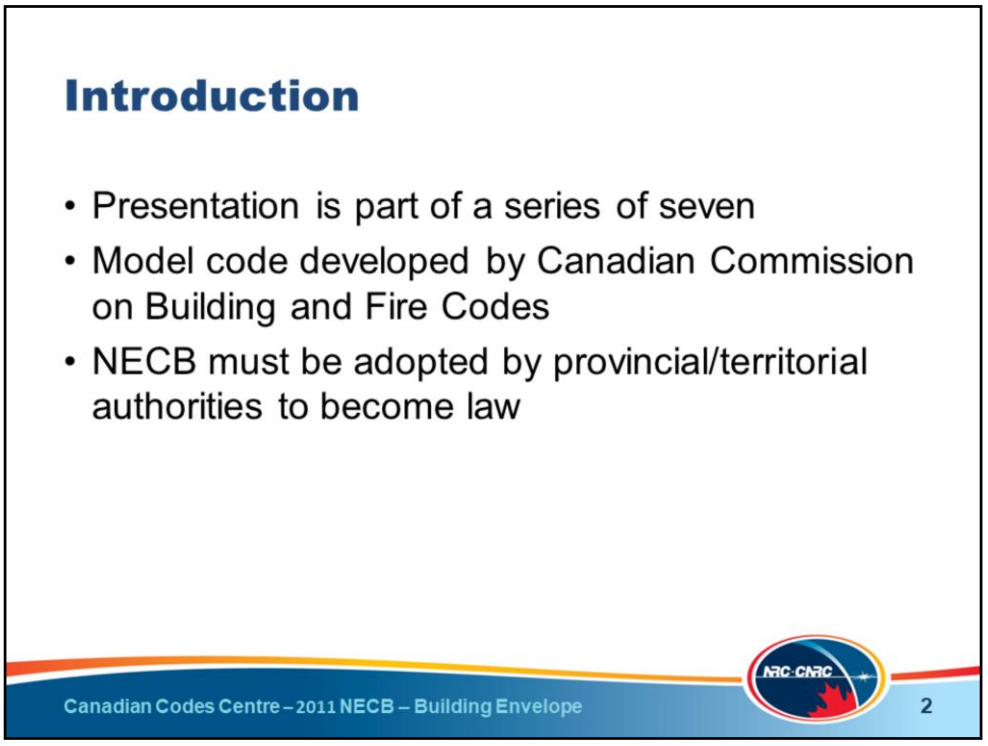
Welcome!
My name is Heather Knudsen.

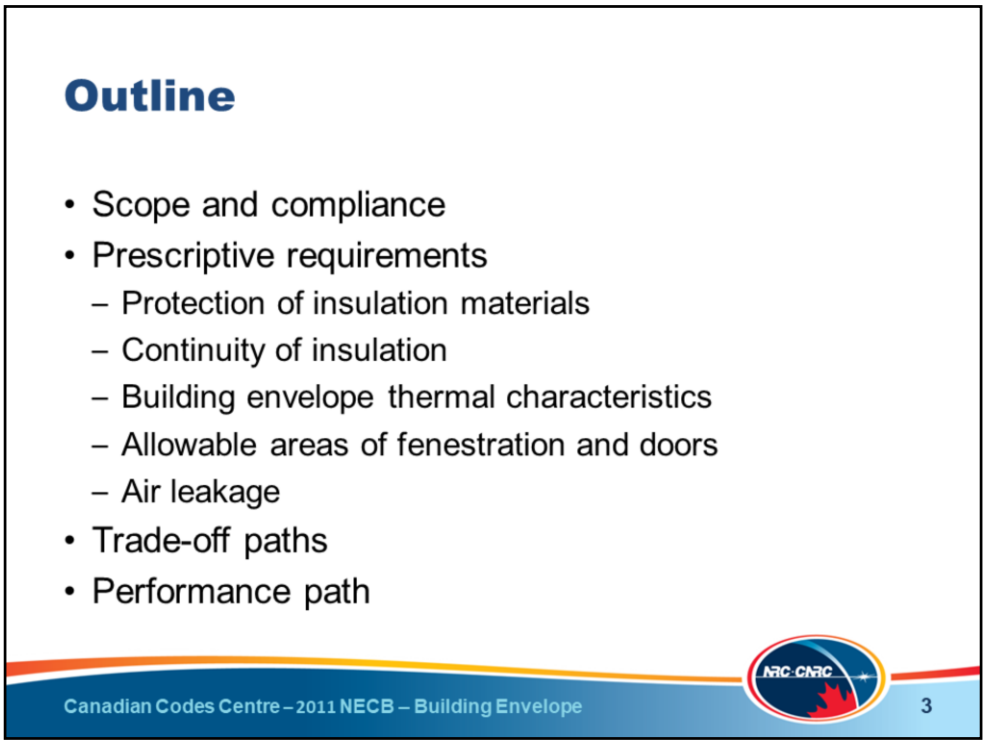
This presentation focuses on Part 3 of the 2011 National Energy Code of Canada for Buildings (NECB), which deals with the building envelope.



This presentation is part of a series of 7 on the 2011 NECB.

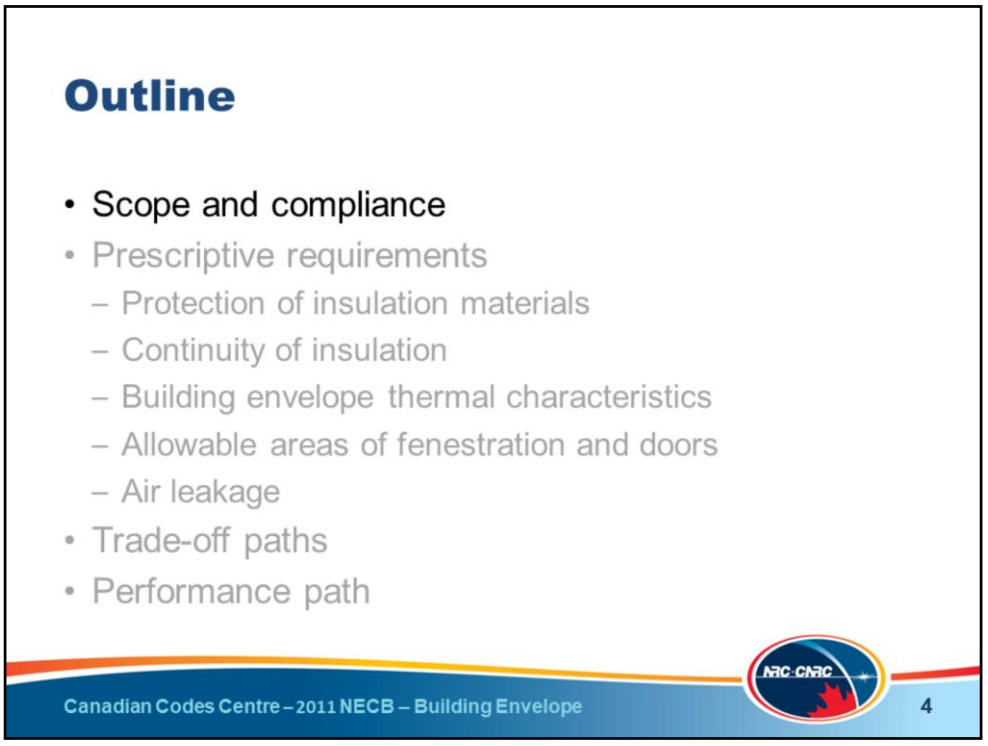
It is important to note that the NECB is a model code developed by the Canadian Commission on Building and Fire Codes that must be adopted by provincial and territorial authorities to become law.

This means that Code requirements enacted by legislation within your province or territory might differ from what is presented here; please check with your local authority.

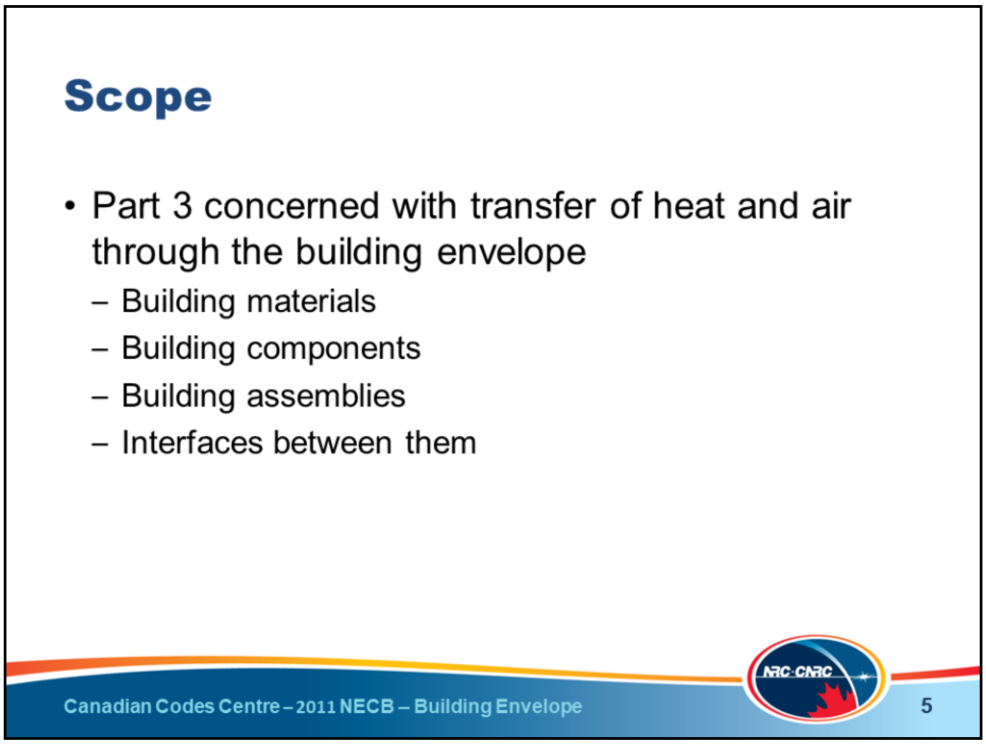


There are four main parts to this presentation.

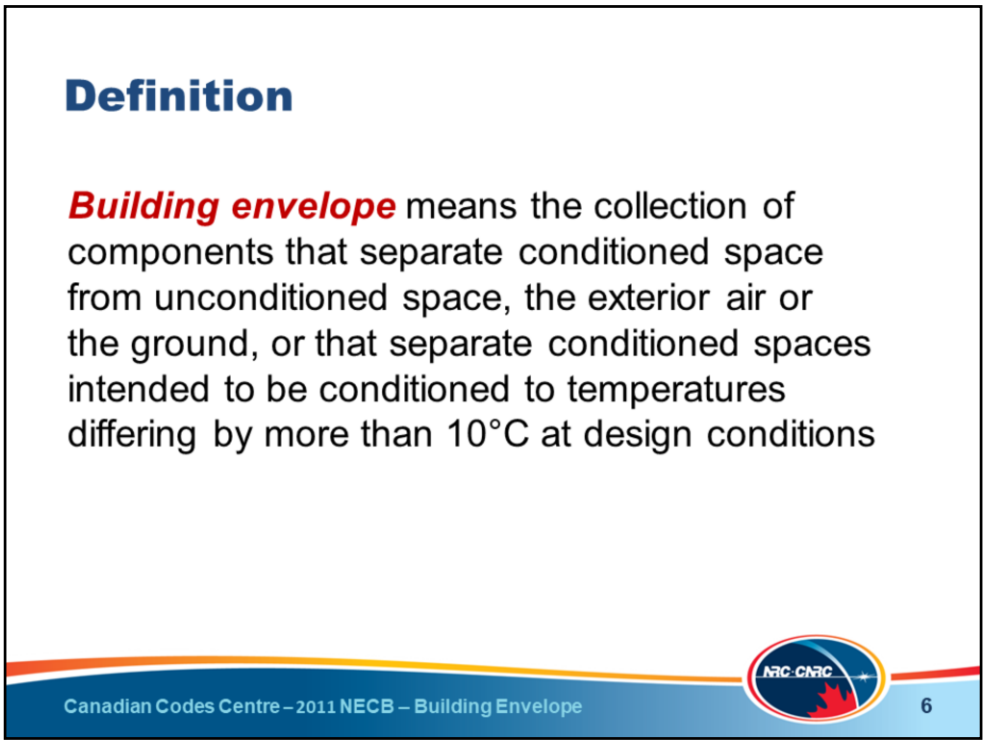
We will first look at scope and compliance options for the building envelope.
Secondly, we will review details on the prescriptive requirements.
We will then cover the two trade-off paths.
Lastly, we will discuss building envelope limitations in the performance path.



Let's now look at the scope of Part 3 and the compliance options available.

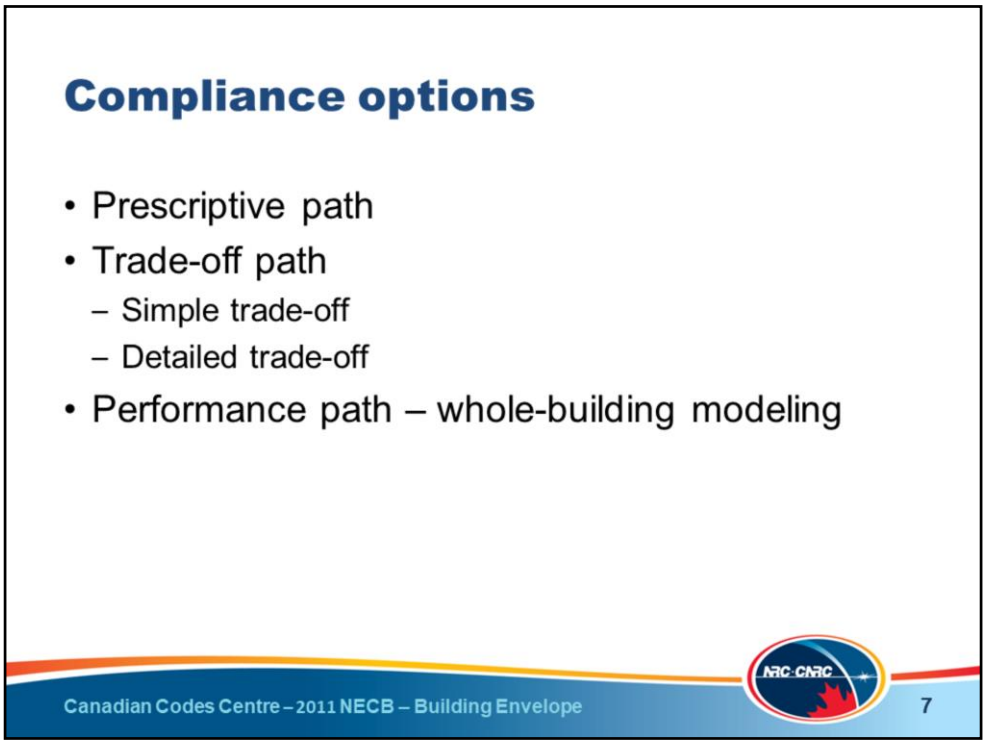


Part 3 of the NECB is concerned with the transfer of heat and air through the building materials, components and assemblies forming part of a building envelope, as well as the interfaces between them.



The term “building envelope” is defined in the NECB as shown here.

To paraphrase, the building envelope includes the exterior enclosure of the building as well as enclosures separating spaces conditioned to temperatures that differ by more than 10°C.



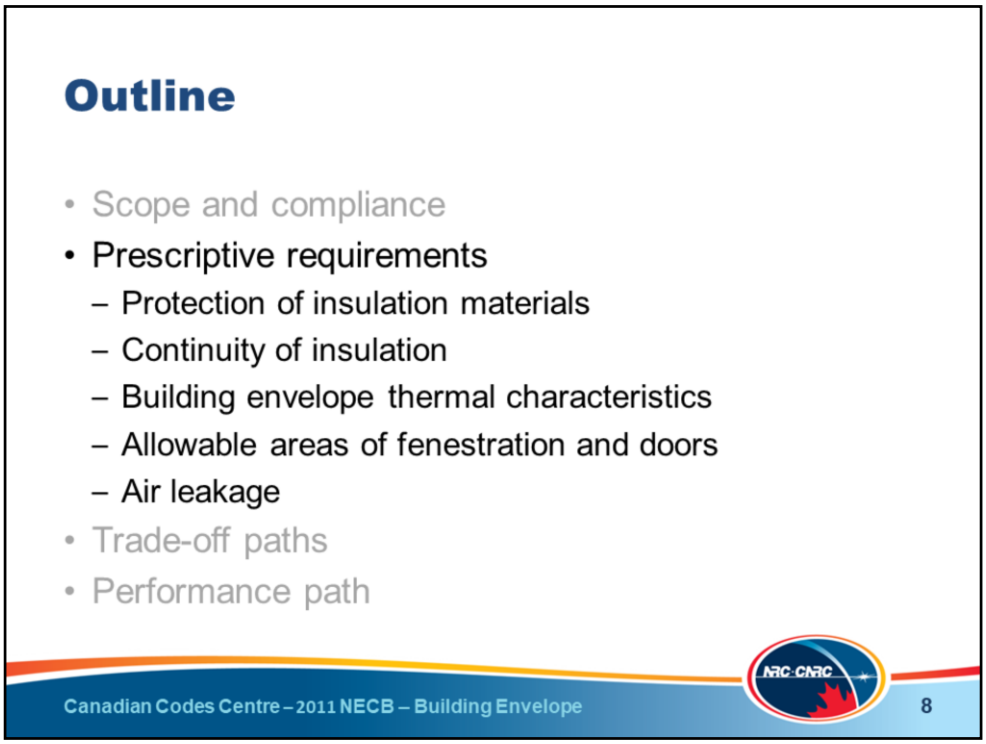
There are three compliance methods to choose from in Part 3.

- First, there is the prescriptive path, which is like a recipe for compliance: "To comply with the NECB building envelope requirements, simply do x and y."

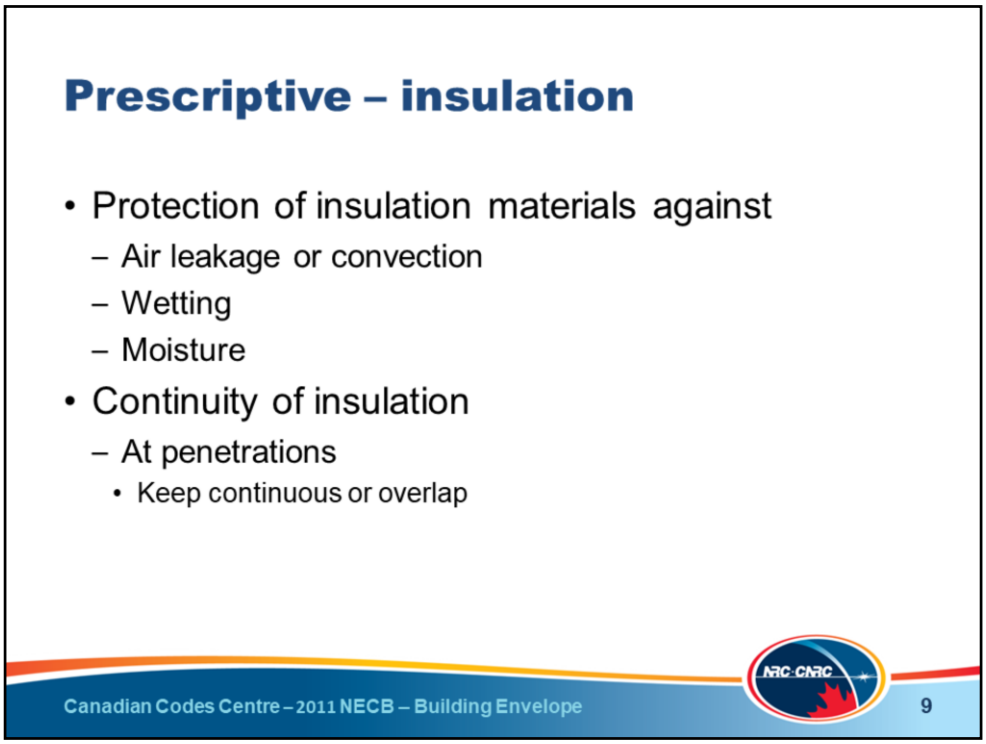
- Then there are two trade-off paths, which provide more flexibility than the prescriptive requirements: the simple trade-off and the detailed trade-off.

- Finally, there is the performance compliance route, which is the whole-building modeling approach.

Each compliance path will now be explained in some detail.



Let's start with the prescriptive requirements.

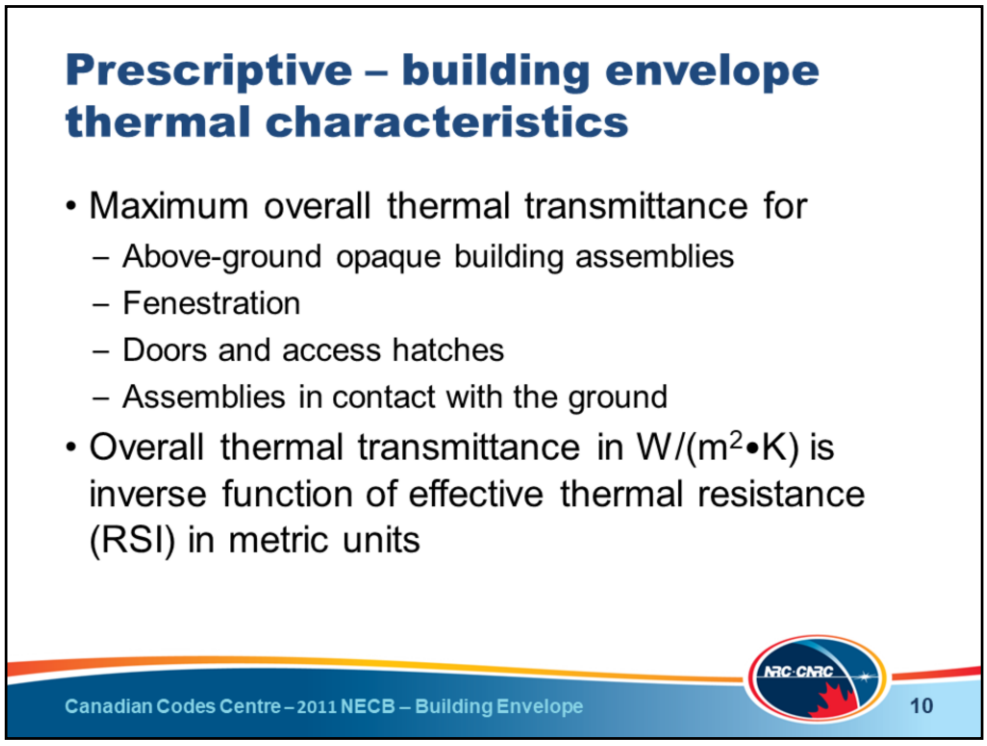


Part 3 of the NECB has provisions dealing with the protection of insulation materials against degradation of their thermal properties due to:

- air leakage or convection
- wetting, or
- moisture bypassing the plane of thermal resistance.

There are also requirements on the continuity of insulation whose general intent is to maintain the integrity of the insulation at the prescribed levels over the entire building envelope.

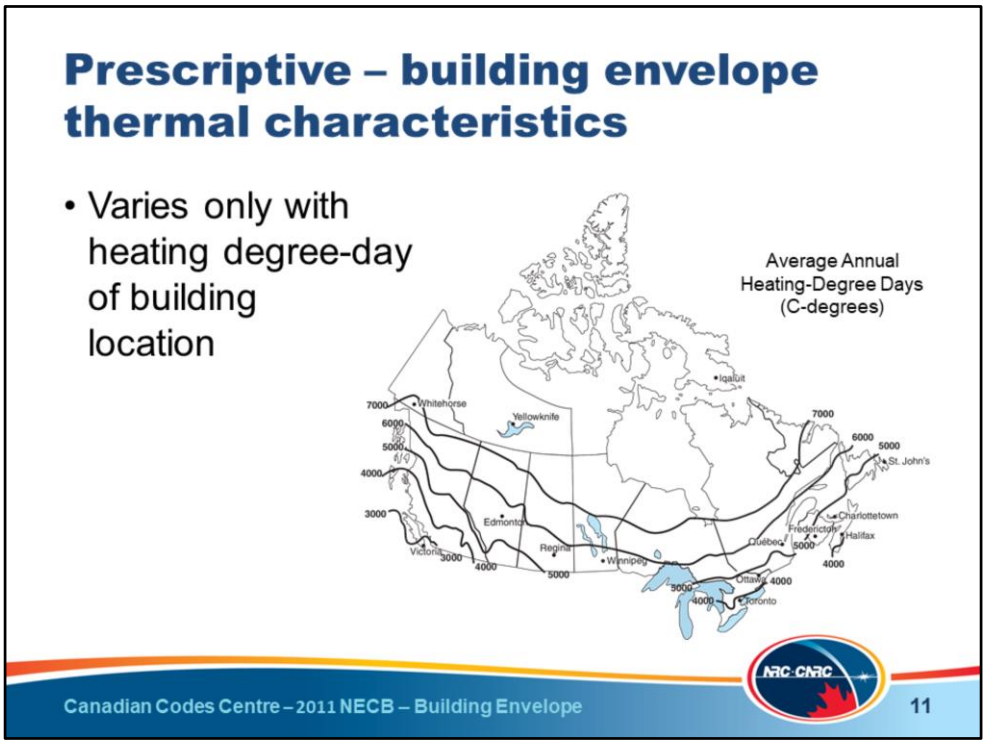
The provisions address issues such as partial penetrations and penetrations that completely break the continuity of the building envelope (such as an interior wall penetrating a roof).



Now let's take a look at the building envelope thermal requirements.

Maximum overall thermal transmittances are given for above-ground opaque building assemblies, fenestration, doors and access hatches and assemblies in contact with the ground.

The overall thermal transmittance in W/(m^2•K) is the rate of heat transfer through the entire building assembly (or the inverse of effective thermal resistance or RSI in metric units)



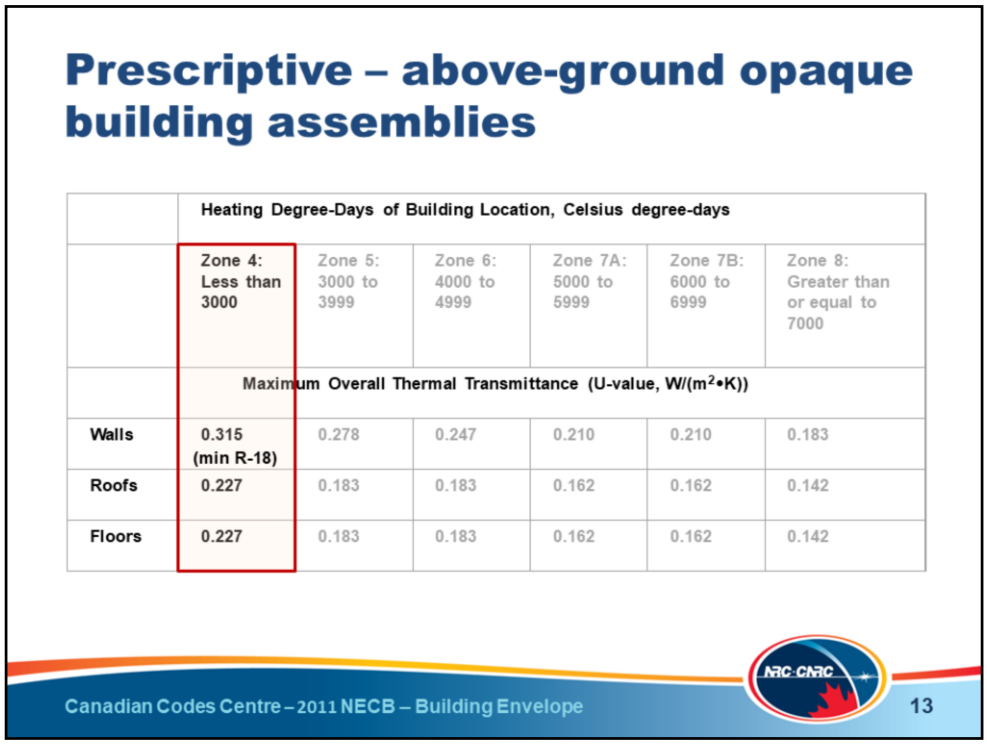
The heating degree-days for a given location can be found in Appendix C of the National Building Code. The climatic zones in the NECB have been set using a 1000 heating degree-day gradation. The zone names are the same as those used in ASHRAE standard 90.1 except that zone 7 is split into two 1000 degree-day zones called 7A and 7B to better reflect the reality of the Canadian climate.

Prescriptive – above-ground opaque building assemblies

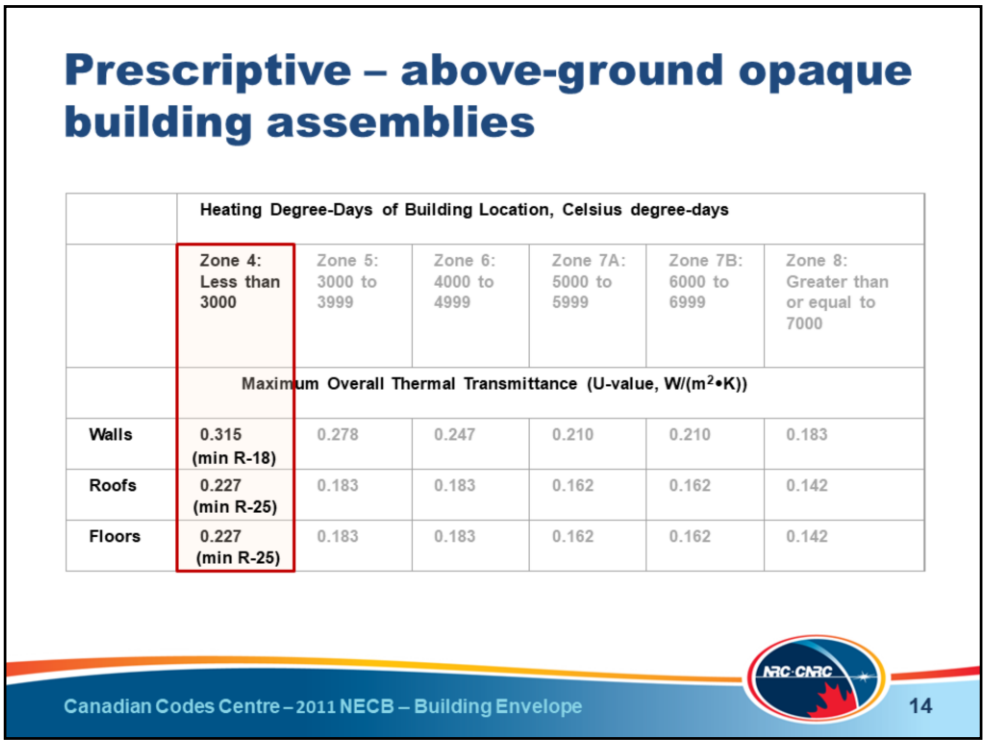
	Heating Degree-Days of Building Location, Celsius degree-days					
	Zone 4: Less than 3000	Zone 5: 3000 to 3999	Zone 6: 4000 to 4999	Zone 7A: 5000 to 5999	Zone 7B: 6000 to 6999	Zone 8: Greater than or equal to 7000
Maximum Overall Thermal Transmittance (U-value, W/(m²•K))						
Walls	**0.315**	0.278	0.247	0.210	0.210	0.183
Roofs	**0.227**	0.183	0.183	0.162	0.162	0.142
Floors	**0.227**	0.183	0.183	0.162	0.162	0.142

The prescriptive requirements of the NECB set a maximum overall thermal transmittance (U-value) for above-ground walls, roofs and floors that are part of the building enclosure as shown in this table. As mentioned earlier, these values vary only with the heating degree-day location of the building, as shown in the columns.

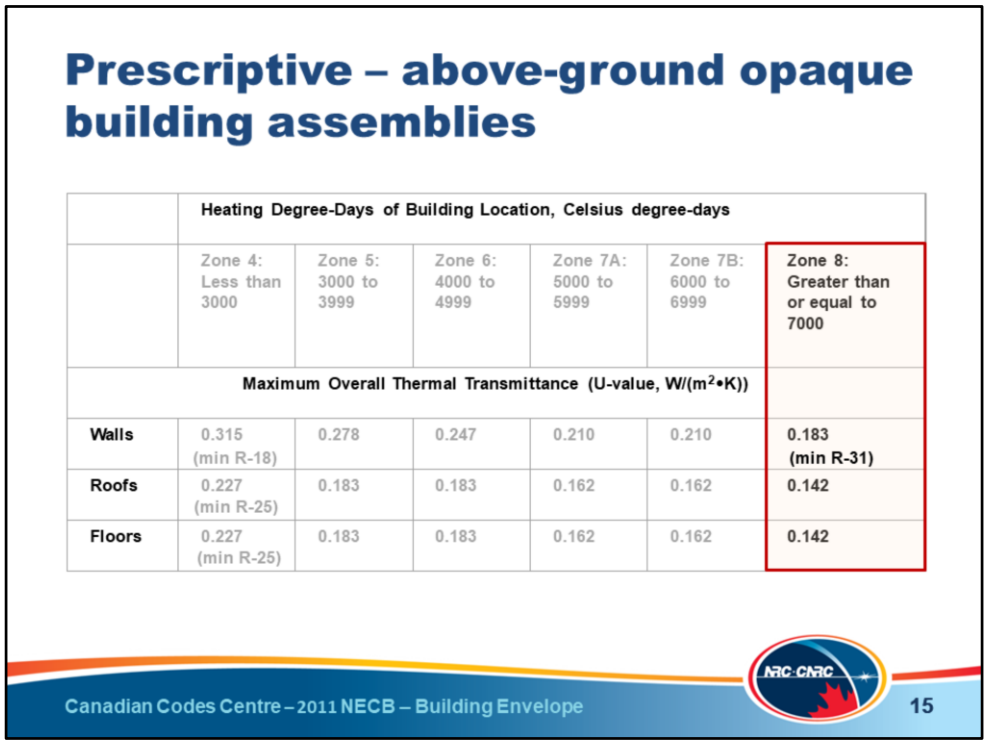
Let's take a closer look at the requirements…



In Zone 4 – areas with less than 3000 heating degree-days, which includes Victoria and the lower BC mainland – the maximum overall U-value for walls is 0.315. This represents a minimum effective RSI of 3.17 or approximately R-18 in imperial units



Roofs and floors in Zone 4 can have a maximum overall U-value of 0.227, which is a minimum effective RSI of 4.41 or approximately R-25.



In Zone 8 – areas with 7000 heating degree-days or more, which applies to Canada's northern regions, including most of the Yukon, Northwest Territories and Nunavut – the maximum overall U-value for walls is 0.183, which is a minimum effective RSI of 5.46 or R-31.

Prescriptive – above-ground opaque building assemblies

	Heating Degree-Days of Building Location, Celsius degree-days					
	Zone 4: Less than 3000	Zone 5: 3000 to 3999	Zone 6: 4000 to 4999	Zone 7A: 5000 to 5999	Zone 7B: 6000 to 6999	**Zone 8: Greater than or equal to 7000**
	Maximum Overall Thermal Transmittance (U-value, W/(m²•K))					
Walls	0.315 (min R-18)	0.278	0.247	0.210	0.210	**0.183 (min R-31)**
Roofs	0.227 (min R-25)	0.183	0.183	0.162	0.162	**0.142 (min R-40)**
Floors	0.227 (min R-25)	0.183	0.183	0.162	0.162	**0.142 (min R-40)**

Roofs and floors in Zone 8 have a maximum overall U-value of 0.142, which is a minimum effective RSI of 7.04 or R-40.

Prescriptive – above-ground opaque building assemblies

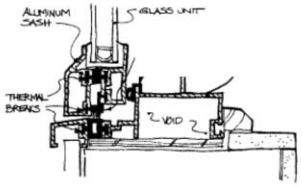
	Heating Degree-Days of Building Location, Celsius degree-days					
	Zone 4: Less than 3000	Zone 5: 3000 to 3999	Zone 6: 4000 to 4999	Zone 7A: 5000 to 5999	Zone 7B: 6000 to 6999	Zone 8: Greater than or equal to 7000
Maximum Overall Thermal Transmittance (U-value, W/(m²•K))						
Walls	0.315	0.278	0.247	0.210	0.210	0.183
Roofs	0.227	0.183	0.183	0.162	0.162	0.142
Floors	0.227	0.183	0.183	0.162	0.162	0.142

*U-values reduced by 20% where radiant heating or cooling included in assembly

All of the maximum allowable U-values in the table would be reduced by 20% (in other words would be more stringent) for assemblies containing embedded radiant heating and/or cooling cables, pipes or membranes.

Prescriptive – fenestration

	Heating Degree-Days of Building Location, Celsius degree-days					
	Zone 4: Less than 3000	Zone 5: 3000 to 3999	Zone 6: 4000 to 4999	Zone 7A: 5000 to 5999	Zone 7B: 6000 to 6999	Zone 8: Greater than or equal to 7000
	Maximum Overall Thermal Transmittance (U-value, W/(m²•K))					
All Fenestration	2.4	2.2	2.2	2.2	2.2	1.6



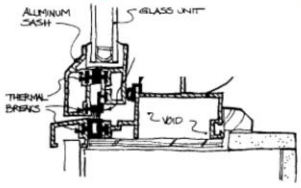
Double glazing units with:
- Low-emissivity coating
- Non-metallic spacer

The NECB prescriptive requirements set maximum U-values for fenestration that is part of the building enclosure as shown in this table.

As with the requirements for opaque assemblies, these values vary only with the heating degree-day location of the building.

Prescriptive – fenestration

	Heating Degree-Days of Building Location, Celsius degree-days					
	Zone 4: Less than 3000	Zone 5: 3000 to 3999	Zone 6: 4000 to 4999	Zone 7A: 5000 to 5999	Zone 7B: 6000 to 6999	Zone 8: Greater than or equal to 7000
	Maximum Overall Thermal Transmittance (U-value, W/(m²•K))					
All Fenestration	2.4	2.2	2.2	2.2	2.2	1.6

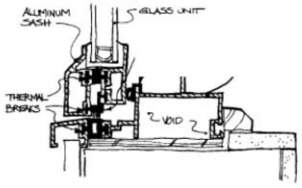


Double glazing units with:
- Low-emissivity coating
- Non-metallic spacer

An overall thermal transmittance of 2.4 W/(m^2•K) in Zone 4 can typically be achieved using the equivalent of a good quality thermally broken aluminum frame, double glazing units with low-emissivity coating and a non-metallic spacer.

Prescriptive – fenestration

	Heating Degree-Days of Building Location, Celsius degree-days					
	Zone 4: Less than 3000	Zone 5: 3000 to 3999	Zone 6: 4000 to 4999	Zone 7A: 5000 to 5999	Zone 7B: 6000 to 6999	Zone 8: Greater than or equal to 7000
	Maximum Overall Thermal Transmittance (U-value, W/(m²•K))					
All Fenestration	2.4	2.2	2.2	2.2	2.2	1.6

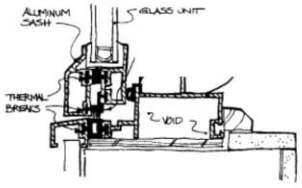


Double glazing units with:
- Low-emissivity coating
- Non-metallic spacer
- Argon fill

A U-value of 2.2 in Zones 5, 6, 7A and 7B can typically be achieved using the equivalent of a good quality thermally broken aluminum frame, double glazing units with low-e, a non-metallic spacer, and argon fill…

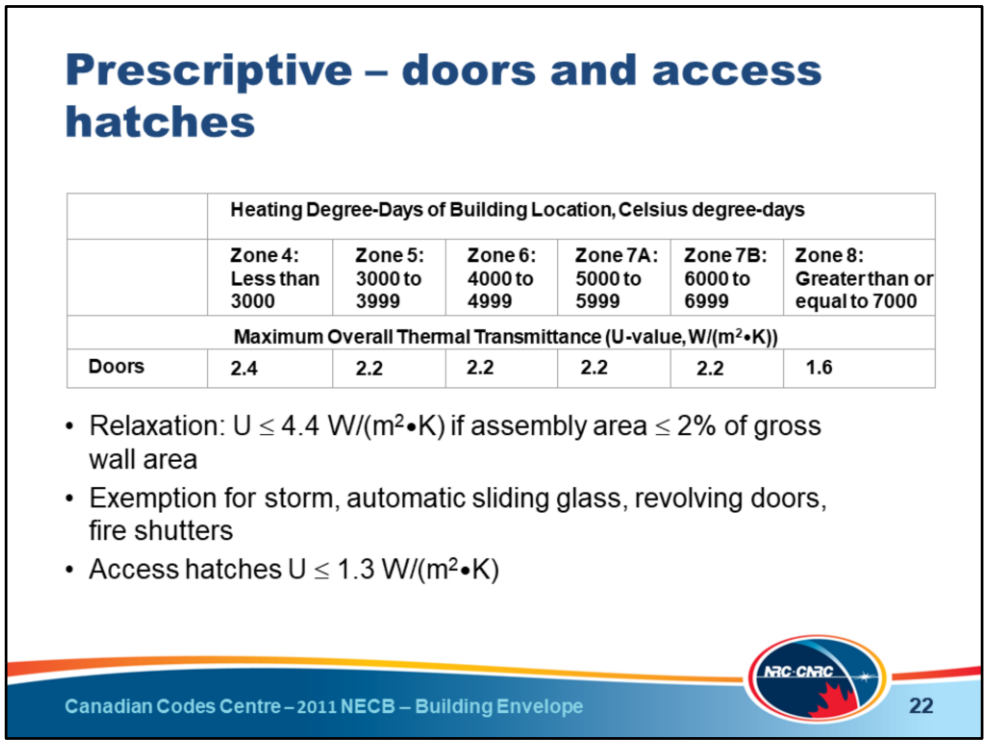
Prescriptive – fenestration

	Heating Degree-Days of Building Location, Celsius degree-days					
	Zone 4: Less than 3000	Zone 5: 3000 to 3999	Zone 6: 4000 to 4999	Zone 7A: 5000 to 5999	Zone 7B: 6000 to 6999	Zone 8: Greater than or equal to 7000
	Maximum Overall Thermal Transmittance (U-value, W/(m²•K))					
All Fenestration	2.4	2.2	2.2	2.2	2.2	1.6



Triple glazing units with:
- Low-emissivity coating
- Non-metallic spacer
- Argon fill

…while a U-value of 1.6 in Zone 8 will typically require the equivalent of a good quality thermally broken aluminum frame, triple glazing units with low-e, non-metallic spacers, and argon fill.



The NECB prescriptive requirements set maximum U-values for doors that are part of the building enclosure as shown in this table. These values also vary only with the heating degree-day location of the building.

You'll note that the required U-values are the same as for fenestration. With respect to the thermal requirements, both doors and fenestration are treated as openings. Areas of doors totaling up to 2% of the gross wall area, however, are given a relaxation to the requirement. This relaxation does not have a significant impact on building energy performance and allows for flexibility in design to address limitations of doors due to function.

Storm doors, automatic sliding glass doors, revolving doors and fire shutters are exempt from the requirements.

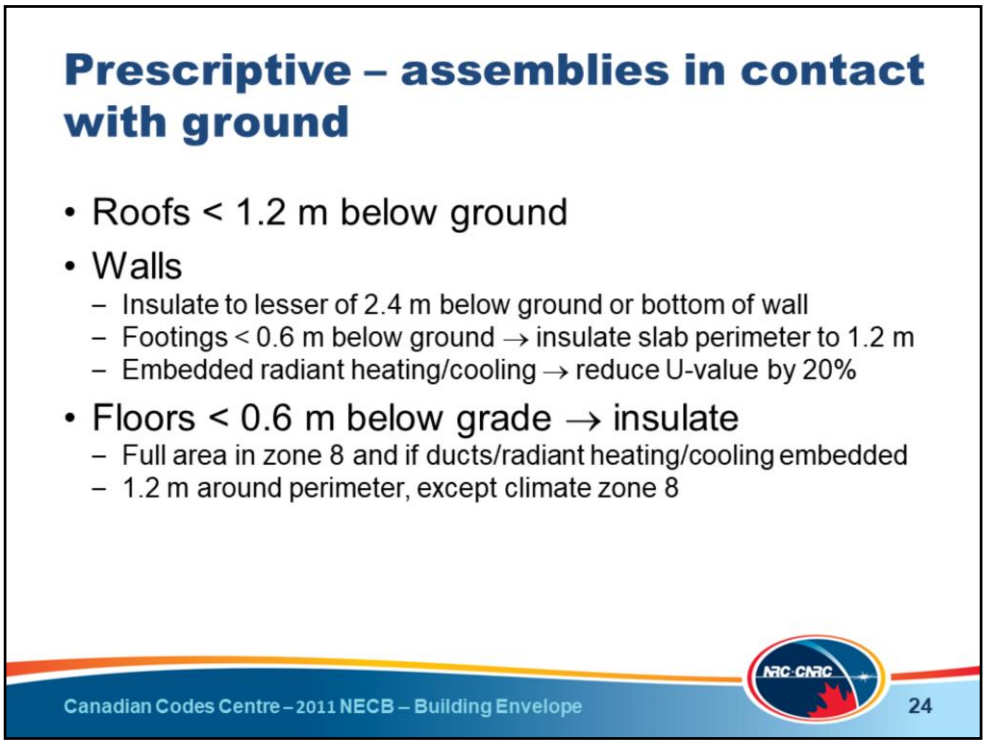
The maximum allowable U-value for access hatches is 1.3 W/(m^2•K).

Prescriptive – assemblies in contact with ground

	Heating Degree-Days of Building Location, Celsius degree-days					
	Zone 4: Less than 3000	Zone 5: 3000 to 3999	Zone 6: 4000 to 4999	Zone 7A: 5000 to 5999	Zone 7B: 6000 to 6999	Zone 8: Greater than or equal to 7000
Maximum Overall Thermal Transmittance (U-value, W/(m²•K))						
Walls	0.568	0.379	0.284	0.284	0.284	0.210
Roofs	0.568	0.379	0.284	0.284	0.284	0.210
Floors	0.757 for 1.2m	0.757 for 1.2m	0.757 for 1.2m	0.757 for 1.2m	0.757 for 1.2m	0.379 full area

The NECB prescriptive requirements set maximum U-values for building envelope assemblies that are in contact with the ground as shown in this table. These values also vary only with the heating degree-day location of the building.

There are specific criteria governing the application of this table, as shown on the next slide.

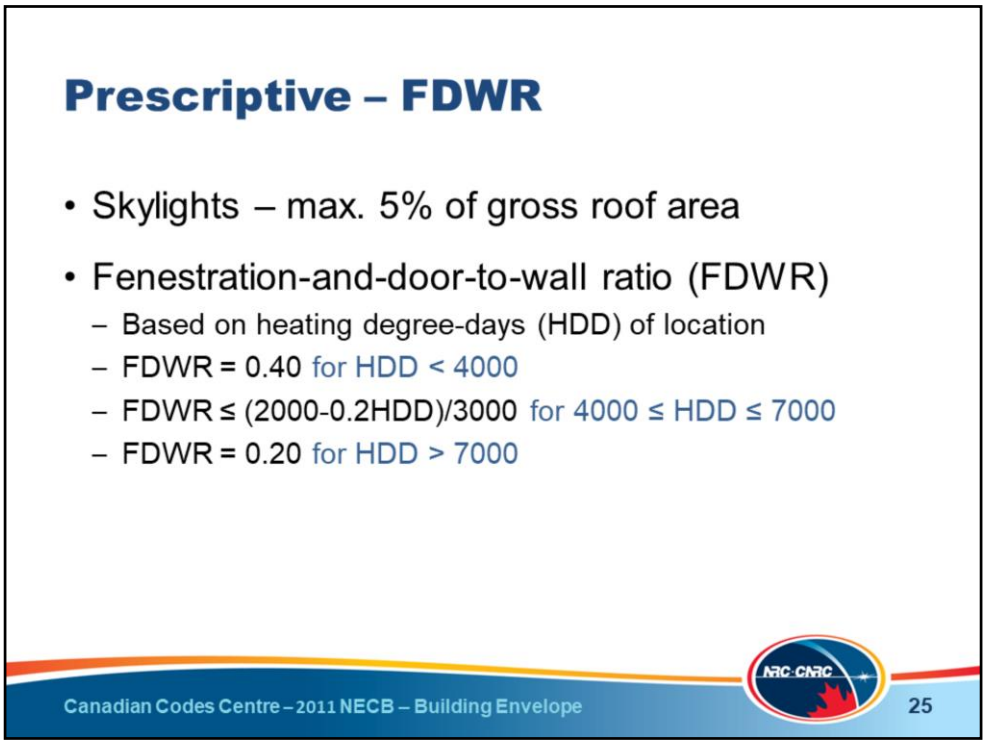


Roofs that are less than 1.2 m below ground must comply with the table of U-values on the previous slide. This would pertain to, for example, the roof of an underground parking garage that extends beyond the footprint of a building.

Walls are required to be insulated to the levels stated in the table for a distance of 2.4 m below ground or to the bottom of the wall, whichever occurs first. Where footings are less than 0.6 m below ground, the level of insulation required by the table must be placed on the top or bottom of the floor slab for 1.2 m.

The U-values for walls with embedded radiant heating cables, heating or cooling pipes or membranes would be reduced by 20% (in other words would be more stringent) from the U-values given in the table on the previous slide.

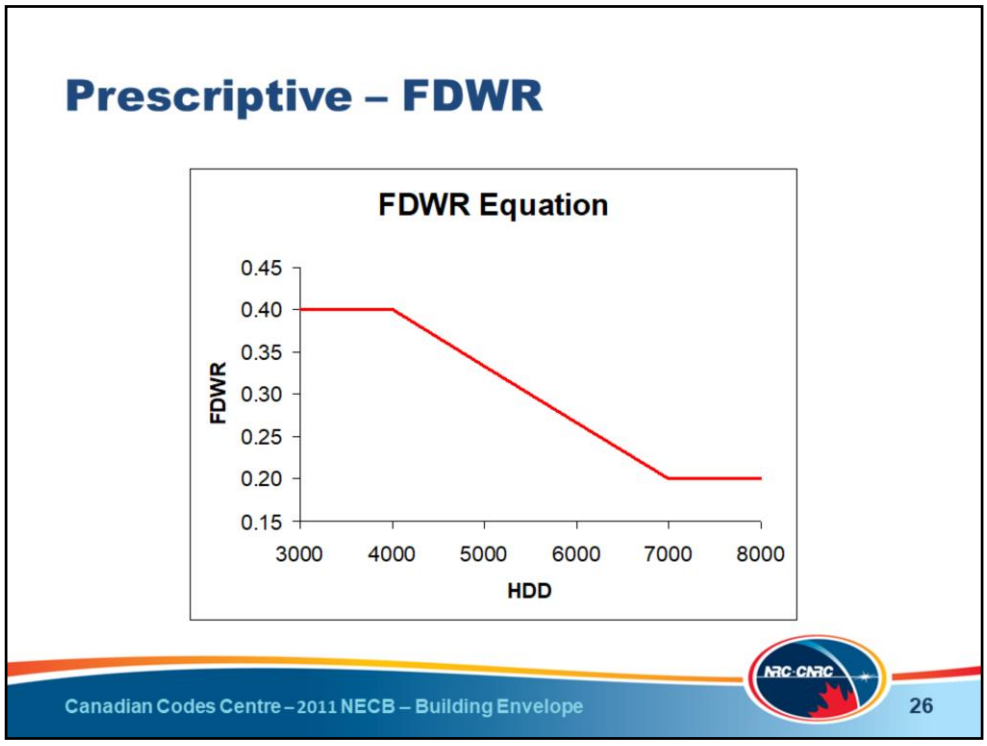
Floors less than 0.6 m below grade (grade as defined in the NECB) are required to be insulated in accordance with the table in the previous slide. Floors containing embedded heating ducts, cables or heating or cooling pipes are required to be insulated over their full area. Otherwise, floors are required to be insulated for 1.2 m around their perimeter.



Now let's take a look at the prescriptive requirements for allowable fenestration and door areas.

The maximum prescriptive skylight area limit is 5% of the gross roof area.

The maximum allowable vertical fenestration and door area to gross wall area ratio (or FDWR) is determined based on the heating degree-days (or HDD) of the building location as shown here. The HDD for a particular location can be found in Appendix C of the National Building Code.

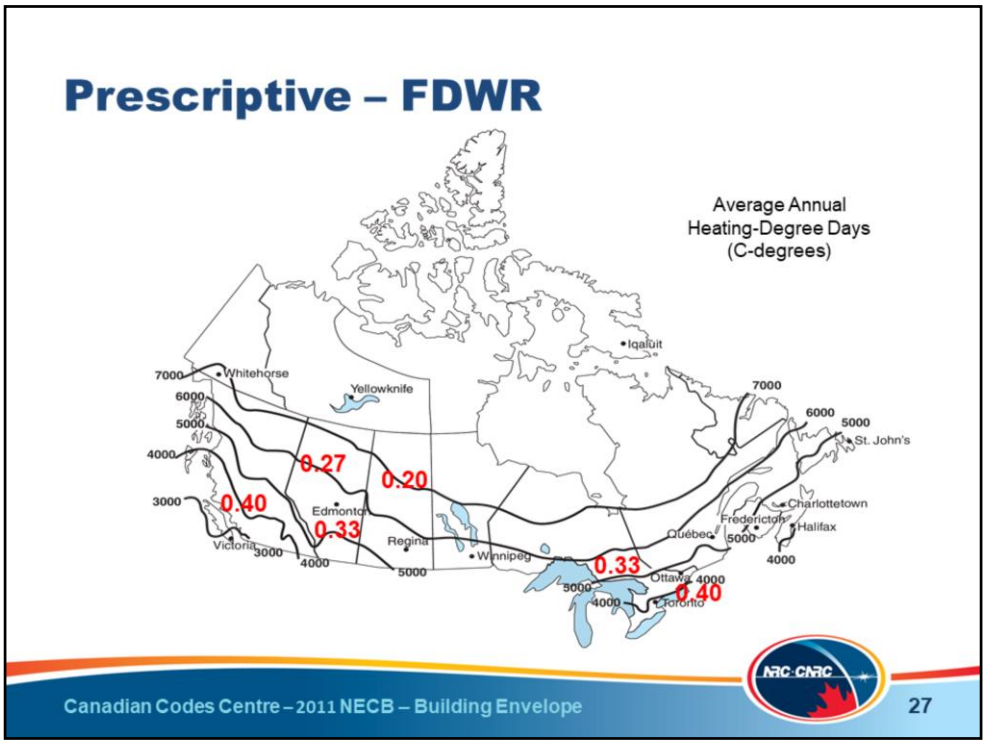


In this graph, you see the prescriptive limits for the fenestration-and-door-to-wall ratio versus the heating degree-days.

At heating degree-day values of 4000 or less – which includes locations such as Toronto, Vancouver and Victoria – the FDWR limit is set at 40%.

At heating degree-day values of 7000 or higher – which includes locations such as Yellowknife and Iqaluit – the FDWR limit is set at 20%.

For sites with heating degree-days between 4000 and 7000, the FDWR varies linearly and the limit can either be calculated using the equation given on the previous slide or interpolated using a table of values in the Appendix of the Code.



Here are the fenestration-and-door-to-wall ratios shown on a heating degree-day contour map.

The 1000 heating degree-day gradations are represented by the black lines.

The FDWR values are shown in red.

Prescriptive – air leakage

- Conditioned space – continuous air barrier system
- Opaque assemblies – air barrier assembly required
- Metal and glass curtain walls, windows → tested to referenced standards
  - Higher air leakage rate for operable windows

Now let's look at the air leakage requirements.

The building envelope must be designed and constructed with a continuous air barrier system to control air leakage into and out of the conditioned space. This air barrier system would be comprised of air barrier assemblies and components (such as pre-manufactured windows) and their interfaces and fastenings.

All opaque building assemblies are required to have an air barrier assembly. Air barrier assembly is a defined term in the NECB which, to paraphrase, means the combination of air barrier materials and air barrier accessories that are designated and designed to act as a continuous barrier to air leakage.

Metal and glass curtain walls and fixed and operable windows are required to meet air leakage test requirements under fixed pressures in accordance with the standards cited in the Code. Operable windows have a higher allowable air leakage rate than fixed windows.

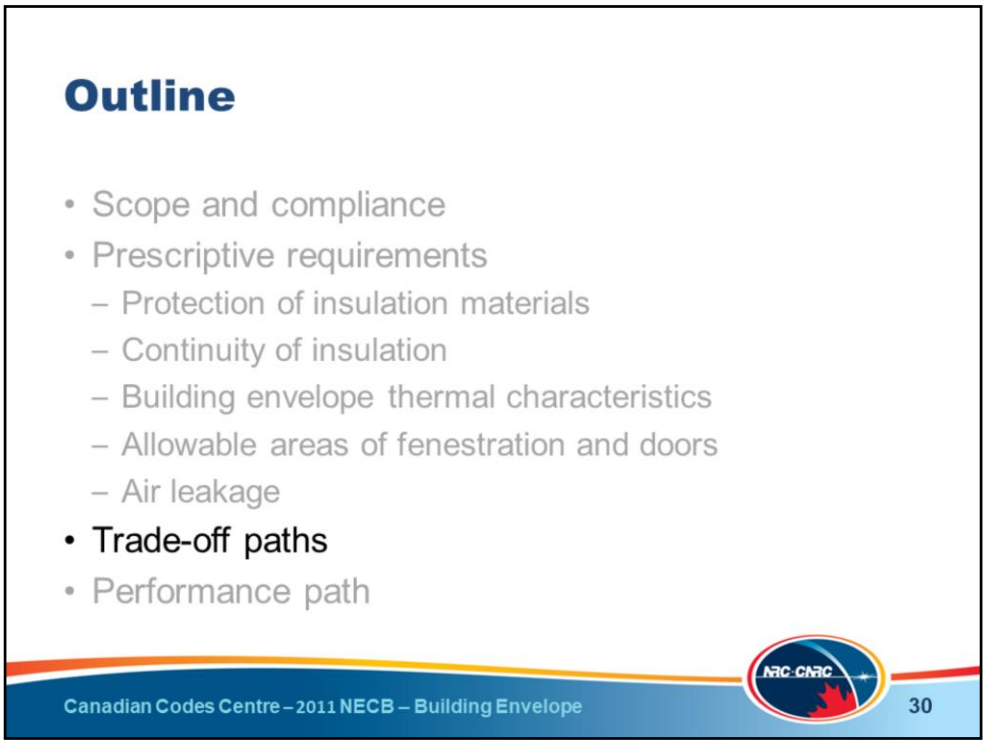
Prescriptive – air leakage

- Doors → tested to referenced standards
  - Higher air leakage rate for
    - Revolving doors
    - Automatic commercial sliding doors
    - Overhead doors
    - Main entry exterior doors
  - Loading docks seal with trucks that interface

Doors are also required to meet air leakage test requirements under fixed pressures in accordance with the standards cited in the Code. A higher air leakage rate is allowed for

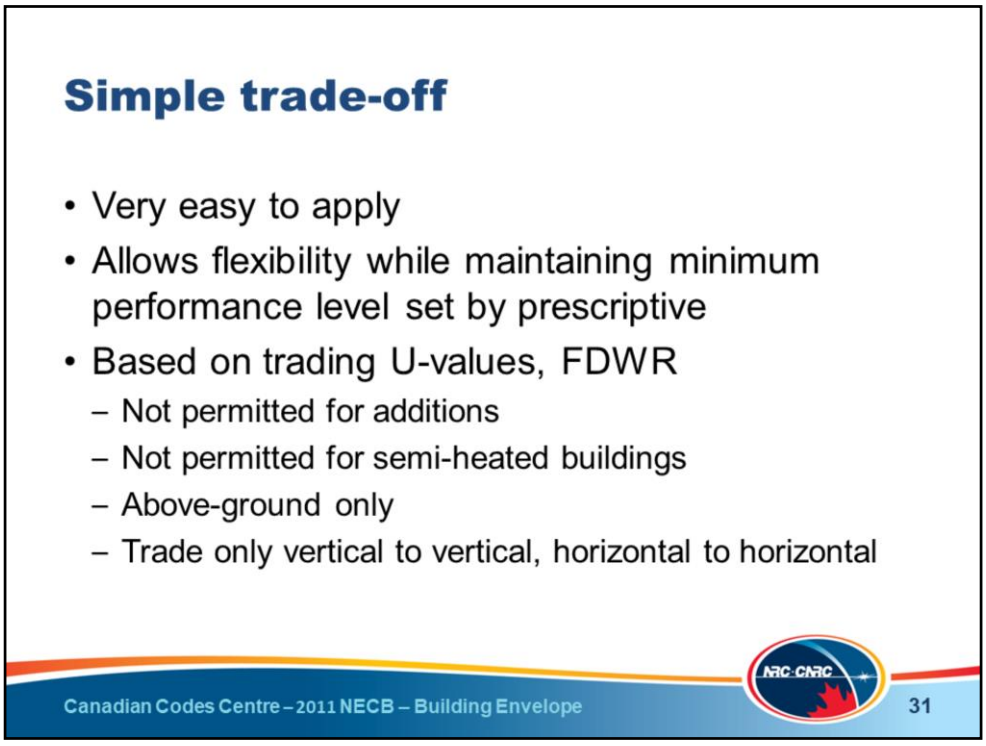
- revolving doors including fixed sections
- automatic commercial sliding doors including fixed sections
- overhead doors, and
- main entry exterior doors.

All loading docks that interface with truck boxes are required to have weather seals that seal the truck box to the building.



Now let's take a look at the trade-off paths available in Part 3.

There are two building envelope trade-off paths in the NECB: the simple trade-off and the detailed trade-off.

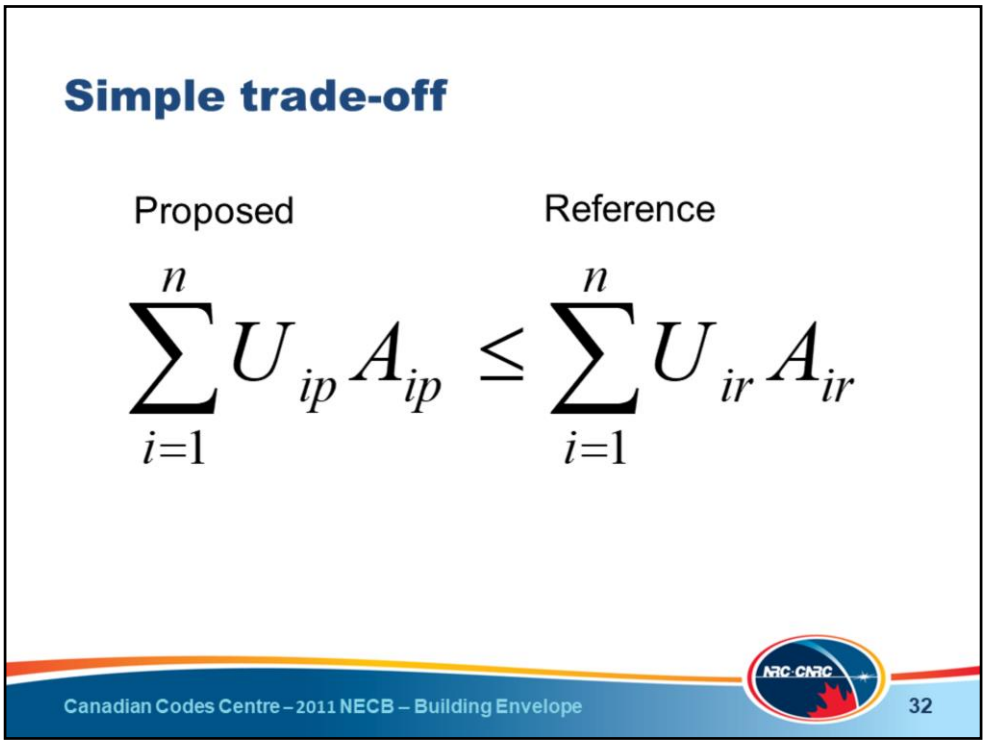


The simple building envelope trade-off is, just as its name asserts, very easy to apply.

It allows for the trading of U-values and areas of fenestration and doors (FDWR), but still maintains the minimum energy performance level set by the prescriptive path.

In order to keep this trade-off option very simple, the following limitations are placed on its use:

- additions and semi-heated buildings cannot use the simple trade-off path
- assemblies in contact with the ground cannot be traded, and
- vertical elements can only be traded against other vertical elements, and horizontal elements can only be traded against other horizontal elements.

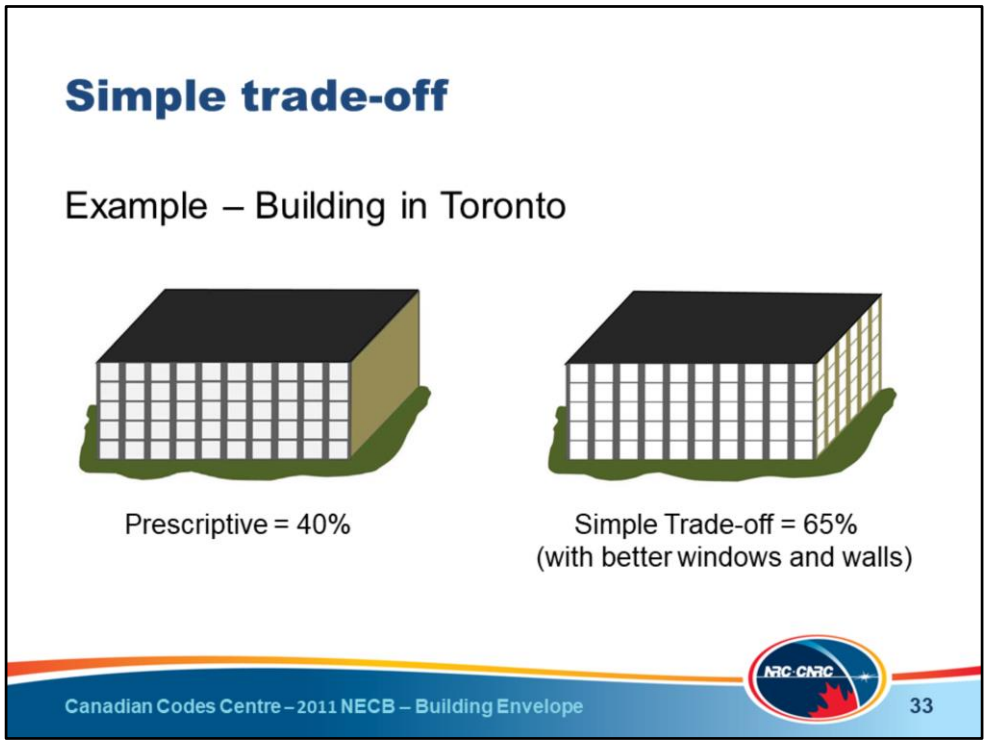


The equation that defines the simple trade-off compliance option is shown here.

The left-hand side of the equation pertains to the proposed building, while the right-hand side pertains to the reference building, i.e. a building constructed according to the NECB's prescriptive requirements.

The sum of the product of the U-values (U) of each building envelope assembly (i) times their area (A) for the proposed building cannot be greater than the sum of the product of the U-values of each building envelope assembly times their area for the reference building.

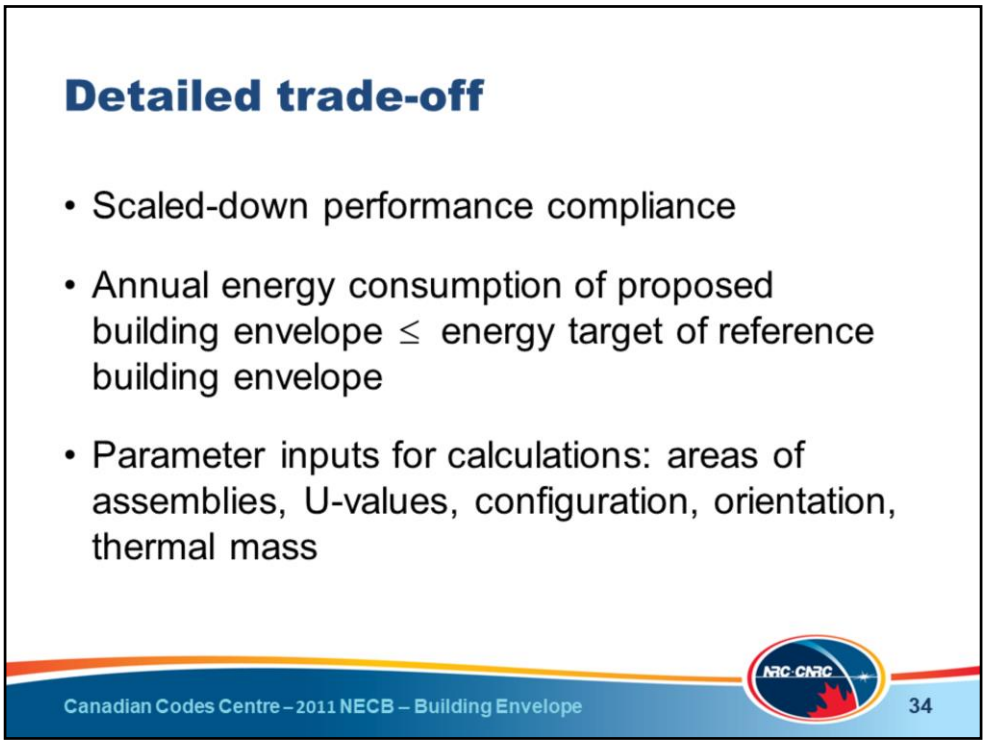
The reference building's U-values and areas (as per the FDWR) must comply with the prescriptive path.



To demonstrate the flexibility created in using the simple trade-off path, a hypothetical building in Toronto was examined. In this location, the prescriptive limit for the fenestration and door to wall ratio is 40% and, for example, windows can be placed on the front and back of the building, as shown in the illustration on the left.

Using the simple building envelope trade-off on this building will permit window areas up to approximately 65% of the total exterior wall area, which, for example, can mean windows on all 4 sides, as shown on the illustration on the right. To achieve this higher fenestration and door to wall ratio, windows would typically need to have better energy performance than those of the prescriptive building, and the opaque exterior wall assemblies would need to be better insulated.

It is important to note that even higher fenestration amounts can be accommodated with the detailed building envelope trade-off path and with the whole building modeling approach of the performance compliance path. The detailed trade-off path, which will be discussed in the next slide, does not have the same limitations placed on its use as the simple trade-off path and therefore allows efficiency gains from other building envelope systems (e.g. roof assemblies) to compensate for increased fenestration. The performance compliance path offers even greater flexibility, as it allows efficiencies gained from other building systems (e.g. HVAC, lighting) to compensate for reduced performance of the building envelope.

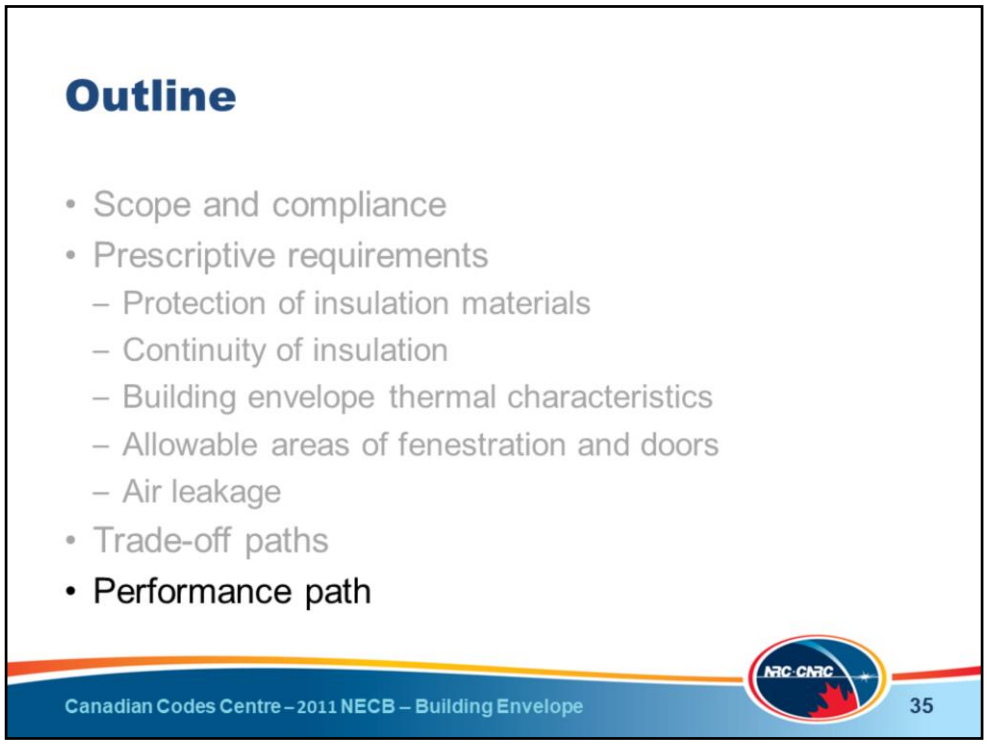


Now let's look at the second building envelope trade-off path: the detailed trade-off. The detailed building envelope trade-off path is a scaled-down version of the whole-building performance compliance path.

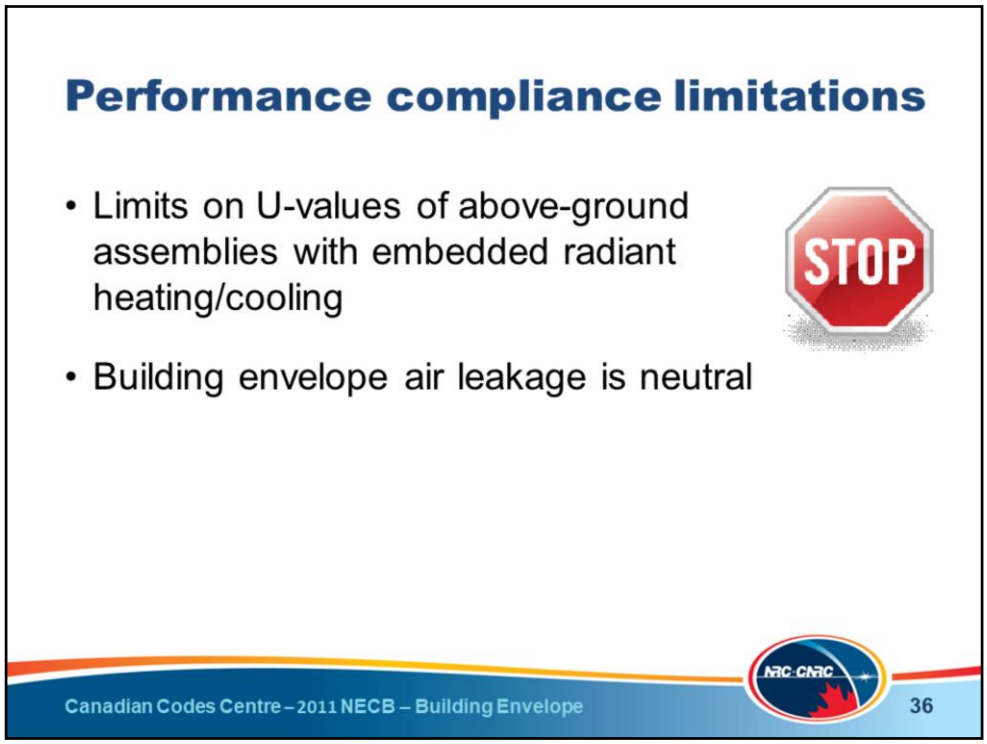
The overriding principle is that the energy use attributed to the building envelope of the proposed building must be less than the energy use attributed to the building envelope of the reference building, or the building that would result if it were constructed using the prescriptive path requirements .

The reference building must use the U-values and fenestration-and-door-to-wall ratio limits of the prescriptive path.

The parameters to include in the trade-off calculations are the building envelope assembly areas, their overall thermal transmittance values, the building configuration, the orientation of the walls and the effect of thermal mass.



Finally, let's take a look at the building envelope design limitations related to using the performance path.



The performance compliance path is a whole-building modeling approach.

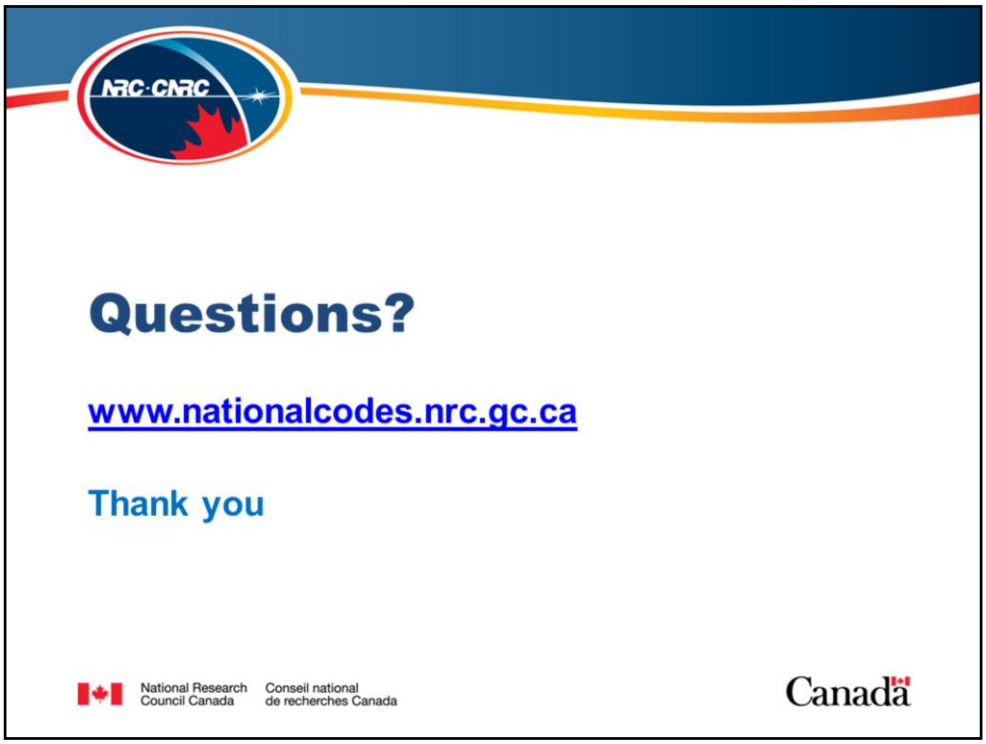
A designer can elect to use the performance path to achieve Code compliance, or may have to use it, because the building does not comply with the other path options – prescriptive, simple trade-off or detailed trade-off.

There are building envelope design limitations to using the performance path. For example:

- the thermal transmittance of above-ground building envelope assemblies that have embedded radiant heating cables, or heating or cooling pipes or membranes must comply with the prescriptive values

  and

- when using the performance compliance option, the building envelope's air leakage characteristics must be neutral, that is to say, the value attributed is the same for both the proposed and reference buildings.



This concludes the presentation on Part 3 of the NECB, Building Envelope.