Chapter 6

Future Horizons

The Guide to Low Thermal Energy Demand Intensity (TEDI) for Large Buildings, or abbreviated to **The Low TEDI Guide**, is an initial attempt to provide insight into how high-rise residential buildings can meet low TEDI targets in Canada. There is no doubt that more examples will help practitioners efficiently and effectively optimize designs to meet low TEDI targets. For example, more analysis can be done to show how thermal bridging can be minimized for other construction types and details, such as for pre-cast concrete sandwich panels, as well as how the same principles can be applied to other non-combustible building type. Nevertheless, the concepts outlined in The Low TEDI Guide apply broadly and provide a starting point for a playbook on the integrated design of low TEDI buildings. The common understanding of what is needed and expected is likely the most challenging hurdle that a design team will face when presented with the opportunity to deliver a low TEDI Multi-unit Residential Buildings (MURB).

This final chapter summarizes the highlights of the Low TEDI Guide so that practitioners can start to implement these principles in practice, and provides examples of the impact of utilizing the concepts presented in Chapter 5.

Thermal Transmittances

An awareness of how thermal transmittance is determined by various approaches is helpful when using and comparing results from various sources. The key guidance from Chapter 2 are:

1. The **window to wall interface** demands the greatest attention for thermal transmittance calculations because of the potential variation in values and impact on the overall thermal transmittance.
2. **Two-dimensional simplifications** are sufficient for moderately conductive structures with simple heat flow paths, such as concrete structures with single insulation layers.
3. **Three-dimensional analysis** is recommended for thermal analysis of assemblies with highly conductive and complex heat flow paths, such as intermittent cladding attachments, metal framing intersections with multidirectional conductive heat flow paths, and for evaluating the risk of condensation at interface details.
4. Assumptions for **air spaces and boundary conditions** do not have a significant impact on opaque thermal transmittances. Thermal values from various sources with slight variations in assumptions are generally comparable for low TEDI buildings, except at the window to wall interface.
5. The biggest impact to realizing low thermal transmittance is the **quality of the details** and design teams aggressively minimizing thermal bridging.

Meeting low TEDI targets is difficult to achieve without higher thermal quality details as outlined in Chapter 5 and the examples at the end of this chapter. Using a detail that is categorized as "efficient" by the BETB Guide based on conventional practice will make meeting low TEDI targets difficult. Accordingly, adjusted performance categories are needed for low TEDI buildings to reflect higher expectations for linear transmittances. **Figure 6.1** outlines the necessary refinements to the BETB performance categories to reflect the expectations of low TEDI buildings.

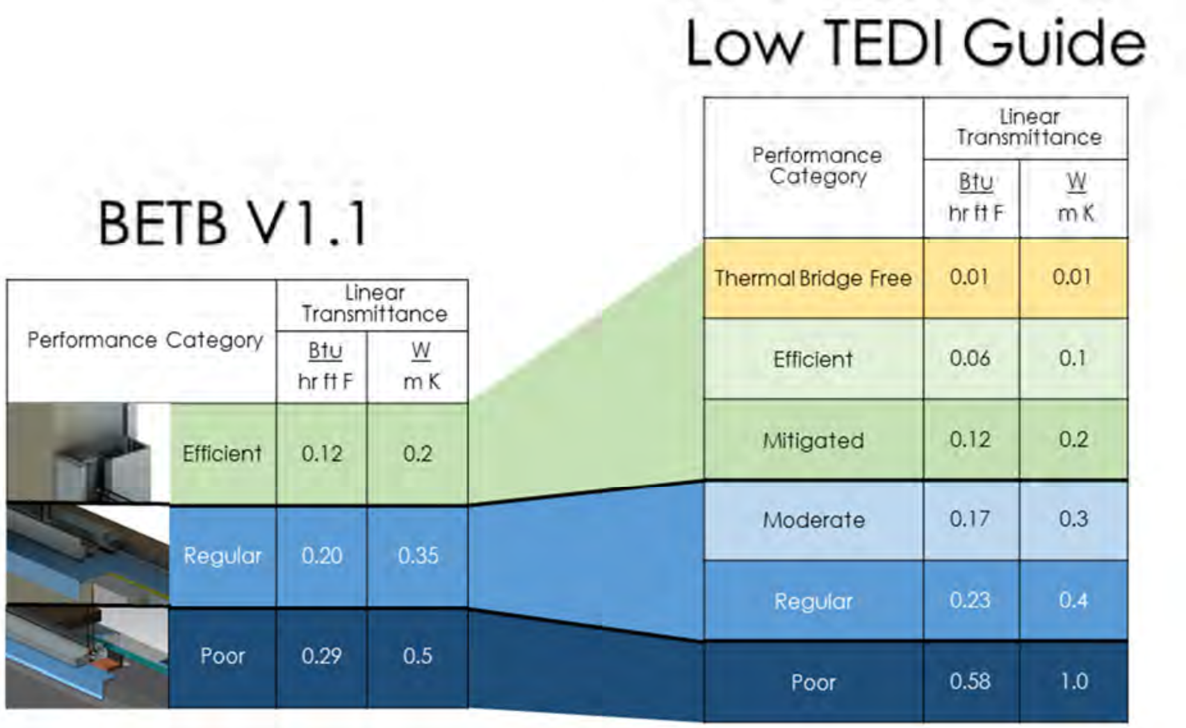
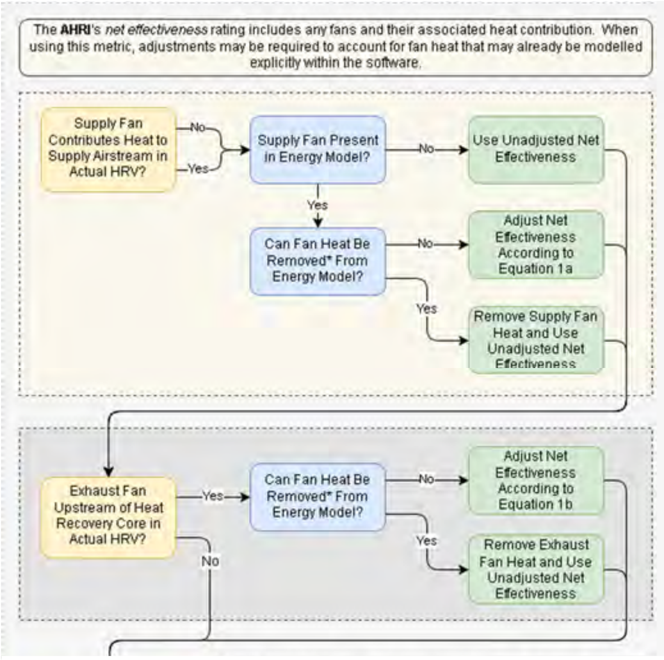


Figure 6.1: Refined Performance Categories for Low TEDI Expectations

Heat Recovery Ventilators (HRV) Protocols

Chapter 3 outlines how HRVs are critical to achieving low TEDI buildings and how focusing too much on protocol differences is not productive to realizing low TEDI buildings.

There is often no choice as to which standard to use, due to available data or project requirements, and a capable energy modeller is able to accurately model the energy-related impact using data derived from any of the protocols summarized by this Guide. However, an energy modeller needs to fully understand the objectives and context of the various standards.



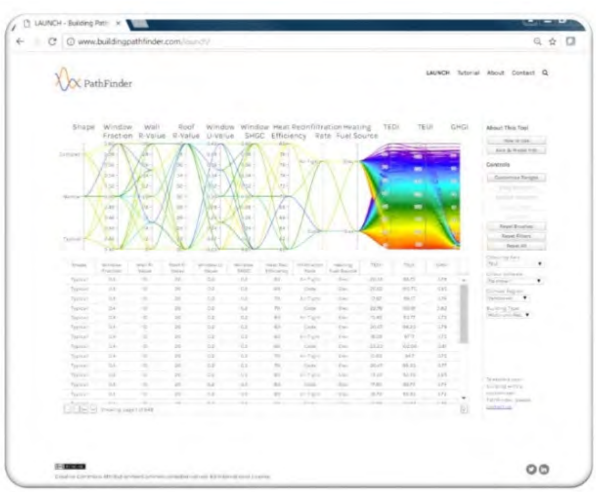
Chapter 4 has flow-charts that outline how to adjust fan power and model HRVs for various available metrics

The main difference between standards is the treatment of fan power. An energy modeller needs to understand the available metrics and energy modeling software so that the fan power efficiency can be adjusted appropriately, if required.

When available, the HVI standard is the easiest to use because it is the most commonly understood and can be directly simulated in commonly used software for whole building energy analysis of MURBs.

TEDI in the Context of Whole Building Energy

TEDI alone does not provide a complete representation of overall building energy consumption and EUI cannot be overlooked. Other building energy loads become increasingly important as TEDI is decreased. Capable software and engineering understanding is critical to capturing how energy use is impacted by the interaction of the various heating load components.



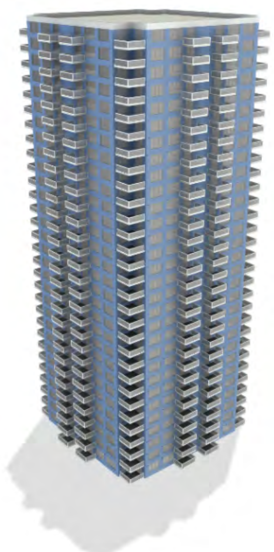
There are many paths to achieve a low TEDI building. Nevertheless, there are common requirements, such as minimized thermal bridging, highly insulated walls, high performance glazing, airtight assemblies, and HRVs. Chapter 4 provides some highlights and considerations per climate zone. Visit BuildingPathfinder.com to visually explore a wider range of design options to achieve low TEDI and EUI targets.

The Low TEDI Guide and BuildingPathfinder can help practitioners set expectations for performance levels of the building envelope and HRVs early in the design process and confirm by project specific calculations as the building design starts to take form.

Design and Construction

Chapter 5 discusses the design principles for large MURBs to meet Low TEDI Buildings. Requirements for Fire Protection and Combustibility, Environmental Separation, Structural Support, Durability, and Constructability are outlined using example details that minimize thermal bridging using methods and assemblies familiar to Canadian construction practice. Thermal transmittance values are provided with and without batt insulation in the stud cavity.

A fundamental question that will be asked during the early days of designing low TEDI MURBs will be how thick the walls need to be to meet the new targets. This will be more challenging to answer than in the past as the ultimate wall thickness is dependent on not only insulation effectiveness for the clear field assembly but also on the quantity and quality of interfaces between building components. The following examples highlight how this question can be answered, putting low TEDI transmittances into perspective, and highlight utilization of the values presented in Chapter 5.



The MURB presented in the examples has the following baseline characteristics:

- Based on the BETB Guide High-rise MURB architype
- 40 storey building with identical layouts and footprint on each floor
- Concrete structure with steel-framed infill per Chapter 5 assembly and details
- 30% glazing with 1.8 m x 1.5 m (6'x5') windows (windows varied in example 3)

EXAMPLE 1 – EXPECTATIONS FOR INTERFACE DETAILS

Essentially the expectations for linear transmittances should be an order of magnitude higher for low TEDI buildings than conventional practice if minimizing wall thickness is a consideration. For example, **Figure 6.2** shows how a target of 0.28 W/m^{2}K (R-20 effective) for the opaque wall can be met for various combinations of transmittances and the impact on wall thickness. Only the window to wall (glazing) interface and clear field transmittances were varied for this example. All the other transmittances are constant using values from Chapter 5. This example does not include the impact of balconies, which is outlined in the following example.

The 0.28 W/m^{2}K target can only be met for the "Efficient Glazing Interface" scenario with a 492 mm (19.5 inch) thick wall and R-19 cavity insulation within the 6 inch steel studs. The window to wall interface linear transmittance for the "Efficient Glazing Interface" scenario is 0.1 W/m K. In comparison, this target can be met with a 16.5mm (14.5 inch) thick wall with R-19 cavity insulation or a 16.5 inch (416 mm) thick wall for a fully exterior insulated wall using any of the scenarios for Detail 4 in Chapter 5 (0.024 W/m K for the uninsulated stud cavity and 0.046 W/m K for the R-19 scenarios).

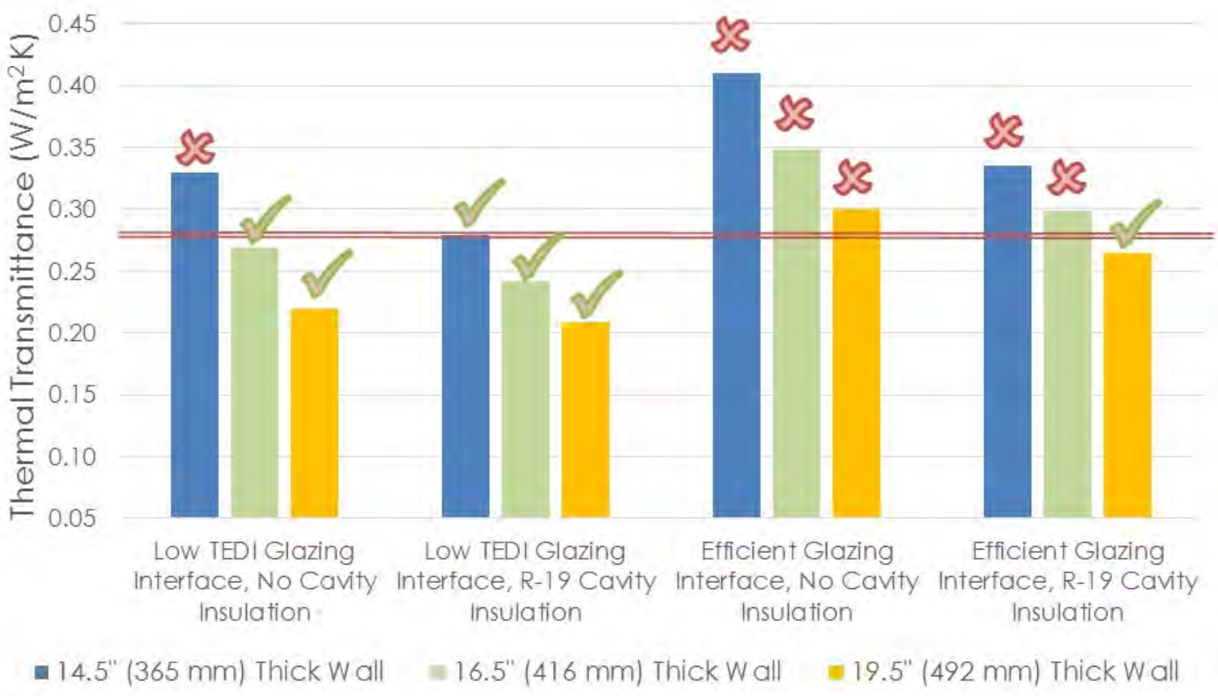


Figure 6.2: Impact of Window to Wall (Glazing) Interface Transmittance on Wall Thickness for a Target of 0.28 W/m^{2}K (R-20 effective)[1]

For this example there is no rational wall thickness (i.e. greater than 1 m) that meets the 0.28 W/m^{2}K target for a window to wall interface linear transmittance of 0.2 W/m K, which is the upper end of the "Efficient" Category in the BETB Guide Version 1.1 (2016) based on conventional practice. Recognition of this reality is part of the reason why the transmittance expectations for interface details needs to be refined for low TEDI buildings as outlined at the beginning of this chapter.

EXAMPLE 2 – IMPACT OF BALCONIES

Components such as balconies add thermal bridging that must be compensated for by thicker walls for fixed thermal transmittance targets. Accounting for thermal bridging related to intermittently attached balconies[2] is slightly more complicated than required for conventional cantilevered concrete balconies. The beam connection to intermediate floor and cable support are accounted for separately in the overall thermal transmittance calculation. Also, point transmittances are accounted for on a number of components basis, which takes more consideration for quantity take-offs than required for a linear value.

[1] The target is met when the thermal transmittance is below the red bar shown on the chart

[2] Values presented in Detail 5 in Chapter 5

A comparison between an intermittently attached and a cantilevered concrete balcony is presented in **Figure 6.3** and **Table 6.1**. This example not only highlights the impact of balconies on the overall thermal transmittance but also shows how the transmittances values for Detail 5 can be incorporated into overall thermal transmittance calculations.

For the cantilevered concrete balcony scenario, the concrete slab bypasses the thermal insulation and the interface length is the width of the balcony. The beam and cable penetrations for the intermittently attached balcony are outlined in **Figure 6.3**.

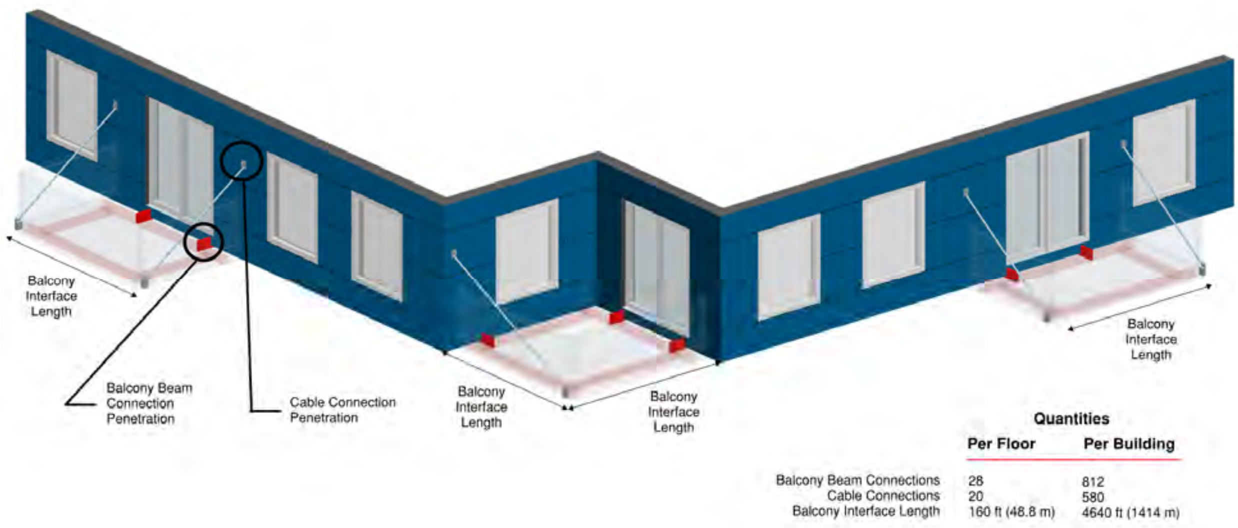


Figure 6.3: Balcony Layout and Quantities for a Floor for Example Thermal Transmittance Calculation (25% of floor shown)

Table 6.1: Comparison of the Impact of Intermittently Attached to Cantilevered Concrete Balconies for Low TEDI Glazing Interfaces and R-19 Cavity Insulation Scenarios

Scenario	Detail	Quantity	Transmittance Value	Heat Flow (W/K)	% Total Heat Flow	Overall Transmittance
Intermittently Attached Balcony	Clear Field	7087 m^2	0.142 W/m^2K	1004	56%	**0.254 W/m^2K (R-22 Effective)**
	Beam Connection	**812**	**0.271W/K**	**220**	**12%**	
	Cable Connection	**580**	**0.147 W/K**	**85**	**5%**	
	Other Interfaces	-	-	488	27%	
Cantilevered Concrete Balcony	Clear Field	7087 m^2	0.142 W/m^2K	1004	36%	**0.390 W/m^2K (R-15 Effective)**
	Balcony	**1414 m**	**0.9 W/m K**	**1273**	**46%**	
	Other Interfaces	-	-	488	18%	

The 0.28 W/m²K target can only be met with intermittently attached balconies using the low TEDI details with a 492 mm (19.5 inch) thick wall and R-19 cavity insulation as seen in **Figure 6.4**. The wall will need to be upwards of 330 mm (13 inches) thick for the "efficient glazing interface" scenario with R-19 cavity insulation to meet the 0.28 W/m²K target.

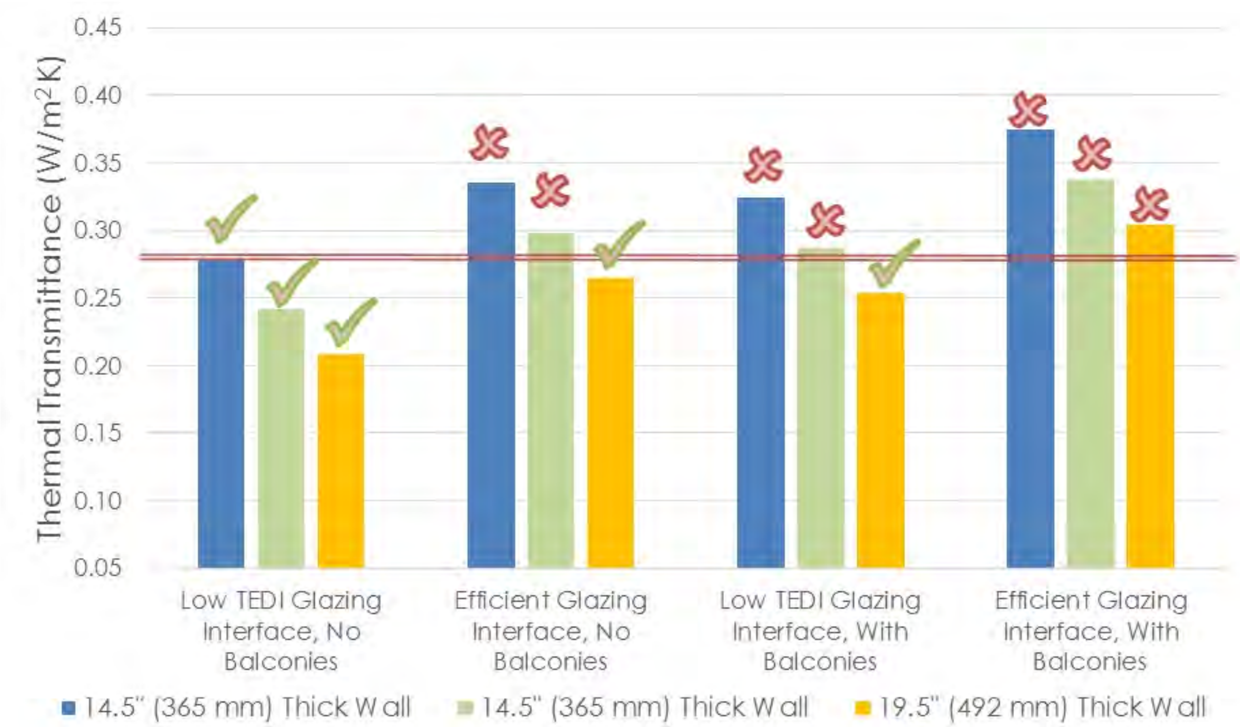


Figure 6.4: Impact of Balconies on Wall Thickness for a Target of 0.28 W/m²K (R-20 effective) for Low TEDI Glazing Interfaces and R-19 Cavity Insulation Scenarios

EXAMPLE 3 – IMPACT OF GLAZING SIZE

Minimizing the window perimeter and frame length by maximizing the size of glass per opening was introduced in Chapter 5 and is illustrated in the graphics above. **Figure 6.5** outlines the impact of glazing size on thermal transmittance and overall wall thickness for a fixed glazing ratio of 30%. The only difference between the two scenarios is the difference in interface length for one window versus two smaller windows. All the scenarios have R-19 cavity insulation.

Similar to the impact of balconies, meeting the 0.28 W/m²K target for the opaque walls is a challenge for the "efficient glazing interface" scenarios and the wall will need to be slightly thicker for the low TEDI glazing scenarios. Moreover, there are opportunities to refine and optimize opaque targets on projects in conjunction to the window thermal transmittances as outlined in Chapter 4 using whole building energy analysis.

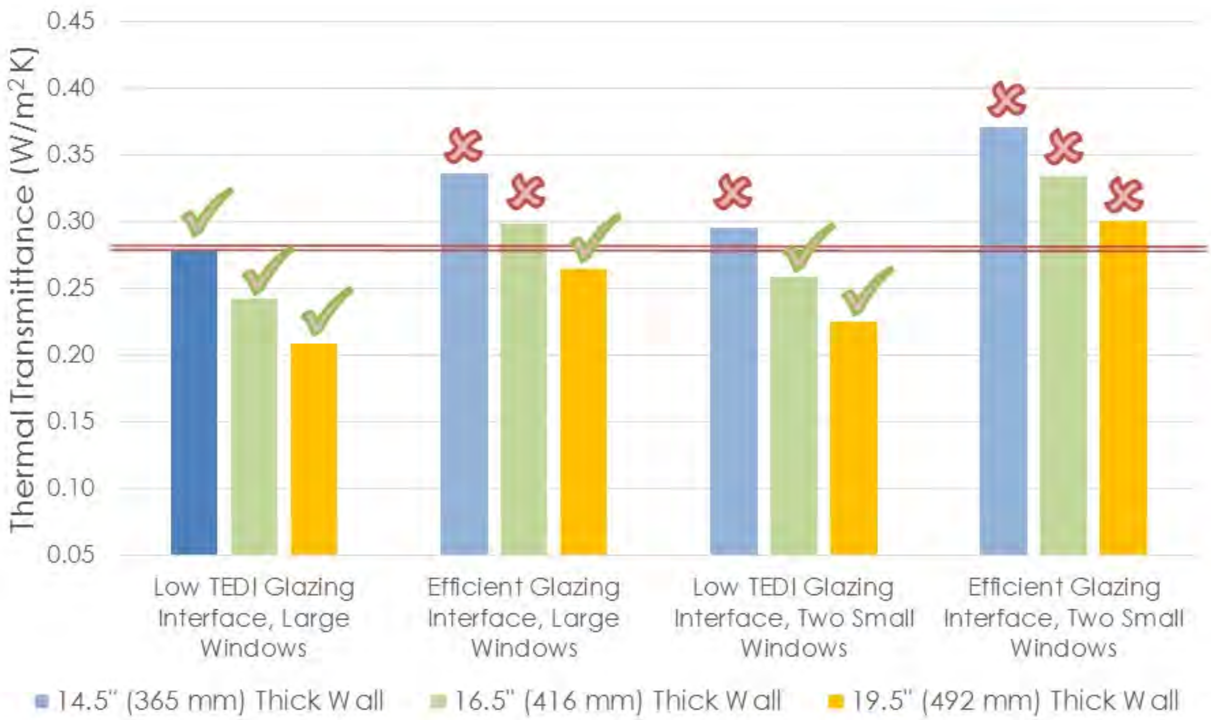


Figure 6.5: Impact of Window Size for a Fixed Glazing Ratio on Wall Thickness for a Target of 0.28 W/m²K (R-20 effective)