



Guidelines for Using HOT2000 with the Performance Path of the 2010 National Building Code of Canada Subsection 9.36.5

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1 INTRODUCTION

Energy efficiency requirements have been introduced in Part 9 of the National Building Code of Canada (NBC). One method of demonstrating compliance with the energy requirements in Part 9 of the NBC (NBC 9.36) is through the performance path (NBC 9.36.5). This compliance path defines how to use energy modeling to demonstrate that a house meets the energy requirements of NBC 9.36. This approach provides code users with increased flexibility in the design and construction of low-rise housing beyond what is available through the prescriptive energy efficiency provisions of NBC 9.36.2 through 9.36.4.

Natural Resources Canada (NRCan) has committed to providing an energy modeling tool that is compliant with the requirements of NBC 9.36.5 Energy Performance Compliance. The chosen energy modeling tool is HOT2000. This guide provides specific steps and guidance on using HOT2000 version 10.51 as a computer program capable of demonstrating compliance in accordance with the requirements of NBC 9.36.5.

2 REFERENCE PUBLICATIONS

The following documents are referenced by this guide and may need to be consulted:

| Issuing Agency | Document Number | Title of Document |
|--|--------------------------|---|
| Canadian Commission on Building and Fire Codes | NRCC 53301 | 2010 National Building Code of Canada |
| Canadian Commission on Building and Fire Codes | | National Building Code of Canada – Revisions and Errata – Dec. 2012 |
| Natural Resources Canada | Revision 4: March 2010 | HOT2000 Procedures Manual |
| Canadian Standards Association | CAN/CSA-F326-M91 (R2010) | Residential Mechanical Ventilation Systems |
| Canadian Standards Association | CAN/CSA-F280-M90 (R2009) | Determining the Required Capacity of Residential Space Heating and Cooling Appliances |

3 ASSUMPTIONS

3.1 Reader knowledge

It is assumed that readers are familiar with building science, building energy modeling, and HOT2000 v10.51, or have access to someone with this knowledge. This guide describes how to use the performance path of NBC Section 9.36.5 with HOT2000 v10.51, and is not a manual describing how to use HOT2000. For more details on the use of HOT2000 please refer to the *HOT2000 Procedures Manual* and the HOT2000 in-program help menus.

3.2 Limitations on building types

NBC 9.36.5 applies only to houses with or without a secondary suite, and buildings containing only dwelling units and common spaces whose total floor area does not exceed 20% of the total floor area of the building (see NBC 9.36.1.3.(3)).

The focus of this document is to provide guidance to users where houses and houses with secondary suites are the types of Part 9 buildings under consideration (see NBC A-9.36.1.3.(3) for additional information). It is possible to use HOT2000 to demonstrate compliance with other Part 9 building types within the application stated in NBC 9.36.1.3.(3), but not all eligible building types are specifically addressed in this document. It is recommended that users modeling these more complicated building types have a thorough knowledge of the requirements pertaining to them in 9.36.5 and are familiar with modelling multi-unit buildings in HOT2000.

4 COMPLIANCE APPROACH AND COMMON SETTINGS

4.1 Overall approach

The general approach taken by the performance path of Section 9.36.5 of the NBC (hereafter referred to as “the performance path”) is to compare the modeled energy performance of a proposed house and a reference house. The proposed house is modeled to reflect the actual construction of the house under consideration while the reference house is modeled to represent a hypothetical house built using the prescriptive path of NBC 9.36.2 through 9.36.4 (hereafter referred to as “the prescriptive path”). Both houses share the same climate data, overall geometry (e.g. ceiling area, wall area, foundation area), overall characteristics (e.g. ceiling type, foundation type, heating system fuel and type), and operating characteristics (e.g. non-heating/cooling electrical loads, occupancy, hot-water loads, etc.).

The proposed house is modeled in a similar manner to houses participating in one of NRCan’s housing initiatives (R-2000, ENERGY STAR® for New Homes, EnerGuide Rating System). That is, the primary focus is the geometry and construction of the house envelope and mechanical equipment, while other factors, such as base loads, are pre-defined.

The reference house is modeled using the same geometry, and the same fuel type and system type of the heating or cooling equipment, as the proposed house. However, in the reference house the equipment efficiencies and the thermal resistance of building envelope components are dictated by NBC 9.36. Furthermore, the distribution of some components (e.g. windows and doors) can change and some mechanical equipment (such as heat recovery ventilators (HRV)) is replaced. Ultimately, the goal is to determine how much energy the proposed house consumes relative to the reference house. To demonstrate compliance with NBC 9.36.5, through simulation, the proposed house must be shown to consume no more energy than the reference house.

4.1.1 Notes on text references

All text references to the National Building Code of Canada will be prefaced with “NBC.” Text references to sections within this document will be prefaced with “Section.” Text references to appendix items in this document will be prefaced with “Appendix.” To assist in carrying out the HOT2000 v10.51 modeling instructions,

some bulleted steps will begin with the expression, “HOT2000 Input.” These pathways are meant to assist in HOT2000 navigation and selection and are to be used along with standard modeling procedures.

4.2 Common settings

All modeling must be performed in the “General Mode” of HOT2000 v10.51. The reference and proposed houses in the performance path share a number of common inputs into HOT2000. These are similar to the EnerGuide Rating System (ERS) standard operating conditions. For single-family homes the common settings for both the proposed and reference houses are as follows. For convenience, values that require to be set to a different value than that applied by the ERS as defaults are highlighted in bold:

- Temperatures Screen
 - Main Floor “Heating Set Point” must equal 21 °C.
 - Main Floor “Cooling Set Point” must equal 25 °C if cooling equipment is present.
 - **Main Floor “Allowable Rise” must equal 5.5 °C.**
 - **If a basement is present, the “Heated” box must be checked.**
 - **If a basement is present and cooling equipment is present, the “Cooled” box must be checked.**
 - Basement “Heating Set Point” must equal 19 °C.
 - If a crawl space is conditioned, the “Crawl Space” “Heating Set Point” must equal 15 °C. If a conditioned crawl space is modeled as a basement (see Section 5.8.1.3.2), set the basement “Heating Set Point” to 15 °C.
 - Set the “Equipment” “Heating Set Point” to 22 °C and the “Cooling Set Point” to 24 °C.
- Base Loads Screen:
 - The sum of “Electric Appliances,” “Lighting,” and “Other Electric” must equal 20 kWh/day.
 - **Avg. Exterior Use must equal 0 kWh/day.**
 - Ensure that the “Internal Gains – basement” is set to a value of 0.15.
 - Hot Water Load of 225 L/day at a temperature of 55 °C.
 - Set occupancy as 2 adults present 50% of the time and 2 children present 50% of the time.
 - Ensure that the “Gas Stove” and “Gas Dryer” boxes are un-checked.
- Specifications Tab (in main “House” component)
 - Set the “House Type”, “Storeys”, “Plan Shape” and “Front Orientation” as per the design of the proposed house.
 - Ensure that “Light, wood frame” is selected from the “Thermal Mass” drop-down menu.

- The value of “Wall Colour” and “**Roof Colour**” **must be set to 0.4**.
- Set the “Foundation Soil Condition” to “Normal conductivity (dry sand, loam, clay)”.
- Set the “Water Table Level” to “Normal (7-10m/23-33ft)”.
- Set values in the “Roof Cavity Inputs” window (accessed by selecting the “Inputs” button) or leave the “Default Roof Cavity Inputs” box checked.
- Window Tightness Tab (in main “House” component)
 - The “Window Air Tightness” drop-down menu selection is used to calculate the reported ER ratings of windows. However, it is not used in the energy calculations and is for information purposes only.
- Specifications Tab (in “Natural Air Infiltration” component)
 - Set the “Terrain” selection to “Suburban, forest”.
 - Set the “Local Shielding” selection for “Walls” and “Flue” to “Very Heavy” and “Light”, respectively.
- Weather Tab (in main “House” component)
 - Make the following selection in HOT2000:
 - **HOT2000 Input: “Weather->Weather Library->Wth100.dir”**
 - **Select the appropriate “Region” and “Location.”**
- Other Factors Tab (in “Natural Air Infiltration” component)
 - Ensure that “Terrain” is set to “Open flat terrain, grass” and that “Anemometer Height” is set to “10 m” in the “Weather Station” section.
 - The drop-down menu in the “Leakage Fractions” section should be set to “Use defaults.”
- Season Tab (in “Heating/Cooling System” component)
 - Ensure the “Cooling” “Start Month” is set to “May”, the “Cooling” “End Month” is set to “October”, and the “Design Month” is set to “July”.
- Foundation Tab (if “Basement” or “Walkout” components are present)
 - Ensure “Library” is selected from the “Data Type” drop-down menu.
 - Select the “Opening to the Upstairs” as per the proposed house specifications.
 - Select the predominant “Foundation Room Type” as per the proposed house specifications.

5 PROPOSED HOUSE MODELING

The proposed house is intended to closely represent the house as it will be built. Following is a description of how to model the proposed house in HOT2000 v10.51.

5.1 Effective thermal resistance in building envelope assemblies

The minimum modeling requirements for building envelope assemblies (such as walls, ceilings, exposed floors, etc.) are knowledge of the interior area of the assembly and its effective thermal resistance (or RSI-value, with units of $K \cdot m^2/W$ in the international system of units). For building assemblies the effective RSI-value can be either calculated manually or using HOT2000. NBC Article 9.36.2.4 explains how to manually calculate effective RSI-values.

When using HOT2000 to calculate the effective RSI-value of building assemblies, adjustments for framing and insulation compression will be made automatically. This greatly reduces the effort required to move windows and doors, or adjust their modeled dimensions. For these reasons NRCan recommends that HOT2000 be used to calculate the effective RSI-value of building envelope assemblies.

Regardless of the manner in which the effective RSI-values of building components are calculated, the RSI-values of building materials or components must be determined by the methods described in NBC Article 9.36.2.2. Generally, this means that the RSI-value of any modeled building material or component must be determined by means of testing to an accepted standard. NBC Table A-9.36.2.4.(1)D provides a list of accepted RSI-values for common building materials.

The RSI-values for many of the materials listed in NBC Table A-9.36.2.4.(1)D are different from those provided in HOT2000 version 10.51. For this reason HOT2000's "Code Selector" and favourite codes cannot be used to determine the effective RSI-value for most building assemblies. The only acceptable method to determine the effective RSI-value of building assemblies using HOT2000 is through the user defined codes created in the "Code Editor." These codes are commonly called "blue codes."

5.2 Ceilings

NBC 9.36 considers ceilings to be building envelope assemblies that separate conditioned and unconditioned space and that are inclined less than 60° from the horizontal. Model ceilings present in the proposed house as per the specifications of the proposed house and following standard HOT2000 v10.51 procedures.

5.3 Above-ground walls

NBC 9.36 considers walls to be building envelope assemblies that separate conditioned and unconditioned space and that are inclined 60° or more from the horizontal. As well as separating conditioned and unconditioned space, walls separating conditioned space from a garage (even one that is conditioned) must be modeled.

In addition to defining walls in general, NBC 9.36 discusses above-ground walls in particular. For the purposes of this document above-ground walls are walls of which no part comes in contact with the ground and that do not form part of a foundation. Model above-ground walls as "Main Walls" in HOT2000.

Model any above-ground walls present in the proposed house as per the specifications of the proposed house and following standard HOT2000 v10.51 procedures.

5.4 Floor headers

Model any floor headers (also called rim joists) present in the proposed house as per the specifications of the proposed house and following standard HOT2000 v10.51 procedures.

5.5 Exposed floors

Model any exposed floors in the proposed house as per the specifications of the proposed house and following standard HOT2000 v10.51 procedures.

5.6 Fenestration

According to NBC Sentence 9.36.1.2.(4), fenestration is considered to be “all building envelope assemblies, including their frames, that transfer visible light, such as windows, clerestories, skylights, translucent wall panels ...” HOT2000 considers windows, doors, and translucent materials (such as architectural glass blocks) separately. Translucent materials must be modeled as walls in HOT2000.

Rough opening dimensions must be used when modeling windows and doors in HOT2000. Windows, skylights, and patio doors are considered as windows in HOT2000 and their rough opening dimensions need to be entered into HOT2000. With the exception of patio doors, doors are modeled as doors in HOT2000. Any windows that form part of doors, including sidelights and transoms, are modeled as part of a door in HOT2000 and not in the adjoining wall. Therefore, the rough opening dimensions of a door with transoms and sidelights will include the transoms and sidelights. Model any doors in the proposed house as per their specifications and following standard HOT2000 v10.51 procedures. If windows, including sidelights and transoms, are part of a door system they must be modeled using the following window calculations and modelling procedures.

Ensure that windows and doors are modeled in the appropriate building assembly so that the additional framing is accounted for in the effective RSI-value of that assembly. If HOT2000 is used to calculate the effective RSI-value of a building assembly, it will adjust the effective RSI-value of the affected assembly automatically to account for framing around openings. If the effective RSI-value is calculated manually, then ensure that the framing around openings is properly accounted for in the appropriate assembly.

To determine the overall coefficient of heat transfer (U-value, or the inverse of RSI-value) and the overall solar heat gain coefficient (SHGC) of windows, the CSA A440.2, NFRC 100, and NFRC 200 test standards specify testing using standard-sized windows. The overall U-value and overall SHGC for the tested window are then applied to all windows of the same design but with different sizes. This is done to reduce the testing burden while providing energy performance metrics to facilitate the comparison of different window designs.

However, when used for energy modeling, the overall U-value and overall SHGC of windows with dimensions that do not match those in the standards must be adjusted to compensate for size effects. Thus, HOT2000 requires that the overall U-value be converted into “Center of Glass”, “Edge of Glass”, and “Frame” RSI-value components. HOT2000 also uses a “Center of Glass” rather than an overall SHGC. Appendix B.2 provides procedures to estimate the RSI values of the “Center of Glass,” “Edge of

Glass” and “Frame” components and the “Center of Glass” SHGC. The “NRCan Window Calculator” has been provided to assist in these calculations.

5.6.1 Fenestration calculations and modeling

The specific characteristics of each window need to be acquired for fenestration calculations and modeling purposes. The following information is required for the “NRCan Window Calculator” and HOT2000 inputs:

1. Overall U-value ($W/m^2 \cdot ^\circ C$ or $W/m^2 \cdot K$)
2. Overall Solar Heat Gain Coefficient (SHGC)
3. Window Height and Width
4. Frame height (distance between sill and window pane)
5. Window type
6. Glazing type
7. Fill type and thickness
8. Spacer type
9. Frame material
10. Orientation
11. Width and height of rough opening
12. Location
13. Overhang, if applicable

For each distinct window, whether distinct by dimensions or design, follow these steps:

1. Calculate the RSI-values for “Centre of Glass,” “Edge of Glass,” “Frame” and the “Center of Glass” “SHGC” using the “NRCan Window Calculator” or the procedure described in Appendix B.2.
2. Using HOT2000’s “Code Editor,” create a user defined window code inputting the RSI-values and SHGC as calculated in Step 1.
3. Use this user defined code and standard HOT2000 v10.51 procedures to model the applicable window(s).
4. Repeat steps 1-3 for each distinct window.

5.7 Air sealing

Proponents can choose to conduct a fan depressurization test (blower door test) in accordance with CGSB 149.10 (or using NRCan’s “as operated” procedure) on the proposed house to obtain the measured airtightness, or may set airtightness rates based on NBC Section 9.25 and NBC Subsection 9.36.2 compliance. Select the correct scenario below and follow the instructions:

Scenario 1: If a blower door test will be performed once the proposed house’s condition permits, follow these steps:

- Use a design airtightness of 3.2 ACH air changes per hour (ACH) @50 Pa. until the house is substantially complete and a valid blower door test can be performed.
- Enter the design ACH and set the ELA to “Calculated.”

- Once a valid blower door test is performed, input the results in HOT2000 following standard procedures.

Scenario 2: If a blower door test will not be performed, select the applicable option:

- If the proposed house complies with NBC Section 9.25, set the “Air Change Rate @ 50Pa” to 3.2 and the ELA to “Calculated.”
- If the proposed house complies with NBC Subsection 9.25.3 and NBC Articles 9.36.2.9 and 9.36.2.10, set the “Air Change Rate @ 50Pa” to 2.5 and the ELA to “Calculated.”

5.8 Foundations

There are a number of restrictions on foundation modeling in the proposed house due to HOT2000’s foundation models and the reference house requirements. Following is a description of these restrictions and how to work with them when modeling foundations in the proposed house.

5.8.1 Determining the foundation type

The first step to foundation modeling in HOT2000 is choosing an appropriate foundation type. This section provides guidance in determining the correct foundation type, be it slab-on-grade, basement, crawl space or walkout basement. Select the foundation type that most closely matches the proposed house’s foundation, taking note of the following points:

- The proposed and reference houses must share the same foundation type.
- If more than one foundation type is present, select the appropriate foundations based on the criteria provided in Sections 5.8.1.1 through 5.8.1.4 and model them as attached foundations following standard HOT2000 v10.51 procedures.
- If several foundations of the same type are present but differ in total height, model them as separate, attached, foundations following standard HOT2000 v10.51 procedures
- In HOT2000, all foundations are assumed to have four corners. If a foundation has more than four corners, model it as multiple attached foundations. For example, for a basement with eight corners, model the house as having two attached basements, each with four corners.
- For the purposes of this document, a “floor-on-ground” is the horizontal foundation component in contact with the ground that can be used as a floor. For example, the slab in a basement or slab-on-grade foundation is a floor-on-ground. In some cases, such as crawl spaces, the floor-on-ground may be the ground itself. Not all horizontal foundation components in contact with the ground, e.g. footings, are floors-on-ground.

Once the foundation type best representing that of the proposed house has been determined, proceed to Section 5.8.2 for direction on determining the foundation insulation configuration.

5.8.1.1 Slab-on-grade

HOT2000 considers slab-on-grade foundations as being any heated and habitable space (even a storage area) where the floor-on-ground is 0.61 m or less below grade. Model any such spaces as slab-on-grade foundations. Heated and habitable spaces (storage areas included) where the floor-on-ground is more than 0.61 m below ground must be treated as basements (see Section 5.8.1.2).

5.8.1.2 Basements

Basements are used in HOT2000 to model any structure whose floor-on-ground is between 0.61 m and 2.4 m below grade. Within this range HOT2000 can approximate the ground heat conduction through the walls and slab. The ability of HOT2000 to accurately represent foundation performance may be reduced where a basement floor in contact with the ground is greater than 2.4 m below grade.

Any heated and habitable space (even a storage area) whose floor-on-ground is between 0.61 m and 2.4 m below grade must be modeled as a basement.

- In addition to following standard HOT2000 v10.51 modeling procedures ensure the following selections described earlier in Section 4.2 have been set:
 - HOT2000 Input: “Temperatures->Basement->check Heated”
 - HOT2000 Input: “Temperatures->Basement->check cooled” (if basement is cooled)

5.8.1.3 Crawl spaces

HOT2000 generally treats crawl spaces as uninhabitable spaces with slab-on-grade foundations or, in the case of open crawl spaces, as the open area under houses on piers. However, some uninhabitable spaces under houses may extend beyond the 0.61-m limit that HOT2000 treats as the distinction between slab-on-grade foundations and basement foundations. Following is a procedure for using HOT2000 to model the uninhabitable foundations traditionally thought of (and referred to) as crawl spaces. Again, only use this procedure to model uninhabitable spaces. Unfinished basements that will likely only be used for storage are still considered basements.

5.8.1.3.1 Determining whether a crawl space is heated

Start by determining whether the crawl space is heated using NBC Sentence 9.18.1.3.(1) as follows:

“Crawl spaces shall be considered to be heated where the space

- a) is used as a hot air *plenum*,
- b) contains heating ducts that are not sealed and insulated to minimize heat loss to the space, or
- c) is not separated from heated space in accordance with Section 9.25.”

Section 9.25, referenced in (c) above, refers to NBC 9.36. Therefore, the above clause includes the requirement that for the crawl space to be considered heated the floor above the crawl space must not have an effective R-value greater than or equal to the specified value for “Floors over unheated spaces” in NBC Table 9.36.2.6.

Next, determine the average depth below grade of the floor-on-ground. There may be no floor per se, as the floor-on-ground may be the ground itself.

5.8.1.3.2 Modeling a heated crawl space

If the floor-on-ground is on average 0.61 m or less below grade, model the foundation as a crawl space. Follow standard HOT2000 v10.51 modeling procedures along with the following selections:

- HOT2000 Input: "Crawlspace->Foundation->Ventilation Type->Closed"
- HOT2000 Input: "Temperatures->Crawl Space->check Heated"
- HOT2000 Input: "Natural Air Infiltration->Specifications->check Includes crawlspace volume"

If the floor-on-ground is on average more than 0.61 m below grade, model the foundation as a basement. Follow standard HOT2000 v10.51 modeling procedures along with the following selections:

- HOT2000 Input: "Temperatures->Basement->check Heated"
- HOT2000 Input: "Foundation->Opening to upstairs->Standard door-closed"
- HOT2000 Input: "Foundation->Foundation Room Type->Utility Room"

5.8.1.3.3 Modeling an unheated crawl space

If the floor-on-ground is on average 0.61 m or less below grade, model the foundation as a crawl space. If the house is built on piers, follow standard HOT2000 v10.51 modeling procedures along with the following selections:

- HOT2000 Input: "Temperatures->Crawl Space->uncheck Heated"
- HOT2000 Input: "Crawlspace->Foundation->Ventilation Type->Open"
- HOT2000 Input: "Natural Air Infiltration->Specifications->uncheck Includes crawlspace volume"

If the house is not built on piers, follow standard HOT2000 v10.51 modeling procedures along with the following selections:

- HOT2000 Input: "Temperatures->Crawl Space->uncheck Heated"
- HOT2000 Input: "Crawlspace->Foundation->Ventilation Type->Vented"
- HOT2000 Input: "Natural Air Infiltration->Specifications->uncheck Includes crawlspace volume"

If the floor-on-ground is on average more than 0.61 m below grade, model the foundation as a basement. Follow standard HOT2000 v10.51 modeling procedures along with the following selections:

- HOT2000 Input: "Temperatures->Basement->uncheck Heated"
- HOT2000 Input: "Temperatures->Basement->uncheck Cooled"
- HOT2000 Input: "Foundation->Opening to upstairs->Standard door-closed"
- HOT2000 Input: "Foundation->Foundation Room Type->Utility Room"

5.8.1.4 Walkout basements

Walkout basements are used in HOT2000 when the grade around a foundation varies substantially, such as is found on a sloping site. HOT2000 treats walkout basements the same way as it does basements. HOT2000 will take the walkout geometry entries and use them to calculate average above and below ground foundation wall areas. These wall areas are then turned into average above and below ground foundation wall heights. HOT2000 models the walkout as a basement with the calculated average above and below ground foundation wall heights. Note that the same restrictions that apply to basements apply to walkouts. Therefore, ensure that the average below-ground wall height of the walkout, without any slab-on-grade portion, is greater than 0.61 m.

If there is a slab-on-grade portion of the walkout, HOT2000 will perform the same calculations as above, except it will also model an attached slab-on-grade foundation. If the proposed house design calls for a walkout basement with attached slab-on-grade foundation, model the two foundation types separately, referring to Appendix B.5 for the details of this modeling procedure.

5.8.2 Determining the foundation insulation configuration

NBC Article 9.36.2.8 embodies numerous effective RSI-value requirements for foundation configurations that must be met by the reference house model. This affects the proposed house as the proposed house and reference house models must share the same foundation type and insulation configuration. The NBC Article 9.36.2.8 foundation requirements and their impact on the proposed house will be discussed here.

5.8.2.1 Unheated foundations

NBC Article 9.36.2.8 does not apply to unconditioned foundations. Therefore, when modeling an unconditioned foundation any foundation insulation configuration can be used.

If a foundation is unheated, follow these steps:

- Determine the effective RSI-value for “Floors over unheated spaces” in NBC Table 9.36.2.6.A.
- HOT2000 Input: “Foundation->Wall/Floor Constructions->Floors Above Foundation”->enter effective RSI-value

Keep all other aspects of unheated foundations the same in the reference and proposed houses.

5.8.2.2 Heated foundations

The following requirements only apply to heated foundations.

As part of defining the effective RSI-value requirements, NBC Article 9.36.2.8 defines where insulation must be placed for different foundation components. The factors that determine the foundation insulation location are the frost depth, the depth of the floor-on-ground, and the presence of active floor-on-ground heating (through embedded heating pipes, cables, etc.). These factors, along with the location of the

house, also determine the effective RSI-value for a given foundation component as per NBC Table 9.36.2.8.A. Where a requirement is determined by the relationship of the element to the frost line, the depth of frost penetration at the site shall be as determined by the authority having jurisdiction. NBC Table 9.36.2.8.A.'s "Unheated floors" row requires knowledge as to whether the floor-on-ground is above or below the frost line.

When modeling the reference house, the requirements in NBC 9.36.2.8 must be followed. As the available foundation insulation configuration choices are limited amongst the different foundation types, to aid in choosing an appropriate foundation insulation configuration Appendix Table A.2: "Permissible Foundation Insulation Configurations" lists acceptable foundation insulation configurations based on foundation type and the insulation placement criteria from NBC 9.36.2.8. Since the reference and proposed foundation models must be consistent, when choosing the foundation insulation configuration for the proposed house ensure it is listed in Appendix Table A.2 for the appropriate foundation type and placement criteria.

Note that none of these requirements affect the amount of foundation insulation modeled in the proposed house. For example, if a proposed house has a concrete basement where the unheated floor-on-ground is below the frost depth, NBC 9.36.2.8 requires foundation wall insulation only. Therefore, a basement insulation configuration with full wall insulation must be chosen. However, if no foundation insulation is called for in the proposed house, the effective RSI-value of the added insulation can be set to 0. Likewise, if the proposed house calls for slab insulation and full interior and exterior foundation wall insulation, an insulation configuration reflecting this can be chosen. In the reference house for this case however, only the interior side or exterior side of the foundation need be insulated and the remaining wall and slab added insulation can be set to 0, making sure to conform to the prescriptive requirements.

5.8.3 Modeling procedures for foundation walls

Aside from choosing an appropriate foundation insulation configuration, NBC Sentence 9.36.2.8.(3) includes further requirements for foundation walls that extend more than 600 mm above finished ground. This sentence requires that if the above-ground portion of a section of foundation wall extends more than 600 mm above the adjoining ground level, it is treated as an above-ground wall. Note that only the above-ground portion of the section of foundation wall is treated as an above-ground wall. The required effective RSI-values for above ground walls are given in the "Walls" row of NBC Table 9.36.2.6.A. and are different than those for foundation walls.

NBC Section 9.36 does not define what a section of foundation wall is. Therefore, for the purposes of this document, a section of foundation wall is defined as the portion of foundation wall between any two corners, interruptions, boundary between foundation types, or any combination thereof.

Note that in this document, pony walls are considered to be above-ground walls and not part of the foundation wall. Therefore, when determining if a section of foundation wall extends more than 600 mm above the adjacent ground level do not include the height of any pony walls present. For the purposes of this document, a pony wall is a frame wall (including structural insulated panels) that is not in contact with the ground and that is built between a concrete foundation wall and the floor joists supporting the first floor. As with sections of extended above-ground foundation walls, the effective

RSI-values of pony walls are set according to the “Walls” row of NBC Table 9.36.2.6.A. in the reference house.

The result of the requirements from NBC 9.36.2.8.(3) is that, in some cases, sections of the reference house foundation wall must be modeled with a different effective RSI-value than the rest of the foundation wall. The way to accomplish this will vary with the foundation type. For crawl spaces in HOT2000, the changes can be made to the reference house crawl space wall without affecting the proposed house. The walls above slab-on-grade foundations in HOT2000 are above-ground walls, so they are not affected. However, for basements and walkouts in HOT2000, the changes in the reference house foundation wall will be significant enough to warrant changing the proposed house foundation wall.

Following are procedures for modeling foundation insulation for basements, crawl spaces, and slab-on-grade foundation types in HOT2000. Only basement foundation types include procedures to account for extended above-grade foundation wall sections in the reference house.

5.8.3.1 Basement and walkout type foundations

The following procedures apply to the basement foundation type. Although not discussed, the same procedures may be used for walkout foundations with little modification.

Ground temperature, unlike air temperature, in HOT2000 is not homogeneous: it varies with depth as well as with position under a floor slab. For this reason, the foundation insulation configuration is important in HOT2000. Placing insulation under a foundation slab will have a different effect than that of placing insulation above a foundation slab. Insulating a foundation slab will have a different effect than that of insulating a foundation wall. Insulating the top of a foundation wall will have a different effect than that of insulating the bottom of a foundation wall.

HOT2000 considers the walls in slab-on-grade type and crawl space type foundations to be above-ground. However, HOT2000 considers the walls in the basement foundation type to extend below ground. Therefore, given that the location of insulation on below-ground walls matters, the insulation configurations are more restrictive for HOT2000 basement foundation types than for slab-on-grade and crawl space foundation types.

In HOT2000 the foundation material and wall thickness are predetermined. Available choices are:

- a concrete foundation with 200 mm thick walls and a 100 mm thick slab,
- a wood foundation with 50 mm thick walls and a 100 mm thick floor, and
- a wood foundation with 50 mm thick walls and a concrete slab 100 mm thick.

These selections are part of the insulation configuration options. The result of this is that the basement wall or foundation floor is modeled and then insulation is modeled as being added to the wall or floor instead of being part of the wall or floor. The added insulation does not have to be just insulation but can be a stud wall, floor system, or other assembly that adds to the thermal resistance of the foundation. However, as with other components, the effective RSI-value is required. Therefore, when modeling a specific overall effective RSI-value for a foundation component, the effective RSI-

value of the foundation type must be taken into account, in addition to the placement of the insulation or structure itself.

For example, we will consider trying to model a foundation wall with a consistent effective RSI-value of 4.000. In addition to choosing an insulation configuration with insulation covering the entire foundation wall height on one or both sides, one would have to model an added insulation effective RSI-value of 3.884 ($RSI\ 4.000 - RSI\ 0.116$). See Table A.1 in Appendix A for the RSI-value of the different foundation components.

Where the basement insulation does not have a consistent RSI-value around the perimeter of the basement wall, users must follow the procedures in Appendix B.3, rather than using the foundation wall “Composite” feature in HOT2000. NRCan’s “Composite foundation calculator” has been provided to assist in these calculations. Note that users must model variation in basement wall insulation over the height of the basement wall using the appropriate basement insulation configuration.

HOT2000 has the ability to include pony walls in basement type foundations. Pony walls are above-ground walls added to the top of basement foundation walls. Thus, the basement foundation walls are homogenous but another assembly can be placed between the foundation walls and the first floor.

Pony walls are modeled by checking the “Pony Wall” box in the basement component “foundation” tab and setting the “Height” of the pony wall. Note that HOT2000 requires at least 100 mm (0.1 m) of basement foundation wall to be above-ground. Therefore, the largest pony wall height entered in the “Height” box is “Total Height” – “Depth Bel. Gr.” – 0.1m. The pony wall construction is set using the “Pony Wall Construction Type” drop-down box in the basement component “Wall/Floor Constructions” tab. A “Composite” button is present here too. This button can be used to combine the effective RSI-value of several different pony wall sections. Note that when using the pony wall “Composite” button, the entire pony wall area must be defined. Therefore, the “% of area” entries in the sections of the HOT2000 “Composite RSI/R Calculator” window must add up to 100%. In addition, since pony walls are above-ground structures the placement of insulation or assemblies is not important, only the total effective RSI-value is.

Pony walls will be used with basements to fulfill the requirements of NBC Sentence 9.36.2.8.(3). Any section of basement foundation wall that extends more than 600 mm above the adjoining ground level will be modeled as a pony wall in the reference house. For consistency in basement modeling these pony walls will be modeled in the proposed house as well.

5.8.3.1.1 Modeling a basement or walkout where a pony wall is not present

Apply the following procedures and HOT2000 entries if one or more section(s) of a basement wall extends more than 600 mm above the adjoining ground level and no pony wall is present in the proposed house:

- HOT2000 Input: “Foundation->Wall Dimensions->check Pony Wall”
- Determine the pony wall area by summing the above-ground areas of all sections of foundation wall that extend more than 600 mm above the adjoining grade level.

- Determine the pony wall height by dividing the pony wall area by the exposed basement perimeter length.
- HOT2000 Input: “Foundation->Wall Dimensions->enter Pony Wall Height”
- HOT2000 Input: “Foundation->Wall/Floor Constructions->Pony Wall Construction Type->select User Specified-> set Value to 0.12 RSI for concrete foundation walls or 0.42 RSI for treated wood foundation walls”
- Make sure to add any proposed house foundation wall insulation that is present on the section of foundation wall extending more than 600 mm above-ground. This is accomplished by adding the effective RSI-value of the added foundation wall insulation to the value from the previous step.

5.8.3.1.2 Modeling a basement or walkout where a pony wall is present

Apply the following procedures and HOT2000 entries if one or more section(s) of a basement wall extend more than 600 mm above the adjoining ground level and a pony wall is present in the proposed house:

- HOT2000 Input: “Foundation->Wall Dimensions->check Pony Wall”
- Determine the reference pony wall area by summing the above-ground areas of all sections of foundation wall that extend more than 600 mm above the adjoining grade level.
- Determine the area of the pony wall specified in the proposed house. This will be called the planned pony wall area.
- Determine the total pony wall area by summing the reference and planned pony wall areas.
- Determine the pony wall height by dividing the total pony wall area by the exposed basement perimeter length.
- HOT2000 Input: “Foundation->Wall Dimensions-> enter Pony Wall Height”
- Determine the planned area fraction by dividing the planned pony wall area by the total pony wall area and multiplying by 100.
- Determine the reference area fraction by dividing the reference pony wall area by the total pony wall area and multiplying by 100.
- Determine the reference effective RSI-value for the sections of foundation wall extending more than 600 mm above ground. This is done by adding the effective RSI-value of any assemblies or insulation added to those sections of foundation wall to the RSI-value of the foundation wall itself (0.12 RSI for concrete, 0.42 RSI for treated wood).
- Determine the effective RSI-value of the pony wall specified in the proposed house. This will be called the planned effective RSI-value.
- HOT2000 Input: “Foundation->Wall/Floor Construction->Pony Wall Construction Type->select User Specified->click Composite”
- In the “Composite RSI/R Calculator” choose a “Section” row and enter the reference area fraction in the “% of area” box and the reference effective RSI-value in the “RSI” box.

- Choose a different “Section” row and enter the planned area fraction in the “% of area” box and the planned effective RSI-value in the “RSI” box.

5.8.3.2 Crawl-space type foundations

The crawl-space type foundation in HOT2000 assumes that the floor-on-ground is a concrete slab 100 mm thick and that all walls are above ground. The RSI-value of the slab is pre-determined at 0.0578 RSI. Therefore, the effective RSI-value of any insulation (or assembly) applied to the slab is added separately. Another result of this is that, as with other foundation models, the insulation configuration used must be chosen from those in Appendix A for the foundation type and circumstances. Refer to Appendix A.1 for how to choose an appropriate insulation configuration.

Since the walls are treated as above-ground walls no special treatment is required. However, crawl space walls are not modeled as “Main Walls.” The air temperature in a crawl space may be different than that of the main floors so the crawl space walls are modeled separately. The “Composite” button in the crawl space component “Wall/Floor Constructions” tab functions in the same way as the pony wall “Composite” button.

5.8.3.3 Slab-on-grade type foundations

The slab-on-grade type foundation in HOT2000 is treated similarly to the crawl space type foundation in HOT2000. The only difference is that the slab-on-grade type is treated as the floor of a main floor’s space. Therefore, the slab-on-grade is exposed to the main floor’s set point air temperature. In addition, any wall on a slab-on-grade is modeled as a “Main Wall.” The slab is treated in the same way as the slab in a crawl space. Refer to Appendix A.1 for direction in choosing an appropriate insulation configuration.

5.9 Ventilation

Determine the principal ventilation rate of the required ventilation system using the number of bedrooms in the proposed house as per NBC Table 9.32.3.3. Calculate an average rate based on the minimum and maximum ventilation requirements. NBC Sentence 9.36.5.11.(5) states that ventilation systems must be modeled as operating at the principal ventilation rate for 8 hrs/day. HOT2000 models ventilation systems as operating continuously. Therefore, when entering the ventilation rates in HOT2000, only enter 1/3 of the principal ventilation rate.

Only model the ventilation systems that are required to provide the principal ventilation rate. For example, if the proposed house contains one supply fan and one exhaust fan (with no heat recovery) that combined are required to provide the principal ventilation rate, then they both must be modeled. If the same house contains a third exhaust fan that is not required to provide the principal ventilation rate, then it should not be modeled.

Following are procedures to determine some required ventilation characteristics that must be modeled. Choose the applicable ventilation scenario below.

5.9.1 Proposed house contains an HRV or ERV

NBC Article 9.36.5.11 treats HRV's and ERV's differently from other ventilation systems as noted below.

- The HRV/ERV fan power and efficiency must be rated at a minimum of two temperatures.
- The modeled HRV/ERV efficiencies must be those rated at the principal ventilation rate determined as per NBC Section 9.32. This principal ventilation rate is only used to determine the HRV/ERV efficiencies and may be different than that calculated using NBC Table 9.32.3.3.
- Only recovery of sensible heat is taken into account. Therefore, the recovery of any latent heat using an ERV is ignored.
- The modeled HRV/ERV fan powers must be 1/3 of those rated at the principal ventilation rate.

5.9.1.1 Modeling an HRV or ERV

In addition to following standard HOT2000 v10.51 modeling procedures, follow these steps and enter the required HOT2000 inputs for ventilation rates, fan powers and capacities:

- Determine the principal ventilation rate of the required ventilation system based on the number of bedrooms as per NBC Table 9.32.3.3. Calculate the average L/s required and divide this number by three. Enter the results as shown below:
 - HOT2000 Input: "Ventilation->Primary/Secondary Supply & Exhaust->Supply" enter supply ventilation rate in L/s. (1/3 of NBC Table's average value)
 - HOT2000 Input: "Ventilation->Primary/Secondary Supply & Exhaust->Exhaust" enter exhaust ventilation rate in L/s. (1/3 of NBC Table's average value)
- Determine the fan powers by finding the fan powers in W for the two rating temperatures and dividing each power by three. Enter the results as shown below:
 - HOT2000 Input: "Ventilation->HRV Specifications->Rating Condition 1->Power" enter fan power at higher temperature. (1/3 of full fan power)
 - HOT2000 Input: "Ventilation->HRV Specifications->Rating Condition 2->Power" enter fan power at lower temperature. (1/3 of full fan power)
- Determine the efficiency at the two rating temperatures.
 - HOT2000 Input: "Ventilation->HRV Specifications->Rating Condition 1" enter efficiency at higher temperature.
 - HOT2000 Input: "Ventilation->HRV Specifications->Rating Condition 2" enter efficiency at lower temperature.
- Proceed to Section 5.9.3 to determine if additional ventilation air circulation modeling is required.

5.9.2 The proposed house contains a ventilation system other than an HRV/ERV

If the proposed house contains a ventilation system other than an HRV or ERV, in addition to following standard HOT2000 v10.51 modeling procedures, follow these steps and enter the required HOT2000 inputs:

- Determine the principal ventilation rate of the required ventilation system based on the number of bedrooms as per NBC Table 9.32.3.3. Calculate the average L/s required and divide this number by three.
- Determine the individual ventilation fan power by multiplying the principal ventilation rate (in L/s) by 2.32 W/L/s.
- Determine the number of ventilation fans in the proposed house, including any supply and exhaust fans, required to deliver the principal ventilation rate.
- Determine the total ventilation fan power by multiplying the individual ventilation fan power by the number of ventilation fans.
- Model 1/3 of the total ventilation fan power in HOT2000 for the proposed house.
- Proceed to Section 5.9.3 to determine if additional ventilation air circulation system modeling is required.

5.9.3 Modeling an air circulation system not used by the heating or A/C system

In addition to the above ventilation fan information, if the proposed house ventilation system includes an air circulation system that is not used by the heating or air conditioning system:

- Determine the principal ventilation rate of the required ventilation system based on the number of bedrooms as per NBC Table 9.32.3.3. Calculate the average L/s required.
- Determine the ventilation circulation fan power by multiplying the principal ventilation rate (in L/s) by 2.32 W/L/s.
- Determine the number of ventilation circulation fans in the proposed house ventilation circulation system.
- Determine the total ventilation circulation fan power by multiplying the ventilation circulation fan power by the number of ventilation circulation fans.
- Add 1/3 of the ventilation circulation fan power to the ventilation fan power modeled in HOT2000 for the proposed house.
- If an HRV or ERV is modeled, add 1/3 of the ventilation circulation fan power to the ventilation fan powers at both rating conditions.

Otherwise, use the space conditioning fan to circulate the ventilation air as modeled in Section 5.10.

5.10 Heating, cooling and air circulation

Following are instructions for modeling heating/cooling equipment, calculating the forced-air heating system circulation fan power and modeling the fan power.

5.10.1 Modeling heating and cooling equipment

NBC Article 9.36.5.4 requires the modeling of primary space heating and space cooling equipment. NBC Article 9.36.5.4 allows the exclusion of redundant or back-up equipment. Therefore, only model primary heating and cooling (if installed) equipment and omit any heating and cooling equipment that is not required to meet the space conditioning demand of the house. Note that supplementary equipment such as electric resistance coils or a fuel-fired furnace, which are often found combined with a heat pump, need to be modeled.

NBC Article 9.36.5.7 requires that primary heating and cooling systems be modeled individually. HOT2000 is capable of modeling multiple heating systems. However, only one heat-pump or air-conditioner can be modeled in a home. In addition, HOT2000 assumes that any modeled space cooling equipment is capable of meeting the entire cooling demand of the house. Therefore, HOT2000 cannot model window mounted air conditioners or any other localized equipment. There are entries in HOT2000 for window mounted air conditioners but they are for information purposes only.

NBC Article 9.36.5.11 requires that individual heating systems be modeled as called by the control system in the proposed house design. HOT2000 runs heating system types in the following order:

1. Heating systems in HOT2000's "Heating/Cooling Equipment->Type 2 tab"
2. Heating systems in HOT2000's "Heating/Cooling Equipment->"Supplementary Heat – System 1 and Supplementary Heat – System 2"
3. Heating systems in HOT2000's "Heating/Cooling Equipment->Type 1"

As only heating equipment necessary to meet the heating demand of the house is modeled, if a supplementary heating system is required to meet the heating demand, set the appliance's "Usage" field to "Always". To comply with NBC Article 9.36.5.11, necessary supplementary heating equipment must be modeled as numbered above. For example, if a house with a gas furnace requires the usage of a gas fireplace to meet the heating demand, the gas fireplace would be modeled in "Type 1" and the furnace would be modeled in "Supplementary Heat-System 1." In addition, when modeling supplementary heating systems, the approximate house floor area heated by the system is required. When modeling supplementary heating systems note that HOT2000 only allows the system to heat either the basement or the main floors (do not use the "Exterior" option).

The "Output Capacity" for any modeled proposed house heating or cooling system must be set to "User specified" and the full rated output capacity (or heating capacity) of the heating or cooling equipment entered. In the case of equipment that can both heat and cool (such as heat pumps) enter the heating capacity. Model the rest of the space conditioning equipment fields according to the proposed house equipment specifications. In the case of heat pumps, the criteria (either temperature or capacity) at which the heat pump shuts down must be included.

HOT2000 assumes that “Type 1” heating systems will meet any otherwise unmet heating demand on the house. If HOT2000 determines that, after all other heating systems present are used, the “Output Capacity” of the “Type 1” heating system is too small it will overwrite the “Output Capacity” of the “Type 1” heating system with one that will meet the house’s heating demand. If this happens HOT2000 will generate a warning giving the option to increase the “Type 1” heating system’s “Output Capacity.”

HOT2000 has some limitations in modeling combo systems tested to CSA P.9. See Appendix B.4 for procedures on modeling these systems.

Note that HOT2000 v10.51 cannot be used for code compliance where the proposed house contains an integrated mechanical system (IMS) within the scope of CSA P.10.

5.10.2 Calculating the forced-air heating system fan power

If the proposed house does not use a forced-air heating system, model the circulation system as per standard HOT2000 v10.51 procedures.

If a house contains a forced-air system, NBC 9.36.5.11 requires that the circulation fan size and power be modeled in a specific manner. Select the following applicable scenario.

5.10.2.1 House with one forced-air heating system

If only one forced-air heating system is present, the procedure for determining the forced-air heating system circulation fan power is as follows:

- Determine the forced-air heating system output capacity (in W).
- Determine the minimum forced-air heating system circulation fan power by using the following equation:
 - $\text{Output Capacity} \times 0.0194 \text{ L/s/W} \times 2.30 \text{ W/L/s} = \text{minimum forced-air heating system circulation fan power.}$
- The forced-air heating system circulation fan power is defined as the larger of:
 - The heating system circulation fan power specified in the design of the proposed house.
 - The minimum forced-air heating system circulation fan power defined above.

Proceed to Section 5.10.3

5.10.2.2 House with more than one forced-air heating system (without heat pumps)

If more than one forced-air heating system is present (excluding heat pumps), the procedure for determining the total forced-air heating system circulation fan power is as follows:

- Determine the total forced-air heating system output capacity (in W) by summing the heating capacities of all forced-air heating systems modeled in the proposed house.

- Determine the minimum forced-air heating system circulation fan power by using the following equation:
 - $\text{Output Capacities} \times 0.0194 \text{ L/s/W} \times 2.30 \text{ W/L/s} = \text{minimum forced-air heating system circulation fan power.}$
- The forced-air heating system circulation fan power is defined as the larger of:
 - The heating system circulation fan power specified in the design of the proposed house.
 - The minimum forced-air heating system circulation fan power defined above.

Proceed to Section 5.10.3

5.10.2.3 House with a heat pump and other forced-air heating systems

If both a heat pump and other forced-air heating systems are present in the house determine the total forced-air heating system circulation fan power as follows:

- Determine the forced-air heating system circulation fan power of the “Other Forced-Air Heating Systems” by following the instructions in Section 5.3.10.2.1 or 5.3.10.2.2.
- Determine the heat pump’s minimum forced-air heating system circulation fan power by using the following equation:
 - $\text{Output Capacity (in W)} \times 0.0604 \text{ L/s/W} \times 2.30 \text{ W/L/s} = \text{minimum forced-air heating system circulation fan power.}$
- Sum the minimum forced-air heating system circulation fan powers of the heat pump and other systems.
- The forced-air heating system circulation fan power is defined as the larger of:
 - The heating system circulation fan power specified in the design of the proposed house (if more than one heating system is specified, sum the fan powers).
 - The minimum forced-air heating system circulation fan power defined above.

5.10.3 Modeling forced-air heating system circulation fan power

Select the appropriate scenario for modeling the forced-air heating system circulation fan power. In addition to following standard HOT2000 v10.51 modeling procedures, follow the prescribed steps and enter the required HOT2000 inputs.

Scenario 1: If the ventilation system uses the forced-air heating system for circulation:

- HOT2000 Input: “Heating/Cooling System->Fans/Pumps->Heating Systems Fan/Pump->Mode->Two Speed”
- HOT2000 Input: “Heating/Cooling System->Fans/Pumps->Heating Systems Fan/Pump->Fan/Pump Power->User Specified”
- Set the “High Speed Power” to the forced-air heating system circulation fan power calculated in Section 5.10.2.1, 5.10.2.2 or 5.10.2.3.

- Set the “Low Speed Power” to 1/3 of the “High Speed Power”
- Proceed to Section 5.10.4.

Scenario 2: If the ventilation system does not use the forced-air heating system for circulation:

- HOT2000 Input: “Heating/Cooling System->Fans/Pumps->Heating Systems Fan/Pump->Mode->Auto”
- HOT2000 Input: “Heating/Cooling System->Fans/Pumps->Heating Systems Fan/Pump->Fan/Pump Power->User Specified”
- Set the “High Speed Power” to the forced-air heating system circulation fan power calculated in Section 5.10.2.1, 5.10.2.2 or 5.10.2.3.
- Proceed to Section 5.10.4.

5.10.4 Modeling auxiliary heating system electrical requirements

In addition to the above, NBC Sentence 9.36.5.11.(20) requires that “For natural gas, oil, propane and wood heating systems, the energy model calculations shall set the auxiliary electricity requirements, including that of combustion fans, to those specified for the proposed house.” Add these auxiliary electricity requirements to the value in “High Speed Power.”

- HOT2000 Input: “HOT2000 Input: “Heating/Cooling System->Fans/Pumps->Heating Systems Fan/Pump->High Speed Power->add auxiliary power”

5.11 Service water heating

Model all service water heating (or domestic hot water - DHW) equipment called for in the proposed house as per HOT2000 v10.51 standard modeling practice. HOT2000 uses energy factor (EF) to model the performance of all fuel burning DHW systems. If the DHW system in the proposed house uses thermal efficiency (E_t) to rate its performance refer to Appendix B.1 to approximate EF using E_t . The “Energy Factor Conversion Calculator” has been provided to assist in these calculations. NBC Article 9.36.5.12 allows credit for drain water heat recovery (DWHR) systems. However, note that although there are entries for DWHR in HOT2000 v10.51 these are for information purposes only and are not actually included in the energy calculations.

6 REFERENCE HOUSE SETTINGS

The reference house is intended to have the same geometry, layout, usage and equipment types as the proposed house. However, the envelope effective RSI-values, window orientations and characteristics, equipment efficiencies and some other specifications are modified to match those defined in the prescriptive path. As such, all HOT2000 entries in the reference house model must match those of the proposed house model unless specifically directed otherwise in the following procedure.

Many characteristics of the reference house model are determined by the number of heating degree days for the house’s weather location. Heating degree days are a method of quantifying the overall amount of heating required in a given climate. Therefore, each weather location will have a heating degree day value associated with it. The weather locations and associated heating degree days in HOT2000 differ from

those in the NBC. Therefore, when looking at the various tables in NBC Section 9.36 to determine the required reference house characteristics use the weather location and heating degree days defined in NBC Table C-2 of Division B, Appendix C.

In addition to the number of heating degree days, some foundation characteristics in the reference house are determined by the frost depth. See your authority having jurisdiction for the local frost depth. NBC Table 9.36.2.8.A.'s "Unheated floors" row requires this information.

The following procedure assumes that the proposed house model has been completed using HOT2000. Save the Proposed House, reopen it and "Save As" the Reference House. This procedure defines the reference house model by what must be changed from the proposed house. Again, if no change is specified below, maintain the proposed house value in the reference house.

6.1 Effective thermal resistance in building envelope assemblies

The required effective RSI-values of all building envelope assemblies in the reference house are defined in NBC Subsection 9.36.2. Therefore, when modifying the proposed house to generate the reference house, in all cases change the HOT2000 component "Type" selection in the "Construction" section to "User specified" and then enter the effective RSI-value defined from the appropriate location in NBC Subsection 9.36.2. With the sole exception of windows, do not use any user defined, "Code Selector," or "Favourite" Codes.

6.1.1 Ceilings

Set the effective RSI-value for ceilings to the value specified in the applicable row (either "Ceilings below attics" or "Cathedral ceilings and flat roofs") of NBC Table 9.36.2.6.A.

6.1.2 Above-ground walls

Set the effective RSI-value for all above-ground walls to the value specified in the "Walls" row of NBC Table 9.36.2.6.A.

6.1.3 Floor headers

Set the effective RSI-value for all floor headers (also called rim-joists) to the value specified in the "Walls" row of NBC Table 9.36.2.6.A.

6.1.4 Exposed floors

Set the effective RSI-value for all exposed floors to the value specified in the "Floors over unheated spaces" row of NBC Table 9.36.2.6.A.

6.2. Fenestration

There are a number of rules in NBC Article 9.36.5.14 regarding fenestration in the reference house. These rules significantly change the size and distribution of windows and doors in the reference house. Therefore, when generating the reference house from the proposed house remove all windows and doors.

NBC Sentence 9.36.5.14.(5) requires that glazing must be evenly distributed around the reference house. To accommodate this, apply the following procedure:

- Model four windows, each with the same area and dimensions.
- Set one window to have the same orientation as the front of the house.
- Set the other three windows to have orientations of +90°, +180° and -90° from the first window.
- If there are skylights in the proposed house model one skylight in the reference house with a “Horizontal” “Tilt.”
- Do not model any overhangs over the reference house windows.

6.2.1 Fenestration calculations

Perform the following calculations in preparation for modeling. In the equations below “RO” will be substituted for “Rough Opening.”

- TOTAL OPAQUE DOOR AREA = total proposed house door RO area - total proposed house window in door area
- GROSS FENESTRATION AREA = proposed house window RO area + door RO area + skylight RO area
- SKYLIGHT TO FENESTRATION RATIO = proposed house skylight RO area ÷ GROSS FENESTRATION AREA
- ABOVE-GROUND GROSS WALL AREA = Adding the area of all proposed house above-ground walls including the area of above-ground foundation walls and pony walls
- FENESTRATION AND DOOR TO GROSS WALL AREA (FDWR) RATIO = GROSS FENESTRATION AREA ÷ ABOVE-GROUND GROSS WALL AREA
- The FDWR of the reference house must be
 - the same as that in the proposed house if the proposed house FDWR is between 0.17 and 0.22,
 - 0.17 if the proposed house FDWR is less than 0.17, and
 - 0.22 if the proposed house FDWR is greater than 0.22.
- REFERENCE HOUSE GROSS FENESTRATION AREA = Reference house FDWR x ABOVE-GROUND GROSS WALL AREA
- REFERENCE HOUSE SKYLIGHT RO AREA = REFERENCE HOUSE GROSS FENESTRATION AREA x SKYLIGHT TO FENESTRATION RATIO

- TOTAL REFERENCE HOUSE WINDOW AREA = REFERENCE HOUSE GROSS FENESTRATION AREA - TOTAL OPAQUE DOOR AREA - REFERENCE HOUSE SKYLIGHT RO AREA
- INDIVIDUAL REFERENCE HOUSE WINDOW AREA = TOTAL REFERENCE HOUSE WINDOW AREA ÷ 4

6.2.2 Modeling windows

The Reference House windows must be modeled using user-defined codes. In addition to following standard HOT2000 v10.51 modeling procedures, follow these steps and enter the required HOT2000 inputs.

- HOT2000 Input: “Editors->Code Editor->click on Window Codes->click on New User-defined Code” (yellow hat icon)
 - ->Window Type->Picture
 - ->Frame Height->0
 - ->Center of Glass SHGC->0.26
- Determine and model the “Center of Glass,” Edge of Glass” and “Frame” RSI-value:
 - Based on the house location heating degree days, from NBC Table 9.36.2.7.A. find the applicable “Max. U-value, W/(m²K).”
 - Calculate the inverse of the U-value using a calculator’s “1/x” feature.
 - Enter the calculated RSI-value in HOT2000. The “Center of Glass,” Edge of Glass” and “Frame” RSI-values share the same RSI-value as just calculated.

6.2.3 Modeling skylights

If there are skylights in the proposed house, set the reference house skylight area to be the reference house skylight rough opening area as calculated in Section 6.2.1. The Reference House windows must be modeled using user-defined codes. In addition to following the standard HOT2000 v10.51 modeling procedures, including modeling the skylight as having a “Horizontal Tilt,” follow these steps and enter the required HOT2000 inputs.

- HOT2000 Input: “Editors->Code Editor->click on Window Codes->click on New User-defined Code” (yellow hat icon)
 - ->Window Type->Picture
 - ->Frame Height->0
 - ->Center of Glass SHGC->0.26
- Determine and model the “Center of Glass,” Edge of Glass” and “Frame” RSI value:

- Based on the house location's heating degree days, from NBC Table 9.36.2.7.B. find the applicable "Max. U-value, W/(m²K)."
- Calculate the inverse of the U-value using a calculator's "1/x" feature.
- Enter the RSI-values in HOT2000. The "Center of Glass," "Edge of Glass" and "Frame" RSI-values share the same RSI-value as just calculated.

6.2.4 Modeling doors

Since the windows in the reference house are modeled separately, any door in the reference house will be modeled as being opaque. Model only one door in the reference house and set its area to be the total opaque door area calculated in Section 6.2.1. Set the effective RSI-value of this door to the inverse of the U-value specified in the "Max. U-value, W/(m²K)" row of NBC Table 9.36.2.7.A. Do not model any windows in this door. If there is a problem with the door being too big, it can be subdivided into any number of doors as long as the total rough opening area of the doors matches the total opaque door area calculated in Section 6.2.1.

6.3 Air sealing

Set the reference house air tightness characteristics utilizing standard HOT2000 v10.51 modeling procedures and following these steps and required HOT2000 inputs:

- HOT2000 Input: "Natural Air Infiltration->Specifications->Air Tightness Type->Blower door test values"
- HOT2000 Input: "Natural Air Infiltration->Specifications->Blower Test->un-check Air Leakage Test Data", if already checked.
- Set the "Equivalent Leakage Area" drop-down menu to "Calculated"
- Enter 2.5 into the "Air Change Rate" @ 50Pa. edit box.
- Set the "Test Type" to CGSB.

6.4 Foundations

6.4.1 Unheated foundations

If a foundation is unheated, follow these steps:

- Determine the effective RSI-value for "Floors over unheated spaces" in NBC Table 9.36.2.6.A.
- HOT2000 Input: "Foundation->Wall/Floor Constructions->Floors Above Foundation"->enter RSI-value
- Keep all other aspects of unheated foundations the same in the reference and proposed houses.

6.4.2 Heated foundations

The following procedures only apply to heated foundations (i.e. the space within the foundation is heated, not necessarily the walls or floor). NBC Article 9.36.2.8 determines the amount and placement of insulation for the reference house foundation. NBC Table 9.36.2.8.A. provides the required effective RSI-value of reference house foundation components. However, as discussed in Section 5.8.1, the proposed house and reference house foundation types and insulation configurations must be the same. Therefore, not many changes are required in the reference house as most of the reference house considerations were made when modeling the proposed house.

Required changes will vary with the HOT2000 foundation type as follows. Note that in some cases (such as walkout basements) the required reference house effective RSI-value for the floors-on-ground may be determined by more than one row in NBC Table 9.36.2.8.A. As per NBC Sentence 9.36.2.8.(2), in these cases use the greatest applicable effective RSI-value.

6.4.2.1 Basement type foundations

Set the effective RSI-value of any basement pony walls as per the “Walls” row of NBC Table 9.36.2.6.A. Refer to Appendix A.2 for instructions on modeling the basement insulation.

6.4.2.2 Crawl-space type foundations

Set the crawl space foundation wall effective RSI-value according to the “Foundation wall” row of NBC Table 9.36.2.8.A. The effective RSI-value of the crawl space foundation wall will need to be adjusted if sections extend more than 600 mm above the adjoining ground level. To do this, apply the following procedure and HOT2000 Inputs:

- Determine the total crawl space wall area.
- Determine the extended section area by summing the above-ground areas of all sections of foundation wall extending more than 600 mm above the adjoining ground level.
- Determine the extended section area fraction by dividing the extended section area by the total crawl space wall area and multiplying by 100.
- Determine the foundation wall area fraction by subtracting the extended section area fraction from 100.
- HOT2000 Input: “Foundation->Wall/Floor Constructions->Composite”
- In the “Composite RSI/R Calculator” window, choose a “Section” and enter the extended section area fraction in the “% of area” box. In the same “Section” enter the appropriate effective RSI-value from the “Walls” row of NBC Table 9.36.2.6.A in the “RSI” box.
- In a different “Section” enter the foundation wall area fraction in the “% of area” box. In this new section enter the appropriate effective RSI-value from the “Foundation walls” row of NBC Table 9.36.2.8.A in the “RSI” box.

Refer to Appendix A.2 for instructions on how to model the crawl space floor-on-ground insulation.

6.4.2.3 Slab-on-grade type foundations

All walls above HOT2000's slab-on-grade type foundation are considered above grade walls and are not included in the foundation model. Refer to Appendix section A.2 for how to model the slab-on-grade insulation.

6.5 Ventilation

Use the same ventilation modeling in the proposed and reference houses. The only exception to this is for HRVs and ERVs. If an HRV or ERV was modeled in the proposed house:

- Change the "Equipment Type" from "HRV" or "HVI Certified HRV" to "Fans w/o HR."
- Model the same ventilation rates in the reference house as in the proposed house.
- Determine the ventilation fan power by multiplying the number of ventilation fans in the proposed house HRV/ERV by the modeled ventilation flow rate (L/s) and 2.32 W/L/s

If any ventilation circulation fan powers were added to the ventilation fan power in the proposed house, add the same amount in the reference house.

6.6 Heating, cooling and air circulation

Following are instructions for modeling heating/cooling equipment, calculating the forced-air heating system circulation fan power and modeling the fan power.

6.6.1 Modeling heating and cooling equipment

Most of the same heating, cooling and air circulation modeling entries in the reference and proposed houses are maintained. The changes made to the reference house are as follows:

- The space heating and cooling system must be sized in accordance with CAN/CSA-F280-M.
- The performance of all heating and cooling equipment must be set to the minimum performance listed in NBC Table 9.36.3.10 for the same fuel type and equipment type.
- Any heating equipment modeled in the proposed house that is not listed in NBC Table 9.36.3.10 will be replaced with a 92% AFUE gas warm air furnace.

Where solid-fuel-burning appliances are used to meet the heat load of the building, their energy efficiency must be accounted for. NBC Table 9.36.3.10 refers to EPA 40 CFR (Part 60) and CSA B415.1 to set performance ratings for "Solid-fuel-burning space-heating equipment". No explicit efficiency minimums are provided in NBC Table 9.36.3.10 for this equipment, rather the equipment must conform to the maximum particulate emissions as required by the listed standards. To set the equipment

efficiency in the reference house, a reasonable approach is to use default efficiency values established by the EPA New Source Performance Standards (NSPS), which forms part of the EPA 40 CFR standard. Table 1 lists the default efficiencies from the EPA NSPS, The use of this approach should be discussed with the authority having jurisdiction to determine if it is acceptable for building code compliance.

Table 1: Default Solid-fuel Burning Space Heating Equipment Efficiencies

| Equipment | Default Efficiency |
|--------------------------|--------------------|
| Non-catalytic woodstoves | 63% |
| Catalytic woodstoves | 72% |
| Pellet woodstoves | 78% |

If the proposed house includes a combo system tested to CSA P.9, refer to Appendix B.4 for the modeling procedure in the reference house.

If the reference house contains a forced-air heating system, NBC Article 9.36.5.15 includes a number of requirements concerning the modeling of the forced-air system circulation fan size and power. These requirements are similar to those for the proposed house.

6.6.2 Calculating the forced-air heating system fan power

If the reference house does not use a forced-air heating system, model the circulation system as per the proposed house.

If a house contains a forced-air system, NBC Article 9.36.5.15 requires that the circulation fan size and power be modeled in a specific way. Select the following applicable scenario.

6.6.2.1 House with one forced-air heating system

If only one forced-air heating system is present, the procedure for determining the forced-air heating system circulation fan power is as follows:

- Determine the forced-air heating system output capacity.
- Determine the minimum forced-air heating system circulation fan power by using the following equation:
 - $\text{Output Capacity (in W)} \times 0.0194 \text{ L/s/W} \times 2.30 \text{ W/L/s} = \text{forced-air heating system circulation fan power.}$

Proceed to Section 6.6.2.4

6.6.2.2 House with more than one forced-air heating system (without heat pumps)

If more than one forced-air heating system is present (excluding heat pumps), the procedure for determining the total forced-air heating system circulation fan power is as follows:

- Determine the total forced-air heating system output capacity by summing the heating capacities of all forced-air heating systems modeled in the reference house.
- Determine the forced-air heating system circulation fan power by using the following equation:
 - Total Output Capacity (in W) x 0.0194 L/s/W x 2.30 W/L/s = forced-air heating system circulation fan power

Proceed to Section 6.6.2.4

6.6.2.3 House with a heat pump and other forced-air heating systems

If both a heat pump and other forced-air heating systems are present in the reference house, determine the total forced-air heating system circulation fan power as follows:

- Determine the forced-air heating system circulation fan power of the “Other Forced-Air Heating Systems” by following the instructions in Section 6.6.2.1 or 6.6.2.2.
- Determine the heat pump’s forced-air heating system circulation fan power by using the following equation:
 - Output Capacity (W) x 0.0604 L/s/W x 2.30 W/L/s = minimum forced-air heating system circulation fan power.
- Sum the forced-air heating system circulation fan powers of the heat pump and other systems.

Proceed to Section 6.6.2.4

6.6.2.4 Modeling forced-air heating system circulation fan power

Select the appropriate scenario for modeling the forced-air heating system circulation fan power. In addition to following standard HOT2000 v10.51 modeling procedures, follow the prescribed steps and enter the required HOT2000 inputs.

Scenario 1: If the ventilation system uses the forced-air heating system for circulation:

- HOT2000 Input: “Heating/Cooling System->Fans/Pumps->Heating Systems Fan/Pump->Mode->Two Speed”
- HOT2000 Input: “Heating/Cooling System->Fans/Pumps->Heating Systems Fan/Pump->Fan/Pump Power->User Specified”
- Set the “High Speed Power” to the forced-air heating system circulation fan power calculated in Section 6.6.2.1, 6.6.2.2 or 6.6.2.3.
- Set the “Low Speed Power” to 1/3 of the “High Speed Power”

- Proceed to Section 6.6.3.

Scenario 2: If the ventilation system does not use the forced-air heating system for circulation:

- HOT2000 Input: "Heating/Cooling System->Fans/Pumps->Heating Systems Fan/Pump->Mode->Auto"
- HOT2000 Input: "Heating/Cooling System->Fans/Pumps->Heating Systems Fan/Pump->Fan/Pump Power->User Specified"
- Set the "High Speed Power" to the forced-air heating system circulation fan power calculated in Section 6.6.2.1, 6.6.2.2 or 6.6.2.3.
- Proceed to Section 6.6.3.

6.6.3 Modeling auxiliary heating system electrical requirements

In addition to the above, NBC sentence 9.36.5.15.(16) requires that "For natural gas-, oil-, propane- and wood-burning heating systems, the energy model calculations shall set the auxiliary electricity requirements, including that of combustion fans, to 208 W during operation." Determine the total auxiliary electricity requirements by multiplying the number of "natural gas-, oil-, propane- and wood burning heating systems" modeled in the reference house by 208 W. Add these auxiliary electricity requirements to the value in "High Speed Power."

- HOT2000 Input: Heating/Cooling System->Fans/Pumps->Heating Systems Fan/Pump->High Speed Power->add auxiliary power

6.7 Service-water heating

Use the same DHW fuel type, system type, input, and volume in the reference house as in the proposed house unless the proposed house DHW system is a tankless water heater as listed in NBC Table 9.36.5.16. The efficiency of DHW systems in the reference house must be modeled to the performance requirements listed in NBC Table 9.36.4.2. If the proposed house DHW system cannot be found in NBC Table 9.36.4.2., the reference house must be modeled with a gas fired, storage type DHW system with an energy factor (EF) and volume as per Table 2 below.

HOT2000 uses EF as the performance metric for modeling DHW systems. In many cases, NBC Table 9.36.4.2 provides performance requirements other than EF. See Appendix B.1 for a procedure to approximate the EF of water heaters that use alternate performance criteria.

If the proposed house uses a gas or oil fired tankless DHW system, the reference house must be modeled with a storage tank type DHW system as per NBC Table 9.36.5.16. In these cases the reference house DHW system should use the same fuel type as the proposed house. NBC Table 9.36.5.16. provides no guidance regarding the tank volume or energy factor to apply in the reference case. NRCAN has therefore provided a reasonable set of values to use in Table 2 below for the reference house DHW tank volume and energy factor to model in HOT2000. These values were determined by choosing the most commonly used tank sizes in residential and commercial use and calculating the EF according to the prescriptive requirements. Smaller capacity equipment was deemed to be intended for residential use while larger

capacity equipment was deemed to be intended for commercial use. Users should discuss this approach with the authority having jurisdiction to determine if it is acceptable for compliance where tankless water heaters are installed.

Table 2: Service Water Heating

| DHW Fuel Type (in proposed house) | System Type (in proposed house) | Proposed House DHW Input (kW) | To be Modeled in Reference House | |
|-----------------------------------|---------------------------------|-------------------------------|----------------------------------|------------|
| | | | Energy Factor (EF) | Volume (L) |
| Not found in NBC Table 9.36.4.2 | Not found in NBC Table 9.36.4.2 | N/A | 0.77 | 281 |
| Natural Gas | Tankless | ≤ 73.2 | 0.59 | 151 |
| Natural Gas | Tankless | > 73.2 | 0.77 | 281 |
| Oil | Tankless | ≤ 61.5 | 0.53 | 113 |
| Oil | Tankless | > 61.5 | 0.73 | 189 |

7 REQUIRED INFORMATION FOR SUBMISSION

As part of using the performance path to demonstrate compliance with NBC Section 9.36 a report is required. The information required in this report is listed in NBC Articles 2.2.8.2 and 2.2.8.3. Appendix C provides a sample report that presents the information required in NBC Articles 2.2.8.2 and 2.2.8.3. The information in this report can be obtained from HOT2000 v10.51 and the design documents. The location of any information required from HOT2000 v10.51 follows, first in a simplified tabular format and then with further details in the sections following the table.

| NBC Clause | Summary of NBC requirement | Where to find it in HOT2000 [†] |
|--------------------|--|--|
| 2.2.8.3.(2)(c)(i) | Annual energy consumption of all sources for the proposed house | Section: Monthly Estimated Energy Consumption by Device Item: Sum of all column “Total” values except “Lights & Appliances” |
| 2.2.8.3.(2)(c)(ii) | House energy target of all energy sources calculated for the reference house | Section: Monthly Estimated Energy Consumption by Device Item: Sum of all column “Total” values except “Lights & Appliances” |
| 2.2.8.3.(2)(d)(i) | name of the software program(s) | Response is HOT2000 v10.51. You do not need |

| | | |
|--------------------|--|--|
| | | to look in the report. |
| 2.2.8.3.(2)(d)(ii) | list of any adaptations made by the user for input to the software or its output | Workaround procedures described in this document can be referenced to fulfil this NBC Subclause. |
| 2.2.8.2.(1)(a) | The R-value and areas of building envelope assemblies | Section: Building Parameters Summary |
| 2.2.8.2.(1)(b) | The U-value, solar heat gain coefficient, and areas of all fenestration and door components | Section: Window Characteristics for window information Door sub-section for door information |
| 2.2.8.2.(1)(c) | The ratio of total vertical fenestration and door area to gross wall area | Section: Window Characteristics for window area Building Parameter Details for door area Building Parameter Details for gross wall area (total vertical fenestration area + total door area)/gross wall area |
| 2.2.8.2.(1)(d) | The performance rating, energy source, and types of all equipment required for space heating, space cooling, and service water heating | Section: Space Heating System Air Conditioning System Domestic Water Heating System |
| 2.2.8.2.(1)(e) | The design basis for the ventilation rates | Ventilation rates are based on the number of bedrooms in the proposed house and NBC Article 9.32.3.3 |
| 2.2.8.2.(1)(f) | Measured airtightness of the building envelope | Section: Air Leakage and Ventilation |
| 2.2.8.2.(1)(g) | Any additional features used in the energy model calculations that account for a significant difference in house energy performance | List any specific parameter of the proposed house that differ from those of the reference house List any features of the house that may account for a significant difference in house energy performance as compared to the reference house energy performance (e.g. solar PV system installed) |

[†] Unless otherwise stated, the location in the Full House Report is given.

7.1 Project information section (NBC Article 2.2.8.3 report information)

Most of the information required by NBC Article 2.2.8.3 is available from design documents and do not require information from HOT2000 v10.51. This information is used in the “Project Information Section” of the sample report in Appendix C. The exceptions are NBC Clauses 2.2.8.3.(2)(c) and 2.2.8.3.(2)(d).

NBC Subclause 2.2.8.3.(2)(c)(i) requires that the “the annual energy consumption of all sources for the proposed house” be reported. As per NBC Sentence 9.36.5.2.(2) the “annual energy consumption” is the sum of the proposed house annual space-

conditioning energy use and DHW energy use, and does not include appliance or base load energy consumption. For the proposed house, this information is found in the “Full House Report” under the “Monthly Estimated Energy Consumption by Device” table. The “annual energy consumption” is calculated by summing the “Total” energy consumption under each column in the table except for the “Lighting & Appliances” column.

NBC Subclause 2.2.8.3.(2)(c)(ii) requires that “the house energy target of all energy sources calculated for the reference house” be reported. As per NBC Sentence 9.36.5.2.(3) the “house energy target” is the sum of the reference house annual space-conditioning energy use and DHW energy use, and does not include appliance or base load energy consumption. For the reference house, this information is found in the “Full House Report” under the “Monthly Estimated Energy Consumption by Device” table. The “house energy target” is calculated by summing the “Total” energy consumption under each column in the table except for the “Lighting & Appliances” column.

NBC Subclause 2.2.8.3.(2)(d)(i) requires that “the name of the software program(s)” be reported. This would be “HOT2000 v10.51”. NBC Subclause 2.2.8.3.(2)(d)(ii) requires “a list of any adaptations made by the user for input to the software or its output” be reported. This may include any workarounds used to enter information into HOT2000. Workaround procedures described in this document can be referenced to fulfil this NBC Subclause.

7.2 NBC Article 2.2.8.2 report information

Following is the required information from NBC Sentence 2.2.8.2.(1) and a description of where to find this information in the HOT2000 v10.51. This information is used in the “Building Envelope,” “Mechanical” and “Additional Features” sections of the sample report in Appendix C.

NBC Clause 2.2.8.2.(1)(a) requires: “The effective thermal resistance values (R-value) and respective areas of all opaque building envelope assemblies, including all above-ground and below-ground roof/ceiling, wall, and floor assemblies.”

All opaque building envelope assemblies can be found in the “Full House Report.” For effective R-value verifications, refer to the “Full House Report” section entitled “Building Parameters Summary.”

If the opaque building envelope assemblies cover less than 2% of the total area, their respective assembly types do not need to be provided.

NBC Clause 2.2.8.2.(1)(b) requires: “The overall thermal transmittance (U-value), solar heat gain coefficient, and respective areas of all fenestration and door components.”

Information related to windows can be found in the “Window Characteristics” section of the “Full House Report”. For doors refer to the “Doors” sub-section immediately above the “Foundations” section of the “Full House Report”. In these two sections RSI-values (called “R-value” in the “Full House Report”) are provided. To determine overall U-value divide 1 by the RSI-value.

NBC Clause 2.2.8.2.(1)(c) requires: “The ratio of total vertical fenestration and door area to gross wall area.”

Total area information related to fenestration can be found in the “Full House Report” under the “Window Characteristics” section, while associated information regarding doors can be found in the “Building Parameter Details” section. Gross wall area can also be obtained in the “Building Parameter Details” section. Once all information is obtained, divide the total area of vertical fenestration and doors by the gross wall area to calculate the required ratio.

NBC Clause 2.2.8.2.(1)(d) requires: “The performance rating, energy source, and types of all equipment required for space heating, space cooling, and service water heating.”

All information related to mechanical equipment can be found either within the multiple tabs under the various mechanical sections in the main “House” tree of HOT2000, or in sections “Space Heating System,” “Air Conditioning System” and “Domestic Water Heating System” of the “Full House Report.”

Note that where part-load characteristics are used in the modelling of the HVAC equipment, they do not need to be provided in the drawings and specifications or report.

NBC Clause 2.2.8.2.(1)(e) requires: “The design basis for the ventilation rates.”

The ventilation rates are based on the number of bedrooms in the proposed house and NBC Article 9.32.3.3.

NBC Clause 2.2.8.2.(1)(f) requires: “Where a test is used to determine the airtightness of a house, the measured airtightness of the building envelope must be in air changes per hour.”

A blower door test may be required to measure the airtightness of a house. In these cases, the measured value can be found in the “Air Leakage and Ventilation” section of the “Full House Report”.

NBC Clause 2.2.8.2.(1)(g) requires: “Any additional features used in the energy model calculations that account for a significant difference in house energy performance.”

When a specific parameter of the proposed house differs from that of the reference house, it must be listed in this section of the report.

Also, list any features of the house that may account for a significant difference in house energy performance as compared to the reference house energy performance (e.g. solar PV system installed).

APPENDIX A: FOUNDATION INSULATION CONFIGURATION

Following are a table and procedure for choosing an appropriate proposed house foundation insulation configuration and for placement of insulation in the reference house.

A.1: Determining the proposed house foundation insulation configuration

To choose the appropriate proposed house foundation insulation configuration, first use the procedure in Section 5.8 to determine the proper HOT2000 foundation type to model. Next, look up the HOT2000 foundation type in Table A.2. For each foundation type there are one or more “floor criteria”. Choose the “floor criteria” that best describes the floor-on-ground for the proposed house. Having chosen the HOT2000 foundation type and floor criteria, the final step is choosing the insulation configuration code that best describes the proposed house. Refer to HOT2000 v10.51 for more information on what each insulation configuration code represents. The Appendix Table A.2 “Notes” column provides additional instructions. These notes will often contain instructions for placement of insulation in the reference house. When choosing an insulation configuration code keep in mind that added insulation values can be set to zero if no additional insulation is present.

A.2: Reference house foundation model

To set the effective RSI-value of foundation components in the reference house refer to Table A.2. First find the HOT2000 “Foundation Type” and the “Floor Criteria” used in the proposed house (the proposed and reference houses must share these). Read the “Reference house instructions” for that combination of foundation type and floor criteria. Then, search for the proposed house “Insulation Configuration Code” (this will be the same as in the reference house) in Table A.2 to determine if there are any special instructions in the “Notes” column. When looking for the “Insulation Configuration Code” make sure that you do not search beyond the appropriate HOT2000 “Foundation Type” and “Floor Criteria” section in Table A.2. Instructions are usually present in the “Notes” column if the chosen insulation configuration allows insulation to be added to more than one location on the foundation.

NBC Table 9.36.2.8.A lists the effective RSI-values required for the reference house foundation components. However, as described in Section 5.8.3.1, the foundation wall and/or floor-on-ground material and thickness are predefined in HOT2000’s foundation models. As part of this, HOT2000’s foundation walls and/or floors-on-ground have a predetermined RSI-value. Therefore, when adding insulation to the reference house foundation walls and/or floors-on-ground to satisfy the NBC Article 9.36.2.8 requirements, the existing RSI-value of the foundation wall and/or floor-on-ground must be taken into account. Table A.1 lists the RSI-values of HOT2000’s foundation components.

Table A.1: Pre-set Effective RSI-values for HOT2000 Foundation Components

| Component | RSI-value |
|---|-----------|
| Concrete basement wall | 0.116 |
| Concrete foundation floor (including all crawl space floors) | 0.0578 |
| Treated Wood basement wall | 0.417 |
| Treated Wood foundation floor | 0.833 |

As an example, consider a house being built in Ottawa that has a concrete basement with a heated floor. From Table A.2, a foundation with the HOT2000 BCIB_1 insulation configuration code would be permissible as per NBC Article 9.36.2.8. According to the proposed house design BCIB_1 is acceptable as well. Therefore, the proposed and reference houses are modeled using the BCIB_1 basement insulation configuration.

According to the “Reference house instructions” from Table A.2 for a basement with a heated floor the following are required:

- Wall insulation values as per “Foundation walls” in NBC Table 9.36.2.8.A
- Slab insulation values as per “Heated Floors” in NBC Table 9.36.2.8.A
- Set any other foundation surface insulation to 0.

According to NBC Table C-2 of Division B, Appendix C, the “Degree-Days Below 18 °C” for Ottawa range from 4440 to 4520, depending on the specific location. This range falls into “Zone 6 – 4000 to 4999” on NBC Table 9.36.2.8.A.

From the “Foundation walls” row on NBC Table 9.36.2.8.A., the required reference house foundation wall effective RSI-value is 2.98. From Table A.1 above, HOT2000 uses a concrete basement wall RSI-value of 0.116. Therefore, the effective RSI-value modeled for the reference house’s “Interior Added Insulation” is 2.86 (2.98 RSI – 0.116 RSI).

From the “Heated floors” row on NBC Table 9.36.2.8.A. the required reference house foundation floor-on-ground effective RSI-value is 2.32. From Table A.1 above, HOT2000 uses a concrete foundation floor RSI-value of 0.0578. Therefore, the effective RSI-value modeled for the reference house “Insulation Added to Slab” is 2.26 (2.32 RSI – 0.0578 RSI).

Table A.2: Permissible foundation insulation configurations

| Conditions | Insulation Configuration Code | Notes |
|---|--|---|
| If the reference house insulation requirements conflict, ALWAYS choose the highest insulation value. | | |
| Foundation Type: Basement | | |
| Floor Criteria: Unheated floor below frost line | | |
| Reference house instructions: - Wall insulation values as per "Foundation walls" in NBC Table 9.36.2.8.A - Set any other foundation surface insulation to 0 | | |
| Interior Wall Insulation | BCIN_1 BWIN_1 BBIN_1 | |
| Exterior Wall Insulation | BCEN_1 BCEN_2 BBEN_1 BWEN_1 | |
| Interior and Exterior Wall Insulation | BCCN_1 | Insulate only the interior of the foundation wall and set the overlap to cover the entire below grade foundation wall height. |
| | BCCN_2 | Same as BCCN_1 |
| | BCCN_3 | Insulate either the interior or exterior of the foundation wall. |
| | BCCN_4 | Insulate only the interior of the foundation wall. |
| | BCCN_5 | Insulate only the exterior of the foundation wall. |
| Interior Wall and Slab Insulation | BCIA_1 BCIA_3 BCIB_1 BCIB_2 BCIB_3 BCIB_4 | The reference house will include a thermal break around the slab that is not required by NBC Article 9.36.2.8. This will yield a stricter than necessary compliance test. |
| | BCIB_5 | Same as BCIB_4. |
| | BCIB_6 | Same as BCIB_4. |
| | BBIA_1 | |
| | | |

| Conditions | Insulation Configuration Code | Notes |
|--|--|---|
| | BBIA_2 BBIB_3 BBIB_1 BBIB_2 BBIB_5 | Same as BCIB_4. |
| Exterior Wall and Slab Insulation | BCEA_1 BCEA_4 BCEA_7 BCEA_3 BCEA_9 BCEB_1 BCEB_2 BCEB_3 BCEB_4 BCEB_5 BCEB_6 BBEA_2 BWEB_1 BWEB_2 BWEB_4 BBEB_1 BBEB_3 BBEB_4 | |
| Exterior, Interior and Slab Insulation | BCCA_7 BCCA_8 BCCA_1 BCCA_4 BCCB_4 BCCB_8 BCCB_9 BCCB_10 | Insulate only the interior of the foundation wall. Insulate only the exterior of the foundation wall. Insulate only the interior of the foundation wall and set the overlap to cover the entire below grade foundation wall height. Same as BCCA_1. Insulate either the interior or exterior of the foundation wall. If the interior foundation wall is insulated the reference house will include a thermal break around the slab that is not required by NBC Article 9.36.2.8. This will yield a stricter than necessary compliance test. Insulate either the interior or exterior of the foundation wall. Insulate only the interior of the foundation wall. Insulate only the interior of the foundation wall. |

| Conditions | Insulation Configuration Code | Notes |
|---|--|--|
| <p>Floor Criteria: Unheated floor above the frost line</p> <p>Reference house instructions:</p> <ul style="list-style-type: none"> - Wall insulation values as per “Foundation Walls” in NBC Table 9.36.2.8.A - Slab insulation values as per “Unheated floors – above frost line” in NBC Table 9.36.2.8.A - Set any other foundation surface insulation to 0 | | |
| | BCEN_1 BCEN_2 BWEN_1 BBEN_1 BCCN_3 BCIA_1 BWIA_2 BBIA_2 BCIB_4 BBIB_3 BCEB_1 BCEB_2 BCEB_3 BCEB_4 BCEB_5 BCEB_6 BWEB_1 BWEB_2 BWEB_4 | Insulate only the exterior of the foundation wall. Insulate only the exterior of the foundation wall. No slab insulation. Insulate only the exterior of the foundation wall. No slab insulation. Insulate only the exterior of the foundation wall. No slab insulation. Insulate only the exterior of the foundation wall. No slab insulation. Insulate only the exterior of the foundation wall. No slab insulation. Insulate only the exterior of the foundation wall. No slab insulation. Insulate only the exterior of the foundation wall. No slab insulation. Insulate only the exterior of the foundation wall. No slab insulation. |

| Conditions | Insulation Configuration Code | Notes |
|------------|-------------------------------|--|
| | BBEB_1 | Insulate only the exterior of the foundation wall. No slab insulation. |
| | BBEB_3 | Insulate only the exterior of the foundation wall. No slab insulation. |
| | BBEB_4 | Insulate only the exterior of the foundation wall. No slab insulation. |
| | BCEA_1 | Insulate only the exterior of the foundation wall. No slab insulation. |
| | BCEA_4 | Insulate only the exterior of the foundation wall. No slab insulation. |
| | BCEA_7 | Insulate only the exterior of the foundation wall. No slab insulation. |
| | BCEA_3 | Insulate only the exterior of the foundation wall. No slab insulation. |
| | BCEA_9 | Insulate only the exterior of the foundation wall. No slab insulation. |
| | BBEA_2 | Insulate only the exterior of the foundation wall. No slab insulation. |
| | BCCA_7 | Insulate only the interior of the foundation wall and slab. |
| | BCCA_8 | Insulate only the exterior of the foundation wall. No slab insulation. |
| | BCCA_1 | Insulate only the interior of the foundation wall (including slab) and set the overlap to cover the entire below grade foundation wall height. |
| | BCCA_4 | Same as BCCA_1. |
| | BCCB_4 | Insulate only the exterior of the foundation wall only. No slab insulation. Alternatively, insulate only the interior of the foundation wall, including the slab. |
| | BCCB_8 | Insulate only the exterior of the foundation wall only. No slab insulation. |

| Conditions | Insulation Configuration Code | Notes |
|--|--|---|
| <p>Floor Criteria: Heated Floor</p> <p>Reference house instructions:</p> <ul style="list-style-type: none"> - Wall insulation values as per “Foundation Walls” in NBC Table 9.36.2.8.A - Slab insulation values as per “Heated Floors” in NBC Table 9.36.2.8.A - Set any other foundation surface insulation to 0 | | |
| | BCIB_4 BBIB_3 BCEB_1 BCEB_4 BBEB_1 BCCB_4 | Insulate the slab and either the interior or exterior of the foundation wall. |
| <p>Foundation Type: Crawlspace</p> | | |
| <p>Floor Criteria: Unheated floor above the frost line</p> <p>Reference house instructions:</p> <ul style="list-style-type: none"> - Do not include below-grade wall height in modeling - Wall insulation values as per “Foundation Walls” in NBC Table 9.36.2.8.A for foundation walls less than 600 mm above grade - Wall insulation values as per “Walls” in NBC Table 9.36.2.6.B. for foundation walls greater than 600 mm above grade - Slab insulation values as per the higher of “Unheated floors – above frost line” and “Slabs-on-grade with an integral footing” in NBC Table 9.36.2.8.A | | |
| | SCA_17 SCA_18 SCA_19 SCA_20 SCA_21 SCA_22 SCA_23 SCA_24 SCB_33 SCB_34 | |

| Conditions | Insulation Configuration Code | Notes |
|---|--|-------|
| <p>Floor Criteria: Floors on permafrost</p> <p>Reference house instructions:</p> <ul style="list-style-type: none"> - Do not include below grade wall height in modeling - Wall insulation values as per “Foundation Walls” in NBC Table 9.36.2.8.A for foundation walls less than 600 mm above grade - Wall insulation values as per “Walls” in NBC Table 9.36.2.6.B. for foundation walls greater than 600 mm above grade - Slab insulation values as per “Heated and Unheated Floors on Permafrost” in NBC Table 9.36.2.8.A | | |
| | SCB_31 SCB_32 | |
| <p>Foundation Type: Slab-on-grade</p> | | |
| <p>Floor Criteria: Unheated floor above the frost line</p> <p>Reference house instructions:</p> <ul style="list-style-type: none"> - Slab insulation values as per “Slab-on-grade with integral footing” in NBC Table 9.36.2.8.A | | |
| | SCA_17 SCA_18 SCA_19 SCA_20 SCA_21 SCA_22 SCA_23 SCA_24 SCB_33 SCB_34 | |
| <p>Floor Criteria: Heated floor above the frost line</p> <p>Reference house instructions:</p> <p>Slab insulation values as per the higher of “Slab-on-grade with integral footing” and “Heated floors” in NBC Table 9.36.2.8.A</p> | | |
| | SCB_33 SCB_34 | |
| <p>Floor Criteria: Floors on permafrost</p> <p>Reference house instructions:</p> <p>Slab insulation values as per “Heated and Unheated Floors on Permafrost” in NBC Table 9.36.2.8.A</p> | | |
| | SCB_31 SCB_32 | |

APPENDIX B: ADDITIONAL HOT2000 MODELING PROCEDURES

B.1: Approximation of energy factor from thermal efficiency and standby loss

Many of the entries in NBC Tables 9.36.5.16 and 9.36.4.2 rate DHW efficiency in terms of thermal efficiency (E_t) as well as Standby Loss (S in %/hr, or SL in W). However, HOT2000 uses energy factor (EF) to model the efficiency of DHW systems. To approximate an EF for use in HOT2000 use the following equations:

To approximate SL from S :

$$SL = 0.432 * S * V \quad (B1.1)$$

where

SL = Standby Loss (W)

S = Standby Loss (%/hr) (amount of energy used by the water heater during the test divided by the energy required to raise the water in the tank from ambient air temperature during the test to the test hot-water temperature)

V = Measured volume of the hot-water tank (L).

To approximate EF from E_t , SL and P_{WH} ,

$$EF = \frac{43.3}{\frac{43.3}{E_t} + SL \left(0.0864 - \frac{43.3}{E_t P_{WH}} \right)} \quad (B1.2)$$

where

EF = Energy Factor

E_t = Thermal Efficiency (as a fraction, not %)

SL = Standby loss (W)

P_{WH} = Water heater input power (W).

When using the above equations to determine the EF of an electric storage hot-water heater assume an E_t of 0.98. If determining the EF of a tankless hot-water heater, assume an SL of 0 W.

B.2: Adjusting solar heat gain coefficient and U-value for fenestration

B.2.1: Introduction

The purpose of this procedure is to estimate the “Center of Glass,” “Edge of Glass,” and “Frame” RSI-values and “Center of Glass” SHGC required by the HOT2000 custom window code editor, using the overall U-value and overall solar heat gain coefficient (SHGC) available from window manufacturers. This is required because the overall U-value and SHGC are derived from tests on windows of a standard size and shape. HOT2000 requires “Center of Glass,” “Edge of Glass,” and “Frame” RSI-values and “Center of Glass” SHGC for windows with different sizes and shapes. This data is rarely available from manufacturer’s data sheets, so it is difficult for users to obtain the data needed for inclusion in HOT2000 runs.

B.2.2: Discussion

Manufacturer's specifications sheets for windows generally provide only overall U-value, and SHGC for windows of a standard size. Other descriptive information is also generally available from published information, or can easily be obtained from physical inspection of the window, or by reference to technical staff. It is expected that the following information can be obtained from various sources:

- Window U-value
- Window SHGC
- Window Height = H (mm)
- Window Width = W (mm)
- Frame height = h (mm)

In addition, it is assumed that the specifications for glazing type, fill type, window type, frame material and spacer type can be obtained, or inferred. Note that the “frame height” described above refers to the distance from the sill to the glass, and not the total height of the window.

B.2.3: Calculation of area fractions

The overall U-value and SHGC of a window is estimated from the sum of area-weighted U-values of the center of glass, edge of glass, and frame. The edge of glass is assumed to be a strip 63.5 mm wide along the perimeter of the frame.

There are essentially two types of geometry to be considered here, “picture” and “slider” windows. In slider windows, the glazing is split into two equal parts, so there is more “edge.”

For picture, hinged, and skylight windows the fraction of the total window area consumed by the frame (P_{fr}) and the center of glass (P_{cg}) are

$$P_{fr} = [(H * W) - (H - 2 * h)(W - 2 * h)] / (H * W), \quad (B2.1)$$

$$P_{cg} = [(H - 2 * h - 127)(W - 2 * h - 127)] / (H * W). \quad (B2.2)$$

For slider windows the fraction of the total window area consumed by the frame (P_{fr}) and the center of glass (P_{cg}) are

$$P_{fr} = [(H * W) - (H - 3 * h)(W - 2 * h)] / (H * W), \quad (B2.3)$$

$$P_{cg} = [(H - 3 * h - 254)(W - 2 * h - 127)] / (H * W). \quad (B2.4)$$

In the above equations for slider windows (B2.3 and B2.4) it is assumed that H is the largest dimension. Therefore, if the actual window's width is greater than its height (i.e. a horizontal slider), exchange the values of H and W in the equations.

In both cases, the fraction of the total window area consumed by the edge of glass (P_{eg}) is given by

$$P_{eg} = 1 - P_{cg} - P_{fr}. \quad (B2.5)$$

It is important to note that in the above equations, the overall window dimensions must be large enough to accommodate both the window frame, and the edge of glass.

The overall U-value ($W/m^2\text{°C}$) of the window is given by

$$U_w = U_{cg} * P_{cg} + U_{eg} * P_{eg} + U_{fr} * P_{fr}. \quad (B2.6)$$

where

U_{fr} = frame U-value ($W/m^2\text{°C}$),

U_{eg} = edge of glass U-value ($W/m^2\text{°C}$),

U_{cg} = center of glass U-value ($W/m^2\text{°C}$).

Similarly, the overall solar heat gain coefficient (S_w) of the window is given by

$$S_w = S_{cg} * (P_{cg} + P_{eg}) + 0.0135 * U_{fr} * P_{fr} \quad (B2.7)$$

where

S_w = overall solar heat gain coefficient,

S_{cg} = center of glass solar heat gain coefficient.

B.2.4: Calculation of parameters using overall U-value and SHGC

To start, determine the glazing cavity width. This can be found from Appendix Table B.2.1 and the glazing type and window fill type. If the glazing cavity width is greater than 26 mm, the frame is considered to be "thick." Otherwise, the frame is considered "thin."

Next determine the frame U-value for windows with metal spacers (A). For thin frames, this can be found from Table B.2.2 and the window type and frame material. If the frame is thick, use Table B.2.4. Subsequently, determine the frame U-value for

windows with insulating spacers (B). For thin frames, this can be found from table B.2.3 and the window type and frame material. If the frame is thick, use Table B.2.5.

Note that any negative values shown in Tables B.2.2 through B.2.5 indicate that there is no frame U-value information available for that combination of window descriptors. That means that the type is either impossible, or no data is available. In these cases, unless the reader has access to specific frame U-value information, windows of this type and frame material cannot be handled using this procedure.

Finally, the frame U-value is determined by combining A and B as determined above. Use the window spacer present to determine which of the following equations to apply:

$$\text{Metal Spacer} \quad U_{fr} = A \quad (B2.8)$$

$$\text{Fused Glass} \quad U_{fr} = (A + B) / 2 \quad (B2.9)$$

$$\text{Insulating} \quad U_{fr} = B \quad (B2.10)$$

$$\text{Metal + Insulating} \quad U_{fr} = 0.15 * A + 0.85 * B \quad (B2.11)$$

Proceed by determining the three edge of glass U-value coefficients (A1, A2, and A3). These can be found using Table B.2.6 and the window spacer type. Two center of glass U-values (U_{cg1} and U_{cg2}) must then be estimated using equation B2.12:

$$U_{cg1} = \frac{[-(P_{cg} + P_{eg} * A_2) + \sqrt{(P_{cg} + P_{eg} * A_2)^2 - 4 * P_{eg} * A_3 * (P_{eg} * A_1 + U_{fr} * P_{fr} - U_w)}]}{[2 * P_{eg} * A_3]}$$

and equation B2.13:

$$U_{cg2} = \frac{[-(P_{cg} + P_{eg} * A_2) - \sqrt{(P_{cg} + P_{eg} * A_2)^2 - 4 * P_{eg} * A_3 * (P_{eg} * A_1 + U_{fr} * P_{fr} - U_w)}]}{[2 * P_{eg} * A_3]}$$

The center of glass U-value (U_{cg}) to use in HOT2000 will be either U_{cg1} or U_{cg2} . U_{cg} will be a positive number and likely has an order of magnitude of 1 W/m²°C. Therefore, set U_{cg} to be whichever of U_{cg1} or U_{cg2} that is positive and has an order of magnitude closest to 1 W/m²°C.

The edge of glass U-value (U_{eg}) can then be calculated as follows:

$$U_{eg} = A_1 + U_{cg} * (A_2 + U_{cg} * A_3). \quad (B2.14)$$

The centre of glass solar heat gain coefficient is then determined using:

$$S_{cg} = [S_w - 0.0135 * U_{fr} * P_{fr}] / [P_{cg} + P_{eg}]. \quad (B2.15)$$

Note that the solar heat gain coefficient for the edge of glass is assumed to be the same as it is for the centre of glass.

To create a user defined window code in the HOT2000 v10.51 code editor the “Center of Glass” RSI-value (R_{cg}), “Edge of Glass” RSI-value (R_{eg}), and “Frame” RSI-value (R_{fr}) must be known along with the “Center of Glass” SHGC, “Frame Height,” and “Window Type.” The “Center of Glass” SHGC is S_{cg} as calculated above in equation C2.15. The “Frame Height” and “Window Type” are assumed to be known. R_{cg} , R_{eg} , and R_{fr} are calculated as follows:

$$R_{cg} = \frac{1}{U_{cg}} \quad (\text{B2.16})$$

$$R_{eg} = \frac{1}{U_{eg}} \quad (\text{B2.17})$$

$$R_{fr} = \frac{1}{U_{fr}} \quad (\text{B2.18})$$

Table B.2. 1: Glazing Cavity Widths (mm)

| Fill Type | Glazing Type | | | | | | | |
|--------------|--------------|-----------------------------------|-----------------------------------|--------------------|----------------|-----------------------|-----------------------|-----------------------|
| | Single (SG) | Double (DG) or Double with 1 coat | Triple (TG) or Triple with 1 coat | TG with 2 coatings | Double Acrylic | DG + 1 Heat Mirror 66 | DG + 1 Heat Mirror 88 | DG + 2 Heat Mirror 88 |
| 13 mm Air | 0 | 19 | 35 | 35 | 19 | 32 | 32 | 45 |
| 9 mm Air | 0 | 15 | 27 | 27 | 15 | 24 | 24 | 33 |
| 6 mm Air | 0 | 12 | 21 | 21 | 12 | 18 | 18 | 24 |
| 13 mm Argon | 0 | 19 | 35 | 35 | 19 | 32 | 32 | 45 |
| 9 mm Argon | 0 | 15 | 27 | 27 | 15 | 24 | 24 | 33 |
| 6 mm Argon | 0 | 12 | 21 | 21 | 12 | 18 | 18 | 24 |
| 9 mm Krypton | 0 | 15 | 27 | 27 | 15 | 24 | 24 | 33 |

Table B.2. 2: U-values of Thin Frames with Metal Spacers (W/m²°C)

| Frame Material | Window Type | | | | | |
|--------------------------|-------------|--------|------------------|------------------|------------|----------|
| | Picture | Hinged | Slider with sash | Semi-sash Slider | Patio Door | Skylight |
| Aluminum | 10.1 | 12.4 | 12.4 | 10.2 | 12.7 | 38.6 |
| Aluminum + Thermal Break | 6.6 | 5.4 | 5.4 | 3.8 | 5.9 | 29.0 |
| Wood | 2.8 | 2.9 | 2.9 | 2.0 | 2.8 | 11.5 |
| Aluminum Clad | 3.0 | 3.6 | 3.6 | 2.0 | 3.1 | 13.1 |
| Vinyl | 2.8 | 2.9 | 2.9 | 2.0 | 2.8 | 11.5 |
| Reinforced Vinyl | 3.0 | 3.6 | 3.6 | 2.0 | 3.1 | 13.1 |

| | | | | | | |
|------------|-----|-----|-----|-----|-----|-----|
| Fibreglass | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | -99 |
|------------|-----|-----|-----|-----|-----|-----|

Table B.2. 3: U-values of Thin Frames with Insulating Spacers (W/m²°C)

| Frame Material | Window Type | | | | | |
|--------------------------|-------------|--------|------------------|------------------|------------|----------|
| | Picture | Hinged | Slider with sash | Semi-sash Slider | Patio Door | Skylight |
| Aluminum | 10.1 | 12.4 | 12.4 | -99 | 12.7 | 38.7 |
| Aluminum + Thermal Break | 5.2 | 4.9 | 4.9 | -99 | 5.5 | 26.6 |
| Wood | 2.4 | 2.6 | 2.6 | -99 | 2.5 | 11.0 |
| Aluminum Clad | 2.6 | 3.2 | 3.2 | -99 | 2.8 | 12.8 |
| Vinyl | 2.4 | 2.6 | 2.6 | -99 | 2.5 | 11.0 |
| Reinforced Vinyl | 2.6 | 3.2 | 3.2 | -99 | 2.8 | 12.8 |
| Fibreglass | 1.6 | 1.6 | 1.6 | -99 | 1.6 | -99 |

Table B.2. 4: U-values of Thick Frames with Metal Spacers (W/m²°C)

| Frame Material | Window Type | | | | | |
|--------------------------|-------------|--------|------------------|------------------|------------|----------|
| | Picture | Hinged | Slider with sash | Semi-sash Slider | Patio Door | Skylight |
| Aluminum | 10.1 | 12.4 | 12.4 | 7.5 | 12.7 | 38.6 |
| Aluminum + Thermal Break | 6.6 | 5.4 | 5.4 | 3.7 | 5.7 | 27.7 |
| Wood | 2.7 | 2.7 | 2.7 | 1.2 | 2.7 | 11.3 |
| Aluminum Clad | 2.8 | 3.3 | 3.3 | 1.2 | 2.9 | 12.9 |
| Vinyl | 2.7 | 2.7 | 2.7 | 1.2 | 2.7 | 11.3 |
| Reinforced Vinyl | 2.8 | 3.3 | 3.3 | 1.2 | 2.9 | 12.9 |
| Fibreglass | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | -99 |

Table B.2. 5: U-values of Thick Frames with Insulating Spacers (W/m²°C)

| Frame Material | Window Type | | | | | |
|--------------------------|-------------|--------|------------------|------------------|------------|----------|
| | Picture | Hinged | Slider with sash | Semi-sash Slider | Patio Door | Skylight |
| Aluminum | 10.1 | 12.4 | 12.4 | -99 | 12.7 | 38.6 |
| Aluminum + Thermal Break | 5.2 | 4.9 | 4.9 | -99 | 5.4 | 26.3 |
| Wood | 2.1 | 2.2 | 2.2 | -99 | 2.3 | 10.6 |
| Aluminum Clad | 2.3 | 2.7 | 2.7 | -99 | 2.5 | 12.6 |
| Vinyl | 2.1 | 2.2 | 2.2 | -99 | 2.3 | 10.6 |
| Reinforced Vinyl | 2.3 | 2.7 | 2.7 | -99 | 2.5 | 12.6 |
| Fibreglass | 1.4 | 1.4 | 1.4 | -99 | 1.4 | -99 |

Table B.2. 6: Coefficients for Edge of Glass U-values (W/m²°C)

| Spacer Type | A1 | A2 | A3 |
|--------------------|-------|-------|--------|
| Metal | 1.266 | 0.842 | -0.027 |
| Glass | 0.897 | 0.774 | 0.010 |
| Insulating | 0.681 | 0.682 | 0.043 |
| Metal + Insulating | 0.769 | 0.706 | 0.033 |

B.2.5: Examples

Below are two example calculations. In both cases, the input data was derived from standard (built in) HOT2000 window types (codes 200002 and 414325) to allow easy checking of the results.

B.2.5.1: Example 1- Picture window

For this example, we have a picture window 900 mm wide by 1200 mm high, with a frame height of 41 mm. This is a double glazed window with one coat, 13 mm air, Metal spacer, and Wood frame, with an overall U-value of 2.938 W/m²°C, and SHGC=0.6493.

From equations B2.1 and B2.2 we have

$$P_{fr} = [(900*1200)-(1200-2*41)(900-2*41)]/[900*1200] = 0.1532 \text{ and}$$

$$P_{cg} = [(1200-2*41-127)(900-2*41-127)]/[900*1200] = 0.6341.$$

Then from equation B2.5 we have

$$P_{eg} = 1 - 0.1532 - 0.6341 = 0.2127.$$

Table B.2.1 indicates that this is a “thin” frame because the glazing cavity width is 19 mm. From Table B.2.2 $A = 2.8 \text{ W/m}^2\text{°C}$. Since this window has a metal spacer equation B2.8 is used and $U_{fr} = 2.8 \text{ W/m}^2\text{°C}$.

From Table B.2.6, we find that for windows with metal spacers $A1=1.266$, $A2=0.842$, and $A3=-0.027$.

Entering this into equation B2.12, we find that U_{cg1} is

$$U_{cg1} = \frac{-(0.6341+0.2127*0.842)+\text{Sqrt}((0.6341+0.2127*0.842)^2-4*0.2127*-0.027*(0.2127*1.266+2.8*0.1532-2.938))}{(2*0.2127*-0.027)} = 2.81 \text{ W/m}^2\text{°C}.$$

From equation B2.13 we find that $U_{cg2} = 138.79 \text{ W/m}^2\text{°C}$.

U_{cg1} is the positive number with an order of magnitude closest to $1 \text{ W/m}^2\text{°C}$. Therefore, $U_{cg} = 2.81 \text{ W/m}^2\text{°C}$.

U_{eg} is calculated using equation B2.14 as

$$U_{eg} = 1.266+2.81*[0.842+2.81*(-0.027)] = 3.4186 \text{ W/m}^2\text{°C}.$$

From equation B2.15 the centre of glass solar heat gain coefficient is

$$S_{cg} = [0.6493-0.0135*2.8*0.1532]/[0.6341+0.2127] = 0.7599 \text{ W/m}^2\text{°C}.$$

R_{cg} , R_{eg} , and R_{fr} are then found as follows:

$$R_{cg} = 1/2.8100 \text{ W/m}^2\text{°C} = 0.3559 \text{ m}^2\text{°C/W (RSI)}$$

$$R_{eg} = 1/3.4186 \text{ W/m}^2\text{°C} = 0.2925 \text{ m}^2\text{°C/W (RSI)}$$

$$R_{fr} = 1/2.8 \text{ W/m}^2\text{°C} = 0.36 \text{ m}^2\text{°C/W (RSI)}.$$

These numbers can then be entered into the HOT2000 v10.51 code editor to define a user defined window code for windows of this size and construction. This window code can then be used to model the windows of this size and construction.

B.2.5.2: Example 2 – Vertical slider with sash

This is a Vertical Slider 900 mm wide by 1200 mm high, with a frame height of 71 mm. Triple glazed window two coats, 9 mm argon, metal + insulating spacer, reinforced vinyl frame, $U\text{-value} = 1.6023 \text{ W/m}^2\text{°C}$, $SHGC = 0.2055$.

From EQ. B2.3 and B2.4, we have

$$P_{fr} = [(1200*900)-(1200-3*71)(900-2*71)]/[1200*900] = 0.3073 \text{ and}$$

$$P_{cg} = [(1200-3*71-254)(900-2*71-127)]/[900*1200] = 0.4283$$

Then from equation B2.5 we have

$$P_{eg} = 1 - 0.4283 - 0.3073 = 0.2645.$$

Table B.2.1 indicates that this is a “thick” frame because the glazing cavity width is 27 mm.

From Tables B.2.4 and B.2.5, respectively, the frame $A = 3.3 \text{ W/m}^2\text{°C}$ and $B = 2.7 \text{ W/m}^2\text{°C}$. Since the window has a metal + insulating spacer equation B2.11 is used. Therefore, $U_{fr} = 0.15*3.3+0.85*2.7=2.79 \text{ W/m}^2\text{°C}$.

From Table B.2.6, find that for windows with metal + insulating spacers $A1=0.769$, $A2=0.706$, and $A3=0.033$.

Entering this into equation B2.12, we find that U_{cg1} is

$$U_{cg1} = \frac{-(-0.4283+0.2645*0.706)+\text{Sqrt}((0.4283+0.2645*0.706)^2-4*0.2645*0.033*(0.2645*0.769+2.79*0.3073-1.6023))}{2*0.2645*0.033} = 0.8698.$$

From equation B2.13 we find that $U_{cg2} = -71.34 \text{ W/m}^2\text{°C}$.

U_{cg1} is the positive number with an order of magnitude closest to $1 \text{ W/m}^2\text{°C}$. Therefore, $U_{cg} = 0.8698 \text{ W/m}^2\text{°C}$.

U_{eg} is calculated using equation B2.14 as

$$U_{eg} = 0.769+0.8698*[0.706+0.8698*0.033] = 1.408 \text{ W/m}^2\text{°C}.$$

From equation B2.15 the centre of glass solar heat gain coefficient is

$$S_{cg} = [0.2055-0.0135*2.79*0.3073]/[0.4283+0.2645] = 0.2799 \text{ W/m}^2\text{°C}.$$

R_{cg} , R_{eg} , and R_{fr} are then found as follows:

$$R_{cg} = 1/0.8698 \text{ W/m}^2\text{°C} = 1.1497 \text{ m}^2\text{°C/W (RSI)}$$

$$R_{eg} = 1/1.408 \text{ W/m}^2\text{°C} = 0.7102 \text{ m}^2\text{°C/W (RSI)}$$

$$R_{fr} = 1/2.79 \text{ W/m}^2\text{°C} = 0.3584 \text{ m}^2\text{°C/W (RSI)}.$$

These numbers can then be entered into the HOT2000 v10.51 code editor to define a user defined window code for windows of this size and construction. This window code can then be used to model the windows of this size and construction.

B.3: Determining a composite foundation added insulation effective RSI-value

As discussed in Section 5.8.3.1 heat conduction through basement walls is complicated, and is influenced by more factors than heat conduction through above-ground walls. Because of this, and the way the HOT2000 heat transfer model was developed, HOT2000 models basement walls separately from the insulation placed on the walls. That is, insulation is modeled as being added to the exterior or interior (or both) of a basement wall. This is unlike above-ground walls where insulation is modeled as being a part of the wall.

The insulation configuration defines the vertical placement of the insulation and whether it is placed on the inside or outside (or both) of the foundation wall. The “Interior Added Insulation” and “Exterior Added Insulation” fields in the basement “Wall/Floor Construction” tab are used to define the amount of insulation added to the inside or outside of the basement wall, as defined by the insulation configuration. The

basement wall itself is implicitly defined in HOT2000's basement model. As a consequence of this, all concrete foundation walls are assumed to be 8" thick with an effective RSI-value of 0.116 and all treated wood foundation walls are assumed to have an effective RSI-value of 0.417.

It is important to note that HOT2000 assumes that the insulation defined by the insulation configuration extends around the entire exposed perimeter of the modeled basement wall. If this is not the case, the effective RSI-value entered in the "Interior Added Insulation" or "Exterior Added Insulation" fields must be modified to compensate.

For example, consider a concrete basement where the inside surface of the basement wall was covered with insulation from the top of the basement wall to 0.6 m below-ground level. The insulation configuration selected would be BCIN_4. If the effective RSI-value of the insulation was 2.0 RSI, and the insulation was placed around the entire exposed perimeter of the inside basement wall then 2.0 RSI would be entered into the "Interior Added Insulation" "Value" field. However, if the insulation only covered ¼ of the exposed perimeter of the inside basement wall then the effective RSI-value entered in the "Interior Added Insulation" "Value" field would have to be adjusted.

The correction is performed using the following procedure:

$$R_{comp. eff.} = \frac{1}{\frac{f_{P1}}{R_{1eff.}} + \frac{f_{P2}}{R_{2eff.}} + \frac{f_{P3}}{R_{3eff.}}} - R_{found. wall} \quad (B3.1)$$

where

$R_{comp. eff.}$ = the effective composite RSI-value of the insulation added to the surface of the foundation wall.

$R_{1eff.}, R_{2eff.}, R_{3eff.}$ = the effective RSI-value of the different basement wall sections. Note that this RSI-value includes both the effective RSI-value of the insulation added to the surface of the basement wall and the RSI-value of the basement wall itself.

$R_{found. wall}$ = the RSI-value of just the basement wall excluding any added insulation (0.116 RSI for concrete, 0.417 for treated wood).

f_{P1}, f_{P2}, f_{P3} = the fraction of the exposed perimeter each section of insulation covers. Note that this is a perimeter fraction and not an area fraction. The insulation configuration defines how far up or down the foundation wall the insulation extends. This fraction defines how far around the foundation wall the insulation extends.

As mentioned above, $R_{1eff.}, R_{2eff.},$ and $R_{3eff.}$ (or $R_{xeff.}$) include the effective RSI-value of both the insulation added to the section of foundation wall and the section of foundation wall itself. It is calculated by adding the effective RSI-value of the insulation applied to the surface of the section of foundation wall to the RSI-value of the foundation wall itself. If no insulation is added to a given section of foundation wall then the $R_{xeff.}$ is equal to $R_{found. wall}$.

Determine $R_{x eff.}$ as follows:

$$R_{x eff.} = R_x + R_{found. wall} \quad (B3.2)$$

where

R_x = the effective RSI-value of the insulation (or assembly) added to basement wall section x.

Determine the perimeter fractions as follows:

$$f_{Px} = \frac{P_x}{P_{total}} \quad (B3.3)$$

where

f_{Px} = the fraction of the exposed perimeter of basement wall section x,

P_x = the perimeter of basement wall section x in m,

P_{total} = the total exposed perimeter of the basement wall in m.

Note that it is only the exposed perimeter (either on the inside or outside of the basement wall) that is considered in this calculation. If multiple foundations are present, and portions are attached, do not include the attached perimeters.

Also, keep in mind that the above composite value is only calculated for the insulation added to one side of the basement wall. If insulation was added to both sides of a foundation wall, conduct the above calculations for one side at a time. Therefore, conduct the calculations for the inside added insulation on its own (R_x would include only insulation added to the inside of the foundation wall). Likewise, conduct the calculations for the exterior added insulation on its own (R_x would include only insulation added to the exterior of the foundation wall).

B.3.1: Example 1

Consider a basement with insulation configuration BCCN_2. The foundation wall has a perimeter of 40.0 m and a total height of 2.1 m. For 10.0 m, the below-ground portion of the outside of the basement wall is covered by insulation with an effective RSI-value of 1.800 RSI. For another 20.0 m, the below-ground portion of the exterior basement wall is covered by insulation with an effective RSI-value of 2.000 RSI. For 25.0 m, a stud wall with an effective RSI-value of 1.600 RSI covers the inside surface of the foundation wall from the top of the foundation wall to 1.0 m below ground. The basement extends a total of 1.6 m below ground. We wish to determine the interior and exterior added insulation values.

We will use only inside dimensions for calculation in the following calculations.

$$P_{total} = 40.0 \text{ m}$$

For the interior added insulation:

The stud wall will be section 1 and the remaining bare wall will be section 2.

$$P_1 = 25.0 \text{ m}$$

$$f_{P1} = P_1/P_{total} = 25 \text{ m}/40 \text{ m} = 0.625$$

$$f_{P2} = 1 - f_{P1} = 0.375$$

$$R_1 = 1.600 \text{ RSI}$$

$$R_{\text{found. wall}} = 0.116 \text{ RSI}$$

$$R_{1\text{eff.}} = R_1 + R_{\text{found. wall}} = 1.600 \text{ RSI} + 0.116 \text{ RSI} = 1.716 \text{ RSI}$$

$$R_{2\text{eff.}} = R_{\text{found. wall}} = 0.116 \text{ RSI}$$

$$R_{\text{comp.eff.}} = \frac{1}{\frac{f_{P1}}{R_{1\text{eff.}}} + \frac{f_{P2}}{R_{2\text{eff.}}}} - R_{\text{found.wall}} = \frac{1}{\frac{0.625}{1.716\text{RSI}} + \frac{0.375}{0.116\text{RSI}}} - 0.116\text{RSI} = 0.162\text{RSI}$$

The effective “Interior Added Insulation” RSI-value would be 0.162.

For the exterior added insulation:

The 1.800 RSI insulation will be added to section 1, the 2.000 RSI insulation will be added to section 2, and the remaining bare wall will be section 3.

$$P_1 = 10.0 \text{ m}$$

$$f_{P1} = P_1/P_{\text{total}} = 10.0 \text{ m}/40.0 \text{ m} = 0.250$$

$$P_2 = 20.0 \text{ m}$$

$$f_{P2} = P_2/P_{\text{total}} = 20.0 \text{ m}/40.0 \text{ m} = 0.500$$

$$f_{P3} = 1 - f_{P1} - f_{P2} = 1 - 0.250 - 0.500 = 0.250$$

$$R_1 = 1.800 \text{ RSI}$$

$$R_2 = 2.000 \text{ RSI}$$

$$R_{\text{found. wall}} = 0.116 \text{ RSI}$$

$$R_{1\text{eff.}} = R_1 + R_{\text{found. wall}} = 1.800 \text{ RSI} + 0.116 \text{ RSI} = 1.916 \text{ RSI}$$

$$R_{2\text{eff.}} = R_2 + R_{\text{found. wall}} = 2.000 \text{ RSI} + 0.116 \text{ RSI} = 2.116 \text{ RSI}$$

$$R_{3\text{eff.}} = R_{\text{found. wall}} = 0.116 \text{ RSI}$$

$$R_{\text{comp.eff.}} = \frac{1}{\frac{f_{P1}}{R_{1\text{eff.}}} + \frac{f_{P2}}{R_{2\text{eff.}}} + \frac{f_{P3}}{R_{3\text{eff.}}}} - R_{\text{found.wall}} = \frac{1}{\frac{0.250}{1.916\text{RSI}} + \frac{0.500}{2.116\text{RSI}} + \frac{0.25}{0.116\text{RSI}}} - 0.116\text{RSI} = 0.281\text{RSI}$$

The effective “Exterior Added Insulation” RSI-value would be 0.281.

Note that in this example the basement wall below-grade depth, the total basement wall height, and the interior and exterior insulation coverage heights were not used when calculating the effective RSI-values of the “Interior Added Insulation” and “Exterior Added Insulation” effective RSI-values. This is because they are irrelevant to the above calculations. They are important dimensions that need to be used when modeling the basement in HOT2000. However, they do not affect the effective RSI-value of the added insulation.

B.4: Entering P.9 combo systems in the HOT2000 proposed and reference house models

B.4.1: Scope

The following modeling procedure applies to

- 1) Natural Gas, oil, or propane-fired equipment tested to CSA P.9-11, with accompanying "Performance Specification Summary" from the testing laboratory.
- 2) HOT2000 Versions 10.51
- 3) Single-family homes.

B.4.2: Proposed-house modeling

In the "Heating/Cooling System" tab of HOT2000, select "Combo Heat/DHW"

In the "Combo Heat/DHW" screen, enter the following data:

1. **Energy Source:** Select Natural Gas, Oil, or Propane
2. **Equipment Type:** Select the most appropriate type from the list, this will most likely be either "Heater w/ induced draft fan" or "Condensing heater".
3. **Output Capacity:** Select "User Specified", and enter the value "Space Heating Capacity" from the summary sheet. Make sure that the units next to the input box are specified as "kW".
4. **Sizing Factor:** Leave at 1.
5. **Efficiency:** Enter the Composite Space Heating Efficiency (CSHE) from the P.9 summary sheet.
6. **Pilot light and Flue Diameter:** It is unlikely that equipment tested to P.9 would have a pilot light, nor an open flue, so these inputs will most likely always be zero.
7. **Tank Capacity:** Input as specified in the "Description of major components" section of the summary. If this is a tankless system, select "User Specified", and enter 0.0.
8. **Energy Factor:** Select "User Specified" and enter the value specified for Water Heating Performance Factor (WHPF).
9. **Tank Location:** As indicated in the plans.
10. **Circulation Pump:** Set the value to 0.0.
11. **Energy Efficient Pump Motor:** Do not check.
12. **Water Temperature:** Enter 60°C (140°F) unless otherwise indicated in the Combo specifications.

Fans / Pumps

In the "Heating/Cooling System" tab of HOT2000, select "Combo Heat/DHW"

In the "Fans/Pumps" tab, enter the following data:

1. **Mode:** Select "Two speed"
2. **Power:** Select "User Specified"

3. **Energy Efficient Motor:** Check this box if indicated in the description.
4. **High Speed Fan Power:** Use the following calculation to determine the value to enter as the "High Speed Power."

$$P = 0.1*(\text{Average Electricity Use @ PLF}=1) + 0.6*(\text{Average Electricity Use @ PLF}=0.4) + 0.3*(\text{Average Electricity Use @ PLF}=0.15)$$

5. **Low Speed Fan Power:** To account for the circulating pumps and standby electrical consumption, the "Low Speed Power" input will be used. Use the following calculation to determine the value to enter as the "Low Speed Power."

$$P = 1000(\text{W/kW}) * \text{Daily Electricity use for water heating (kWh)} / 24(\text{h}) + 1/3 \text{ of } P_{\text{circ}}$$

NBC Section 9.36.5.11 specifies a procedure to determine the minimum forced-air heating system circulation fan power. This procedure is provided in Section 5.10 of this document. If the P.9 system "Circulating Blower" power at "PLF 1" is the same as, or higher than, the minimum forced-air heating system circulating fan power determined in Section 5.10 then apply the following procedure to the modeled P.9 system:

1. Determine the fan power adjustment factor by dividing the minimum forced-air heating system circulating fan power from section 5.10 by the P.9 system "Circulating Blower" power at "PLF 1."
2. **High Speed Fan Power:** Multiply the "High Speed Fan Power" determined in step 5 of the above "Fans / Pumps" procedure by the fan power adjustment factor and use this new number as the high speed fan power.

B.4.3: Reference-house modeling

If a P.9 combo system is present in the proposed house use the same model in the reference house with the following changes:

1. **Output Capacity:** If the P.9 combo is used to meet the full heating demand of the house, size the output capacity according to NBC Article 9.33.5.1. Otherwise, ensure the total capacity of all heating systems is sized to meet NBC Article 9.33.5.1.
2. **Efficiency:** Enter a steady state efficiency of 64%.
3. **Energy Factor:** Enter an Energy Factor of 0.69.
4. **High Speed Fan Power:** Set the high speed and low speed fan powers according to the procedure outlined in Section 6.6.

B.5: Modeling a walkout basement with attached slab-on-grade foundation

To model the slab-on-grade and walkout foundations separately use the following procedure:

- Model a slab-on-grade foundation with the same total perimeter and area as the slab-on-grade portion of the walkout with slab-on-grade foundation.
- Set the slab-on-grade foundation's "Exposed Surfaces Perimeter" to the perimeter of the slab-on-grade foundation that is not attached to the rest of the foundation.
- Model the portion of the walkout basement that is not a slab-on-grade foundation (hereafter referred to as the "remainder") as a basement.
- Set the total floor perimeter and area of the basement to that of the remainder.
- Set the "Exposed Surfaces Perimeter" of the basement to be the perimeter of the remainder that is not attached to the slab-on-grade foundation.
- Calculate the total wall area of the entire foundation (basement and slab-on-grade portions).
- Calculate the total below-ground wall area of the basement.
- Divide the total below-ground wall area of the basement by the "Exposed Surfaces Perimeter" of the basement to determine the average depth below grade.
- Enter the average depth below grade into the basement "Depth Bel. Gr." edit box.
- Calculate the average basement height by dividing the total wall area of the entire foundation by the "Exposed Surfaces Perimeter" of the basement.
- Enter the average basement height into the basement "Total Height" edit box.
- If there is a pony wall, determine the pony wall height by dividing the total pony wall area (for both the basement and slab-on-grade foundations) by the "Exposed Surfaces Perimeter" of the basement.
- Check the "Pony Wall" box and enter the pony wall height into the basement "Height" edit box.
- Model all foundation walls as being part of the basement. Do not model any foundation wall as a "Main Wall" above the slab-on-grade foundation.

APPENDIX C: SAMPLE NBC 9.36.5 COMPLIANCE REPORT

Statement that Calculation Was Performed in Compliance with Section 9.36.5 of Division B

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Building Envelope

Note: Verify all parameters in the HOT2000 Full House Report

Above-Ground

Below-Ground

| Walls | R-Value* (K·m ² /W) | Area (m ²) |
|------------|--------------------------------|------------------------|
| | | |
| | | |
| | | |
| Total Area | | |

| Walls | R-Value* (K·m ² /W) | Area (m ²) |
|------------|--------------------------------|------------------------|
| | | |
| | | |
| | | |
| Total Area | | |

| Floors | R-Value* (K·m ² /W) | Area (m ²) |
|------------|--------------------------------|------------------------|
| | | |
| | | |
| | | |
| Total Area | | |

| Floors | R-Value* (K·m ² /W) | Area (m ²) |
|------------|--------------------------------|------------------------|
| | | |
| | | |
| | | |
| Total Area | | |

| Ceilings | R-Value* (K·m ² /W) | Area (m ²) |
|------------|--------------------------------|------------------------|
| | | |
| | | |
| | | |
| Total Area | | |

* The effective thermal resistance values and respective areas for opaque building envelope assemblies that cover less than 2% of total area of their respective assembly type need not be provided.

Windows

Doors

| Window # | U-Value W/(m ² K) | SHGC | Area (m ²) | Door # | U-Value W/(m ² K) | Area (m ²) |
|------------|------------------------------|------|------------------------|--------|------------------------------|------------------------|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Total Area | | | | | | |
| Total Area | | | | | | |

Windows & Doors Total Area / Gross Wall Area Ratio: _____ %

