \cdot C$)	Description of Mass Inside the Insulation
Light	0.060	wood frame construction, 13 mm gypsum interior finish on walls and ceilings, carpets over wooden floors
Medium	0.153	as "Light" but 50 mm gypsum interior finish on walls, and 25 mm gypsum interior finish on ceilings
Heavy	0.415	100 mm brick interior wall finish, 13 mm gypsum interior finish on ceilings, carpet over wooden floor
Very Heavy	0.810	heavy construction typical of commercial office buildings with 300 mm concrete floors

2) Thermal mass, when specified as an input, shall be interpreted to be the thermal mass of structure, including:

a) mass to the inside of insulation in external walls;

b) mass of interior walls; and

c) mass inside of the centre-line of party walls.

User must satisfy the *authority having jurisdiction* that the included thermal mass is reasonable, i.e. not of a time constant so long as to have no appreciable effect.

3) The following shall <u>not</u> be included in the thermal mass:

a) furniture; and

Occupant dependent and unverifiable from the house plans.

b) basement walls and floor unless a specific system for accessing thermal storage in the basement mass is installed and the *energy analysis engine* is capable of modeling the performance of this system.

Basement mass is generally not coupled to the source of heat gain (and heat gains to basement mass are lost to the ground and not returned to the living space).

3.7. Inputs to Specify Heating System Performance

Covers warm air systems, hydronic systems, direct electric space heating, heat pumps, HRV duct heater.

1) Each heating system shall be modeled separately. If a single zone model is used then identical, multiple heating appliances within the same dwelling unit shall be considered as a single appliance with a capacity equal to the sum of the individual capacities, and the same efficiency as the least efficient individual unit.

3.7.1. Space Heating Systems

1) The *compliance shell* shall request sufficient input from the user to allow accurate modeling by the *energy analysis engine.*

The specific inputs are system and *energy analysis engine* dependent.

For example, the following inputs may be acceptable, depending on the system, type, and the modeling capability of the *energy analysis engine*:

- overall heating output capacity and part-load performance curve;
- a seasonal performance characteristic, i.e. AFUE, seasonally adjusted *coefficient of performance* (COP);
- seasonal energy source split characteristic, e.g. ratio of electricity to gas use for fuel-assisted heat pump.

2) The *compliance shell* shall request inputs determined in accordance with standards listed in MNECH Table 5.2.10.1.

3) No inputs shall be requested for duct and pipework losses.

Other parts of MNECH ensure these are small.

3.7.2. Heat Pumps

1) In addition to the other inputs necessary for system modeling, the *compliance shell* shall request the following input from the user:

a) heat source and type; and

e.g. air, well water.

b) source temperature at which the heat pump will be de-activated.

"Cut off" temperature in HOT-2000 [1].

2) The *compliance shell* shall request inputs determined in accordance with standards listed in MNECH Table 5.2.10.1.

3.7.3. Supplementary Heating Systems

1) The *compliance shell* shall not request inputs for *supplementary heating system*s such as stand-alone portable electric heaters or wood burning fireplaces.

Principal heating systems must be sized to provide all required space heating. The rationale is that the use of these supplementary systems is occupant behaviour dependent.

2) ***[Optional]*** Where an active solar space heating system is proposed and can be modeled by the *energy analysis engine,* the *compliance shell* shall request from the user sufficient input to accurately model the system, including the energy requirements of the primary circulation loop.

3.8. Mechanical Ventilation

1) The *compliance shell* shall request the following input from the user:

Note that fan power is not a required input since it will be the same between reference and design.

a) whether an HRV is in use;

b) if an HRV is used, the sensible heat recovery efficiency at 0°C and at -25 or -40°C, as per the requirements of Table 5.3.1.1. of the MNECH; and

c) the *compliance shell* shall request any additional inputs required by the *energy analysis engine.*

e.g., air exchange rate, separate duct heaters.

Note that where an HRV duct heater is taken into account as part of the HRV system, in evaluating the efficiency of the HRV in conformity with the standard referenced in the MNECH, no further input is required.

Chapter 4
Specifications for Modeling the Proposed Design and Reference House

4.1. General

4.1.1. Scope

1) This chapter describes how the inputs from the *compliance shell* are combined with various defaults, prescriptive values and restrictions in order to prepare input data sets to enable the *energy analysis engine* to model the *proposed design* and the *reference house.*

2) As an aid in showing how the *proposed design* and the *reference house* are specified, each section / sub-section below is headed by a table that shows the *proposed design* and the *reference house* input values for the relevant parameters. The most commonly used terms in these tables are described below:

a) "as input": value input by the user in *compliance shell* (specified in Chapter 3);

b) "as design": the *reference house* input parameter shall be the same as the *design building* input parameter;

c) "fixed": user may not vary the parameter from its default value;

d) "prescriptive": value prescribed in the MNECH appropriate for the administrative region considered, *principal heating source* and the building components used.

4.2. Professional Judgement

1) Where specified, the modeling techniques and assumptions prescribed in this manual shall be used; however, in many areas the proper exercise of professional judgement is required.

2) The following rule shall be used in meeting this requirement: the *proposed design* and the *reference house* shall both be analysed using the same techniques and assumptions, except where differences in building components and / or energy conservation features require a different approach.

4.3. Climate Data

Parameter	Design	Reference
Climate Data	fixed	fixed

1) Except as permitted in Sentence (2), the energy analysis module shall perform simulation using hourly values of climate data, such as temperature and insolation derived from measured climate data and shown to be a good representation of climate, compared to the average of at least 10 years of measured data, for the weather station representative of the administrative region (see Appendix B).

TMY, WYEC and CWEC are examples of data that could satisfy this requirement.

Ground temperature data (used by HOT-2000 [1]) can be found in: "Canadian Climate Normals, Volume 9: Soil Temperature, Lake Evaporation...1951-1980," Canada Atmospheric Environment Service (Environment Canada), Ottawa, 1984.

2) For analysis methods using other than hourly data, the climate data described in Sentence (1) shall be used as the basis for the simplified / integrated weather data.

3) Both the *proposed design* and the *reference house* shall be modeled with the same weather data.

4) Where ground reflectance is a variable in the *energy analysis engine*, it shall account for the increase in ground reflectance due to snow cover. The ground reflectance shall be 30% without snow cover and 70% with snow cover.

Presence of snow might be indicated in the weather data itself, or determined from a suitable algorithm (dependent on the mean monthly temperature, for example), or by some other suitable means.

5) Alternatively, other suitable models that take into account changes in ground reflectance throughout the heating season may be used.

4.4. Floor Surface Area & Heated Volume

Parameter	Design	Reference
Floor surface area	as input	as design
Heated volume	as input	as design

1) The floor surface area for the *reference house* shall be the same as that input for the *proposed design*.

2) The heated volume for the *reference house* shall be the same as that input for the *proposed design*.

4.5. Heat Gains From Occupants, Lighting and Miscellaneous Equipment

Includes service hot water incidental gains.

Parameter	Design	Reference
Internal gains	fixed	fixed

1) Both the *proposed design* and the *reference house* shall be modeled with the same, fixed internal gains.

2) The base hourly sensible internal gains (Watts per dwelling unit) are described by the following formula:

$$\text{Base} = (10.4 + 0.063 \bullet \text{floor surface area}) \bullet 1000/24$$

3) For an hourly model, the following hourly multipliers are applied to the base value to yield an hourly schedule:

0.6, 0.6, 0.6, 0.6, 0.6, 0.6, 0.6, 1.4, 1.8, 1.4, 0.6, 0.6, 1.4, 0.6, 0.6, 0.6, 1.4, 1.8, 1.4, 1.4, 1.4, 1.4, 1.4, 0.6.

Schedule of internal gains as a fraction of the base value (from Barakat and Sander [2]).

4) For non-hourly models, the gains shall be summed over the calculation interval (e.g. month) to provide a total gain over the period.

5) The above schedule applies every day of the year.

Weekends and holidays follow the same schedule.

4.6. Envelope Components

4.6.1. Above Ground Exterior Walls

Parameter	Design	Reference
Type	as input	as design
Orientation	as input	as design
Area	as input	as design/adj.
Effective thermal resistance	as input	prescriptive
Absorptance	fixed (0.0)	fixed (0.0)

"adj.: " adjusted due to the choice of *proposed design* window area (see below).

1) The exterior wall type of the *reference house* shall be the same as that of the *proposed design*.

Wood frame or log, for example.

2) Since absorptance is 0.0 as described below in Sentence (6), orientation shall only be specified if it is used to identify window orientation (which will be *energy analysis engine* dependent).

3) Except as described in Sentence (4), exterior walls for the *reference house* shall have the same area as those for the *proposed design*.

4) The window area of the *reference house* shall be the same as that of the *proposed design* if the *proposed design* total window-to-floor surface area ratio is equal to or less than 20%. For a *proposed design* total window-to-floor ratio of more than 20%, the window area of the *reference house* will be adjusted down to 20%. Therefore, in this case, the opaque exterior wall area will also differ between the *reference house* and the *proposed design*. In all cases the net wall area shall be:

If the *proposed design* window-to-floor ratio is greater than 20%, the net opaque wall area of the *proposed design* will be less than that of the *reference house*. This action in isolation is likely to lead to a reduction in envelope *effective thermal resistance* for which the *proposed design* must compensate (through lower window *U-value*, better furnace efficiency etc.). See Article 1.1.3.2.

gross wall area - window area - door area

Skylight area not included, assumed to impact on roof only.

The method by which the window area is adjusted in the *reference house* is described in Sentence 4.6.4.(2). The *compliance shell* shall ensure that the exterior wall areas are adjusted appropriately.

5) Except as provided in Sentences (7) and (8), the *effective thermal resistance* of exterior walls of the *reference house* shall be as prescribed in Table 3.3.1.1. of the MNECH for the applicable *principal heating source* and administrative region. The *effective thermal resistance* of exterior walls for the *proposed design* shall be as input, subject to the limit on allowable reduction in *effective thermal resistance* shown in Sentence 1.1.6.1.(3).

6) The exterior walls of the *proposed design* and the *reference house* shall have an absorptance of 0.0.

Solar gain at opaque surfaces is not modeled.

7) The *effective thermal resistance* of log walls shall be calculated as follows, for the *proposed design*: the thermal resistance of the log layer shall be added to that of an interior and an exterior air film and then multiplied by the appropriate profile factor. After this step is complete, the thermal resistance of any other layers (such as interior or exterior finishes), if any, shall be added to determine the *effective thermal resistance*.

8) Log walls shall be modeled as follows:

a) Log walls installed with an interior or exterior finish that incorporates insulation or creates a space that could accommodate insulation shall follow the same prescriptions as other types of walls.

b) Where a log wall is installed with no interior or exterior finish that incorporates insulation or creates a space that could accommodate insulation and such a log wall is the object of trade-off calculations, the following prescriptions shall be followed [see Sentences 3.4.1.1.(1) and (2) of the MNECH]:

   i) if the *effective thermal resistance* of the log wall in the *proposed design* is equal to or less than the *effective thermal resistance* required for log walls as prescribed in MNECH Sentence 3.4.1.1.(1), then the *effective thermal resistance* of the log wall in the *reference house* shall be that required for log walls as prescribed in MNECH Sentence 3.4.1.1.(1);

ii) if the *effective thermal resistance* of the log wall in the *proposed design* is more than the *effective thermal resistance* required for log walls as prescribed in MNECH Sentence 3.4.1.1.(1), but is equal to or less than the *effective thermal resistance* required for other types of walls in the prescriptive tables of the MNECH, then the *effective thermal resistance* of the log wall in the *reference house* shall be the same as that of the *proposed design*;

iii) if the *effective thermal resistance* of the log wall in the *proposed design* is greater than the *effective thermal resistance* required for other types of walls in the prescriptive tables of the MNECH, then the *effective thermal resistance* of the log wall in the *reference house* shall be the prescriptive *effective thermal resistance* required for other types of walls.

4.6.2. Roofs

Parameter	Design	Reference
Type	as input	as design
Orientation	as input	as design
Area	as input	as design/adj.
Effective thermal resistance	as input	prescriptive
Absorptance	fixed (0.0)	fixed (0.0)

"adj.: " adjusted due to the choice of *proposed design skylight* area (see below).

1) The roof type of the *reference house* shall be the same as that of the *proposed design*.

2) Since absorptance is 0.0 as described below in Sentence (6), orientation shall only be specified if it is used to identify *skylight* orientation (which will be *energy analysis engine* dependent).

3) Except as described in Sentence (4), roofs for the *reference house* shall have the same area as the *proposed design*.

4) Where there are *skylights* in the roof, the net roof area shall be:

gross roof area - *skylight* area

The method by which the *skylight* areas for the *reference house* and the *proposed design* are determined is described in Sentence 4.6.5.(2). The *compliance shell* shall ensure that the roof areas are adjusted appropriately.

Window area not included, assumed to impact on walls only.

5) The *effective thermal resistance* of the roofs of the *reference house* shall be as prescribed in Table 3.3.1.1. of the MNECH for the applicable *principal heating source* and administrative region. The *effective thermal resistance* of roofs for the *proposed design* shall be as input, subject to the limit on allowable reduction in *effective thermal resistance* shown in Sentences 1.1.6.1.(1) and (2).

6) The roofs of the *proposed design* and the *reference house* shall have an absorptance of 0.0.

Solar gain at opaque surfaces is not modeled.

7) The part of the roof above the insulation (attic space) shall be treated as outdoors, and thus no input is required to account for that part of the roof.

4.6.3. Exposed Floors

Parameter	Design	Reference
Type	as input	as design
Area	as input	as design
Effective thermal resistance	as input	prescriptive
Absorptance	fixed (0.0)	fixed (0.0)

1) The *reference house* exposed floor type shall be the same as that of the *proposed design*.

2) The *reference house* exposed floor area shall be the same as the *proposed design* exposed floor area.

3) The *effective thermal resistance* of the exposed floor of the *reference house* shall be as prescribed in Table 3.3.1.1. of the MNECH for the applicable *principal heating source* and administrative region. The *effective thermal resistance* of the floor for the *proposed design* shall be as input, subject to the limit on allowable reduction in *effective thermal resistance* shown in Sentence 1.1.6.1.(4).

4) The floor of the *proposed design* and the *reference house* shall have an absorptance of 0.0.

Solar gain at opaque surfaces is not modeled.

4.6.4. Windows and Other Glazed Areas

Parameter	Design	Reference
Orientation	as input	as design/adj.
Type	as input	as design
Area	as input	as design/adj.
U-value	as input	formula
SHGC	as input	formula
Shading	fixed (0.8)	fixed (0.8)

"adj.": adjusted due to the choice of *proposed design* window area (see below).

"adj.": adjusted due to the choice of *proposed design* window area (see below).

"formula": see Sentence 4.6.4.(3) below.

"formula": see Sentence 4.6.4.(3) below.

1) Windows and other glazed areas for the *reference house* shall be of the same type as the *proposed design*.

Window types are: fixed or operable with sash, or fixed without sash.

2) The area and orientation of windows and other glazed areas, including *skylights*, of the *reference house* shall be the same as those of the *proposed design* for a total window-to-floor ratio that is less than or equal to 20% in the *proposed design*. If the *proposed design* window-to-floor ratio is greater than 20%, then the area of windows and other glazed areas, including *skylights*, of the *reference house* shall be adjusted to 20% according to the following formula:

$$R_i = (D_i / D_{tot}) \bullet (0.2 \bullet \text{floor surface area})$$

where,

R_i = area of windows or other glazed areas or *skylights* of the *reference house* on orientation i (m^2),

D_i = area of windows or other glazed areas or *skylights* of the *proposed design* on orientation i (m^2),

D_{tot} = total area of windows and other glazed areas, including *skylights*, of the *proposed design* (m^2).

For example:

Proposed design floor surface area: 160 m^2;

Area of windows and other glazed areas in the *proposed design*:

- South: 16 m^2 (40% of total windows)
- North: 10 m^2 (25% of total windows)
- East: 5 m^2 (12.5% of total windows)
- West: 5 m^2 (12.5% of total windows)
- *Skylight*: 4 m^2 (10% of total windows)

Total area of windows and other glazed areas: 40 m^2;

Proposed design window-to-floor ratio: 25%;

Reference house windows' areas must total 32 m^2 or 20% of floor surface area:

- South: $(16/40) \bullet (0.2 \bullet 160) = 12.8\ m^2$
- North: $(10/40) \bullet (0.2 \bullet 160) = 8\ m^2$
- East: $(5/40) \bullet (0.2 \bullet 160) = 4\ m^2$
- West: $(5/40) \bullet (0.2 \bullet 160) = 4\ m^2$
- *Skylight*: $(4/40) \bullet (0.2 \bullet 160) = 3.2\ m^2$

3) Except for *skylights* where *skylights* form no more than 2% of the roof area, windows and other glazed areas for the *reference house* shall have an overall *U-value* and *solar heat gain coefficient* (SHGC) equivalent to the prescriptive energy rating shown in MNECH Table 3.3.1.3. for the window type specified, for the applicable *principal heating source* and administrative region. These values are derived from the energy rating (ER) according to the following formula:

For fixed or operable with sash:

SHGC = 0.45

U = 1.45 - ER / 22.

For fixed without sash:

SHGC = 0.62

U = 2.05 - (ER+10) / 22.

Skylight U-value dealt with in Subsection 4.6.5. below.

Taken from Trade-off Compliance for Houses.

4) Windows and other glazed areas for the *proposed design* shall have an overall *U-value* and *solar heat gain coefficient* (SHGC) as input.

5) Windows between heated and unheated spaces shall have a *solar heat gain coefficient* (SHGC) equal to 0.0.

For example, a window looking from a heated living area onto an unheated vestibule is part of the external envelope but will receive little solar gain.

6) Except for *skylights*, windows and other glazed areas for both the *proposed design* and the *reference house* shall have a shading coefficient of 0.8 to account for incidental shading.

Landscape features, trees, operable interior shading devices are not modeled explicitly as their presence or use cannot be guaranteed.

Skylight shading coefficient dealt with in Subsection 4.6.5. below.

7) Exterior attached shading devices such as fins and overhangs shall not be modeled.

The MNECH is concerned with only *space heating requirements*, and shading devices will only act to increase heating load. However, the use of shading devices is not intended to be discouraged since they may be very beneficial in terms of comfort and cooling energy consumption in the summer, therefore they shall not be modeled.

4.6.5. Skylights

Parameter	Design	Reference
Orientation	as input	as design/adj.
Area	as input	as design/adj.
U-value	as input	as design/pres.
SHGC	as input	0.45
Shading	fixed (1.0)	fixed (1.0)

"adj.": adjusted due to the choice of *proposed design skylight* area (see below).

"adj.": adjusted due to the choice of *proposed design* window-to-floor area (see Subsection 4.6.4.).

Depends on *proposed design skylight-to-roof ratio*.
"pres.": prescriptive value.

1) *Skylights* for the *reference house* shall have the same orientation as the *proposed design*.

2) The *proposed design skylight* area shall be as input. The *reference house skylight* area shall be adjusted, where applicable, from the area in the *proposed design*, as prescribed in Sentence 4.6.4.(2).

3) If the *proposed design* total *skylight-to-roof ratio* is greater than 2%, then the *skylights* for the *reference house* shall have the prescriptive overall *U-value* shown for windows in MNECH Table 3.3.1.3., for the applicable *principal heating source* and administrative region. If the *proposed design* total *skylight-to-roof ratio* is less than or equal to 2%, then the *skylights* for the *reference house* shall have an overall *U-value* of

$$3.4\ \mathrm{W/m^2 \cdot {}^\circ C}.$$

The reference *solar heat gain coefficient* (SHGC) shall be 0.45.

The *reference house* overall *U-value* for *skylights* is determined here as a function of the *proposed design skylight-to-roof ratio*. The *reference house skylight* area is determined according to the window-to-floor ratio calculation in Subsection 4.6.4., since *skylights* are considered part of windows and other glazed areas.

4) *Skylights* for both the *proposed design* and the *reference house* shall be considered to experience no external shading (shading coefficient = 1) at any time.

No shading assumed for *skylights*, they are considered to face unobstructed sky.

No accounting for winter snow cover, for simplicity. Also, no account is made of its insulating effect.

5) Exterior attached shading such as fins and overhangs shall not be modeled.

4.6.6. Walls in Contact with the Ground

Parameter	Design	Reference
Soil type	fixed (low)	fixed (low)
Area	as input	as design
Area above ground	as input	as design
Effective thermal resistance	as input	prescriptive
Wall depth	as input	as design
Insulation depth	as input	prescriptive
Insulation position	as input	as design/interior

Low conductivity.

Interior, exterior, or combination.

1) Appropriate ground temperatures shall be taken from the approved climate file for the region.

2) The soil type shall be fixed at low conductivity for both the *reference house* and the *proposed design*.

See NRC basement heat loss model [3], [4] conductivity categories.

3) Below ground walls for the *reference house* shall have the same area as the *proposed design*.

4) Above ground portion of basement walls for the *reference house* shall have the same area as the above ground portion of basement walls of the *proposed design*.

Value needed for calculating infiltration leakage area.

Rules out possibility of obtaining benefit for earth shelter if buried depth must be same in the *reference house* and the *proposed design*.

5) Below ground walls for the *reference house* shall have the prescriptive *effective thermal resistance* in accordance with Table 3.3.2.1. of the MNECH for the applicable *principal heating source* and administrative region. The *effective thermal resistance* of the *proposed design* shall be as input, subject to the limit on allowable *effective thermal resistance* shown in Sentence 1.1.6.1.(7).

6) The mean wall depth below ground for the *reference house* shall be the same as that for the *proposed design*.

7) Below ground walls for the *reference house* shall have a mean insulation depth below ground in accordance with Table 3.3.2.1. of the MNECH. The *proposed design* insulation depth below ground shall be as input.

8) The insulation position for the *proposed design* shall be as input. The below ground insulation position for the *reference house* shall be the same as that for the *proposed design* except when the *proposed design* insulation position is 'combination.' In this case, the *reference house* insulation position shall be 'interior.'

4.6.7. Floors in Contact with the Ground

Parameter	Design	Reference
Type	as input	as design
Area	as input	as design
Effective thermal resistance	as input	prescriptive
Floor depth	as input	as design
Insulation width	as input	prescriptive
Perimeter	as input	as design

1) Appropriate ground temperatures shall be taken from the approved climate file for the region.

2) The floor type for the *reference house* shall be the same as that of the *proposed design*.

3) Below ground floors for the *reference house* shall have the same area as those for the *proposed design*.

4) Below ground floors for the *reference house* shall have the prescriptive *effective thermal resistance* in accordance with Table 3.3.2.1. of the MNECH for the applicable *principal heating source* and administrative region. The *effective thermal resistance* of the *proposed design* shall be as input, subject to the limit on allowed *effective thermal resistance* shown in Sentence 1.1.6.1.(8).

5) The mean floor depth below ground for the *reference house* shall be the same as that for the *proposed design*.

6) Below ground floors for the *reference house* shall have a mean insulation width from the edge of the slab in accordance with Table 3.3.2.1. of the MNECH for the applicable *principal heating source* and administrative region. The *proposed design* insulation width shall be as input.

7) The perimeter length of the floor slab for the *reference house* shall be the same as that for the *proposed design*.

4.6.8. Doors

Parameter	Design	Reference
Area	as input	as design
U-value	as input	1.2
SHGC	as input	0

1) Door area for the *reference house* shall be the same as that for the *proposed design*.

2) The door *U-value* for the *proposed design* shall be as input.

3) The door *U-value* for the *reference house* shall be as follows [see Sentence 8.2.1.4.(5) of the MNECH]:

a) except as provided in Clauses (b) and (c) below, in the *reference house*, the *U-value* of a door referred to in Sentence 3.3.1.4.(1) of the MNECH shall be 1.2 $W/m^2 \cdot °C$;

b) in any *dwelling unit*, if the *U-value* of only one door referred to in Sentence 3.3.1.4.(2) of the MNECH is greater than 1.2 $W/m^2 \cdot °C$ but not more than 2.6 $W/m^2 \cdot °C$, then the *U-value* for that door in the *reference house* shall be the same as in the *proposed design;*

c) in any *dwelling unit*, if the *U-value* of only one door referred to in Sentence 3.3.1.4.(2) of the MNECH is greater than 2.6 W / m^2 • °C, then the *U-value* for that door in the *reference house* shall be 2.6 W / m^2 • °C.

4) The door *solar heat gain coefficient* for the *proposed design* shall be as input. The door *solar heat gain coefficient* for the *reference house* shall be 0.0.

Patio doors are included in windows and other glazed areas.

4.6.9. Airtightness

Parameter	Design	Reference
Leakage rate	fixed (0.25)	fixed (0.25)
Normalized leakage area	as input	fixed (2 cm^2/m^2)

1) The modeling of air leakage as a function of climatic conditions is optional. If air leakage is not explicitly modeled, both the *reference house* and the *proposed design* shall have a constant leakage rate of 0.25 ac / h.

2) If air leakage is modeled explicitly then the envelope normalized leakage area for the *proposed design* shall be as input subject to a minimum acceptable value of 0.6 cm^2 / m^2.

Leakage algorithm must be based on envelope normalized leakage area and climatic conditions (see Article 5.4.3.12.).

3) If air leakage is modeled explicitly then *proposed designs* with a normalized leakage area between 1.0 and 2.0 cm^2 / m^2 will be assigned a normalized leakage area of 2.0 cm^2 / m^2.

In other words, no benefit will be given for lower normalized leakage area unless the area is less than 1.0 cm^2 / m^2.

4) If air leakage is modeled explicitly then the *reference house* normalized leakage area shall be 2.0 cm^2 / m^2.

5) The *compliance shell* must calculate building surface area above ground so that the normalized leakage area can be converted to a total leakage area. The surface area above ground shall be:

wall area + roof area + exposed floor area + door area + window area + *skylight* area.

"Wall area" includes basement walls above ground.

4.7. Thermal Mass

Parameter	Design	Reference
Mass	as input	fixed (0.06)
Used fraction	as input	as design

See Table in Sentence 3.6.(1).

1) The thermal mass of the *proposed design* shall be modeled as input. The thermal mass of the *reference house* shall be 0.06 $MJ/m^2 \cdot °C$.

"Light" construction as defined by Barakat and Sander. [2],[5]

2) The fraction of the mass that can be usefully used shall be the same value for both the *reference house* and the *proposed design*.

These inputs may be ignored by finite difference/element models that model thermal mass implicitly from the thermal properties of the construction materials.

3) The fraction of mass that can be usefully used shall be determined by the coupling between the mass and the source of the gains. For multiple zone modeling this determination may be made on a zone by zone basis.

How this is done is *energy analysis engine* dependent. Hourly models might use empirically determined coupling coefficients. Monthly correlation models might specify the proportion of total interior mass that is available for a mass-gain ratio calculation.

4) A maximum temperature rise of 3.5°C above the setpoint shall be allowed before considering excess solar and internal gains to be completely vented.

4.8. Heating Systems

4.8.1. Thermostats

Parameter	Design	Reference
Setpoint	fixed (20)	fixed (20)

1) Thermostat setpoint shall be 20°C (air temperature) for both the *reference house* and the *proposed design*.

Since cooling is not to be considered, cooling set point is not an input.

2) Thermostat setting shall be constant.

Setbacks not considered since they depend on occupant behaviour.

3) For hourly models, a maximum deadband of ± 0.5°C shall be allowed.

4.8.2. Space Heating Systems

Includes heat pumps.

Parameter	Design	Reference
Principal H.E.S.	as input	as design
Capacity	calculated	calculated
Primary E.S.	as input	as design
Second. E.S.	as input	as design
Efficiency	as input	prescriptive

"H.E.S." = Heating Energy Source.

see Sentence 4.8.2.(2).

"E.S." = Energy Source.

1) The *principal heating source* for the *reference house* shall be the same as that for the *proposed design*.

2) If the *energy analysis engine* is capable of modeling part-load performance of the heating system, then the heating system of the *reference house* and the *proposed design* shall be automatically correctly sized according to Article 9.33.5.1. of the NBC 1995 (CAN / CSA-F280-M).

To prevent alteration of energy performance due to deliberate over- or under-sizing.

3) The *primary* and *secondary energy sources* for the *reference house* shall be the same as those for the *proposed design*.

4) When a fuel-assisted heat pump is specified for the *proposed design*, a seasonal energy source split is required. The energy source split for the *proposed design* shall be as input. The *reference house* shall have an air-source heat pump with a *coefficient of performance* (COP) of 2.

5) The performance characteristics [AFUE, seasonally adjusted *coefficient of performance* (COP)] necessary for modeling the system for the *reference house*, for systems and equipment types listed in Table 5.2.10.1. of the MNECH, shall be consistent with the mandatory efficiency value in that Table. The performance characteristic for the *proposed design* shall be as input.

Prescriptive value is equivalent to the minimum efficiency in the Provincial / Federal Energy Efficiency Act. Performance characteristic of heat pumps is included here.

6) The performance characteristic [AFUE, seasonally adjusted *coefficient of performance* (COP)] necessary for modeling the system for the *reference house*, for systems and equipment types not listed in Table 5.2.10.1. of the MNECH, shall be the same as input or defaulted for the *proposed design*.

7) If the *energy analysis engine* requires specific inputs regarding the energy performance of other components of the heating system independent of the system efficiency, these inputs shall be the same for both the *reference house* and the *proposed design*.

Applies to fans, pumps, etc.

4.8.3. Supplementary Heating Systems

Parameter	Design	Reference
Supplementary system	as input	none

1) With the exception of active solar systems, *supplementary heating systems* shall not be modeled.

2) Where (supplementary) active solar heating systems are proposed for the *proposed design* they shall be modeled as input. The *reference house* shall be modeled without the supplementary solar system, i.e. with the *principal heating system* providing all of the load.

4.9. Mechanical Ventilation

Parameter	Design	Reference
Rooms	as input	as design
Ventilation rate	calculated	as design
HRV present	as input	prescriptive
HRV performance	as input	prescriptive

Calculated in conformance with Section 9.32. of the NBC 1995, given the number and type of rooms.

Including heat recovery efficiency with respect to testing temperatures.

1) The number and type of rooms for the *reference house* shall be the same as those for the *proposed design*.

2) From the number and type of rooms in the *proposed design*, the *compliance shell* calculates the principal portion of the required ventilation rate in l/s from Section 9.32. of the NBC 1995.

3) In all cases the *reference house* ventilation rate will be the same as the *proposed design* ventilation rate.

4) The ventilation rate shall be held constant throughout the simulation.

5) The *reference house* shall have an HRV if prescribed by Appendix A, Table A-5.3.1.1. of the MNECH. The *proposed design* shall have an HRV if input.

6) The performance characteristic of the *reference house* HRV shall be in accordance with the prescriptive requirements of Table 5.3.1.1. of the MNECH. The *proposed design* HRV performance characteristic shall be as input.

7) For modeling purposes, fan energy associated with mechanical circulation of ventilation air is ignored, or is set to be the same in both the *reference house* and the *proposed design*.

4.10. Other Inputs

Parameter	Design	Reference
Other inputs	as input/fixed	as design

1) All inputs not specifically addressed in this Chapter shall be the same for both the *reference house* and the *proposed design*.

Chapter 5
Requirements of the Energy Analysis Engine

Intent

Ideally, a rigorous and comprehensive method for demonstrating conformity to a standard set of energy analysis benchmarks would preclude the need for specifying the requirements of an *energy analysis engine*. In the absence of such a procedure, Chapter 5 has been structured to specify minimum requirements of the *energy analysis engine* in detail, and only broad direction for software certification is specified in Chapter 7.

5.1. Scope

This section will define the minimum requirements for energy calculations to be carried out by the *energy analysis engine*. Only software meeting all these requirements (as demonstrated in Chapter 7) can be used as an *energy analysis engine* for the *compliance software*.

5.2. General

In general, all algorithms proposed for use in the *energy analysis engine* shall be supported by peer-reviewed, referencable, published documentation.

Further, the *energy analysis engine* shall be capable of processing all data in the input files created by the *compliance shell*, and specified in Chapter 4.

5.3. Calculation Tools

1) The *compliance software* shall be computer based; hand calculations are not permissible.

Implies that software should take advantage of the calculation capacity of the computer to perform calculations more complex and more accurate than those achievable using a manual technique.

2) The *compliance shell* and the *energy analysis engine* shall be sufficiently documented to allow evaluation of their compliance with this specification.

3) Documentation of the compliance process shall be sufficient to ensure that all calculations are reproducible and verifiable.

4) Limitations of the *compliance software* shall be documented.

e.g. can't model active solar, sloped fenestration.

5.4. Minimum Calculation Requirements

5.4.1. Modeling Approach

1) Three basic modeling approaches to the response of the building to climate data may be used:

a) methods using mean monthly climate data;

b) methods using binned hourly data; or

c) hour-by-hour simulation.

2) The compatibility of combined approaches shall be demonstrated using the method described in Chapter 7.

3) The same version of the *compliance shell* and *energy analysis engine* shall be used for the performance analysis of both the *proposed design* and the *reference house.*

This is designed to eliminate differences arising purely from modeling techniques.

5.4.2. Space Use and Internal Gains

1) The *energy analysis engine* shall be capable of:

a) accounting for a single, constant setpoint (air temperature) for the heated volume; and

b) modeling internal gains from all sources as identical for all days of the year. For hourly models, the internal gains shall follow a fixed schedule, as described in Section 4.5.

5.4.3. Envelope Components

1) The *energy analysis engine* shall be capable of modeling heat transfer through envelope components via one of six methods:

a) mean monthly temperature difference multiplied by UA (mass associated with envelope handled separately, using correlations);

e.g. Barakat and Sander Solar Load Ratio method [2], [5].

"UA" = envelope *U-value* • envelope area.

b) hour-by-hour temperature difference multiplied by UA (mass associated with envelope handled explicitly or through transfer functions);

e.g. DOE 2 [8].

c) hourly temperature data statistically compiled into bins. Temperature difference of each bin multiplied by UA (mass associated with envelope handled separately by correlations);

e.g. HOT-2000 [1].

d) balance temperature technique (includes variable-base degree-days) involving derivation of adjusted temperature differences (on an hourly, monthly or annual basis) that account for internal and solar gains. This involves deriving a balance temperature (temperature below which the heating system comes on) and using it to calculate temperature difference and multiplying by UA. Hours with outdoor temperatures above the calculated balance point are dropped from the analysis;

e.g. CMHC-2 [9].

e) correlation method for below ground components. Mean ground temperature multiplied by corresponding UAs for steady state and variable components of heat loss, derived from correlations with added assembly *effective thermal resistance* for each insulation placement. Mass of envelope and earth handled implicitly in the variable component of heat loss;

e.g. NRC basement heat loss method [3], [4].

f) finite difference / finite element methods (applicable to above and below ground) involving detailed solutions to the temperature fields in envelope components and adjacent earth (for below ground). Solutions for conduction heat transfer and mass effect handled simultaneously. Resulting surface heat loss rates deduced from predicted temperature fields.

e.g. ESP [10].

5.4.3.1. Exterior Walls

1) The *energy analysis engine* shall:

a) not model solar radiation absorbed by opaque elements, i.e. absorptance of opaque surfaces = 0.0;

To promote consistency between models, i.e. the simplest models don't model this heat transfer process. The more complex models must be capable of accepting an absorptance of 0.0.

b) model thermal bridging through envelope elements. Thermal bridging must be accounted for either by including it in the *effective thermal resistance* or by explicit modeling of the wall;

Calculation of an *effective thermal resistance* including thermal bridging is shown in Section 2.2. of the MNECH and its Appendix C.

c) not model variation of thermal properties with temperature, humidity, and wind.

5.4.3.2. Walls Separating Heated and Unconditioned Spaces

1) The *energy analysis engine* shall not model variation of thermal properties with temperature, humidity, and wind.

To promote consistency between models, i.e. the simplest models don't model this heat transfer process.

5.4.3.3. Walls Separating Unconditioned Spaces and the Outdoors

1) These walls shall not be modeled.

If multizone modeling is employed the multiple zones will include heated spaces only.

5.4.3.4. Walls Separating Conditioned Spaces

1) The *energy analysis engine* shall be capable of modeling these walls in the following way:

a) interior walls within the modeled space or separating the modeled space from another heated building are considered to be adiabatic (*U-value* = 0.0).

".. another heated building ...," e.g. the party wall separating adjacent row houses.

b) However, they may impact on the modeled space due to thermal mass effects.

5.4.3.5. Roofs

1) The *energy analysis engine* shall:

a) not model solar radiation absorbed by opaque elements, i.e. absorptance of opaque surfaces = 0.0;

To promote consistency between models, i.e. the simplest models don't model this heat transfer process. The more complex models must be capable of accepting an absorptance of 0.0.

b) model thermal bridging through envelope elements. Thermal bridging must be accounted for either by including it in the *effective thermal resistance* or by explicit modeling of the roof;

Calculation of an *effective thermal resistance* including thermal bridging is shown in Section 2.2. of the MNECH.

c) not model variation of thermal properties with temperature, humidity, and wind.

To promote consistency between models, i.e. the simplest models don't model this heat transfer process.

5.4.3.6. Exposed Floors

1) The *energy analysis engine* shall:

a) not model solar radiation absorbed by opaque elements, i.e. absorptance of opaque surfaces = 0.0;

To promote consistency between models, i.e. the simplest models don't model this heat transfer process. The more complex models must be capable of accepting an absorptance of 0.0.

b) model thermal bridging through envelope elements. Thermal bridging must be accounted for either by including it in the *effective thermal resistance* or by explicit modeling of the floor;

Calculation of an *effective thermal resistance* including thermal bridging is shown in Section 2.2. of the MNECH.

c) not model variation of thermal properties with temperature, humidity, and wind.

To promote consistency between models, i.e. the simplest models don't model this heat transfer process.

5.4.3.7. Windows and Other Glazed Areas

1) The *energy analysis engine* shall:

a) calculate solar gain sensitive to orientation (in at least the four cardinal directions) and tilt (optional);

Tilt need not be modeled.

b) not model shading explicitly; a single, fixed shading coefficient shall be employed.

5.4.3.8. Skylights

1) The *energy analysis engine* need not be capable of modeling *skylights*. However, if modeled, the *energy analysis engine* shall:

a) calculate solar gain sensitive to orientation (in at least the four cardinal directions, plus gain on a horizontal surface), and tilt (optional);

Tilt need not be modeled.

b) not model shading explicitly; a single, fixed shading coefficient shall be employed.

5.4.3.9. Walls in Contact with the Ground

1) The *energy analysis engine* shall:

a) model heat transfer through walls in contact with the ground sensitive to ground temperature, insulation *effective thermal resistance* and position, wall depth below ground and wall geometry;

Likely to be NRC basement heat loss method [3], [4], but other finite element / difference model may be acceptable.

b) model thermal bridging through envelope elements. Thermal bridging must be accounted for either by including it in the *effective thermal resistance* or by explicit modeling of the wall;

Calculation of an *effective thermal resistance* including thermal bridging is shown in Section 2.2. of the MNECH.

c) not model variation of thermal properties with temperature and humidity.

To promote consistency between models, i.e. the simplest models don't model this heat transfer process.

5.4.3.10. Floors on Ground

1) The *energy analysis engine* shall:

a) model heat transfer through floors on ground sensitive to ground temperature, insulation *effective thermal resistance* and position, floor depth below ground and geometry;

Likely to be NRC basement heat loss method [3], [4], but other finite element / difference model is acceptable.

b) model thermal bridging through envelope elements. Thermal bridging must be accounted for either by including it in the *effective thermal resistance* or by explicit modeling of the floor;

Calculation of an *effective thermal resistance* including thermal bridging is shown in Section 2.2. of the MNECH.

c) not model variation of thermal properties with temperature, and humidity.

To promote consistency between models, i.e. the simplest models don't model this heat transfer process.

5.4.3.11. Doors

1) If the door has a glazed component, the *energy analysis engine* shall:

a) calculate solar gain sensitive to orientation in at least the four cardinal directions;

b) not model shading explicitly; a single, fixed shading coefficient shall be employed.

5.4.3.12. Airtightness

1) Detailed modeling of air leakage is optional.

2) The *energy analysis engine* shall at least model air leakage as a constant air change rate.

3) If detailed modeling of air leakage is used then the *energy analysis engine* shall model air leakage as a function of envelope leakage area, temperature and wind speed according to an accepted, published method.

See Sherman [6] or Shaw [7], or Walker and Wilson [11] for example.

5.4.4. Thermal Mass

1) The *energy analysis engine* shall:

a) model the effect of thermal mass on building heat load (including net utilisation of solar and internal gains);

b) discriminate between "useful" and "non-useful" mass, if the algorithm is more sophisticated than the mass-fraction approach.

5.4.5. Space Heating Systems

1) The *energy analysis engine* shall:

a) model heating system performance with either a simple, overall efficiency (i.e. AFUE), or a dependence part-load (performance curve);

b) model heat pump performance as a function of outdoor air or ground temperature, as appropriate;

c) differentiate between the energy consumption of differing energy sources where a combined energy source system is used (e.g. fuel-assisted heat pump);

d) <u>not</u> model duct and pipework losses.

Considered to have a neutral effect between the *proposed design* and the *reference house*.

5.4.6. Mechanical Ventilation

1) The *energy analysis engine* shall:

a) model mechanical ventilation as a constant air change rate;

b) model the performance of an HRV as a function of outdoor temperature;

c) model the effect of ventilation systems as they impact on space heating load (e.g. HRV duct heaters);

d) <u>not</u> model duct losses.

Considered to have a neutral effect between the *proposed design* and the *reference house*.

5.4.7. Service Hot Water

1) The *energy analysis engine* shall either:

a) <u>not</u> model service hot water heating systems; or

b) be capable of displaying the service hot water energy consumption separately so that the *compliance shell* can exclude it from the *annual adjusted energy consumption* calculation.

Heat gains associated with losses from service hot water systems are considered included in the fixed internal gain schedule.

5.5. Space Heating Requirement Calculation

5.5.1. General

1) All of the above algorithms lead directly or indirectly to a calculation of building heat gain or loss. The actual *space heating requirement* of the building will be some combination of these heat gains and losses, though not necessarily a simple sum of gains and losses. The appropriate combination will be dependent on the techniques and assumptions of the *energy analysis engine.*

2) The legitimacy of these techniques and assumptions will be tested indirectly when demonstrating conformity of the proposed *compliance software* to this specification, as outlined in Chapter 7.

5.5.2. Space Heating Requirement

1) The *energy analysis engine* shall calculate the *space heating requirement* for both the *reference house* and the *proposed design*.

2) The *space heating requirements* shall be specified in a format to facilitate the process specified in Chapter 6.

Chapter 6
Calculation of the Annual Adjusted Energy Consumption and Assessment of Compliance

6.1. Scope

1) This chapter describes the steps that need to be performed by the *compliance shell* to process the outputs of the *energy analysis engine* and to produce the *annual adjusted energy consumption* of the *proposed design* and the *reference house*.

6.2. Application of the Energy Source Adjustment Factor

1) The *compliance shell* shall apply *energy source adjustment factor*s from Table D-1 of Appendix D of the MNECH to the energy requirement of each energy source (as determined by the *energy analysis engine*). The *energy source adjustment factors* shall be for the applicable energy source and administrative zone.

Each energy source takes its own *energy source adjustment factor* regardless of the *principal heating source* of the building.

2) The *energy source adjustment factor* for heat pumps powered by electricity shall be 1. For a mixed fuel heat pump the appropriate *energy source adjustment factor* shall be applied to each fuel.

3) The *energy source adjustment factor* for the space heating load met by solar will be 0.0.

Since this energy source is free.

4) Any additional energy required by the active solar system (water pump, for example) shall be accounted for, with an *energy source adjustment* factor appropriate for the energy source.

5) The *compliance shell* shall ensure that the restrictions of Article 1.1.6.3 are observed.

6) These adjusted values shall then be summed for both the *reference house* and the *proposed design* to produce an *annual adjusted energy consumption* for each building. The *annual adjusted energy consumption* for the *reference house* is termed the *energy target*.

6.3. Assessment of Compliance

1) The *compliance shell* shall compare the *annual adjusted energy consumption* for the *proposed design* with the *energy target*. If the *proposed design* consumption is equal to or less than the *energy target* (and all other mandatory requirements of the MNECH are met) then the *proposed design* complies with the MNECH via the performance path.

6.4. Performance Compliance Report

1) The *compliance shell* shall prepare a *performance compliance report* (which can be made available in hard-copy) detailing the *proposed design*, the *reference house*, and the simulation results. The information to be included in the *performance compliance report* is shown in Appendix A.

Chapter 7
Demonstrating Conformity of Compliance Software to these Specifications

7.1. General

7.1.1. Scope

1) This chapter describes benchmark tests that would provide a standard of performance to be met by an *energy analysis engine* proposed for use as part of the *compliance software*. This is intended to act as a guide to the development of a test procedure to demonstrate the conformity of the *compliance software* to this specification.

The benchmark tests should be carried out on the version of the *energy analysis engine* that will be used in the *compliance software* and not some other version of the same engine.

7.2. Capabilities to be Tested

7.2.1. Annual Heating Energy Consumption

1) The ability of a model to predict the annual heating energy consumption, for a range of Canadian climates and house types, for ranges of the following characteristics will be tested:

a) *effective thermal resistance* of opaque assemblies (without sol-air effects);

b) *effective thermal resistance* of assemblies in contact with the ground and placement of below-ground insulation;

c) interior thermal mass;

d) *solar heat gain coefficients* of windows, by orientation;

e) air leakage rate / airtightness characteristic / mechanical ventilation rate; and

f) space heating equipment efficiency or coefficient of performance; including HRVs, heat pumps.

2) The ranges of climates, buildings, and parameter variations over which the benchmark tests will be conducted shall be determined according to the scope of the model's intended application.

3) Further, the change in total annual heating energy consumption predicted by the model for changes in these characteristics will be tested.

4) The benchmark tests will apply to the standard set of algorithms needed to model the characteristics listed above. Modeling physical processes or innovative features outside this set is not to be covered by the protocols for benchmark testing; for example, active solar space heating benchmarks can be developed separately. Modeling innovative features would require individual approval.

5) For the purpose of benchmark testing, the proposed *energy analysis engine's* algorithms shall not change in any way between simulations.

7.3. Acceptable Performance

1) The output of the proposed *energy analysis engine* for each parameter combination will be compared to that of a reference model for the same case. The comparisons shall be as follows:

a) For every parameter combination the annual heating energy consumption (Q) predicted by the proposed model must be within 15% of that predicted by the reference model; see Figure 7-1 for clarification.

b) For every parameter combination the change in annual heating energy consumption with a change in parameter (e.g. dQ / dR) predicted by the proposed model must be within 10% of that predicted by the reference model and have the same sign; see Figure 7-1 for clarification.

(b) requires a closer agreement than (a) because it is the change in energy with parameter that is encouraged by the performance path.

2) The reference model shall be HOT-2000 (version for MNECH).

see [1]

7.4. Documentation

1) Documentation describing the results of the benchmark tests in sufficient detail that the tests may be reproduced shall be presented.

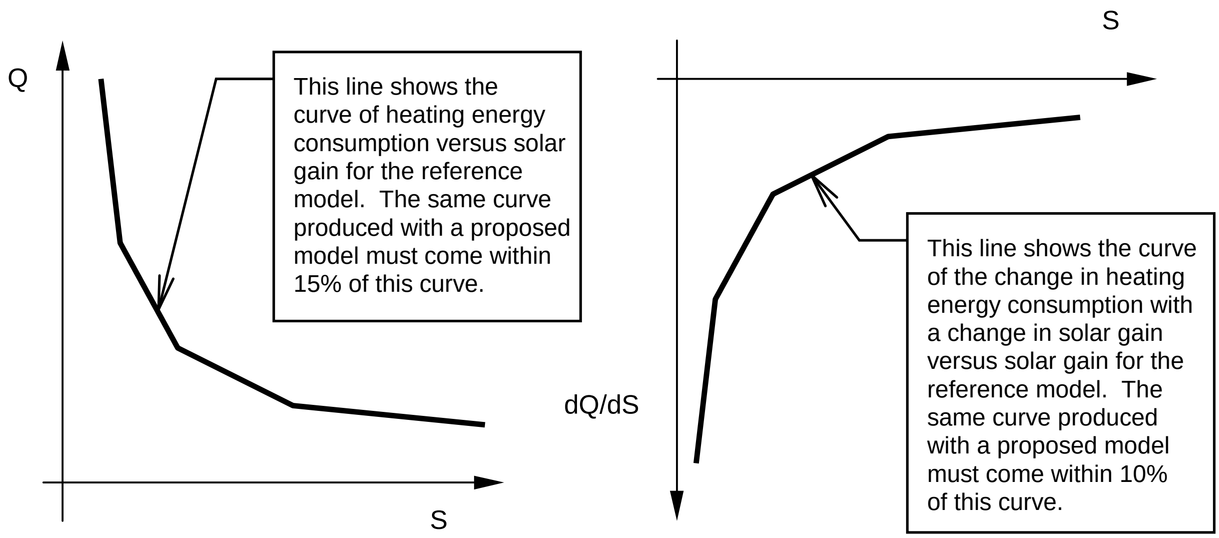

Figure 7-1. To be accepted as a compliance model the proposed model must predict heating energy consumption (Q) and changes in heating energy consumption (dQ) to within a certain percentage of the same predictions made with a reference model. Shown for example are what might be typical plots versus solar gain. Similar plots would have to made for Q and dQ versus other parameters of interest, e.g. *RSI-value*, thermal mass, infiltration rate.

Reference Publications

1. HOT-2000 Technical Manual. Published by the Canadian Home Builders' Association for CANMET, Energy Mines and Resources Canada, May 1989.

2. Barakat, S.A., Sander, D.M., Utilization of Internal Heat Gains. ASHRAE Transactions, Vol. 92, Part 1A, NRCC 27637, National Research Council, Ottawa, 1986.

3. Mitalas, G.P., Basement Heat Loss Studies at DBR/NRC. Division of Building Research (now Institute for Research in Construction) paper No. 1045, NRCC 20416-2, National Research Council, Ottawa, September 1983.

4. Mitalas, G.P., Calculation of Below-Grade Residential Heat Loss: Low-Rise Residential Building. ASHRAE Transactions, Vol. 93, Part 1, 1987, NRCC 29605.

5. Barakat, S.A., Sander, D.M., Utilization of Solar Gain Through Windows for Heating Houses. Building Research Note No. 184, Division of Building Research (now Institute for Research in Construction), National Research Council of Canada, Ottawa, March 1982.

6. Sherman, M., Estimation of Infiltration from Leakage and Climate Indicators. Energy and Buildings, Vol. 10, pp. 81-86, 1987.

7. Shaw, C.Y., Method for Estimating Air Change Rates and Sizing Mechanical Ventilation Systems for Houses. ASHRAE Transactions, Vol. 93, Part II, pp. 2284 - 2302, 1987.

8. Building Energy Analysis Group. DOE-2. Lawrence Berkeley Laboratory, California, LBL-8688, 1979.

9. CMHC. CMHC2 Technical Analysis Manual. Canada Mortgage and Housing Corporation, Ottawa. DRAFT, 1991.

10. Clarke, J.A. (University of Strathclyde, U.K.), Energy Simulation in Building Design. Adam Hilger Ltd., 1985

11. Walker, I. S., D. J. Wilson. The Alberta Air Infiltration Model AIM-2. University of Alberta Report 71, 1991.

12. National Building Code of Canada 1995, NRCC 38726, National Research Council, Ottawa.

13. Model National Energy Code of Canada for Houses 1997, NRCC 38730, National Research Council, Ottawa.

Appendix A
Minimum Contents of the Performance Compliance Report

General

This Appendix expands on Subsection 2.2.6. After the analyses have determined whether the *proposed design* complies with the performance path or not (*annual adjusted energy consumption* for the *proposed design* less than or equal to the *energy target*), the *compliance shell* shall prepare a *performance compliance report*. Its purpose is to:

- accompany an application for a building permit and confirm that the *proposed design* meets the requirements of the MNECH;
- alert the building inspector as to departures from prescriptive requirements; and
- provide enough information for the calculation to be reproduced.

The report shall be in hard-copy.

Requirements

In general, all user-defined inputs shall be included in the *performance compliance report*. As a minimum, the following information should be present in the *performance compliance report*:

Compliance Software Identification

a) name of *compliance software*, including version number;

b) organization that developed the *compliance software*;

c) identification of climate data used by the *compliance software*.

Project Identification

a) project name;

b) project geographical location;

c) project owner or client;

d) "designer" who has the responsibility for certifying that the *performance compliance report* represents a true record of the energy analysis;

e) total occupied heated floor surface area;

f) number and type of rooms; separate entries for kitchen, living, dining, utility, bedrooms, bathrooms, basement, and other;

g) heated volume, including basement.

Heating Source Classification

a) The *principal heating source*.

Above Ground Exterior Walls

For each wall, including foundation walls above ground:

a) wall type;
b) surface area;
c) *effective thermal resistance* of the assembly, correctly accounting for thermal bridging.

Roofs

For each roof:

a) roof type;
b) surface area;
c) *effective thermal resistance* of the assembly, correctly accounting for thermal bridging.

Exposed Floors

For each floor:

a) floor type;
b) surface area;
c) *effective thermal resistance* of the assembly, correctly accounting for thermal bridging.

Windows and Other Glazed Areas

For each window separating heated space from outdoors:

a) window type;
b) orientation, specified as the azimuth and tilt (if specified) of the surface;
c) area, including sash, frame and construction clearances (to rough opening);
d) overall *U-value* accounting for complete window;
e) *solar heat gain coefficient* (SHGC), accounting for complete window.

Skylights (if included)

For each *skylight*:

a) orientation, specified as the azimuth and tilt (if specified) of the surface;
b) area, including sash, frame and construction clearances (to rough opening);
c) overall *U-value* accounting for complete *skylight*;
d) *solar heat gain coefficient* (SHGC) accounting for complete *skylight*.

Walls in Contact with the Ground

For each wall in contact with the ground:

a) surface area;
b) surface area above ground;
c) *effective thermal resistance*;
d) average depth of the wall below ground;
e) average depth of the insulation (below ground);
f) insulation position.

Floors on Ground

For each floor on ground:

a) floor type;
b) surface area;
c) *effective thermal resistance*;
d) depth of the floor below *grade*;
e) perimeter length of the floor;
f) width of the insulation from the inside edge of the floor slab.

Doors

For each door:

a) the surface area;
b) overall *U-value* of complete door and frame assembly;
c) *solar heat gain coefficient* (SHGC) of complete door and frame assembly.

Airtightness

a) normalized leakage area (cm^2 / m^2).

Thermal Mass

a) thermal mass [$MJ / m^2 \cdot °C$, or category as per 3.6. (1)]; m^2 refers to floor area.

Space Heating Systems

a) seasonal performance characteristic;
b) seasonal energy source split characteristic.

Heat Pumps

In addition to the other inputs necessary for system modeling:

a) heat source;
b) source temperature at which the heat pump will be de-activated.

Supplementary Heating Systems (e.g. active solar)

a) all inputs used to accurately describe / model the system.

Mechanical Ventilation

a) whether an HRV is in use;
b) if an HRV is used, the sensible heat recovery efficiency at 0°C and at -25 or -40°C;
c) air exchange rate (if specified).

Flags

All *proposed design* inputs that deviate from prescriptive requirements shall be flagged. The purpose of flagging these components is to alert the building inspector to aspects of the *proposed design* that may require particular attention. Inputs that do not satisfy the *prescriptive requirements* shall have a different flag than those that do satisfy the *prescriptive requirements.*

Summary of Energy Analysis Results

The *performance compliance report* shall contain a summary of energy analysis results. The summary shall contain:

- a listing of each building component (e.g. wall 1, wall 2, window 1), as above;
- the properties of each component as they affect the heating energy consumption (e.g. *effective thermal resistance* and area for walls, efficiency for space heating systems) in both the *reference house* and the *proposed design*. For clarity, the *reference house* and *proposed design* component properties shall be listed side by side;
- the difference between the *annual adjusted energy consumption* and the *energy target* (it is recommended that the *annual adjusted energy consumption* and the *energy target* not be printed in the compliance report, since they are not required to be reported on by the MNECH and because such figures could lead to disputes regarding the actual consumption of energy of the house for a given year);
- a clear statement indicating whether the *proposed design* complies; and
- limitations of the software (e.g. inability to model active solar).

Though it may not always be possible, the *performance compliance report* may denote:

- what fraction of the difference between the *annual adjusted energy consumption* and the *energy target* is due to which building components.

Compliance Certification

The *performance compliance report* should include (at the beginning or at the end) the following statement:

The undersigned certifies that:

1) The physical descriptors of the building listed in this report correspond to the building on the building permit application;
2) The prescriptive requirements listed in this report correspond to the applicable requirements of the MNECH;
3) All deviations from the prescriptions listed in this report correspond to the information recorded on the plans; and
4) Text and numbers appearing in this report have not been altered from the original output of the *compliance software.*

Name:

Signature: Date:

Appendix B
Administrative Regions

Province/ Territory	Administrative Region	Identification	Representative Weather Station
Newfoundland	A	Island, except Northern Peninsula	A & B: St John's
	B	Northern Peninsula & Labrador Coast	
	C	Goose Bay/Happy Valley	C & D: Goose Bay
	D	Western Labrador	
Prince Edward Island	A	Prince Edward Island	Charlottetown
Nova Scotia	A	Nova Scotia	Halifax
New Brunswick	A	New Brunswick	Fredericton
Quebec	A	Existing Zone A*	A: Montréal (Dorval)
	B	Existing Zones B*, C* and D*	B: Bagotville
	C	Existing Zone E* and F*	C: Schefferville
Ontario	A	< 5000 Degree-days	A: Toronto
	B	≥ 5000 Degree-days	B: Thunder Bay
Manitoba	A	South of the 53rd Parallel (< 6500 degree-days approximately)	A: Winnipeg
	B	At or North of the 53rd Parallel	B: Thompson
Saskatchewan	A	Saskatchewan	Saskatoon
Alberta	A	Calgary, Lethbridge	A: Calgary
	B	Red Deer, Edmonton, Grand Prairie	B: Edmonton Int'l
	C	Fort McMurray	C: Fort McMurray

* As defined in the existing Québec Regulation Respecting Energy Conservation in New Buildings

Province/ Territory	Administrative Region	Identification	Representative Weather Station
British Columbia	A	< 3500 Degree-days. Excluding: Vancouver Island • the District of Squamish • the Communities of Woodfibre, Port Mellon, Gibsons, Sechelt and Powel River • Texada Island	A: Vancouver
	B	> 4500 Degree-days	B: Prince George
	C	Vancouver Island Gas Pipeline Service Area, Including • Vancouver Island • the District of Squamish • the Communities of Woodfibre, Port Mellon, Gibsons, Sechelt and Powel River • Texada Island	C: Victoria
	D	3501 to 4500 Degree-days, B.C. Hydro Service Area	D & E: Kamloops
	E	3501 to 4500 Degree-days, West Kootenay Power Service Area	
Yukon	A	Southern Yukon	A: Whitehorse
	B	Central Yukon	B: Dawson (Norman Wells)
	C	Northern Yukon	C: Old Crow (Inuvik)
NWT	A	Southwest NWT	A: Fort Smith
	B	Great Slave Lake	B: Yellowknife
	C	Mackenzie Valley	C: Norman Wells
	D	Western Arctic	D: Inuvik
	E	Keewatin	E: Baker Lake
	F	Baffin	F: Iqualuit/Coral H.
	G	Eastern Arctic	G: Iqualuit/Coral H.
	H	Arctic Islands	H: Resolute
