Building Envelope Energy Efficiency

How to Avoid Surprises

February 6, 2020

Langley

Hamid Heidarali

HAMID DESIGN BUILD

Note to Readers:

To better comprehend the content of this presentation, please refer to the video-recorded version of this presentation available on the tol.ca/stepcode

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Let’s get into some fun science!

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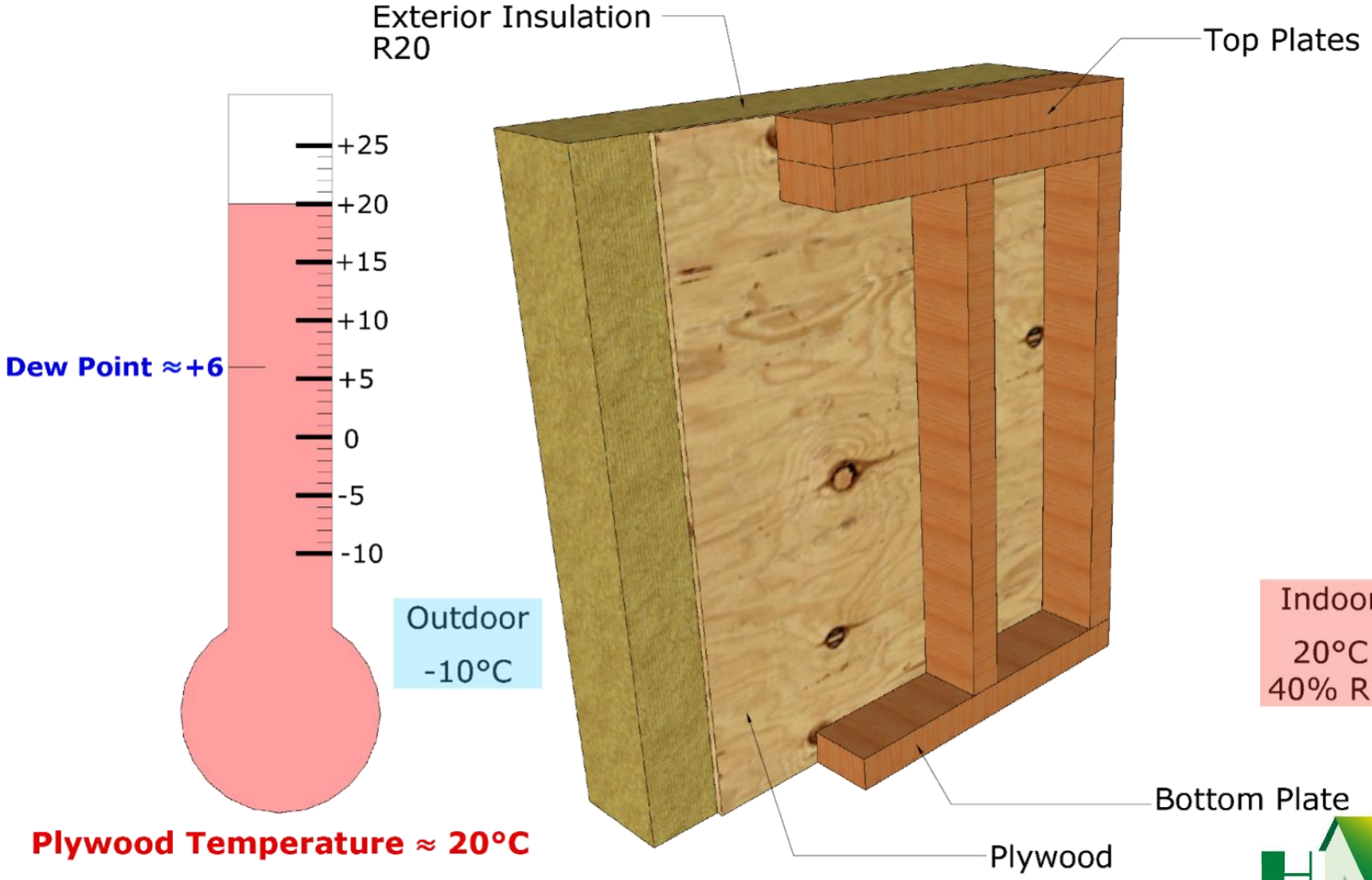

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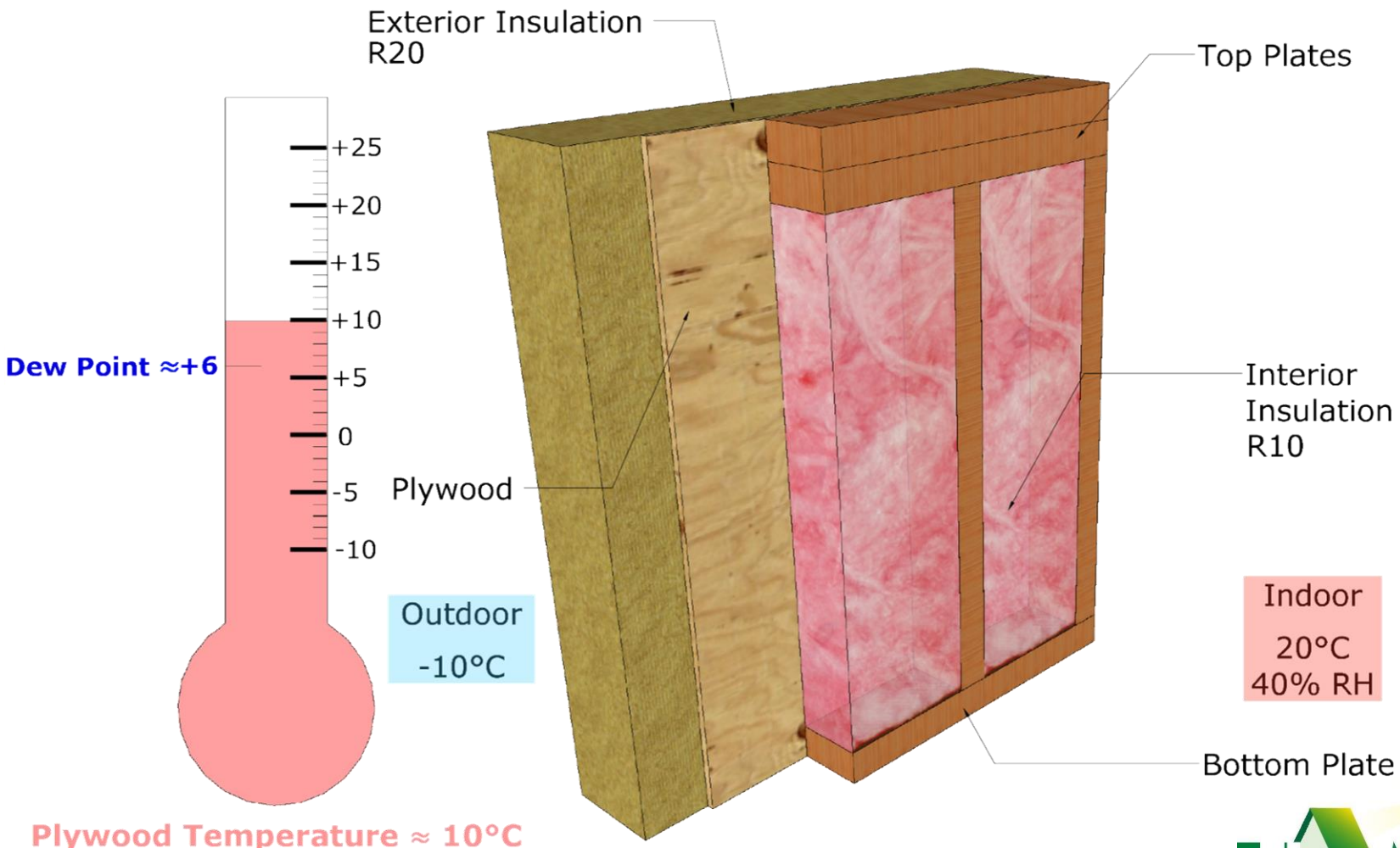

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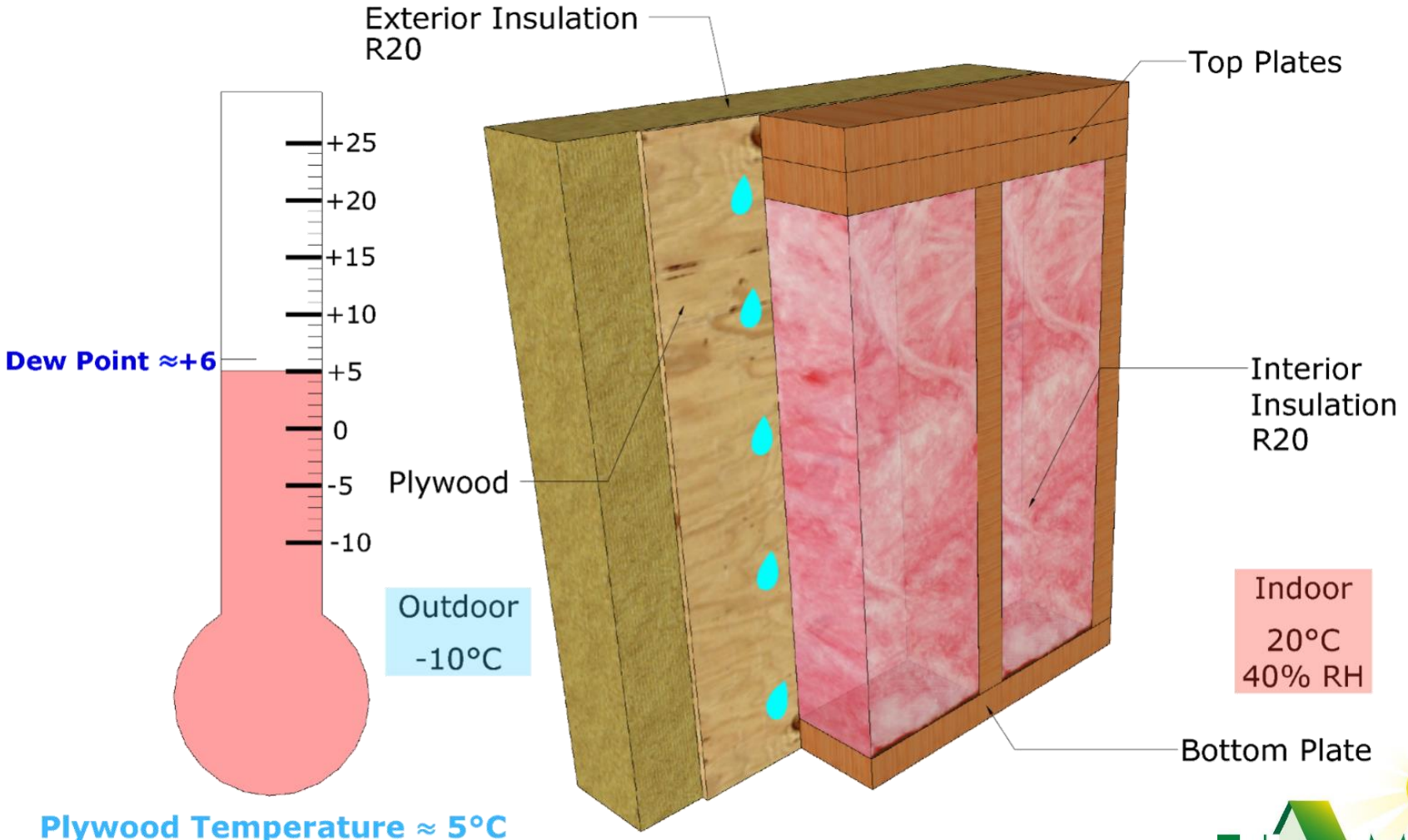

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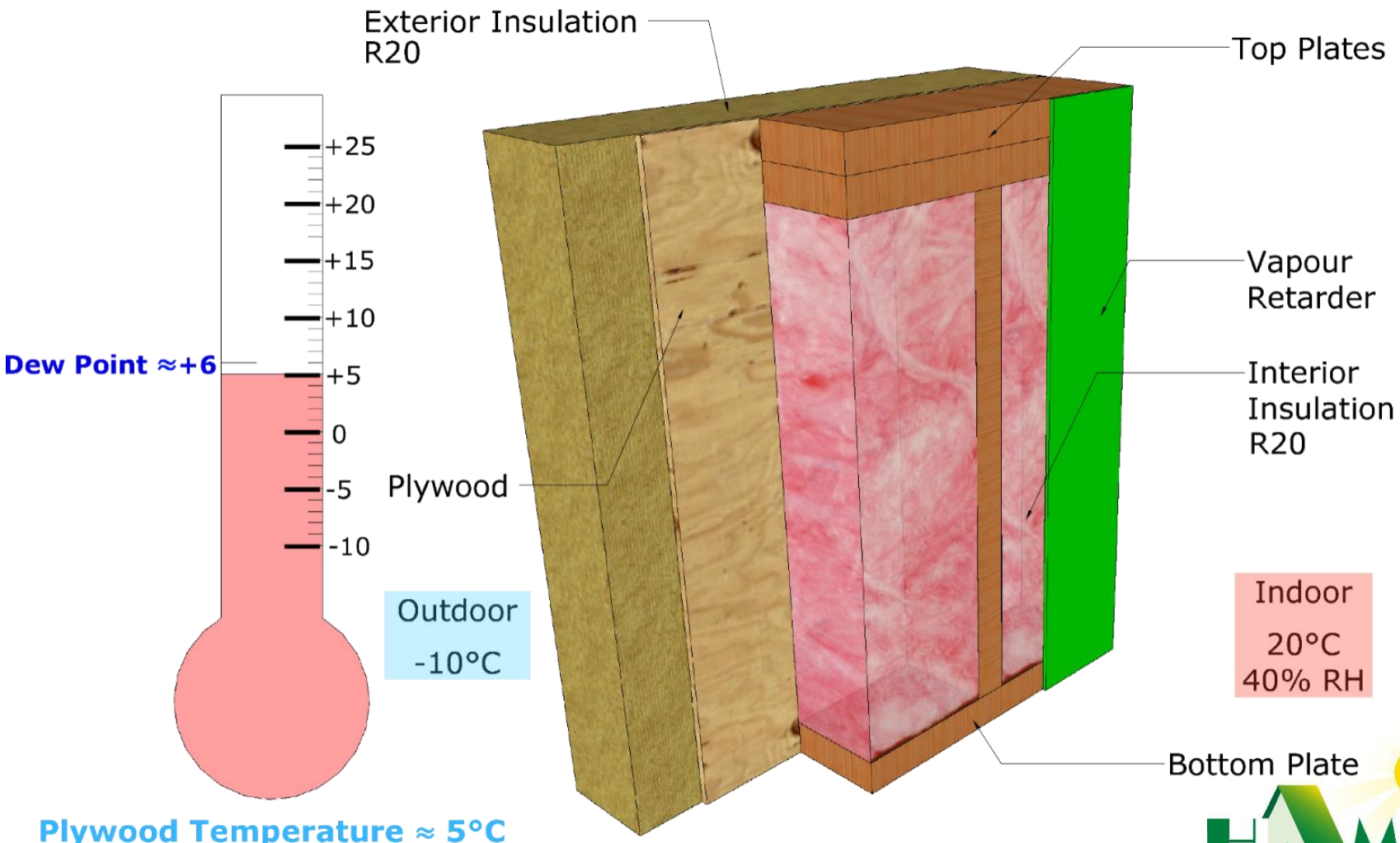

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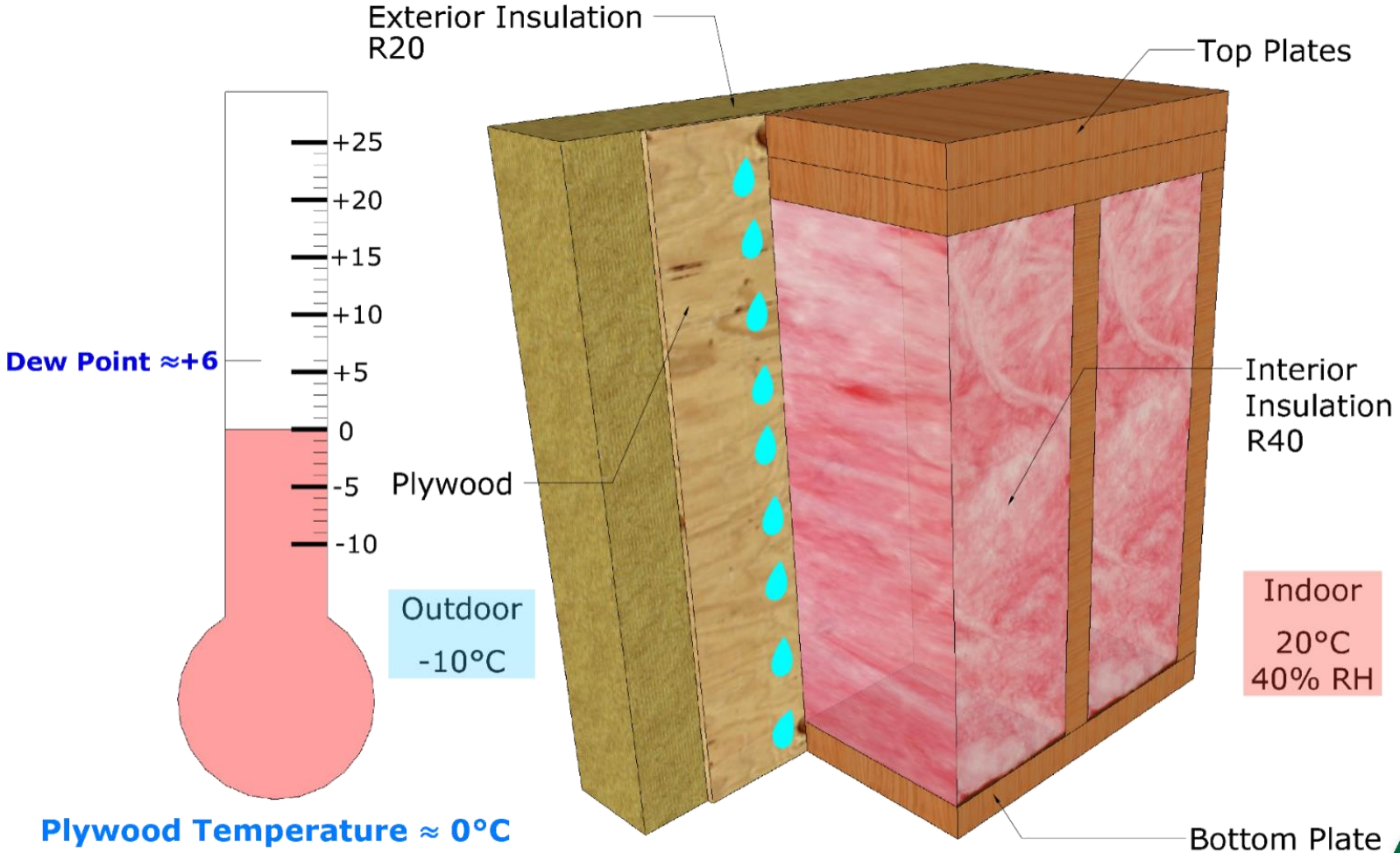

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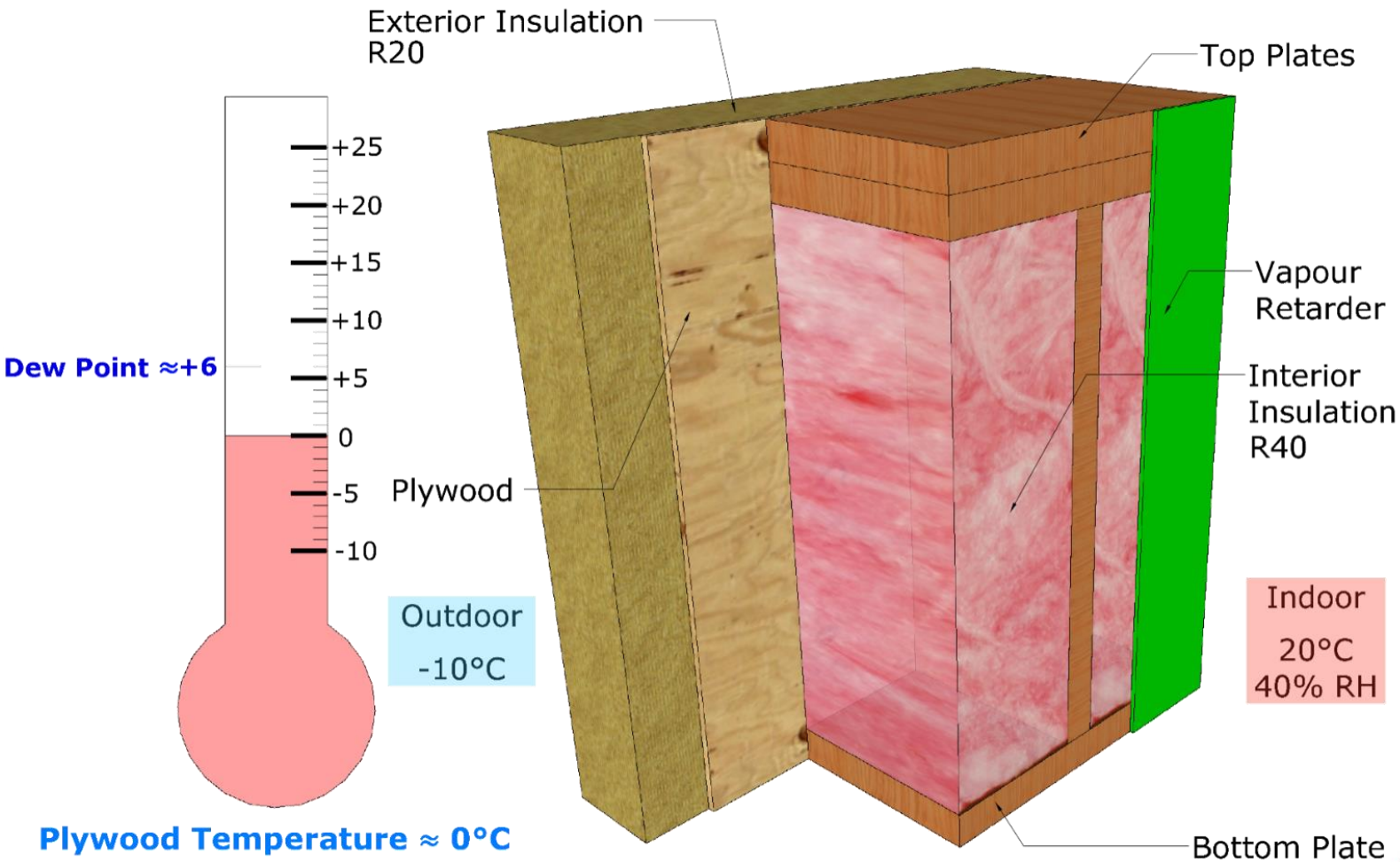

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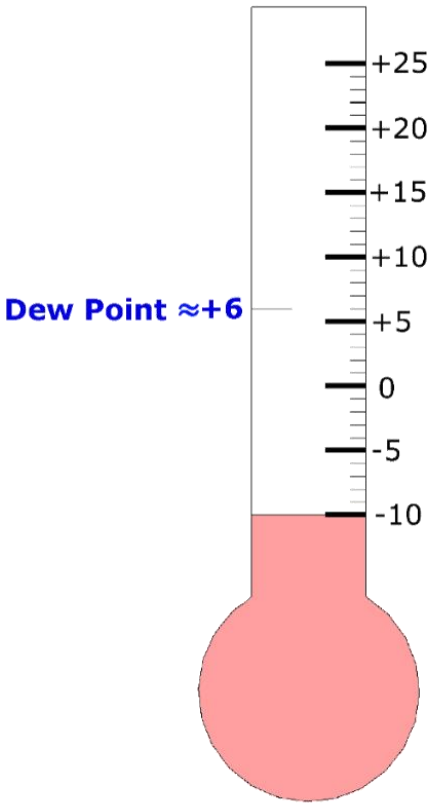
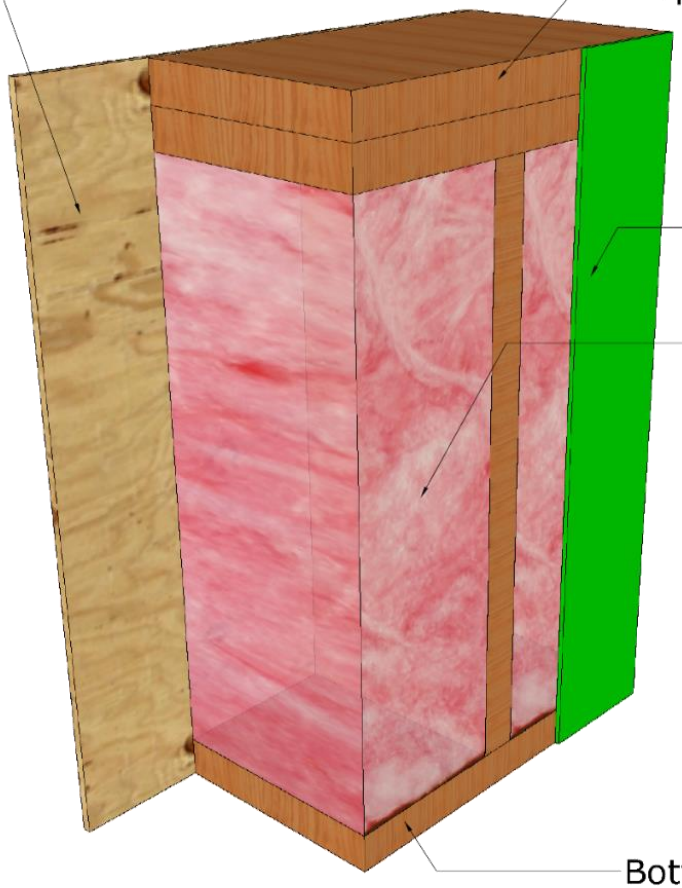


Outdoor
-10°C

Plywood Temperature ≈ -10°C



Indoor
20°C
40% RH

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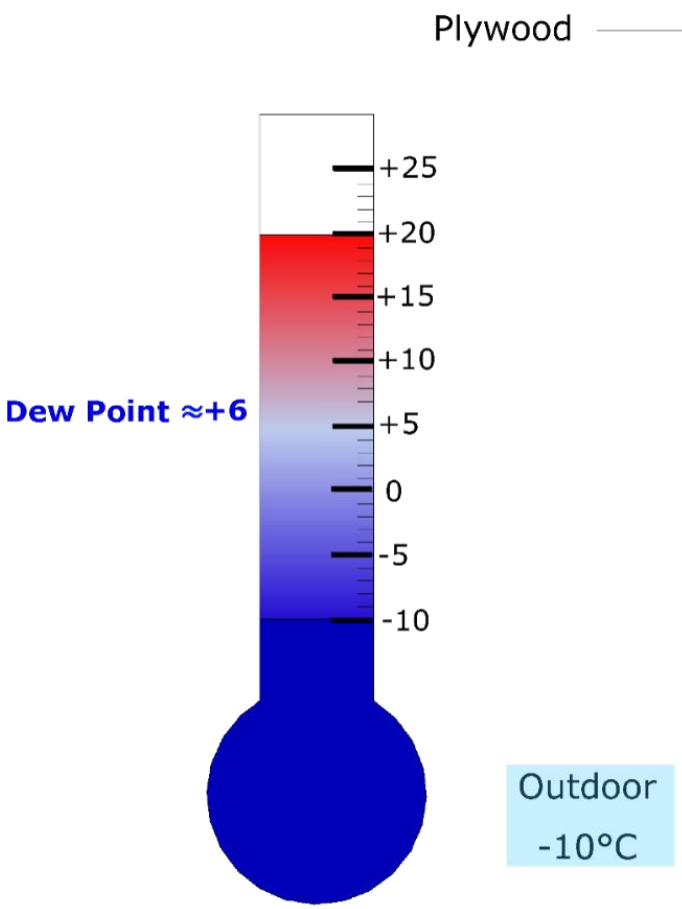
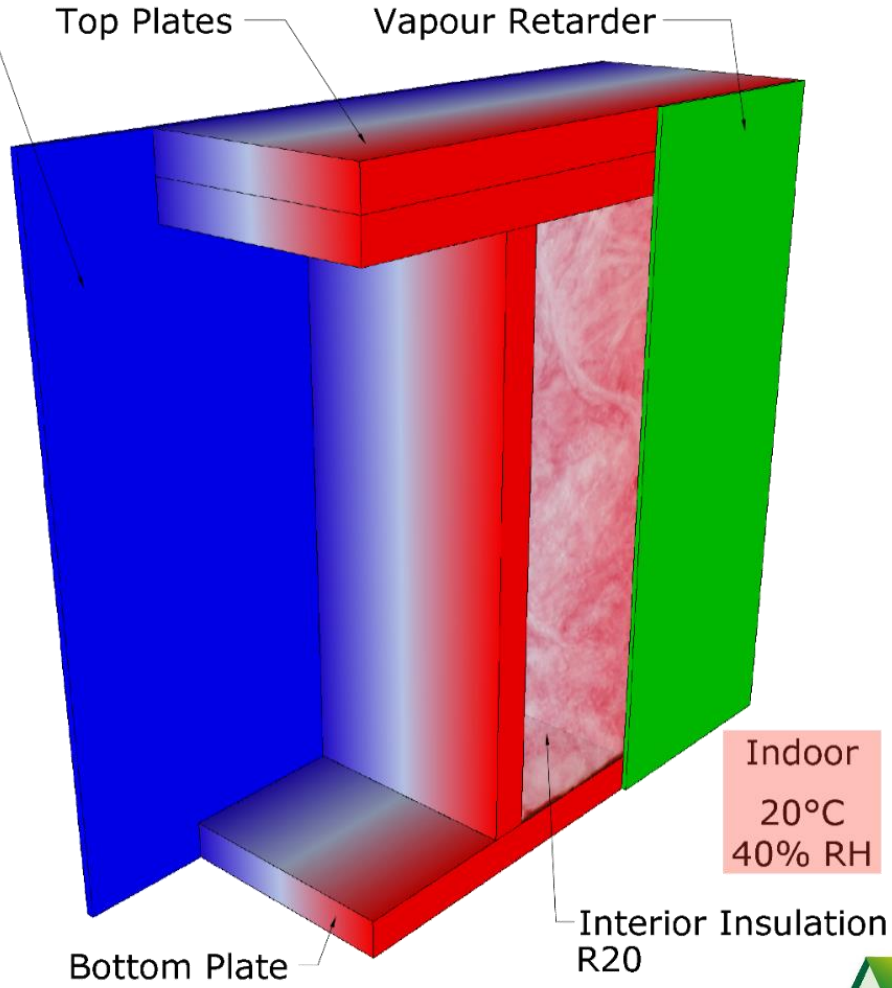


Wood Framing Temperature Varies Between -10°C to +20°C



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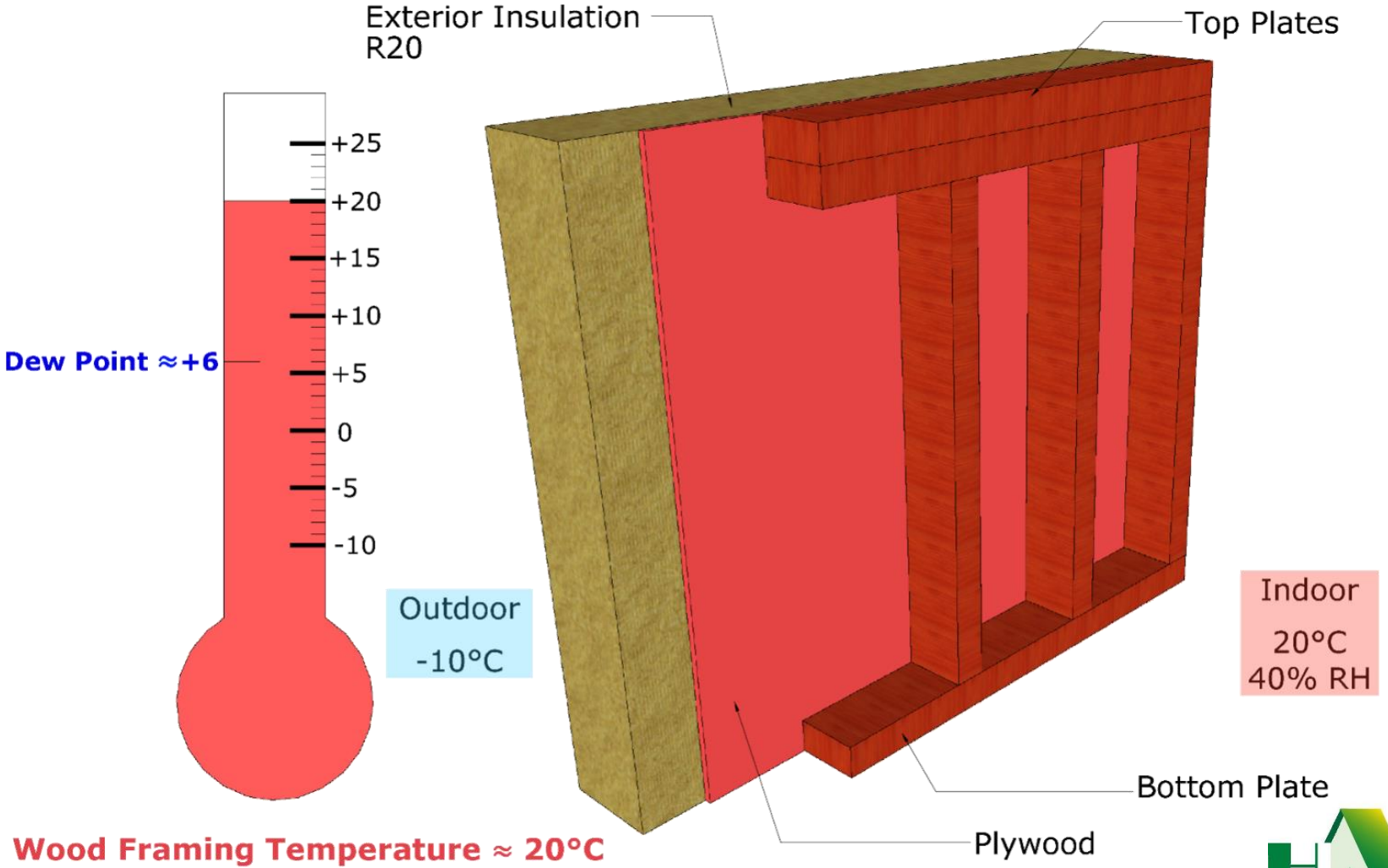

Wood Framing Temperature ≈ 20°C

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Assemblies to Watch For!

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Assembly # 1

Above Grade Wall

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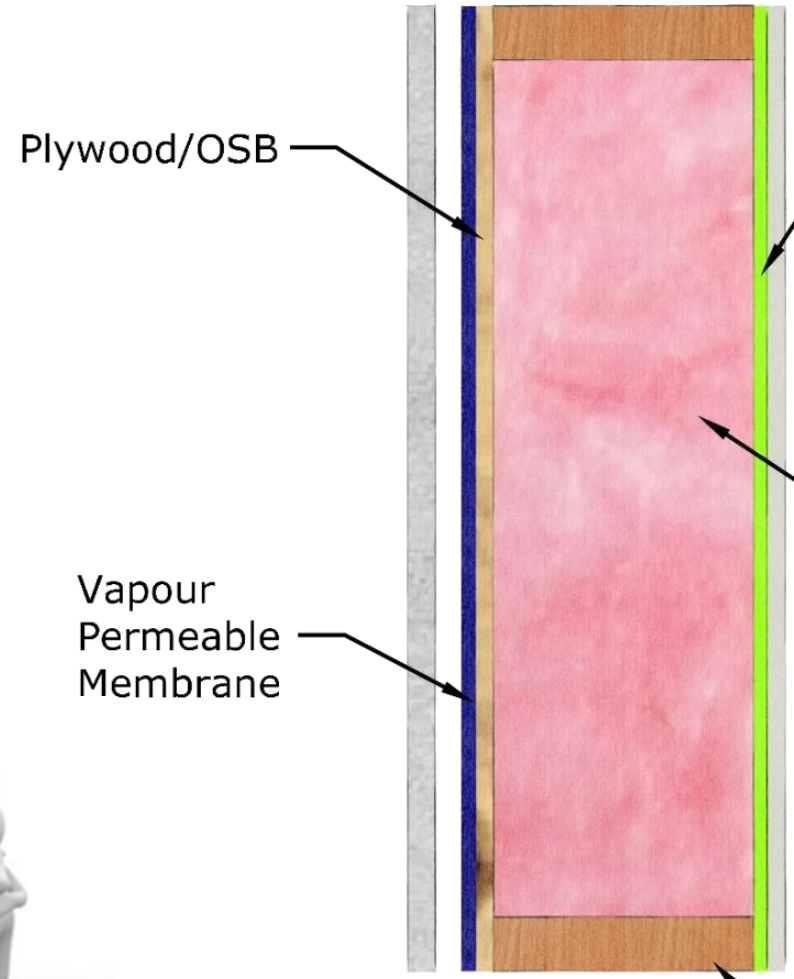
Assembly # 1



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Assembly # 1

- Low drying potential when exposed to incidental moisture

Assembly # 2

Above Grade Wall

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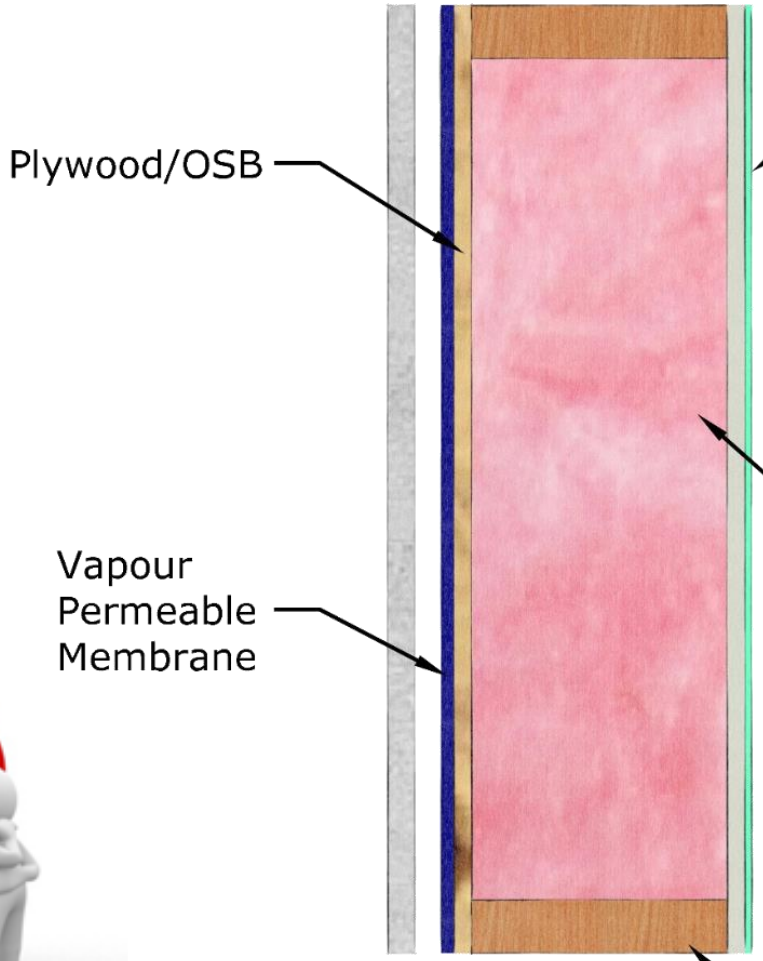
Assembly # 2



Outdoor

Indoor

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Assembly # 2

- Watch for potential risk of convective looping around the insulation and the resultant condensation. Convective looping is a different mechanism than air leakage, and becomes an important factor to watch for in assemblies in which air barrier is located outboard of the thermal insulation, such as sheathing membrane in Assembly # 2

- Verification of site-applied perm rating of the vapour retarding paint is rarely done

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Assembly # 3

Above Grade Wall

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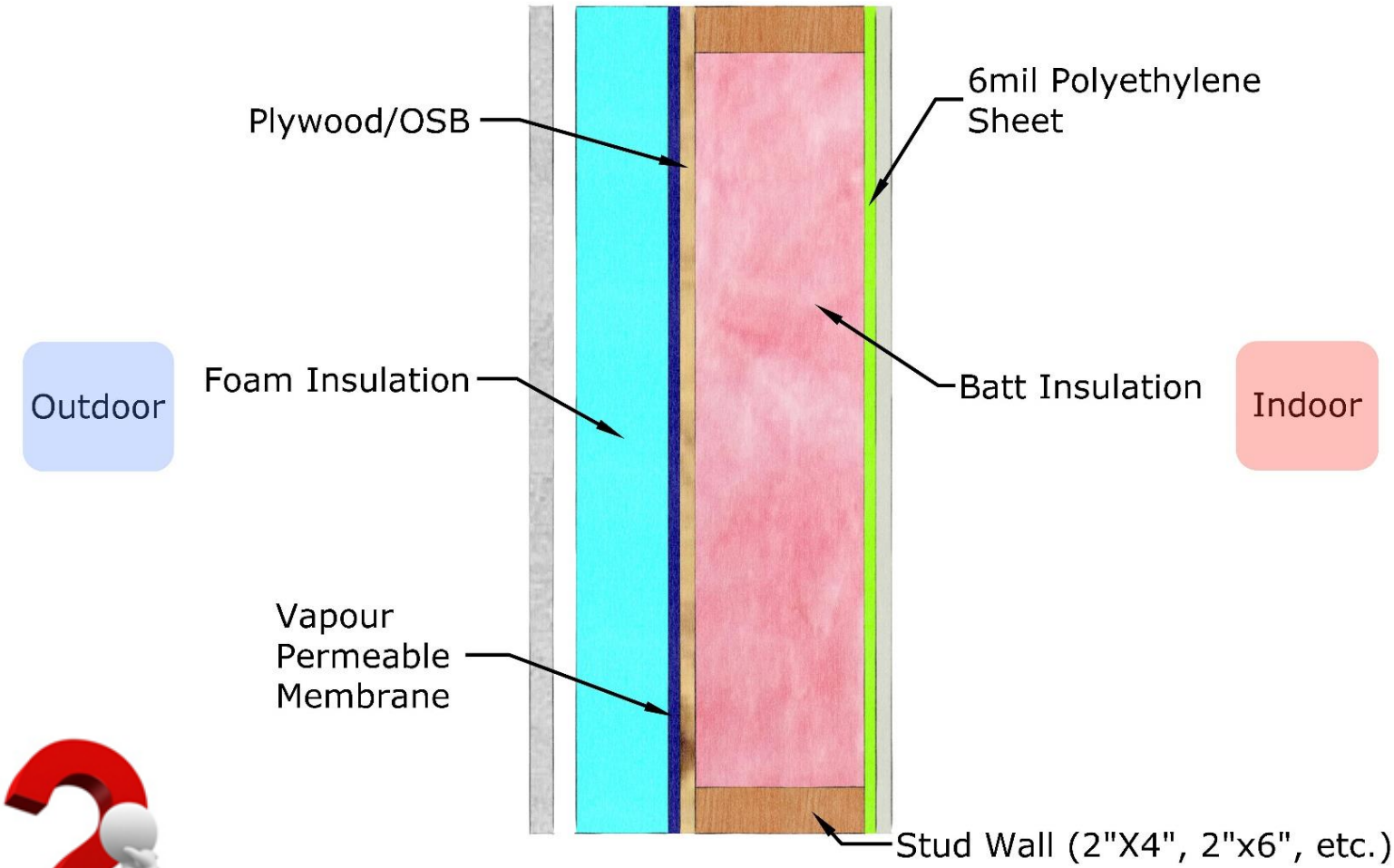
Assembly # 3



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Assembly # 3

- Wall is sandwiched between vapour barrier (6 mil poly) and vapour retarder (XPS)
- There is a misconception that this assembly is accepted by the BCBC. It is Not! See notes on the next slides
- Extremely low drying potential when exposed to incidental moisture

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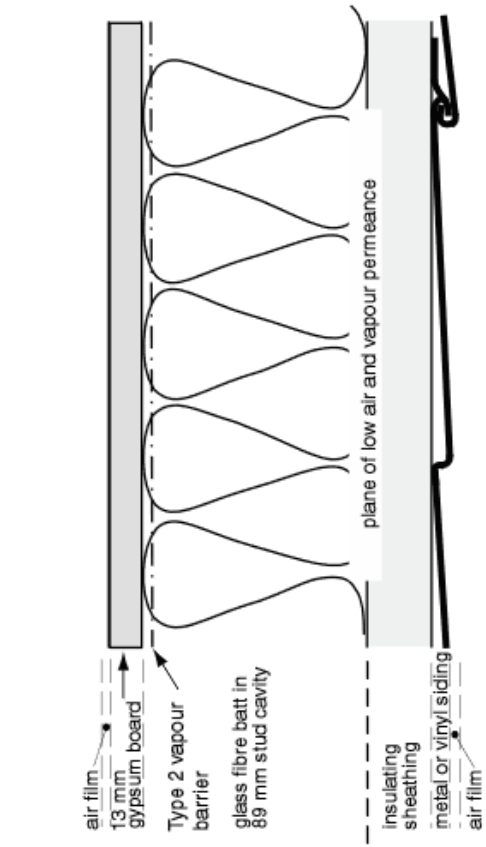
Assembly # 3

Calculating Inboard to Outboard Thermal Resistance



	Inboard			Outboard		
RSI value	0.12	0.08	2.11	0.87	0.12	0.03
Total RSI value	2.31			1.02		
Ratio	$\frac{1.02}{2.31} = 0.44$					

EG00382C

Figure A-9.25.5.2.
Example of a wall section showing thermal resistance inboard and outboard of a plane of low air and vapour permeance

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Assembly # 3

See underlying assumptions behind developing this table

Table 9.25.5.2.
atio of Outboard to Inboard Thermal Resistance
Forming part of Sentence 9.25.5.2.(1)

Heating Degree-Days of *Building* Location(1), Celsius degree-days	Minimum Ratio of Total Thermal Resistance Outboard of Material's Inner Surface to Total Thermal Resistance Inboard of Material's Inner Surface
up to 4 999	0.20
5 000 to 5 999	0.30
6 000 to 6 999	0.35
7 000 to 7 999	0.40
8 000 to 8 999	0.50
9 000 to 9 999	0.55
10 000 to 10 999	0.60
11 000 to 11 999	0.65
12 000 or higher	0.75

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Assembly # 3

A-9.25.5.2. Assumptions Followed in Developing Table 9.25.5.2. Article 9.25.5.2. specifies that a low air- and vapour-permeance material must be located on the warm face of the assembly, outboard of a vented air space, or within the assembly at a position where its inner surface is likely to be warm enough for most of the heating season such that no significant accumulation of moisture will occur. This last position is defined by the ratio of the thermal resistance values outboard and inboard of the innermost impermeable surface of the material in question.

The design values given in Table 9.25.5.2. are based on the assumption that the building includes a mechanical ventilation system (between 0.3 and 0.5 air changes per hour), a 60 ng/Pa·s·m^2 vapour barrier, and an air barrier (values between 0.024 and 0.1 L/sm^2 through the assembly were used). The moisture generated by occupants and their use of bathrooms, cleaning, laundry and kitchen appliances was assumed to fall between 7.5 and 11.5 L per day.

It has been demonstrated through modelling under these conditions that assemblies constructed according to the requirements in Table 9.25.5.2. do not lead to moisture accumulation levels that may lead to deterioration as long as the average monthly vapour pressure difference between the exterior and interior sides over the heating season does not increase above 750 Pa, which would translate into an interior relative humidity of 35% in colder climates and 60% in mild climates.

Health Canada recommends an indoor relative humidity between 35% and 50% for healthy conditions. ASHRAE accepts a 30% to 60% range. Environments that are much drier tend to exacerbate respiratory problems and allergies; more humid environments tend to support the spread of microbes, moulds and dust mites, which can adversely affect health.

In most of Canada in the winter, indoor RH is limited by the exterior temperature and the corresponding temperature on the inside of windows. During colder periods, indoor RH higher than 35% will cause significant condensation on windows. When this occurs, occupants are likely to increase the ventilation to remove excess moisture. Although indoor RH may exceed 35% for short periods when the outside temperature is warmer, the criteria provided in Table 9.25.5.2. will still apply. Where higher relative humidities are maintained for extended periods in these colder climates, the ratios listed in the Table may not provide adequate protection.
Some occupancies require that RH be maintained above 35% throughout the year, and some interior spaces support activities such as swimming that create high relative humidities. In these cases, Table 9.25.5.2. cannot be used and the position of the materials must be determined according to Part 5.

It should be noted that Part 9 building envelopes in regions with colder winters have historically performed acceptably when the interior RH does not exceed 35% over most of the heating season. With tighter building envelopes, it is possible to raise interior RH levels above 35%. There is no information, however, on how Part 9 building envelopes will perform when exposed to these higher indoor RH levels for extended periods during the heating season over many years. Operation of the ventilation system, as intended to remove indoor pollutants, will maintain the lower RH levels as necessary.

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Assembly # 3

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Vapour Permeance of 6 mil poly is **much lower** than this figure!

Assembly 3 does NOT fall under the assumption developed for Table 9.25.5.2

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Assembly # 4

Above Grade Wall

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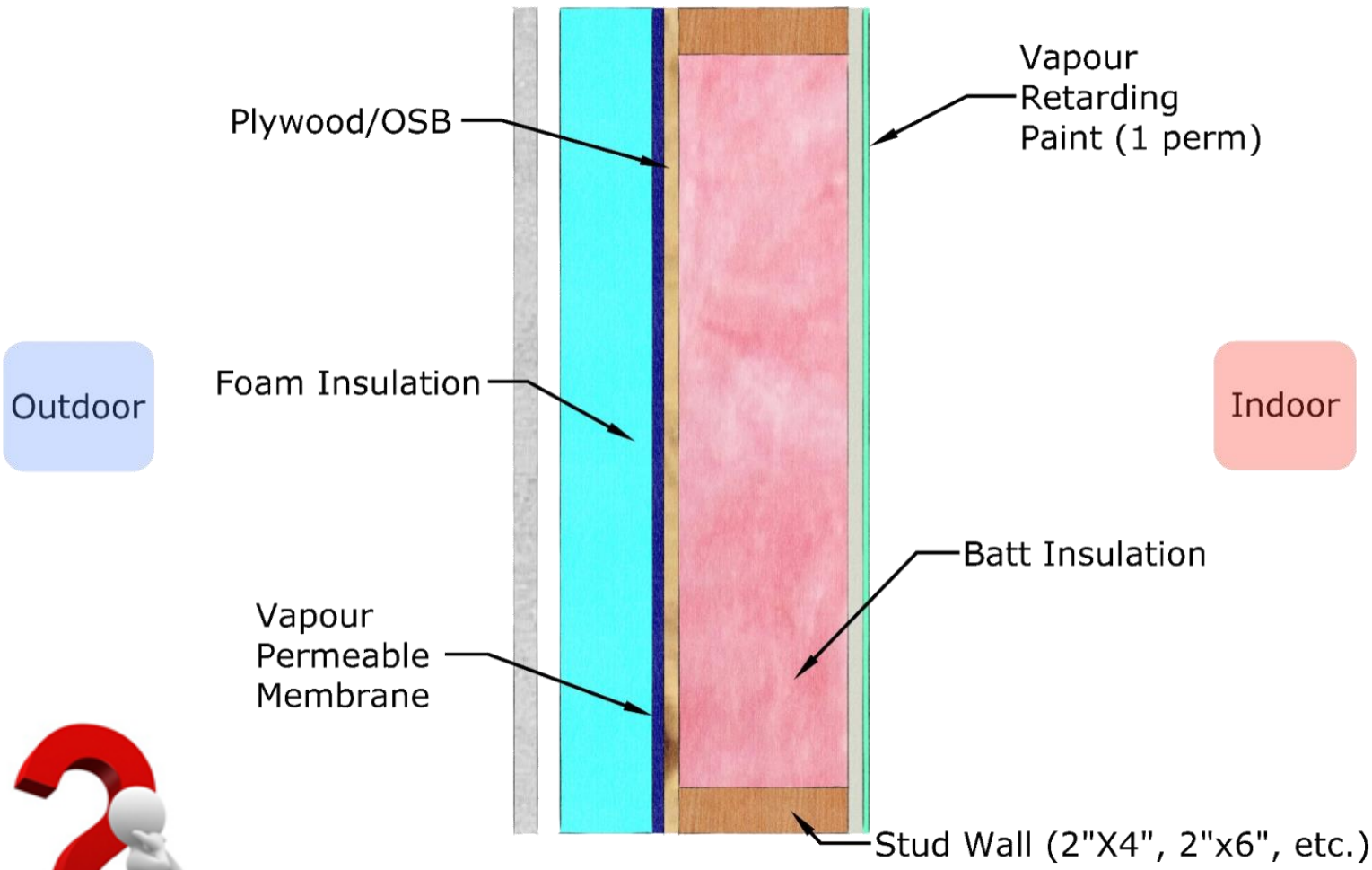
Assembly # 4



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Assembly # 4

- While Assembly # 4 is accepted by BCBC under certain conditions, there are limitations on using this assembly. Read the Appendix for the underlying assumptions for Table 9.25.5.2

- Verification of site-applied perm rating of the vapour retarding paint is rarely done

Assembly # 4

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Assembly # 4

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Assembly # 4

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What does "no information" mean to you, and how does that relate to your projects and long-term performance?

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Assembly # 5

Above Grade Wall

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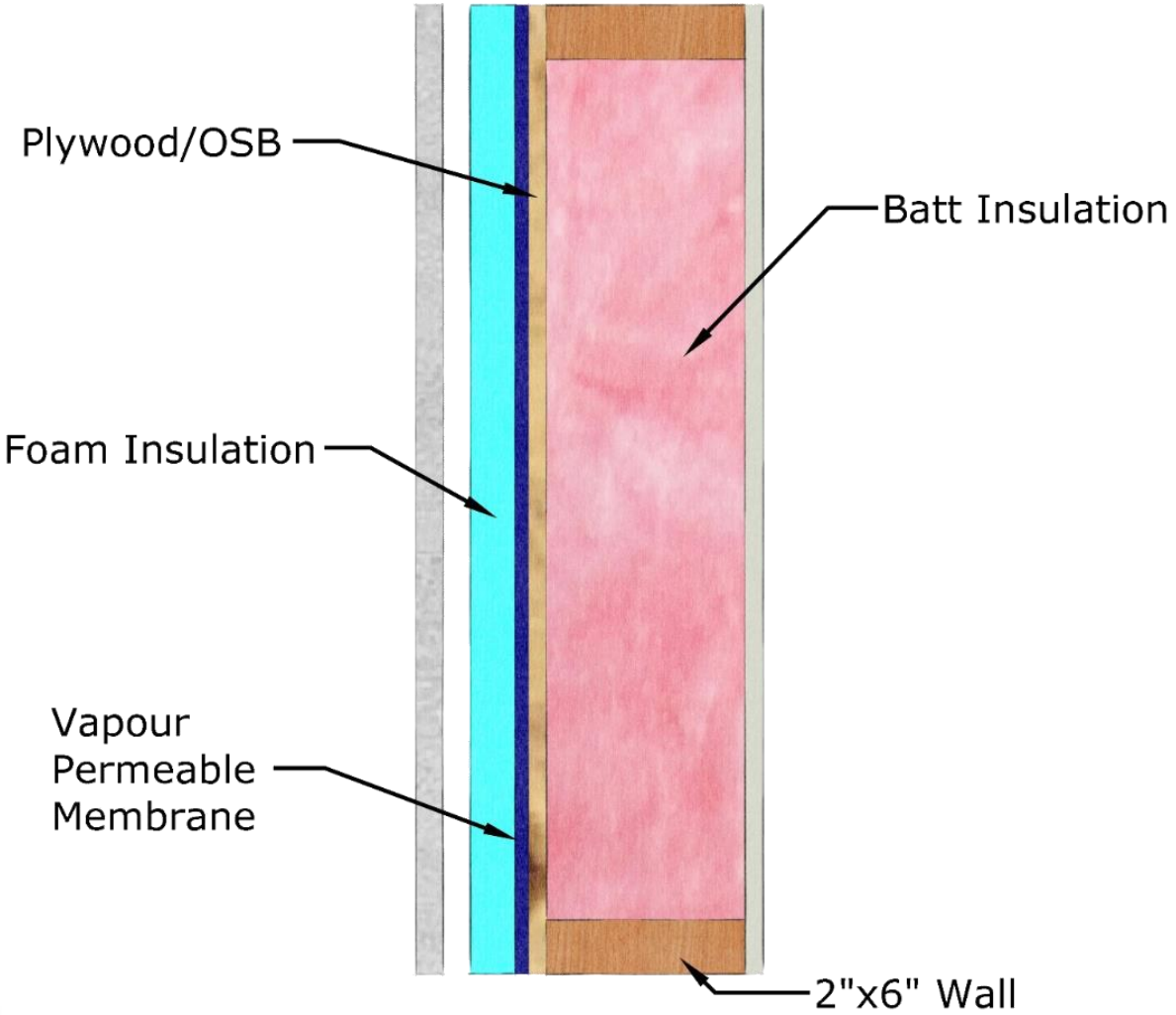
Assembly # 5



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Assembly # 5

- ✗ Vapour retarder is located on the cold side of the assembly
- ✗ High risk of condensation on the plywood sheathing

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Assembly # 6

Above Grade Wall

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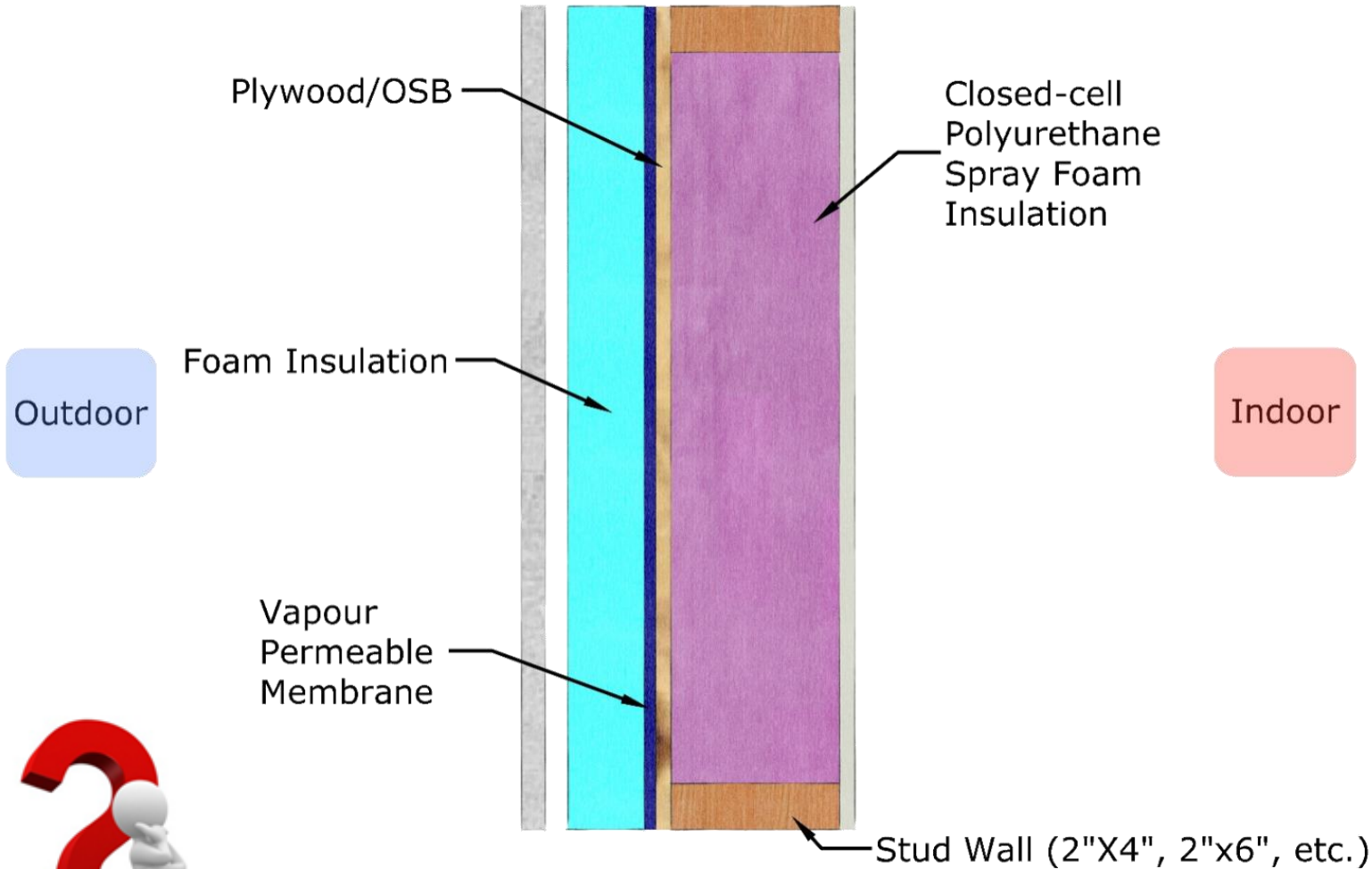
Assembly # 6



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Assembly # 6

- Plywood is sandwiched between two vapour retarders (Closed cell spray foam & XPS)
- Very low drying potential for plywood and studs when exposed to incidental moisture
- Utilities (pipes, ducts, wires, etc.) are encapsulated in the foam, making the future access to them exceptionally challenging and costly for end users when it comes to addressing leak, repair, renovation, etc.

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Assembly # 6

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Assembly # 7

Roof / Deck

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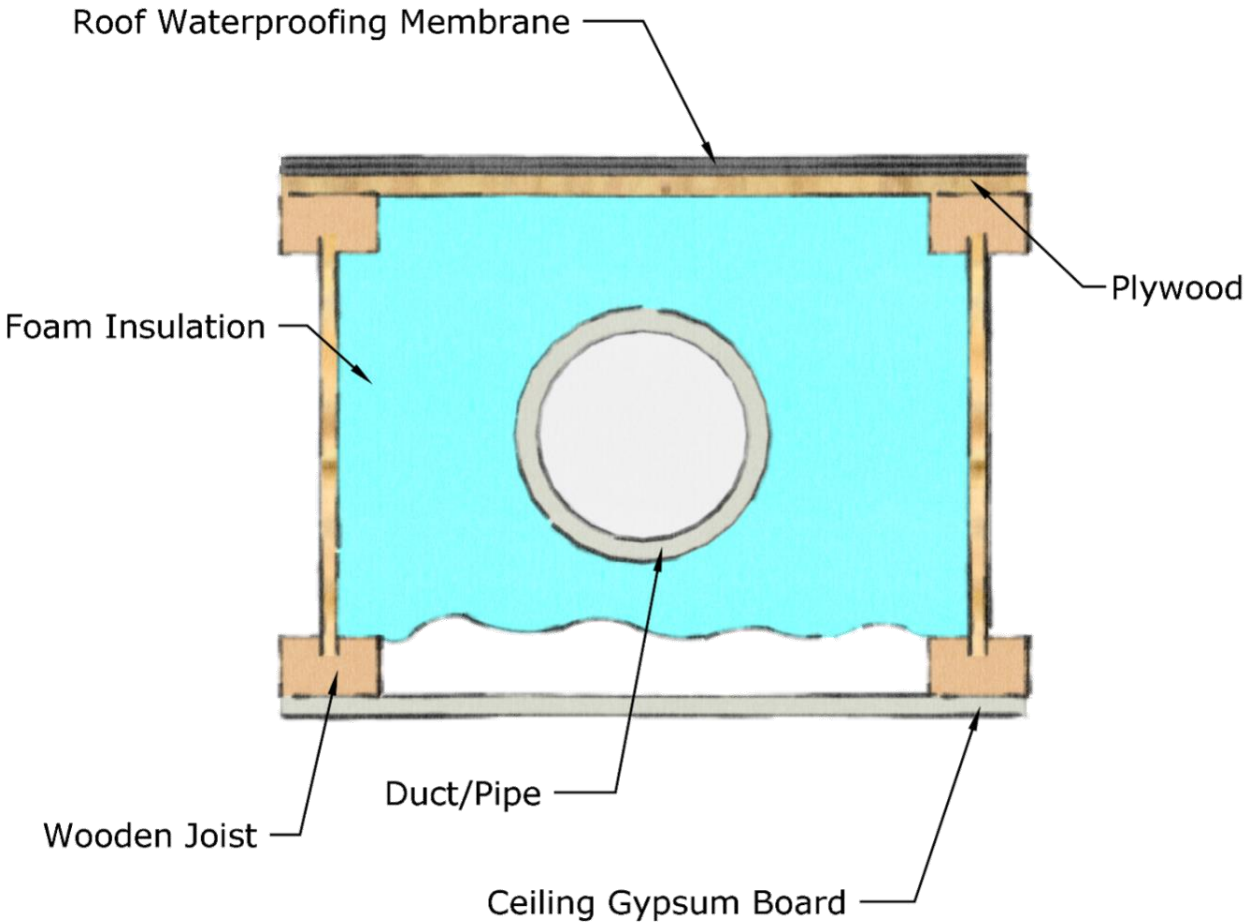
Assembly # 7



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Assembly # 7

- Risk of moisture trap when exposed to incidental moisture
- Utilities (pipes, ducts, wires, etc.) are encapsulated in the foam, making the future access to them exceptionally challenging and costly for end users when it comes to addressing leak, repair, renovation, etc.

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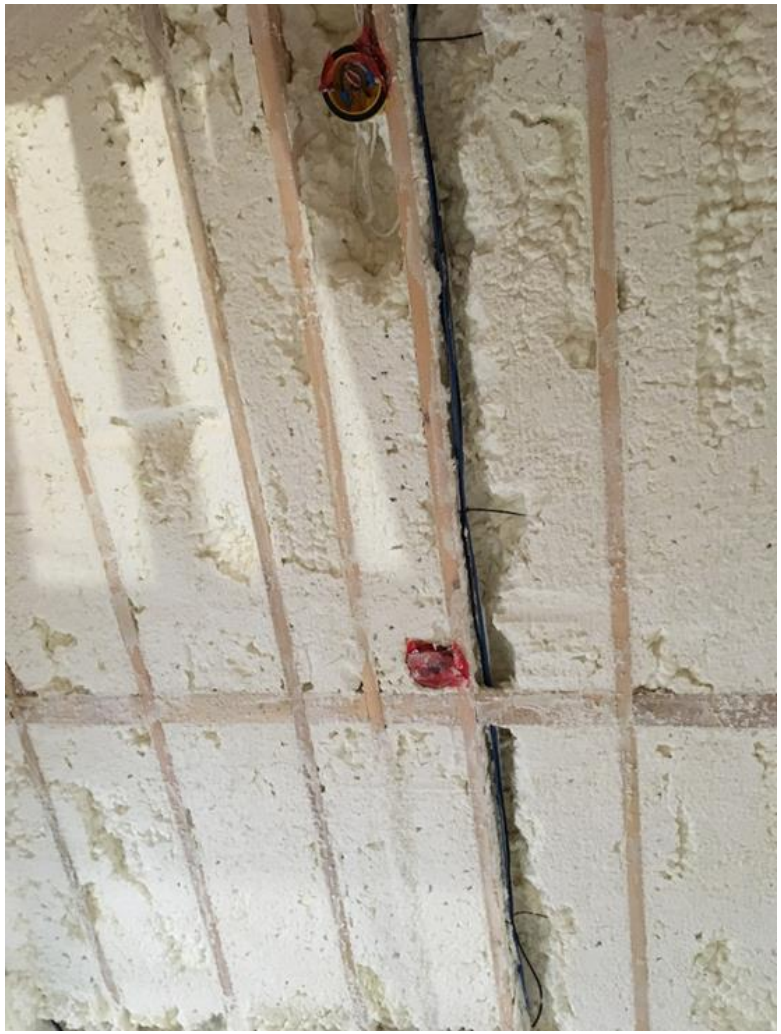
Assembly # 7



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Assembly # 7

HAMID DESIGN BUILD

Assembly # 7

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Assembly # 7

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Assembly # 7

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Assembly # 8

Roof / Deck

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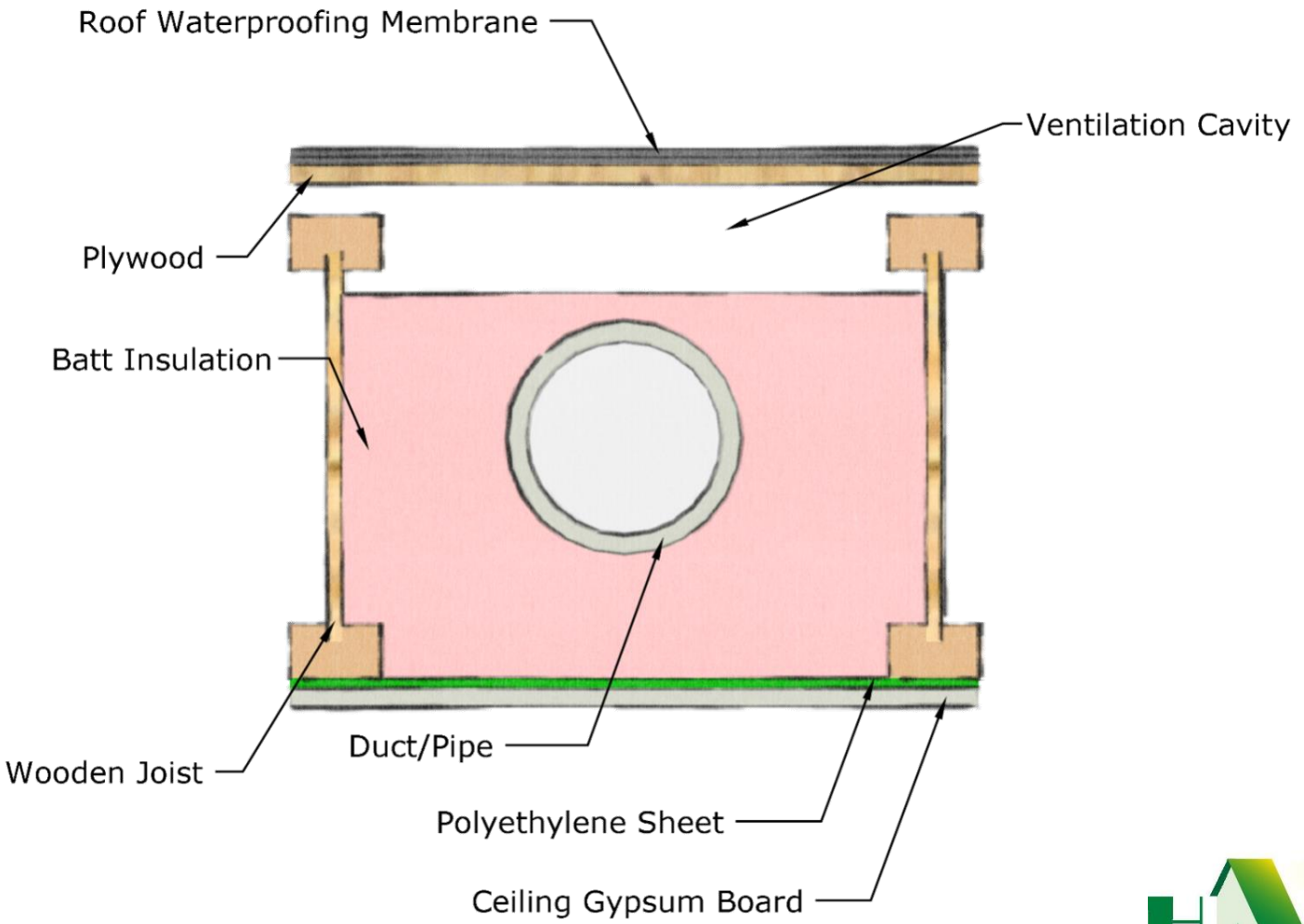
Assembly # 8



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Assembly # 8

- Prone to moisture problems, known as early as 1960s. See notes on the next slides
- Ventilation not effective in addressing moisture problems
- Achieving long-term airtight detailing around ceiling penetrations (potlight, etc.) very challenging

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Assembly # 8

HAMID DESIGN BUILD

Assembly # 8

HAMID DESIGN BUILD

Assembly # 8

National Research Council Canada | Conseil national de recherches Canada

Canada

ARCHIVED - CBD-16. Thermal insulation in dwellings

Canadian Building Digests | **NRC-IRC publications**

Please note

This publication is a part of a discontinued series and is archived here as an historical reference. Readers should consult design and regulatory experts for guidance on the applicability of the information to current construction practice.

Originally published April 1961

W. H. Ball

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Assembly # 8

The Insulation of Flat Roofs

Insulation for flat roofs may be placed either between joists as illustrated in Fig. 3 (a), or on top of the roof deck as in Fig. 3(b). Variations of both methods are also used. That of Fig. 3(a) may, for example, have batt insulation placed between furring strips running at right angles, below the joists.

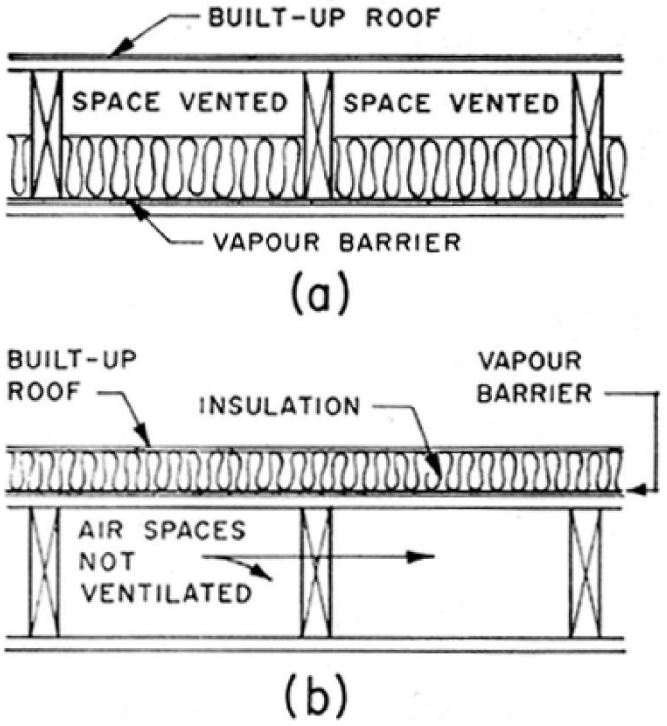

Figure 3. Roof insulation arrangements

The methods of installation similar to that of 3(a) are sometimes criticized because it is often difficult to provide adequate ventilation above the insulation in large roof areas, and in locations where buildings are erected side by side. Condensation problems have been reported in constructions of this type even where an attempt has been made to control it by the use of a vapour barrier and ventilation. As a result there has been a tendency to favour the type of installation illustrated by Fig. 3 (b).

We learned this in 1961!. Yet we still seem to follow the same practice!

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Assembly # 9

Roof / Deck

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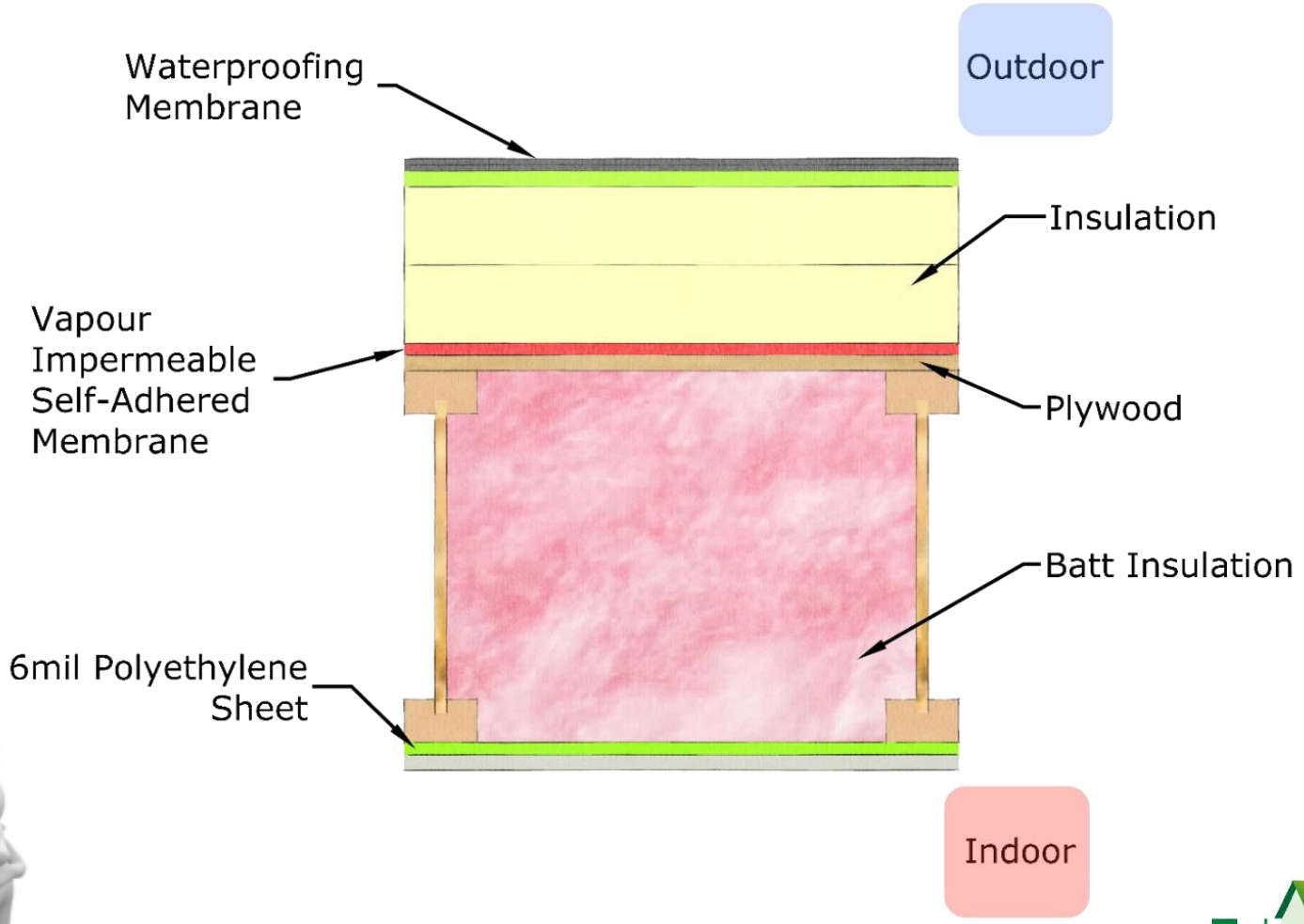
Assembly # 9


Waterproofing Membrane
Outdoor
Insulation
Vapour Impermeable Self-Adhered Membrane
Plywood
Batt Insulation
6mil Polyethylene Sheet
Indoor

Assembly # 9

- ✗ Structure sandwiched between two vapour barriers
- ✗ Insulation sandwiched between two vapour barriers
- ✗ Extremely low drying potential when exposed to incidental moisture

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Assembly # 10

Roof / Deck

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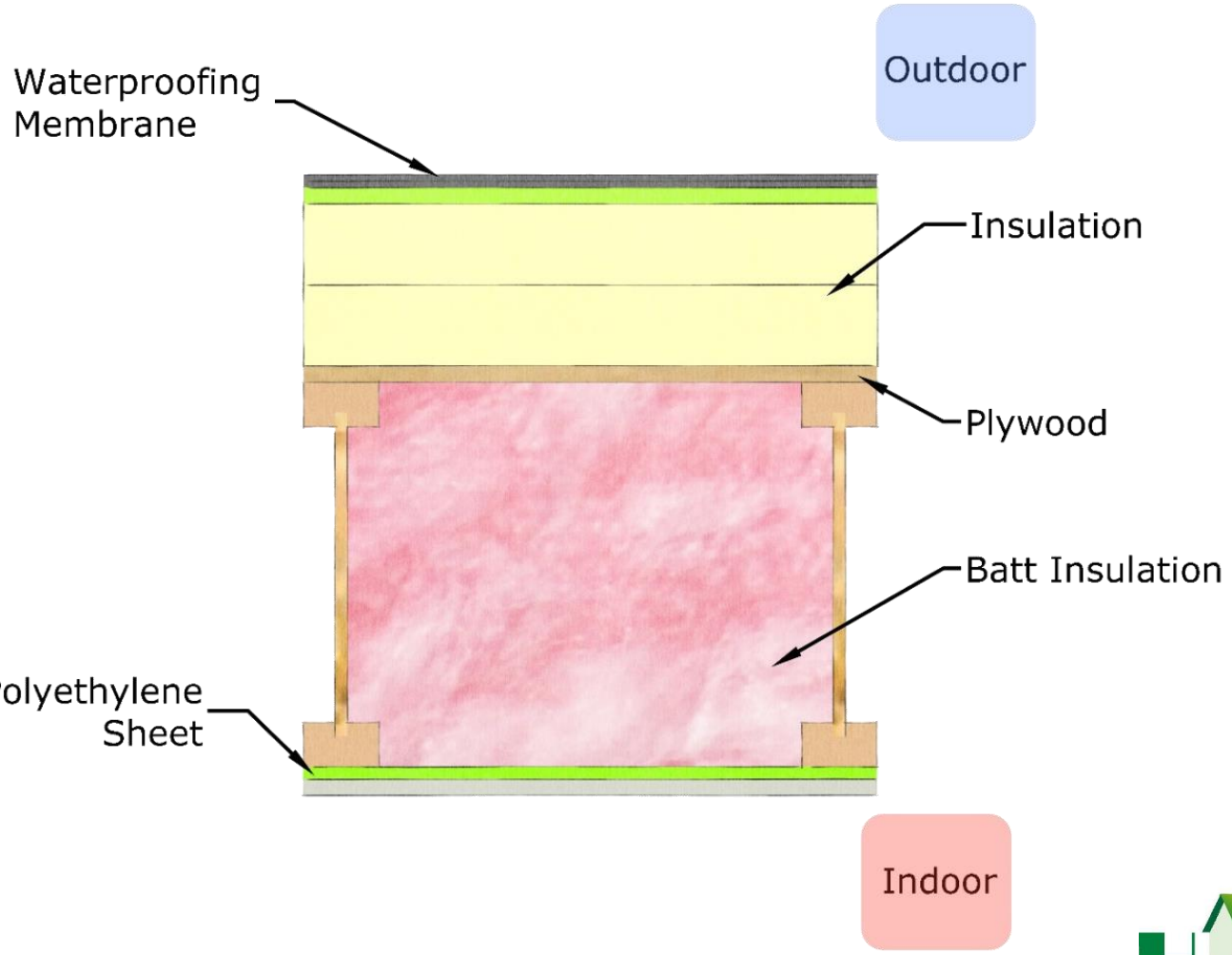
Assembly # 10



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Assembly # 10

- ✗ Structure sandwiched between two vapour barriers
- ✗ Insulation sandwiched between two vapour barriers
- ✗ Extremely low drying potential when exposed to incidental moisture

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Assembly # 11

Below Grade Wall

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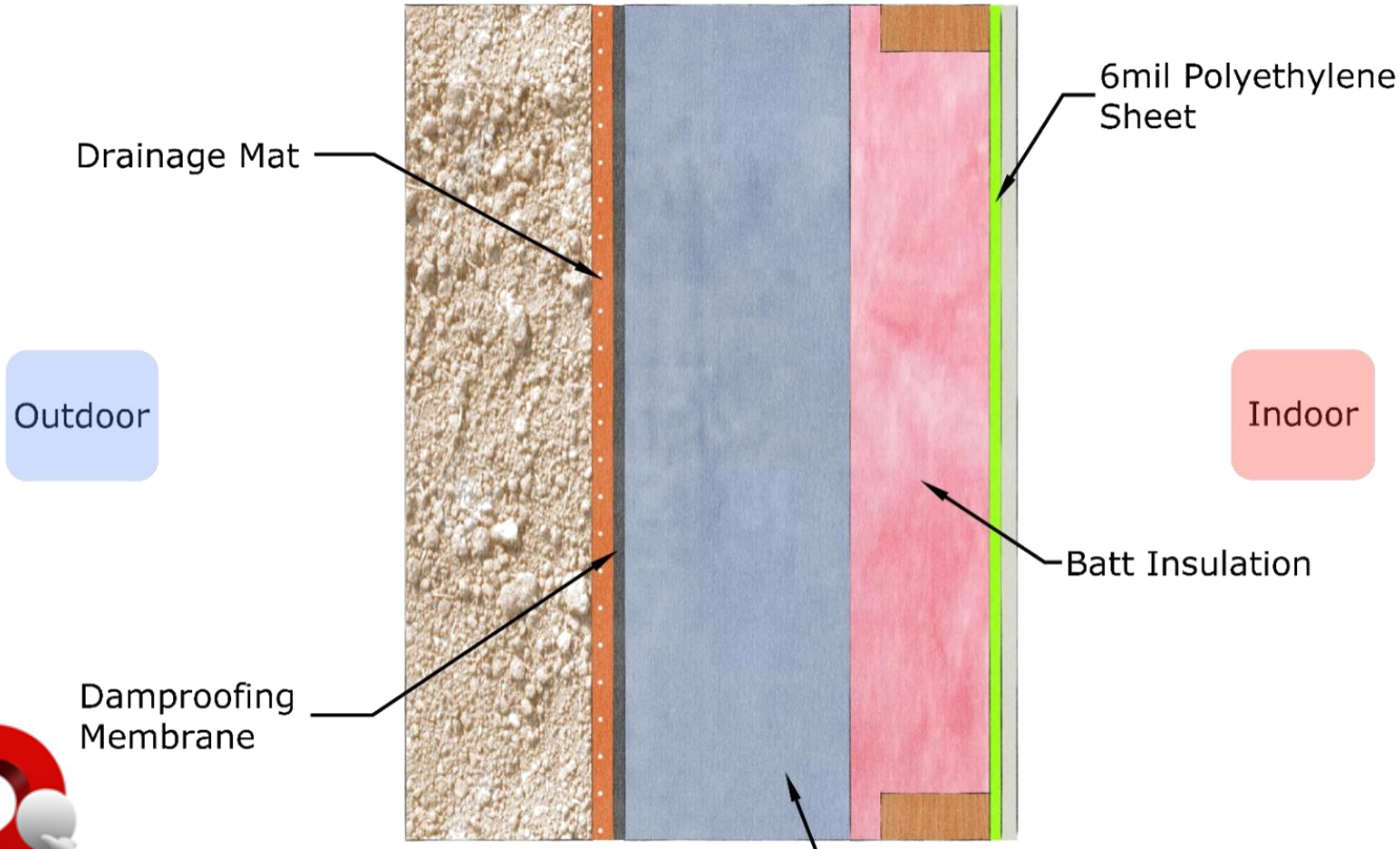
Assembly # 11



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Assembly # 11

- Does not follow basic Building science principles associated to below grade wall design
- The whole wall is sandwiched between vapour barriers (6 mil poly, dampproofing membrane/drainage mat)
- Extremely low drying potential when exposed to incidental moisture

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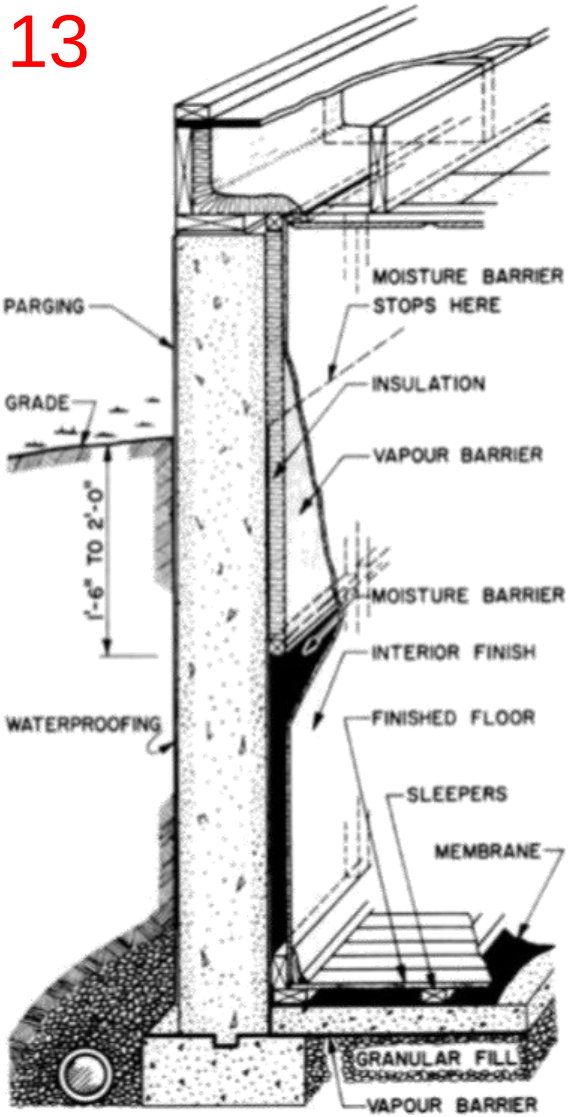
Assembly # 11

Canadian Building Digest 13

House Basement



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Assembly # 12

High Solar Heat Gain Coefficient Window **without Shading**

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Summer Overheating

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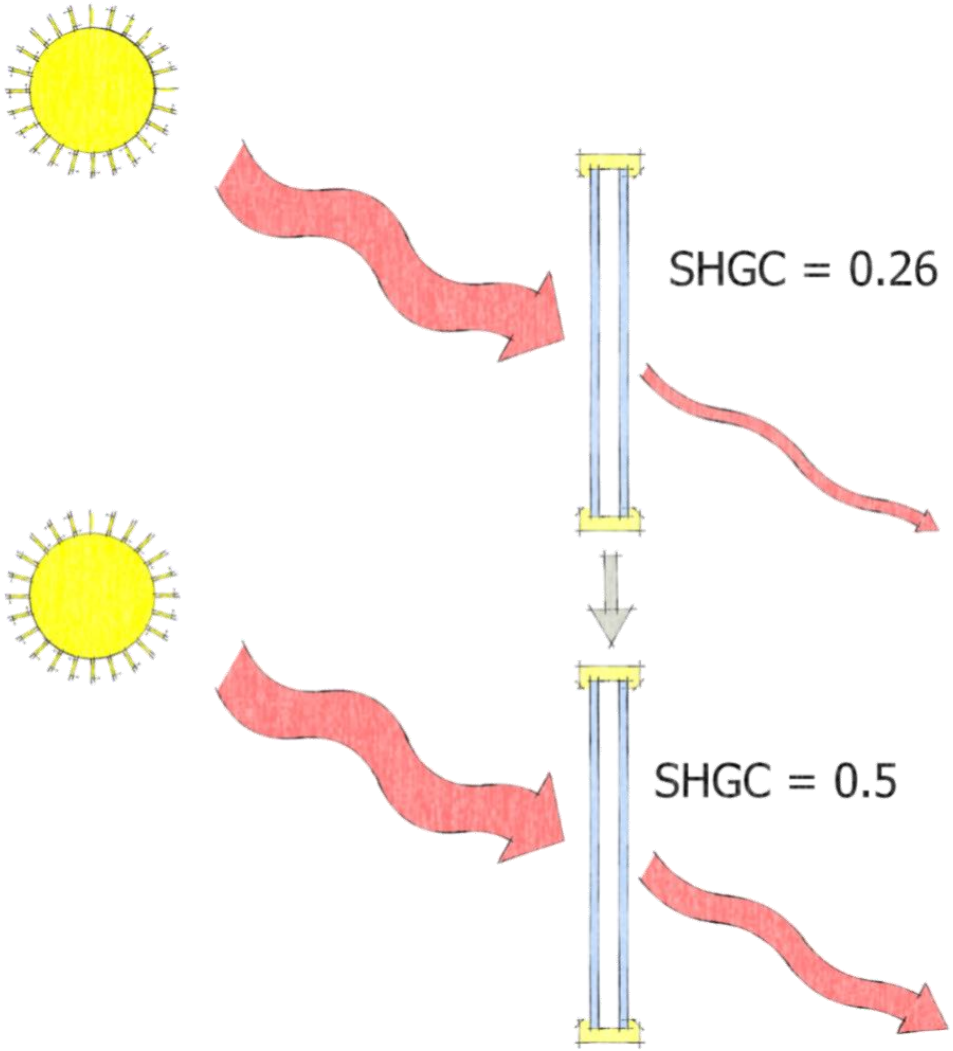
Assembly # 12

- Windows with high solar heat gain coefficient can result in excessive solar gain during summer in the absence of effective shading strategies (overhang along south, exterior blinds along east and west), leading to occupant discomfort.

Solar Heat Gain Coefficient



HAMID DESIGN BUILD

Overhang

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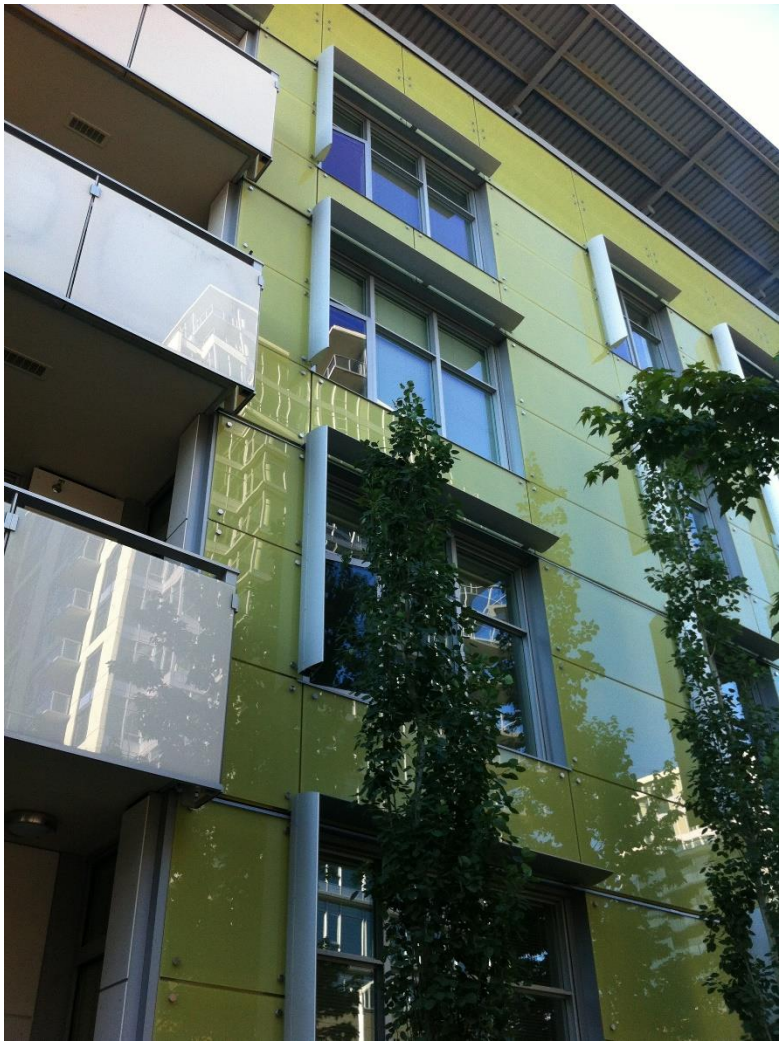
DESIGN BUILD

Overhang



HAMID
DESIGN BUILD

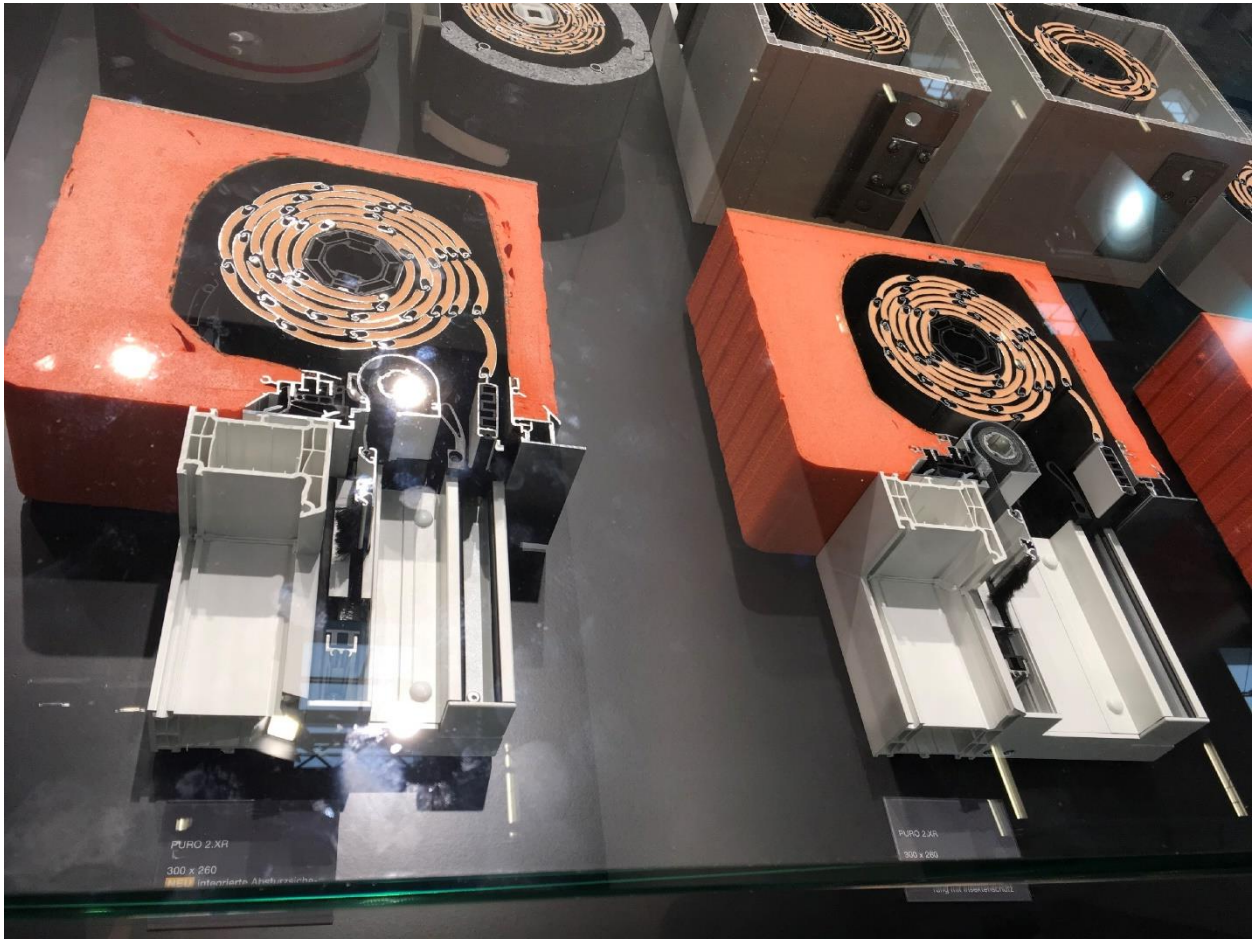
Exterior Blind

HAMID
DESIGN BUILD

Exterior Blind

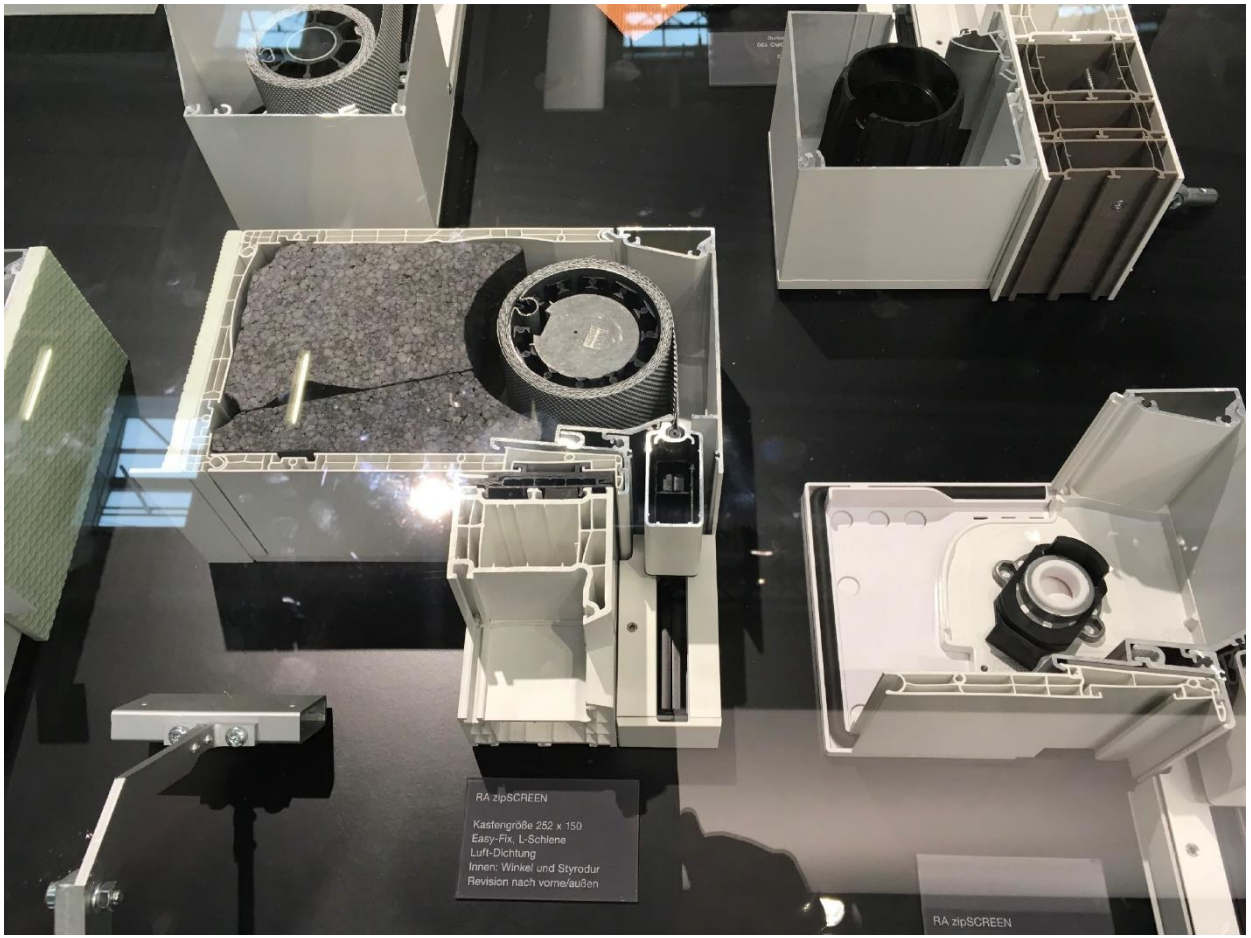
HAMID
DESIGN BUILD

Exterior Blind



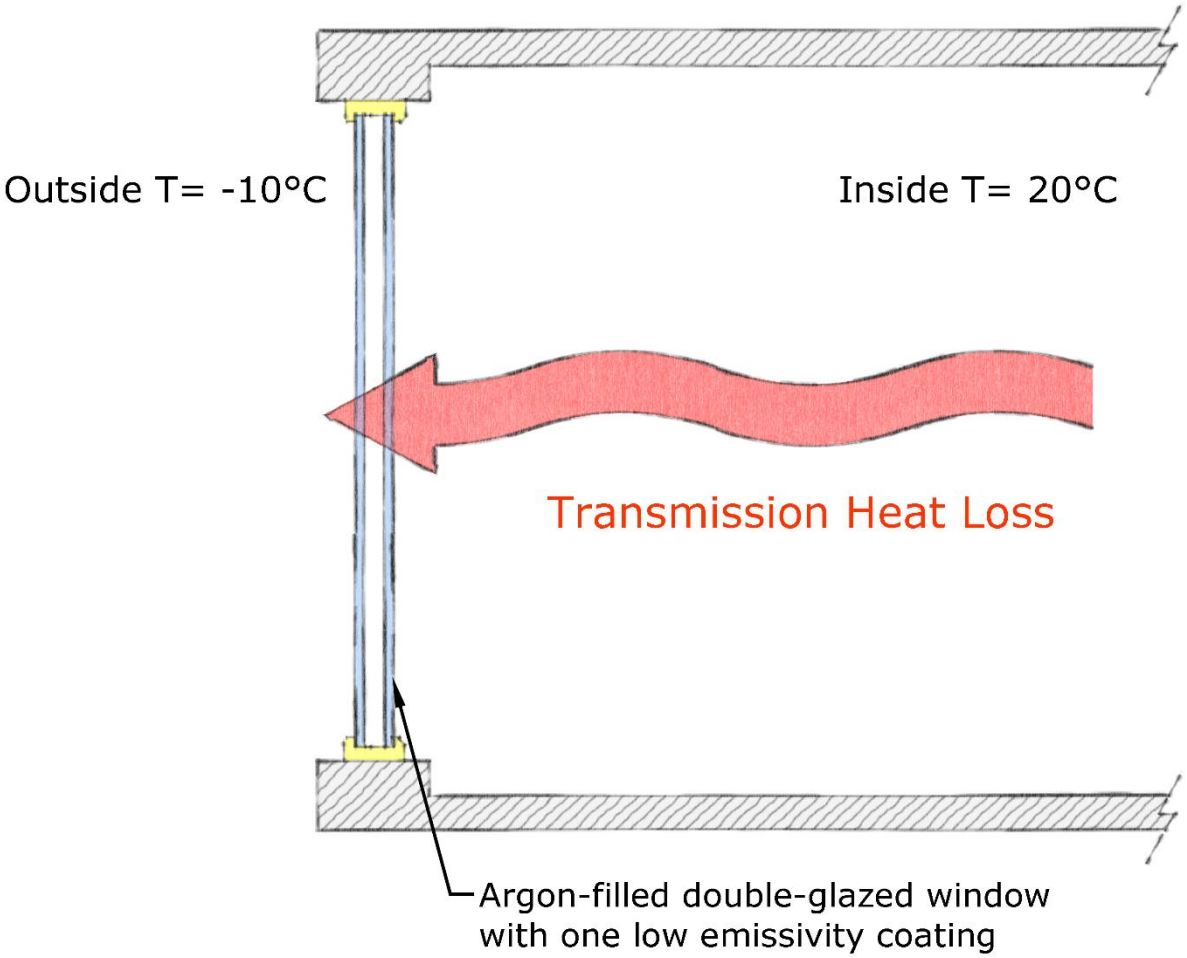
HAMID DESIGN BUILD

Exterior Blind



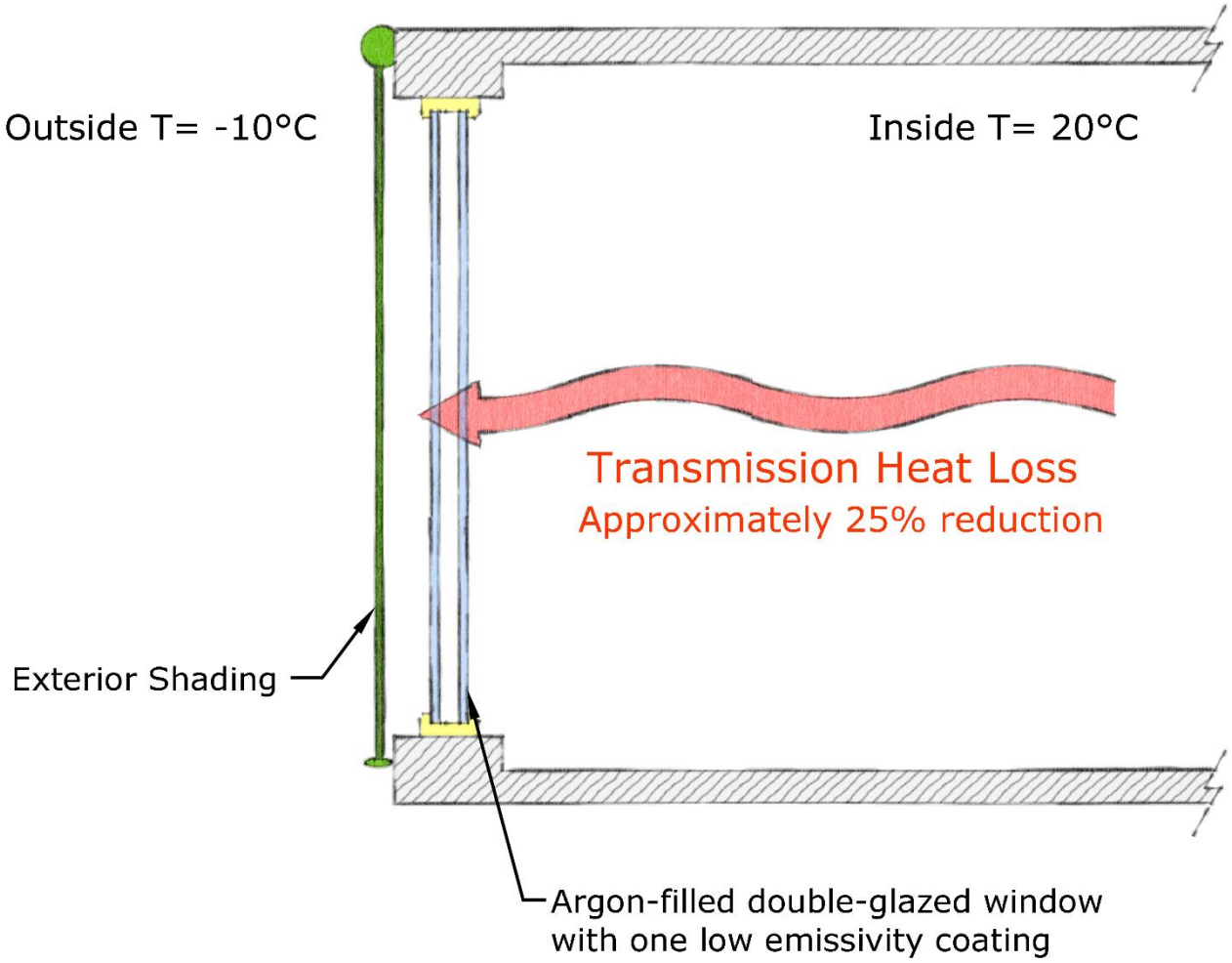
HAMID DESIGN BUILD

Exterior Blind



HAMID DESIGN BUILD

Exterior Blind



HAMID DESIGN BUILD

Exterior Blind

HAMID DESIGN BUILD

Exterior Blind

HAMID
DESIGN BUILD

Shade

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DESIGN BUILD

Assembly # 13

Double-Glazed Window with Low E on Surface # 4

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Assembly # 13

- Low E coating applied over the inner pane of IGU in double-glazed windows can pose the risk of compromised thermal comfort (due to increased rate of net radiation heat exchange between our bodies and inner pane of glass), and potential risk of condensation (due to reduced temperature of the inner pane of glass). In addition, the long-term performance of such coatings when exposed to window cleaning agents is questionable.

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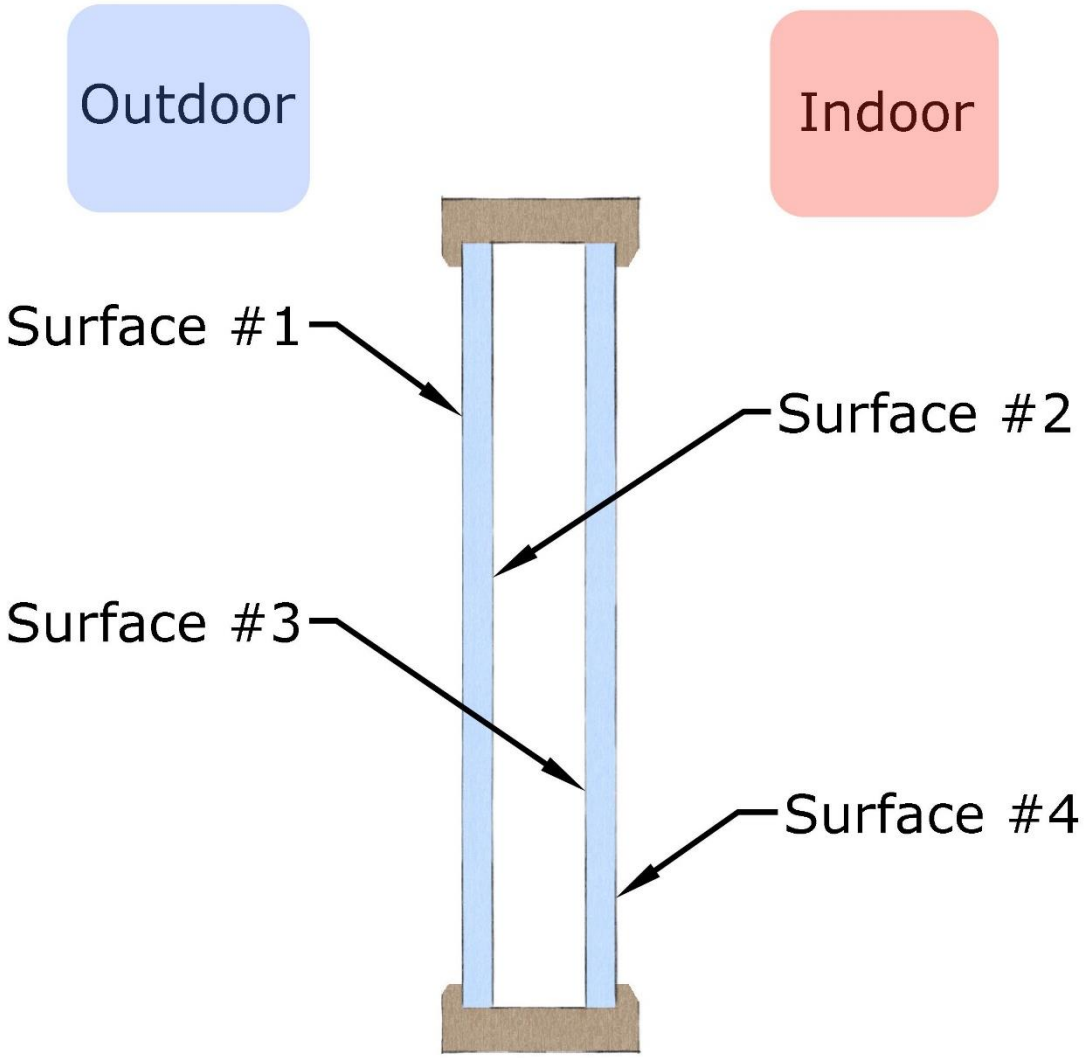
DESIGN BUILD

IGU



Low E on Surface # 2, and the associated impact on the temperature of the inner pane of glass

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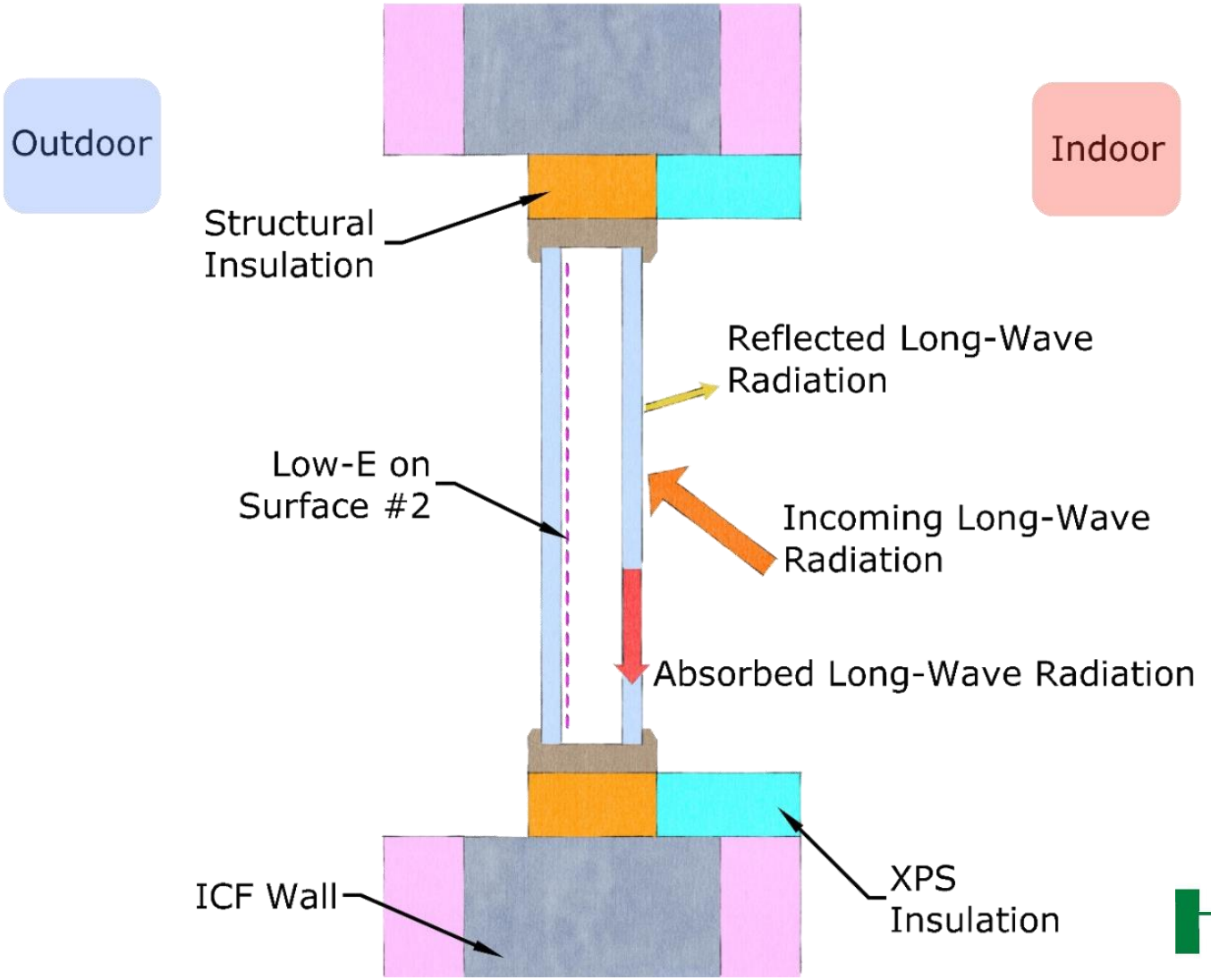
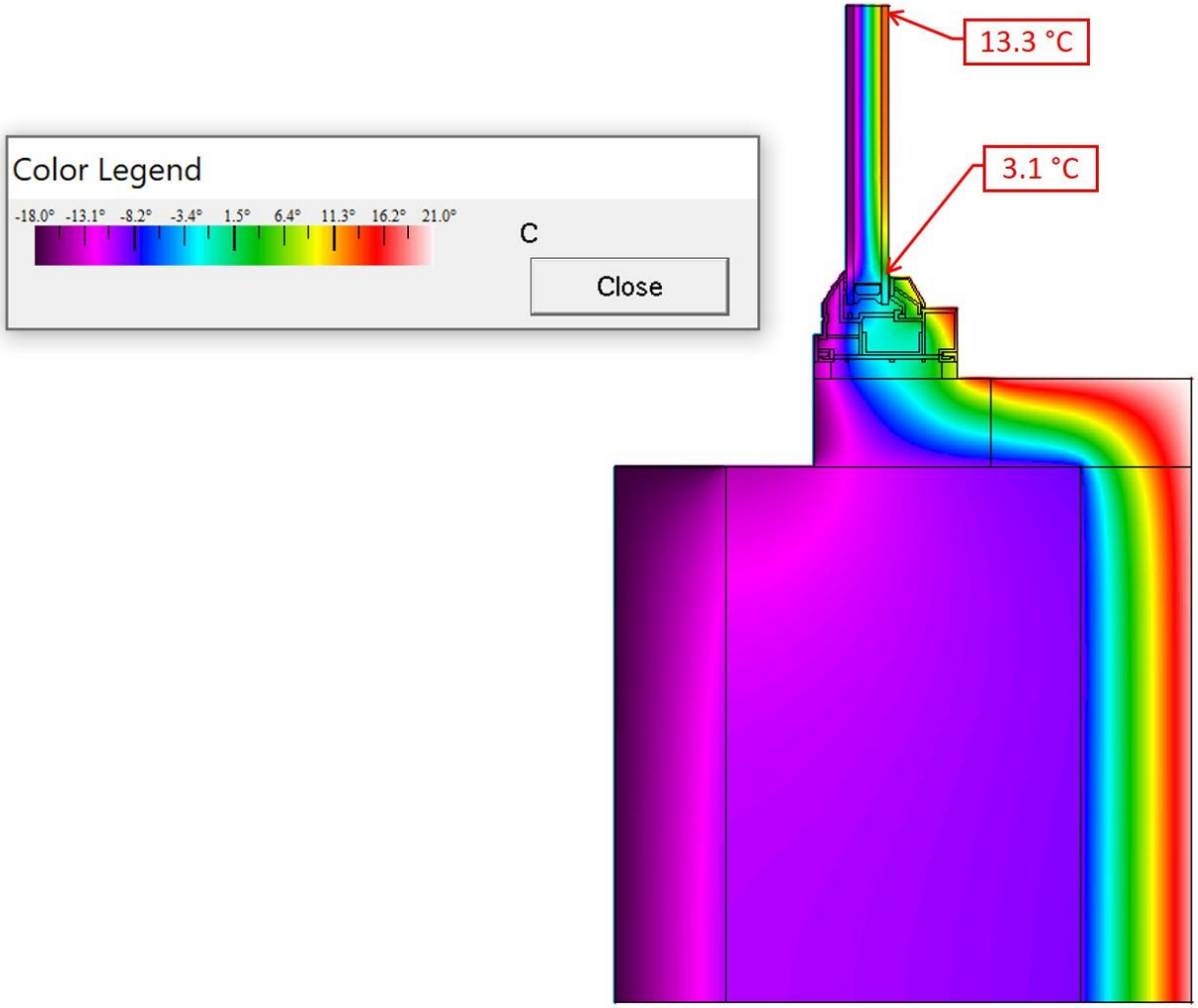
Low E on Surface # 2



HAMID DESIGN BUILD

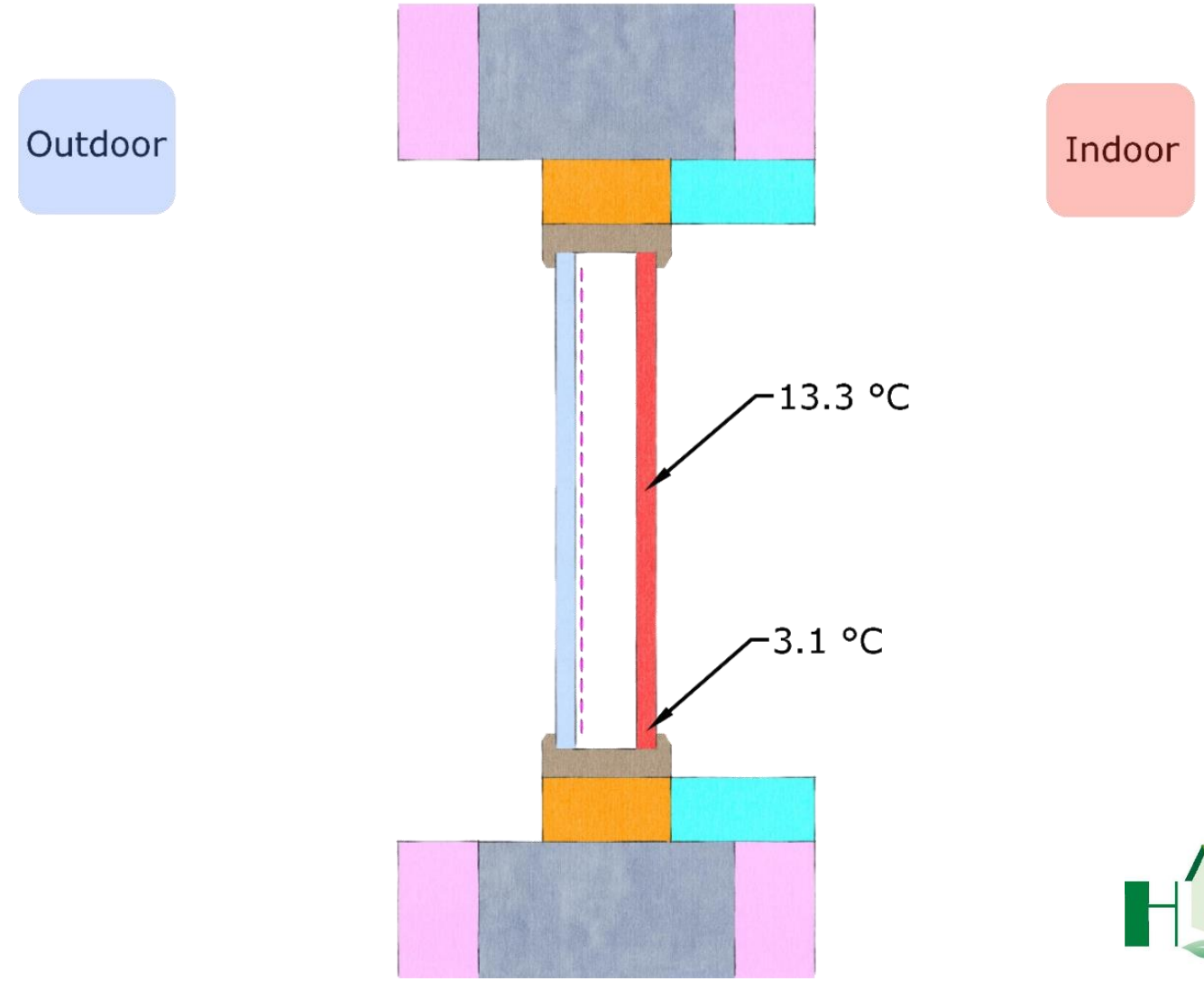
Low E on Surface # 2

LoE 366 on Surface #2



HAMID DESIGN BUILD

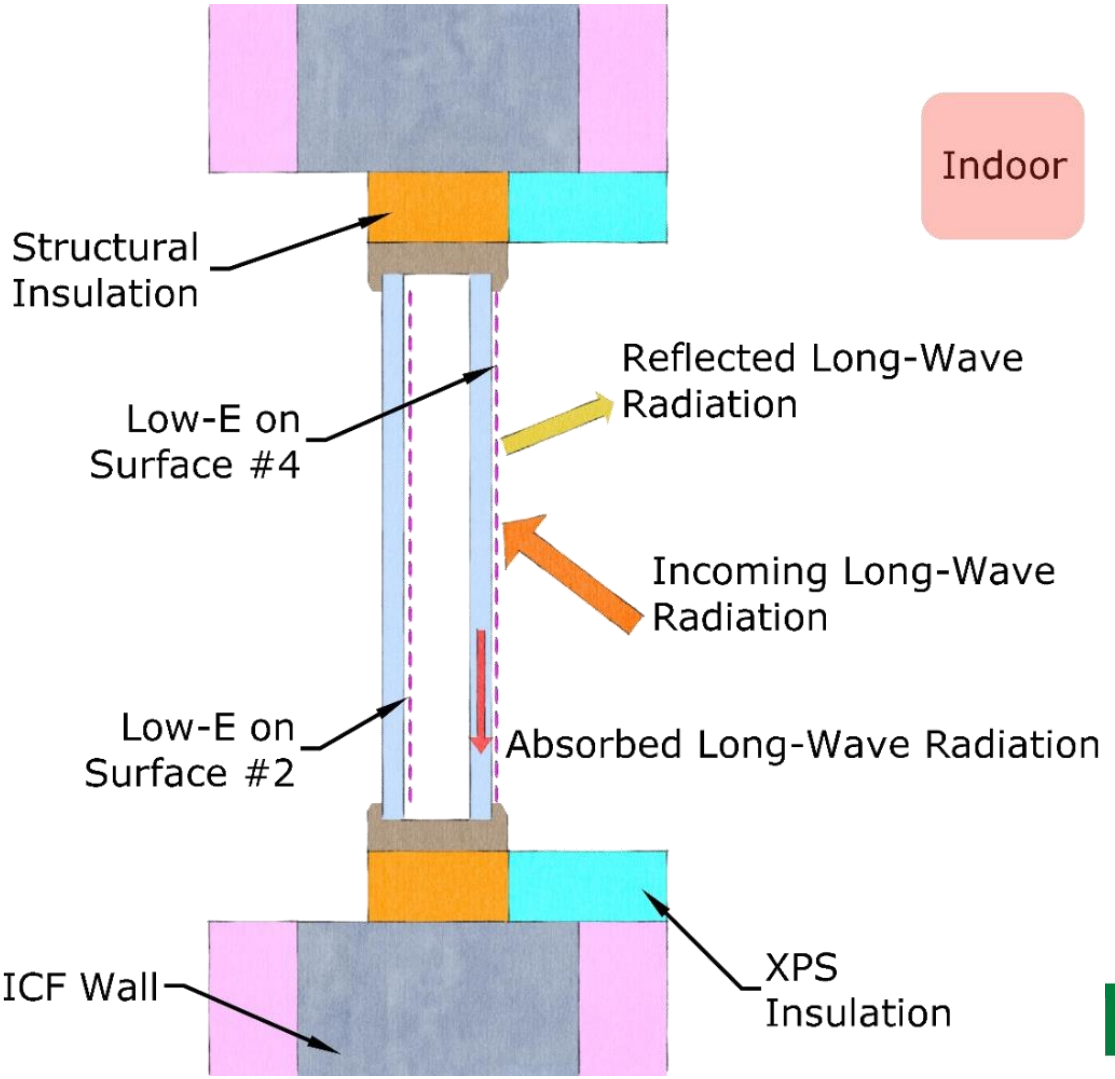
Low E on Surface # 2



Low E on Surface # 2 & # 4, and the associated impact on the temperature of the inner pane of glass

HAMID DESIGN BUILD

Low E on Surface # 2 & # 4



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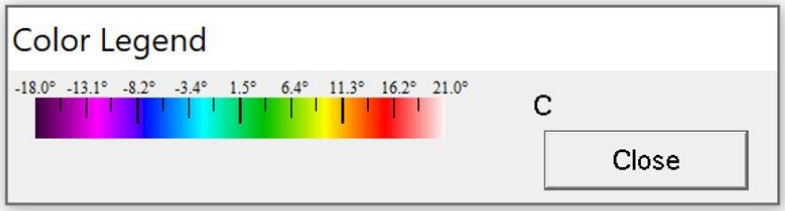
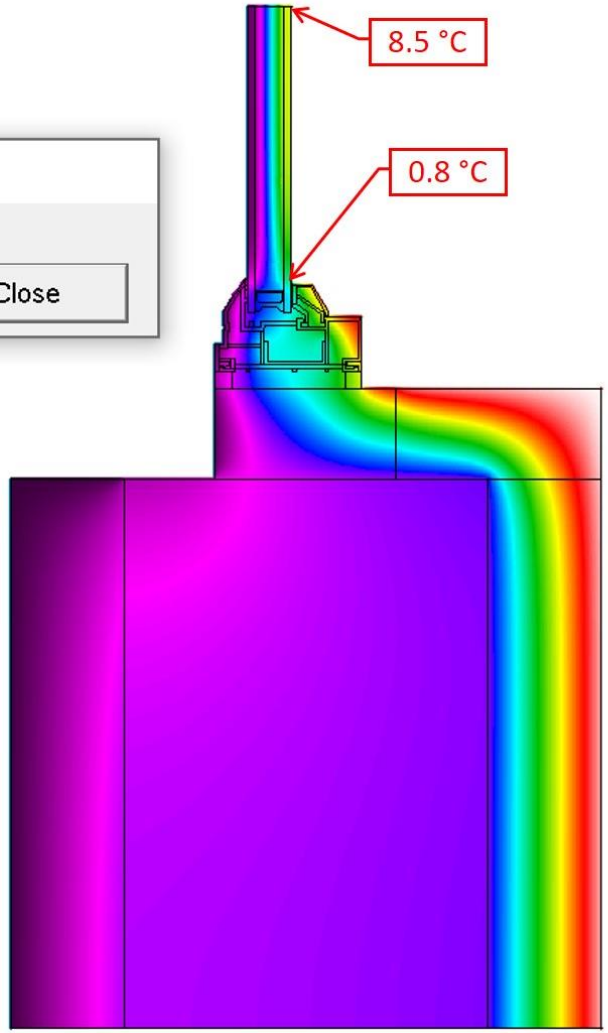
Low E on Surface # 2 & # 4

LoE 366 on Surface #2 and LoE i89 on Surface #4





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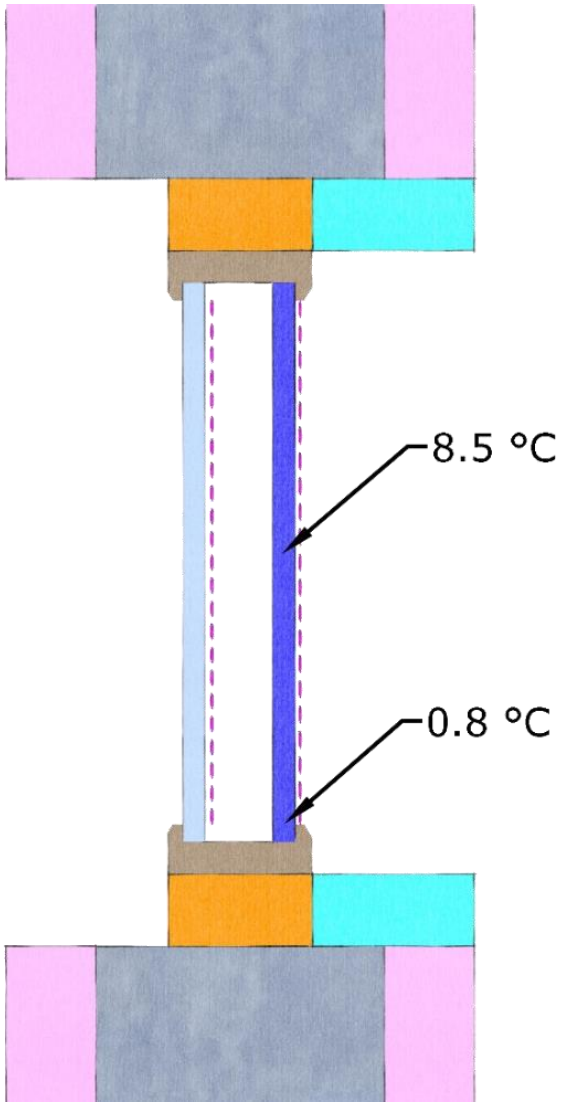
Low E on Surface # 2 & # 4

Outdoor

Indoor



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Assemblies 1 to 13 highlighted in the previous slides showed some examples of assemblies that lack holistic approach towards improving energy efficiency, thus posing the risk of compromised long-term performance.

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Incorporation of higher level of thermal insulation and lower rate of air leakage needs to be done **holistically**. Following the below tips will put you on that path!

- **#1** Aim for placement of majority of insulation outboard of wall/roof structure.

- **#2** The optimum location of an air barrier is outboard of the wall/roof structure (to minimize interruptions) and at the same time inboard of the thermal insulation (to minimize convective looping). The sheathing membrane in a fully exterior insulated wall meets such configuration.

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Incorporation of higher level of thermal insulation and lower rate of air leakage needs to be done **holistically**. Following the below tips will put you on that path!

- **#3** Avoid sandwiching the wall/roof structure (and insulation), with vapour barriers/retarders
- **#4** Locate vapour barriers/retarders on the warm side of thermal insulation. Switching to a smart vapour retarding membrane, in many instances, will improve the long-term performance
- **#5** Materials outboard of the thermal insulation to be vapour permeable

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For additional tips on **holistic approach** towards wall and roof/deck design, please refer to below two booklets, available at **www.hamiddeisgnbuild.com**

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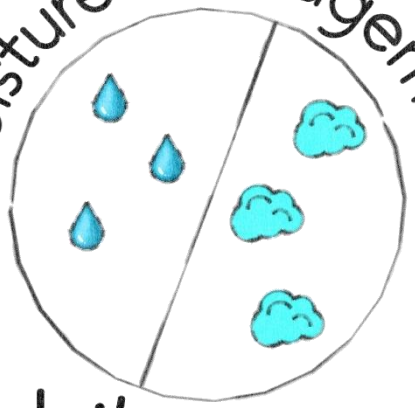
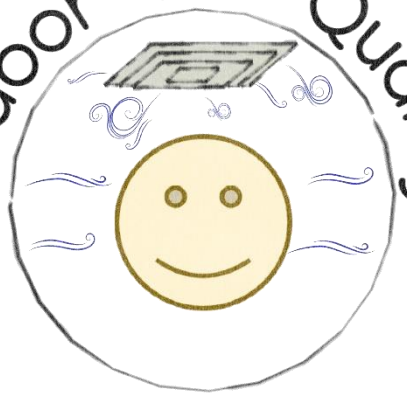
Moisture Management

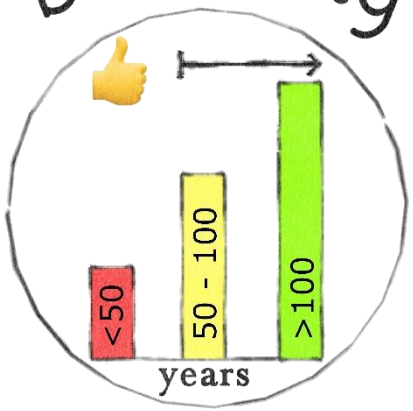


Adaptability to Repair / Renovation

Indoor Air Quality

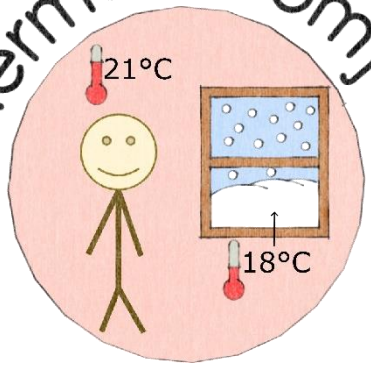


Durability

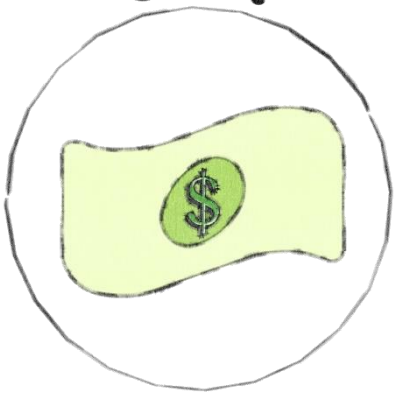


Carbon Footprint

Thermal Comfort

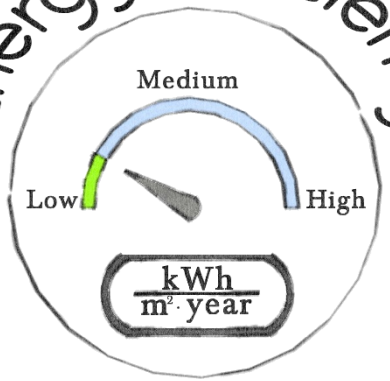


Cost



Architecture

Energy Efficiency



Acoustics

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Trade

Owner

Builder

Consultant

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Thank you

Questions?

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