



Réseau Energie  
et Bâtiments



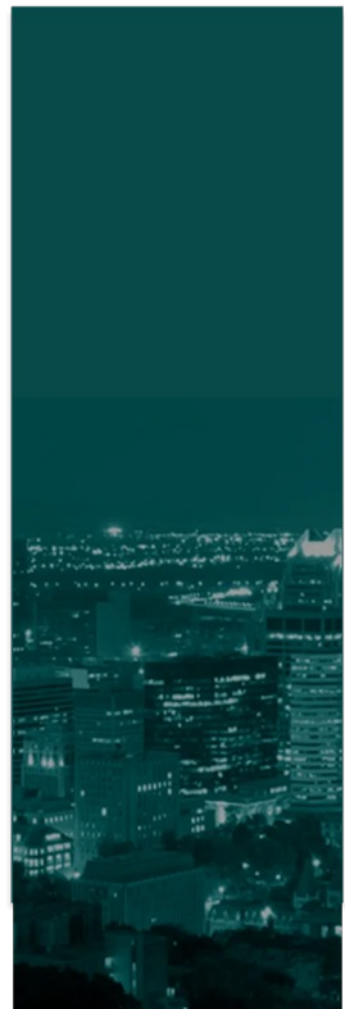
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Denis Bourgeois PhD  
directeur **rd<sub>2</sub>.ca**

**ponts thermiques *majeurs***  
*dépréciation* et modélisation énergétique

automatisation et applications





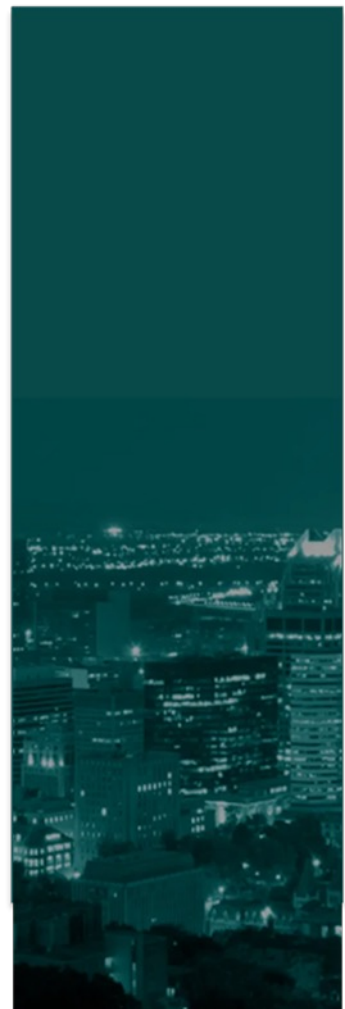
Réseau Energie  
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## DÉROULEMENT

1. contexte et enjeux
2. *ponts thermiques 101*
3. modélisation et simulation énergétique
4. *Battle royale* : **CNÉB 2017 vs I.1 CCQ**
5. limites et travaux (en cours)





### + descriptif

### + quantitatif

#### 1970s

- crises énergétiques
- LoCal/Saskatchewan
- ASHRAE 90
- Schöck Isokorb

#### 1990s

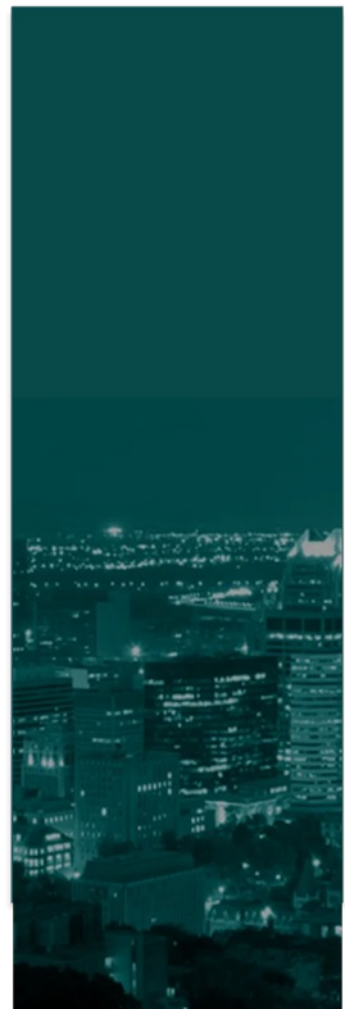
- PassivHaus
- encouragements \$
- codes d'énergie v2
- ISO 12011/14683

#### 2010s

- DPÉB (UE)
- RP-1365
- ... BETBG
- I.1 CCQ
- NECB 2015 > 2017
- 90.1 2019 av

#### 2020s

- CSA Z-5010
- 90.1 2022
- BTAP (CNRC/RNCan)
- OpenStudio-Standards
- encouragements \$\$
- futurs codes : l'existant
- cotation énergétique
- jumeaux numériques
- rôle des manufacturiers





### + portée limitée

### + englobant

#### 1970s

- crises énergétiques
- LoCal/Saskatchewan
- ASHRAE 90
- Schöck Isokorb

#### 1990s

- PassivHaus
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Schöck

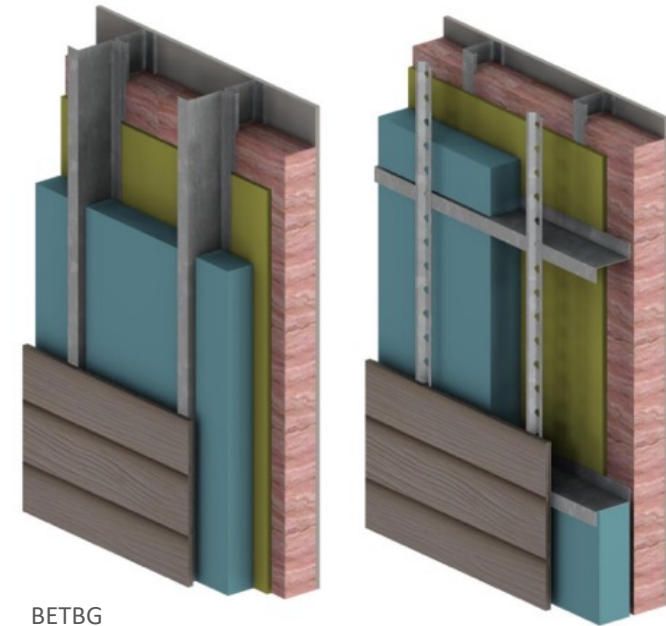
*ponts thermiques MAJEURS*

- coefficients **linéaires** et **ponctuels**
- très **liés** à la géométrie des surfaces
- *ex. balcons, parapets, colonnes*

$U_o$     $\Psi$     $X$

*... intègre ponts thermiques MINEURS*

- **répétitif**, *ex. montants, barres Z, attaches*
- **indépendant** de la géométrie des surfaces
- $R_o$  (*effective ou « clear-field »*) =  $1 / U_o$

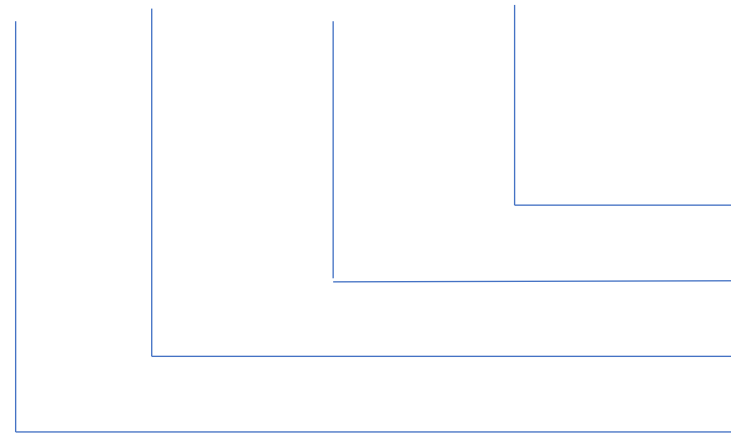


BETBG



$\Psi$  &  $X$  ... peut être facilement **+50%** du  $U_t$   
... **+5 to 15%** en GJ chauffage annuel (Z7)

$$U_t A = U_o A + \sum \Psi L + \sum X$$



*khi*, propre(s) à chaque **surface**

*psi*, propre(s) à chaque **surface**

*clear-field*, propre à chaque **construction**

*déprécié*, propre à chaque **surface**





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# PONTS THERMIQUES 101

*I1 vs CNÉB 2017*

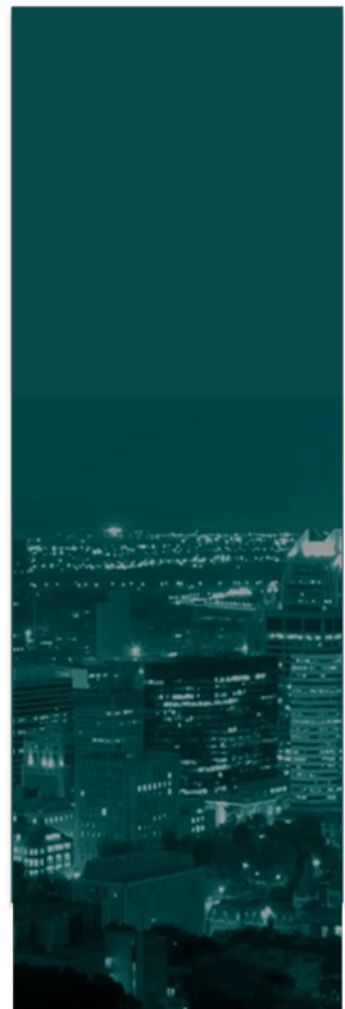
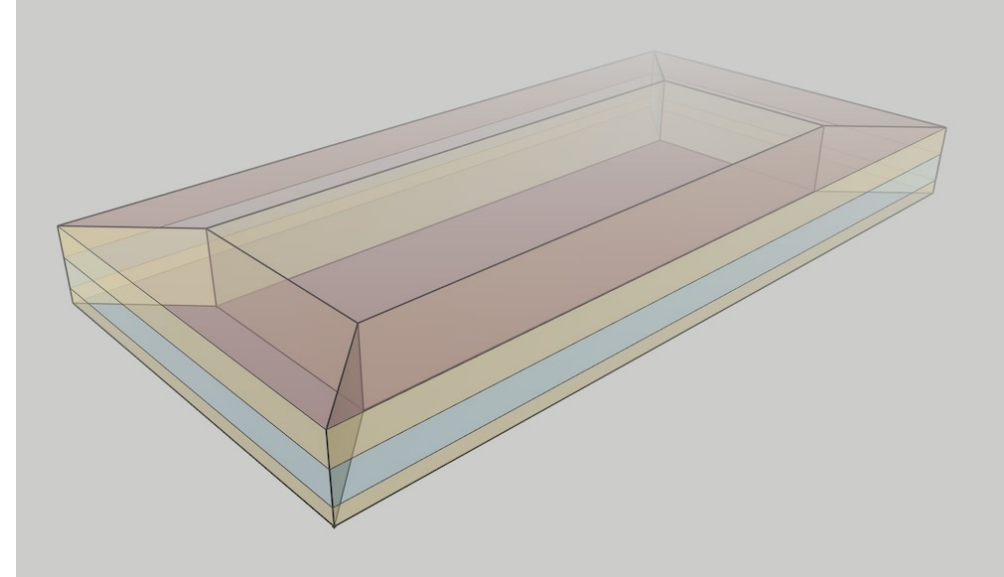
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$$? U_t A = U_o A + \sum \Psi L + \sum X$$

CNÉB-QC I1

$$? U_o A = U_t A - (\sum \Psi L - \sum X)$$

CNÉB 2017





### 3. RECOMMENDATIONS

In our view, there are two primary paths to implementing modified base building U-values into BC Hydro's New Construction Program. They are described in further detail below.

#### 3.1 Method 1: Simplified Approach - Recommended

The first approach is simple and involves using one of the correlation lines in Figure 6 to equate energy code clear wall U-values to the de-rated U-value to be used in the program. This approach is simple and does not require the use of base building calculations. As the values were derived from archetype buildings with average amounts of interface details, it allows room for projects to improve in effective U-value not only by having better performing interface details, but also by having less of them.

#### 3.2 Method 2: Base Building Calculations Approach – Secondary Recommendation

The second approach would involve base building calculations. The base building would use the same quantity take-offs as the proposed, but the performance values for the linear interface details would be prescribed. The recommended prescribed values would be based on the efficient performance category for all building types except MURBs or 0.12 Btu/h ft F. The downside with this approach is that it does not incent reducing the amount of interface details. A design that has little additional heat loss because it limits the quantity of interface details would also have few interface benefit over the base building, since the base building would also have few interface details. It also does not put a cap on base building heat loss for designs that have excessive articulating architecture (i.e. large quantity of interface details).

Although the analysis above only considered the major interface details, this approach would include all interface details, each with a base building value of 0.12 Btu/h ft F. High rise MURBs would use 0.20 Btu/hr ft F for slabs and glazing, 0.17 Btu/hr ft F for parapets and 0.26 Btu/hr ft F for everything else. Balconies in base building high-rise MURBs shall have the same number of balconies and performance as the proposed, up to 25% of the building perimeter per floor. Point transmittances shall have a base building value of 0.3 Btu/h F for all scenarios.

- Context
- To "de-rate" or not?
- Case study
- Recommendations

### Thermal bridging calculations – to "de-rate" or not? August 2018

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Iain Macdonald, PhD

denis@rd2.ca  
iain.macdonald@nrc-cnrc.gc.ca



### Accounting for Thermal Bridging at Interface Details

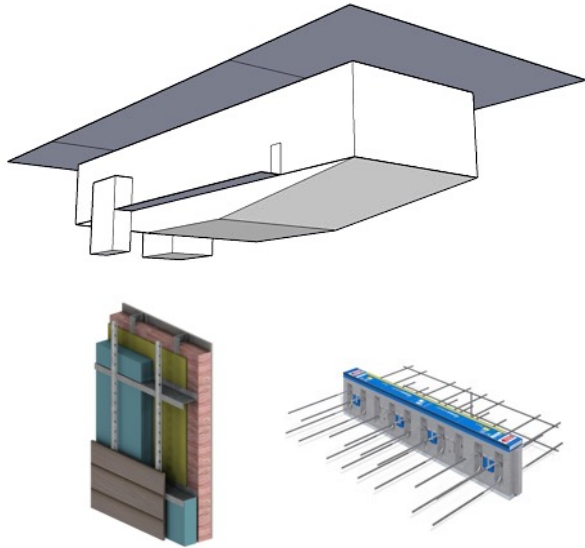
A Methodology for De-Rating Prescriptive Opaque Envelope Requirements in Energy Codes

April 29, 2015





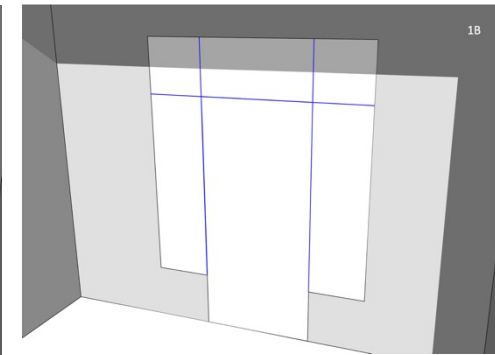
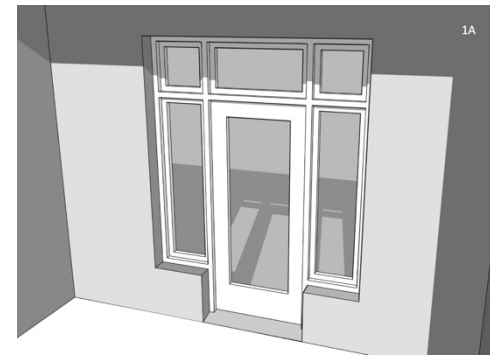
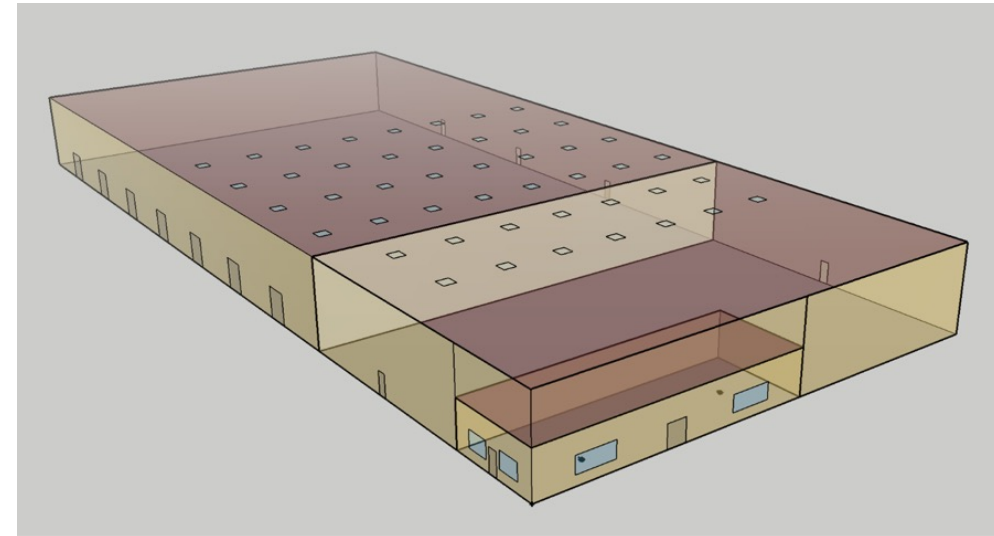
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# MODÉLISATION & SIMULATION

*... objectif du webinaire*

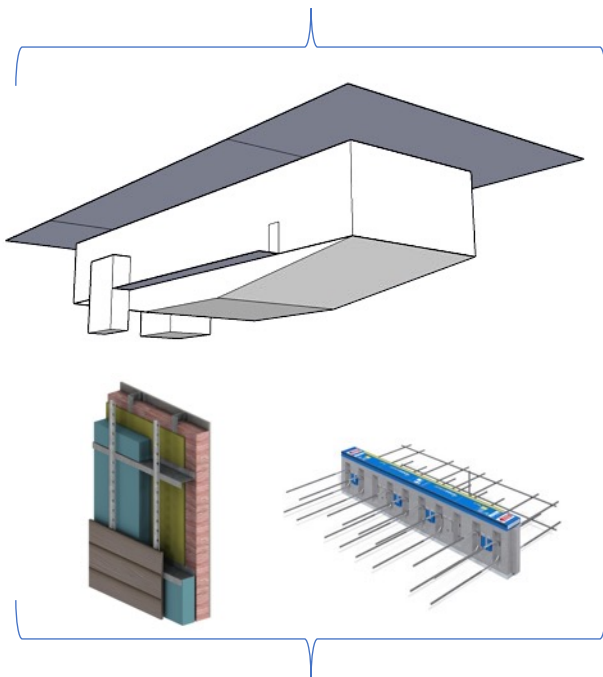
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## 1. intrants

relevés **manuels**



$U_o$     $\Psi$   $X$     $AL$

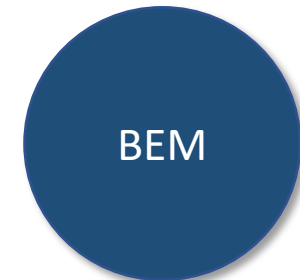
## 2. dépréciation

$$U_t A = U_o A + \sum \Psi L + \sum X$$

ex. tableurs

## 3. extrants

Section 3.3



Partie 8

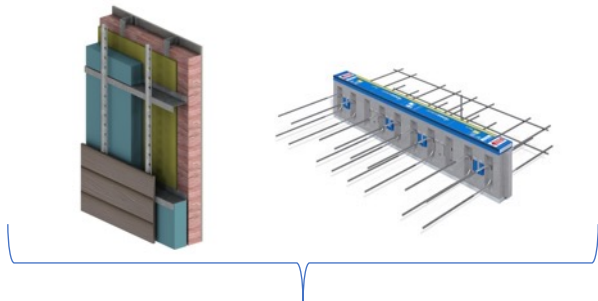
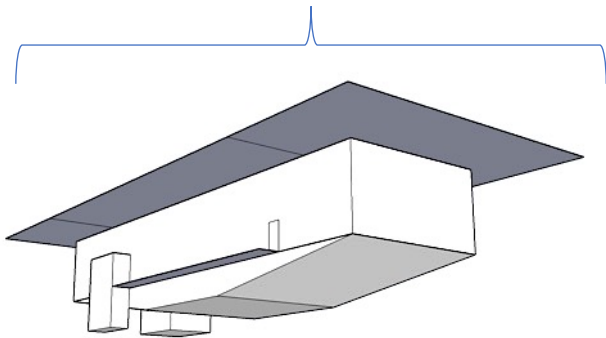


optimisation



## 1. intrants

relevés **manuels** automatisés



$U_o$     $\Psi X$     $AL$

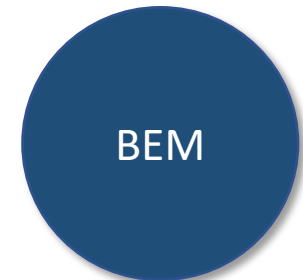
## 2. dépréciation automatisée

$$U_t A = U_o A + \sum \Psi L + \sum X$$

ex. tableurs

## 3. extrants, ex. rapports automatisés

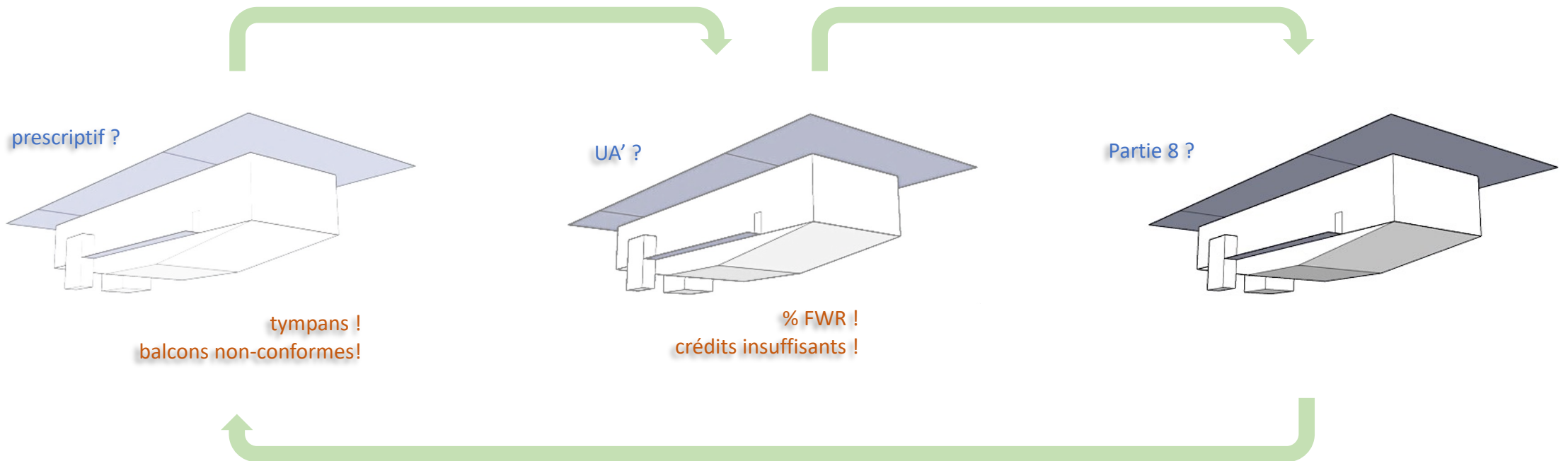
Section 3.3



Partie 8



optimisation





## Réseau Énergie et Bâtiments

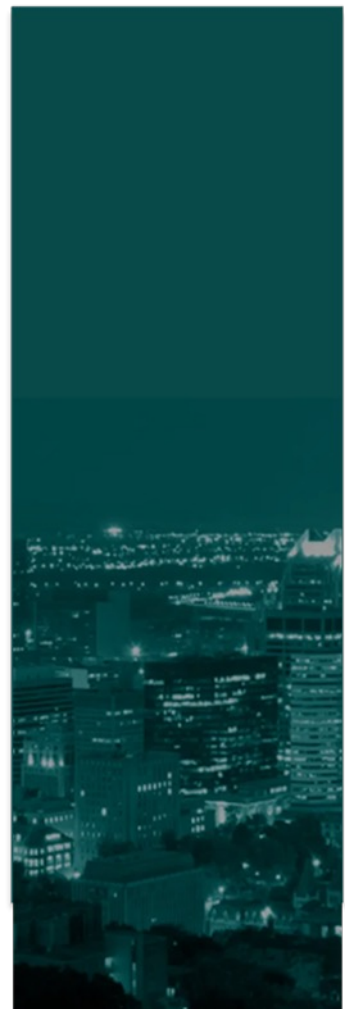


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## MODÉLISATION

*... impacts chez les professionnels ?*

- ~1000 bureaux d'architectes au QC
- @ 10 projets/année/bureau
- @ 4 itérations par projet
- @ 3 heures/itération
- @ 100\$/heure
  
- ~ **12 000 000\$**/année au QC ?
  
- *... habituellement non-facturables*







Réseau Energie  
et Bâtiments

MODÉLISATION & SIMULATION  
rd2.github.io/tbd



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## TBD

Thermal Bridging & Derating

 Download .zip

 Download .tar.gz

A guide to **TBD** - a Ruby **gem** and **OpenStudio Measure** that auto-detects **major** thermal bridges (like balconies, parapets and corners) and then **derates** outside-facing opaque constructions (walls, roofs and exposed floors). The guide is mainly written for architects, echnologists and envelope consultants who are new to energy simulation, and to OpenStudio in particular.

### a nutshell ...

**Thermal bridges** are structural elements that interrupt the continuity of insulation in building envelopes. A curtain wall spandrel back pan may hold in place an R17 (RSi 3.0) of insulation, yet the spandrel's overall R-value may trickle down to R5 (RSi 0.9) - less than a third of its nominal value. This drop in spandrel performance is due to its reliance on highly conductive materials (e.g. galvanized steel, aluminium), spandrel area to depth ratio, and how the back pan is held in place.

## Thermal Bridging & Derating

- *gemme* Ruby & *measure* OpenStudio

Denis Bourgeois    rd<sub>2</sub>.ca

Dan Macumber    automaticmagic.com

openstudiocoalition.org

Québec 

Canada 



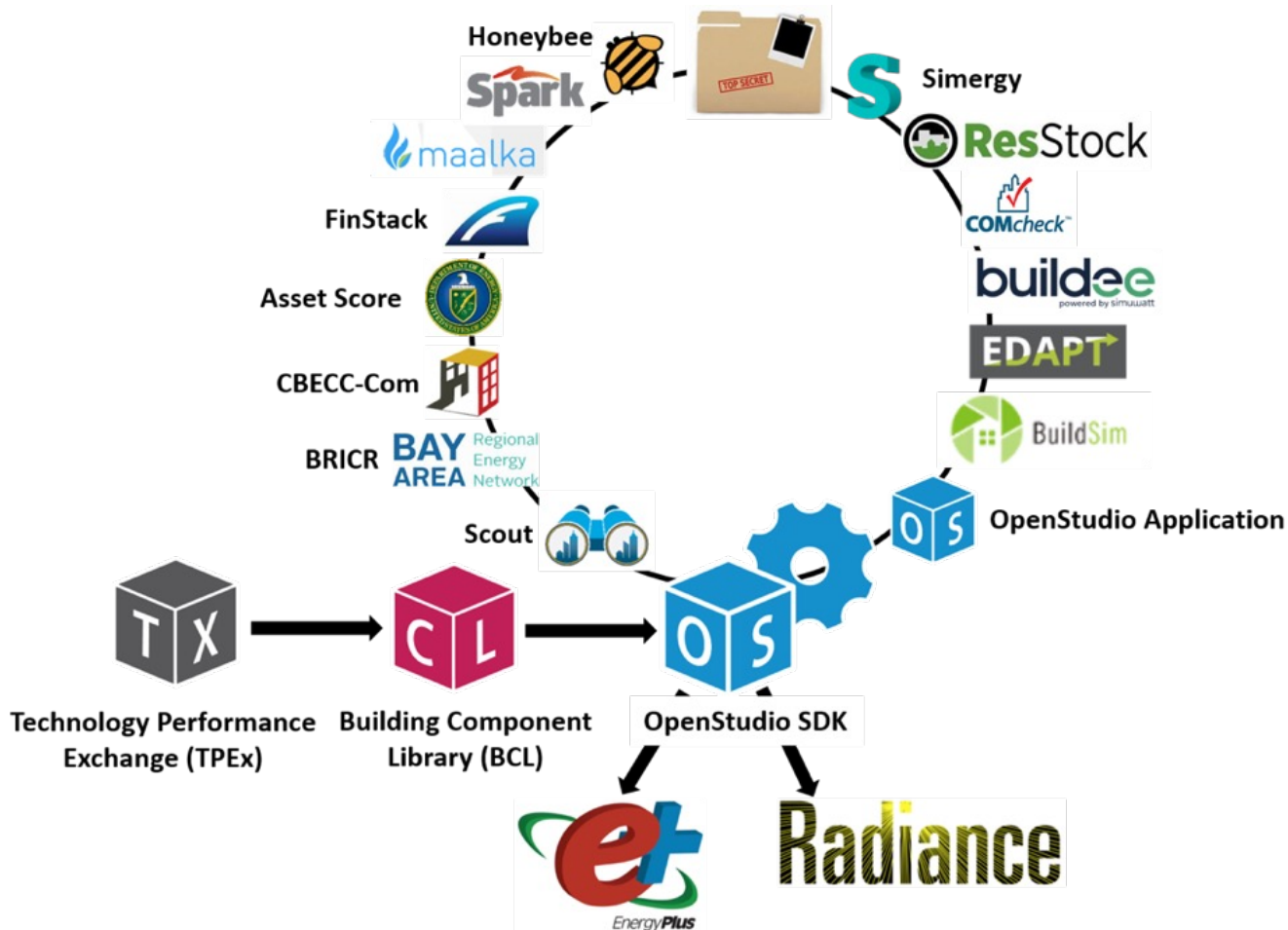
# Réseau Energie et Bâtiments

## MODÉLISATION & SIMULATION

[rd2.github.io/tbd](https://rd2.github.io/tbd)



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### Thermal Bridging & Derating

- *gemme* Ruby & *mesure* OpenStudio
- compatible avec SDK
- licence libre (MIT, BSD-3)
- désormais distribué avec OpenStudio
- partie intégrante de BTAP/OpenStudio-Standards
- partie intégrante de SIMEB+





# Réseau Energie et Bâtiments

# MODÉLISATION & SIMULATION

rd2.github.io/tbd



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**OpenStudio Application**

**Measures**

- Envelope (5)
- Form (4)
- Opaque
- My IdfToOsm
- BCL Increase R-value of Insulation for Exterior Walls to a Specific
- My SlabHeat for OpenStudio
- My Thermal Bridging and Derating - TBD (1)**
- Fenestration
- Construction Sets
- Daylighting
- Infiltration
- Electric Lighting
- Equipment
- People
- HVAC
- Refrigeration
- Service Water Heating
- Onsite Power Generation (2)
- Whole Building
- Economics

**Inputs**

Alter OpenStudio model (Apply Measures Now)

For EnergyPlus simulations, leave CHECKED. For iterative exploration with Apply Measures Now, UNCHECK to preserve original OpenStudio model.

Load 'tbd.json'

Loads existing 'tbd.json' file (under 'files'), may override 'default thermal bridge' set.

Default thermal bridge set

e.g. 'poor', 'regular', 'efficient', 'code' (may be overridden by 'tbd.json' file).

poor (BETBG)

Write 'tbd.out.json'

Write out 'tbd.out.json' file e.g., to customize for subsequent runs (edit, and place under 'files' as 'tbd.json').

Wall construction(s) to 'uprate'

Target 1x (or 'ALL') wall construction(s) to 'uprate', to achieve wall Ut target below.

NONE

Roof construction(s) to 'uprate'

Target 1x (or 'ALL') roof construction(s) to 'uprate', to achieve roof Ut target below.

NONE

Floor construction(s) to 'uprate'

Target 1x (or 'ALL') floor construction(s) to 'uprate', to achieve floor Ut target below.

NONE

Wall Ut target (W/m<sup>2</sup>·K)

Overall Ut target to meet for wall construction(s). Ignored if previous wall 'uprate' option is set to 'NONE'.

0.21

Roof Ut target (W/m<sup>2</sup>·K)

Overall Ut target to meet for roof construction(s). Ignored if previous roof 'uprate' option is set to 'NONE'.

0.138

Floor Ut target (W/m<sup>2</sup>·K)

Overall Ut target to meet for floor construction(s). Ignored if previous floor 'uprate' option is set to 'NONE'.

0.162

Generate UA' report

Apply Measure Cancel

## COMPLIANCE ASSESSMENT

Quebec Construction Code, Chapter I.1  
NECB 2015, modified version (2020)  
Division B, Section 3.3  
Building Envelope Trade-off Path

**SUMMARY**

$\sum U \cdot A + \sum \text{PSI} \cdot L + \sum \text{KH} \cdot n$  : Design vs 'code (Quebec)'

- heated : 196.6 W/K (vs 107.2 W/K) +83.3%
  - walls : 60.1 W/K (vs 35.0 W/K) +71.7%
  - doors : 23.3 W/K (vs 5.3 W/K) +341.8%
  - windows : 41.6 W/K (vs 35.3 W/K) +17.7%
  - rimjoists : 14.9 W/K (vs 5.3 W/K) +183.3%
  - trim : 23.3 W/K (vs 9.3 W/K) +150.0%
  - corners : 3.6 W/K (vs 1.3 W/K) +183.3%
  - grade : 29.8 W/K (vs 15.8 W/K) +88.9%
- semi-heated : 4859.4 W/K (vs 2274.4 W/K) +113.7%
  - walls : 1342.0 W/K (vs 732.0 W/K) +83.3%
  - roofs : 2169.2 W/K (vs 961.8 W/K) +125.5%
  - doors : 245.6 W/K (vs 67.5 W/K) +263.9%
  - skylights : 454.3 W/K (vs 225.9 W/K) +101.1%
  - rimjoists : 14.9 W/K (vs 5.3 W/K) +183.3%
  - parapets : 234.1 W/K (vs 95.1 W/K) +146.2%
  - trim : 155.0 W/K (vs 62.0 W/K) +150.0%
  - corners : 25.4 W/K (vs 9.0 W/K) +183.3%
  - grade : 218.9 W/K (vs 115.9 W/K) +88.9%

**DESCRIPTION**

project : warehouse.osm  
model : warehouse.osm (v3.4.0)  
BD : v2.4.5  
date : 2022-08-04 07:21:03 -0400  
status : success !

2411.7 m<sup>2</sup> (net), 2497.0 m<sup>2</sup> (gross)  
4529.9 m<sup>2</sup> (net), 4598.3 m<sup>2</sup> (gross)

Assessment from the OpenStudio Measure, Thermal Bridging and Derating (TBD). Open source and MIT-licensed, TBD is without warranty). Procedures are documented in the source code: <https://github.com/rd2/tbd>. Calculations comply with requirements. Results are based on user input not subject to prior validation (see DESCRIPTION), and as such the results should not be considered as a certification of compliance.





Réseau Energie  
et Bâtiments



# MODÉLISATION & SIMULATION

rd2.github.io/tbd

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```
1 {
2   "schema": "https://github.com/rd2/tbd/blob/master/tbd.schema.json",
3   "description": "TBD JSON example – combining building vs space PSI sets",
4   "psis": [{
5     "id": "OK",
6     "rimjoist": 0.7,
7     "parapet": 0.7,
8     "fenestration": 0.7,
9     "corner": 0.7,
10    "balcony": 1,
11    "party": 0.7,
12    "grade": 0.7
13  },
14  {
15    "id": "Awesome",
16    "rimjoist": 0.2,
17    "parapet": 0.2,
18    "fenestration": 0.2,
19    "corner": 0.2,
20    "balcony": 0.3,
21    "party": 0.2,
22    "grade": 0.2
23  }
24  ],
25  "building": {
26    "psi": "Awesome"
27  },
28  "spaces": [{
29    "id": "ground-floor restaurant",
30    "psi": "OK"
31  }]
32 }
```



[www.telerama.fr/scenes/musa-c-e-des-confluentes,121164.php](http://www.telerama.fr/scenes/musa-c-e-des-confluentes,121164.php)

## TBD JSON I/O

interopérabilité BIM/BEM

... ~OpenStudio *default construction sets*

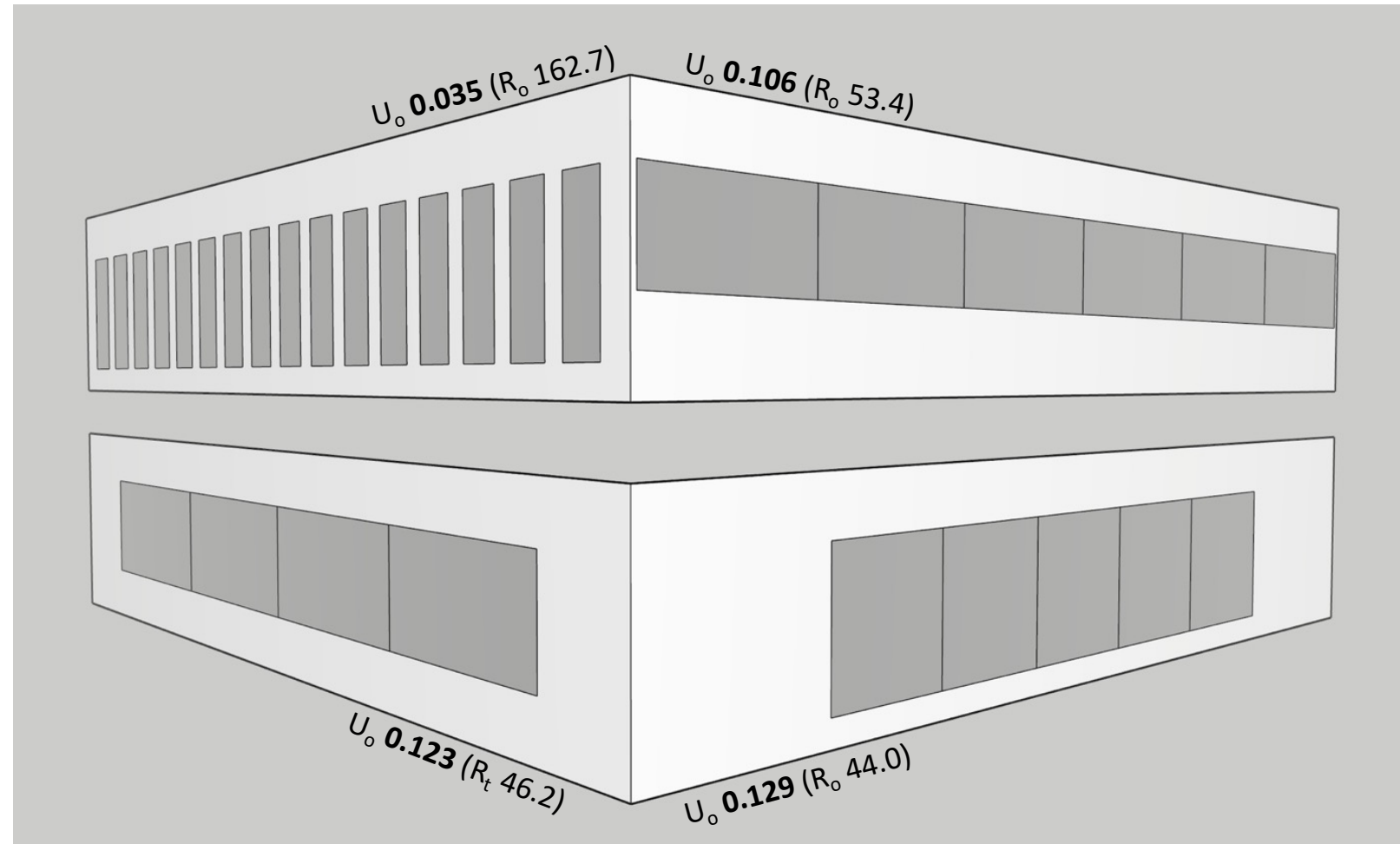


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CNÉB 2017 : 5000 DJC



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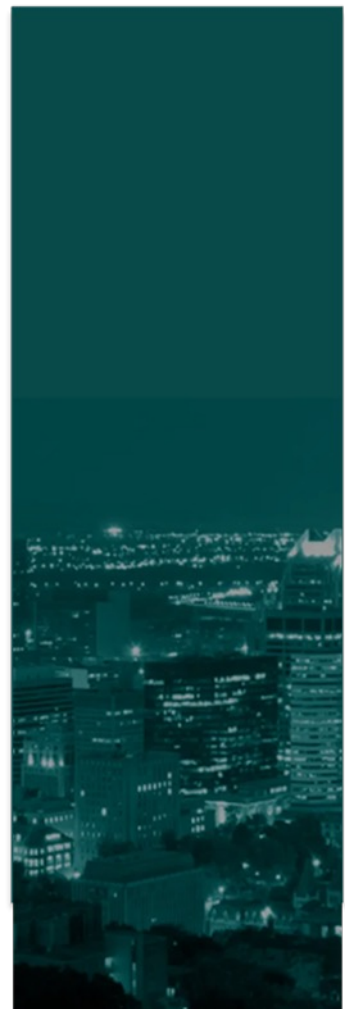
$U_t$  **0.210** ( $R_t$  27)  
aire fenêtrée **33%**

fondation  $\Psi$  : **0.090**

rive  $\Psi$  : **0.017**

coins  $\Psi$  : **0.090**

fenêtrage  $\Psi$  : **0.078**





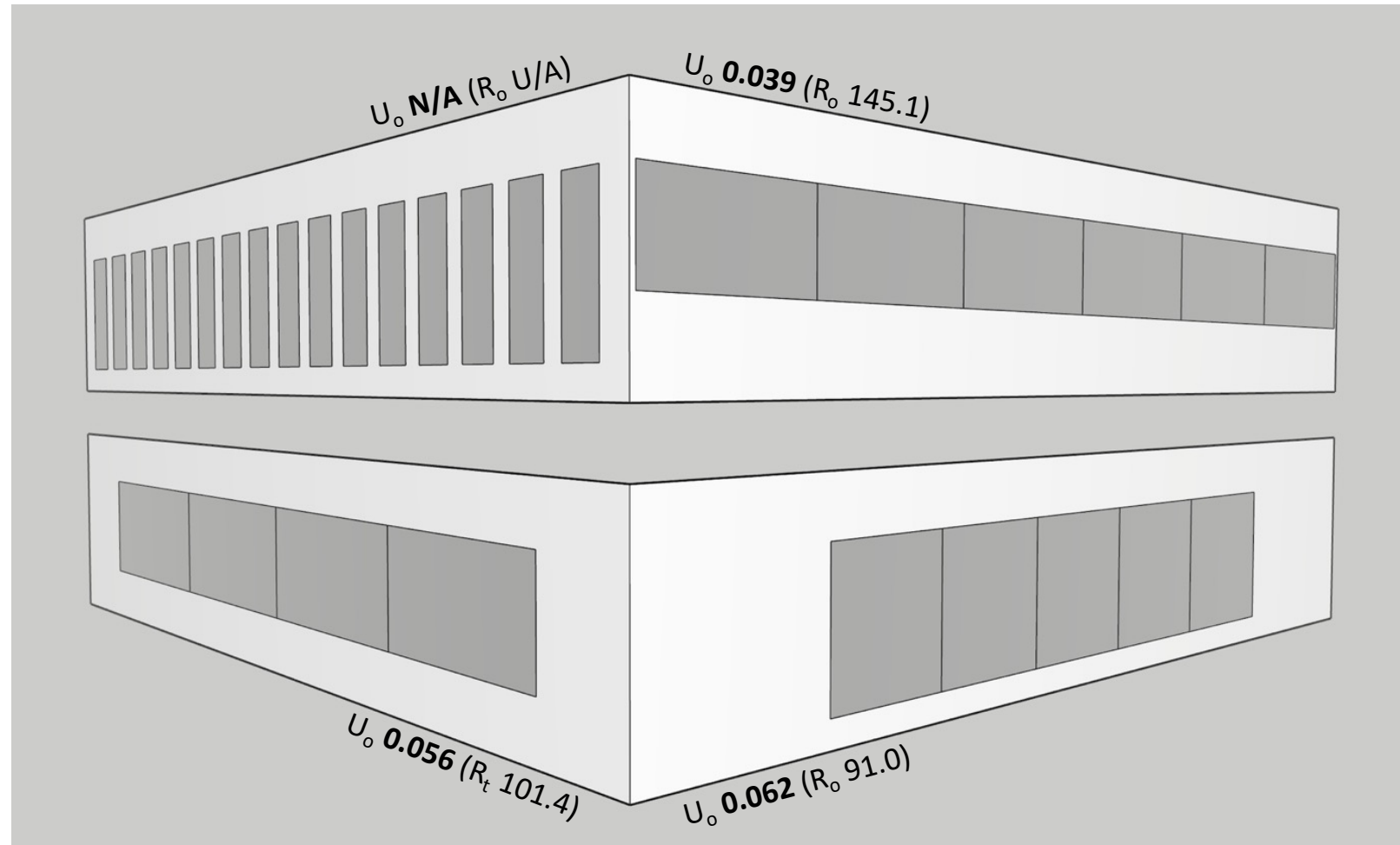


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CNÉB 2017 : 5000 DJC



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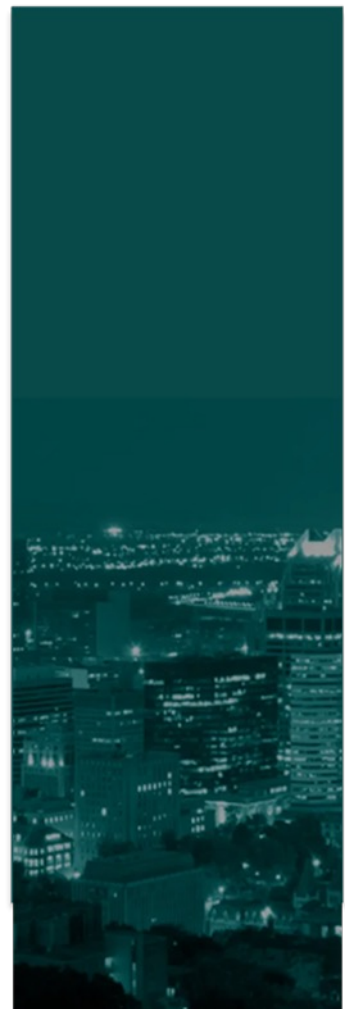
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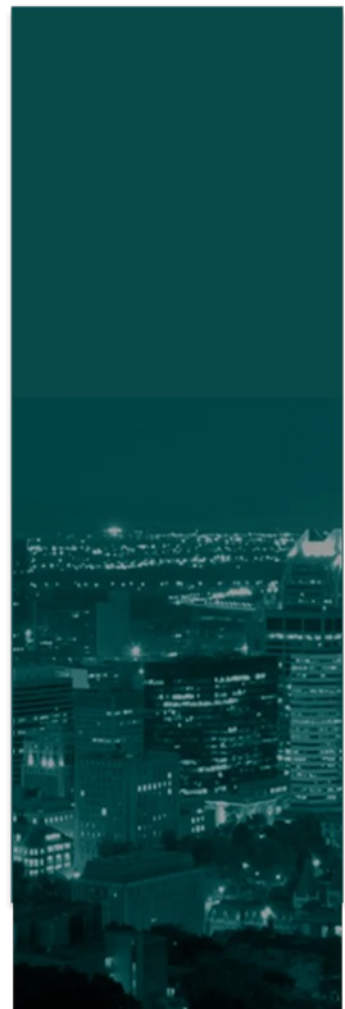
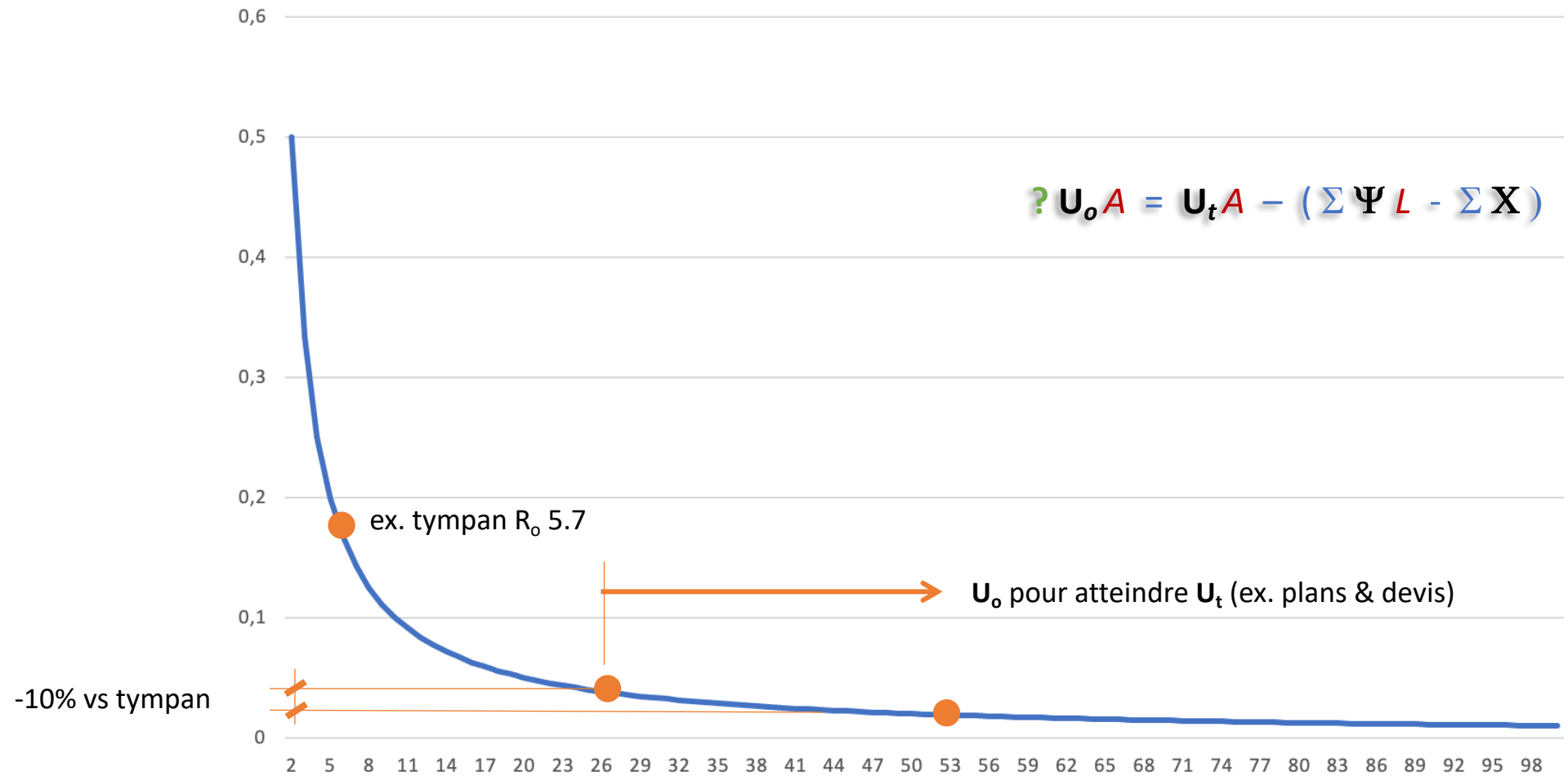
coins  $\Psi$  : **0.090**

fenêtrage  $\Psi$  : **0.078**





### U vs R



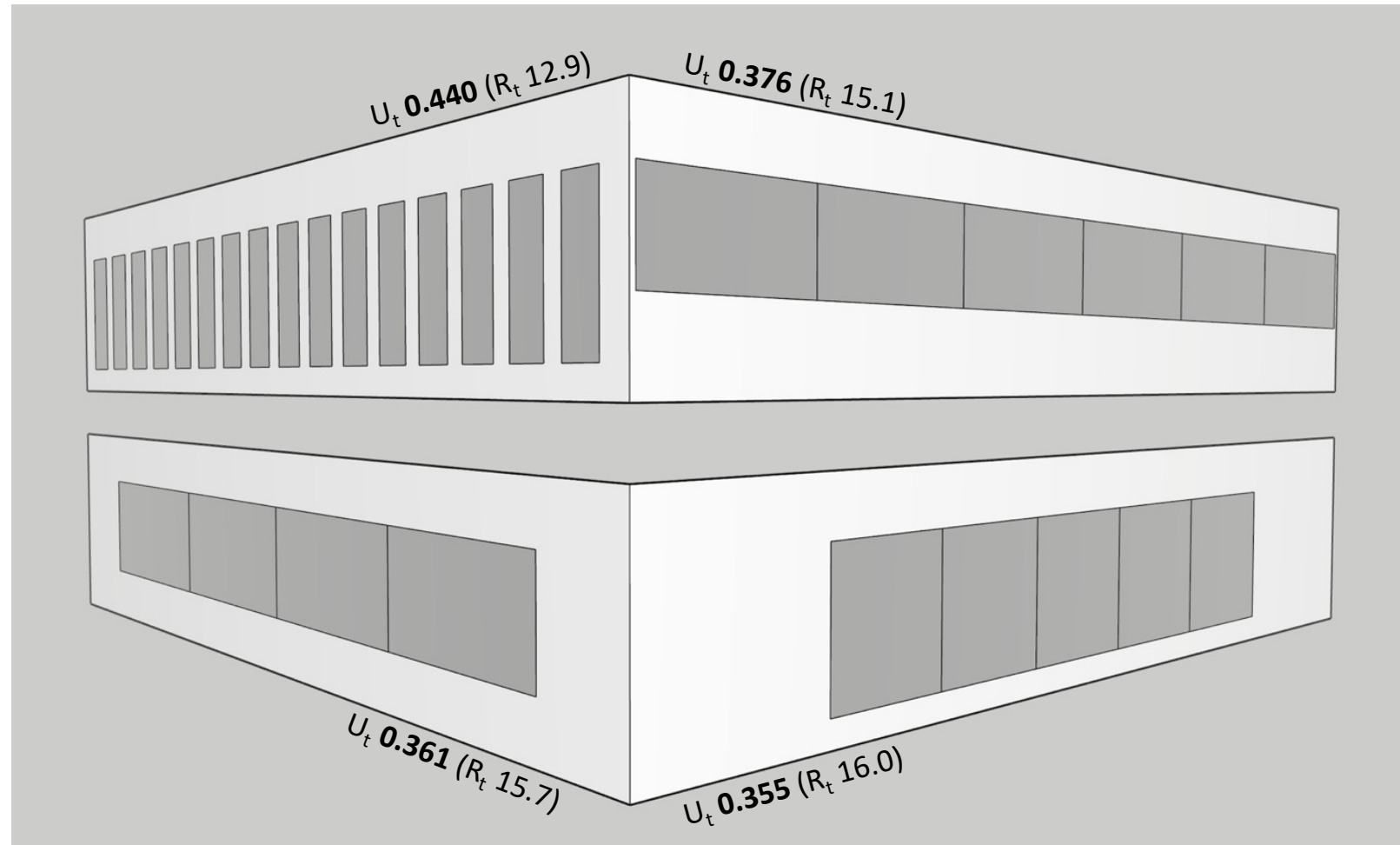


Réseau Énergie  
et Bâtiments



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CNÉB-QC I1 : 5000 DJC



$U_o$  **0.278** ( $R_o$  20)  
aire fenêtrée **33%**

fondation  $\Psi$  : **0.090**

rive  $\Psi$  : **0.017**

coins  $\Psi$  : **0.090**

fenêtrage  $\Psi$  : **0.078**

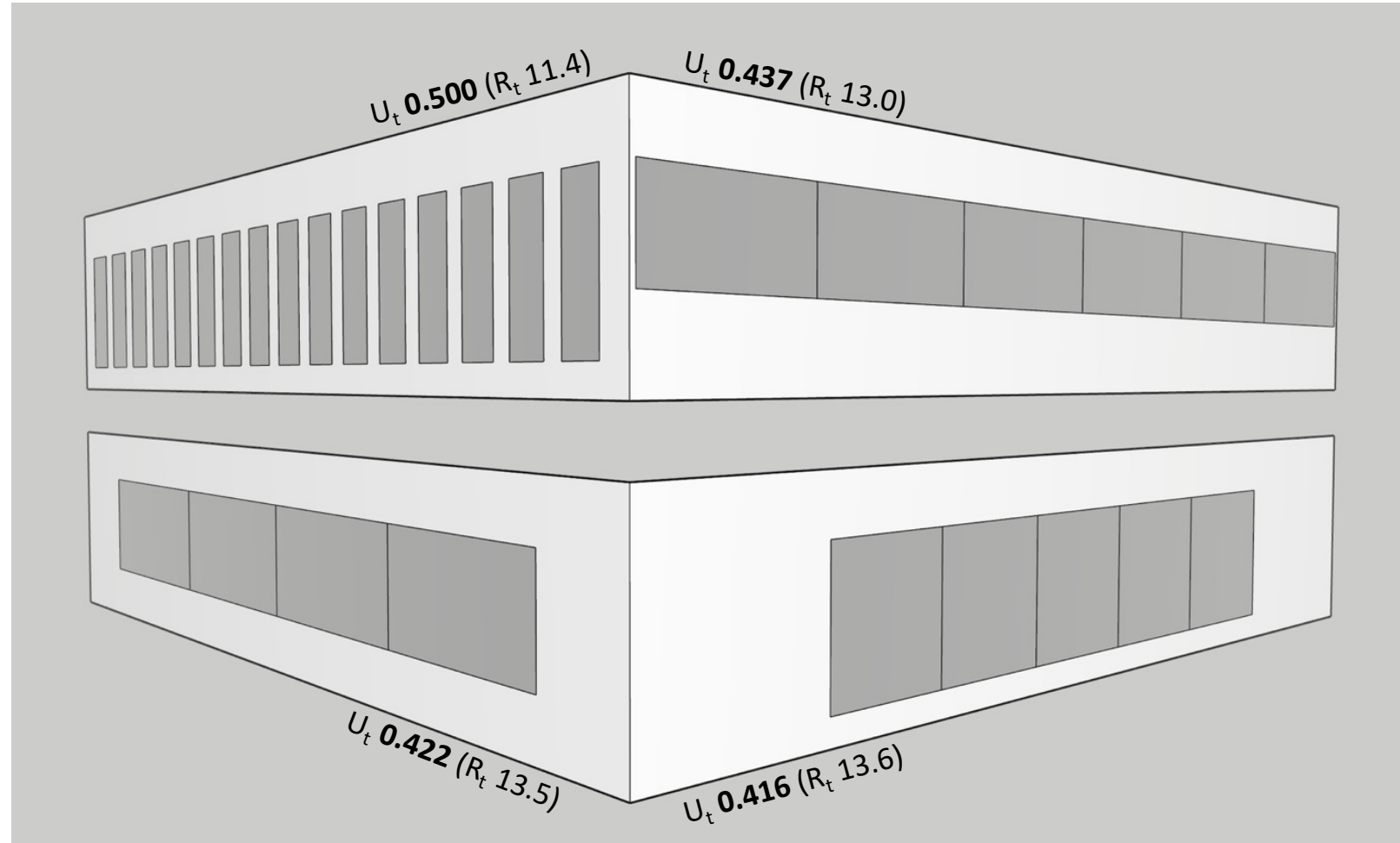


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CNÉB-QC I1 : 5000 DJC



$U_o$  **0.278** ( $R_o$  20)  
aire fenêtrée **33%**

fondation  $\Psi$  : **0.090**

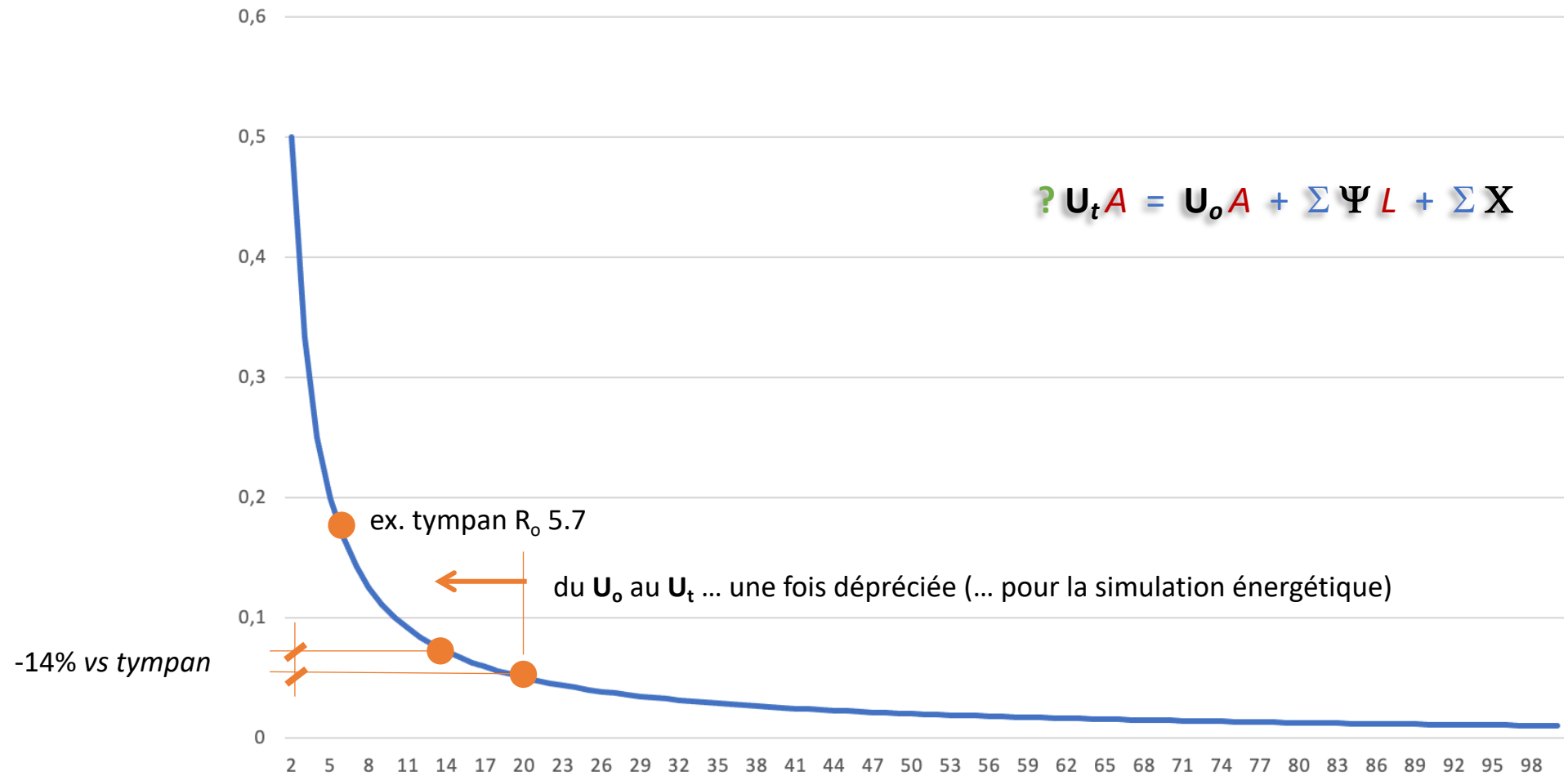
rive  $\Psi$  : **0.200**

coins  $\Psi$  : **0.090**

fenêtrage  $\Psi$  : **0.078**



U vs R







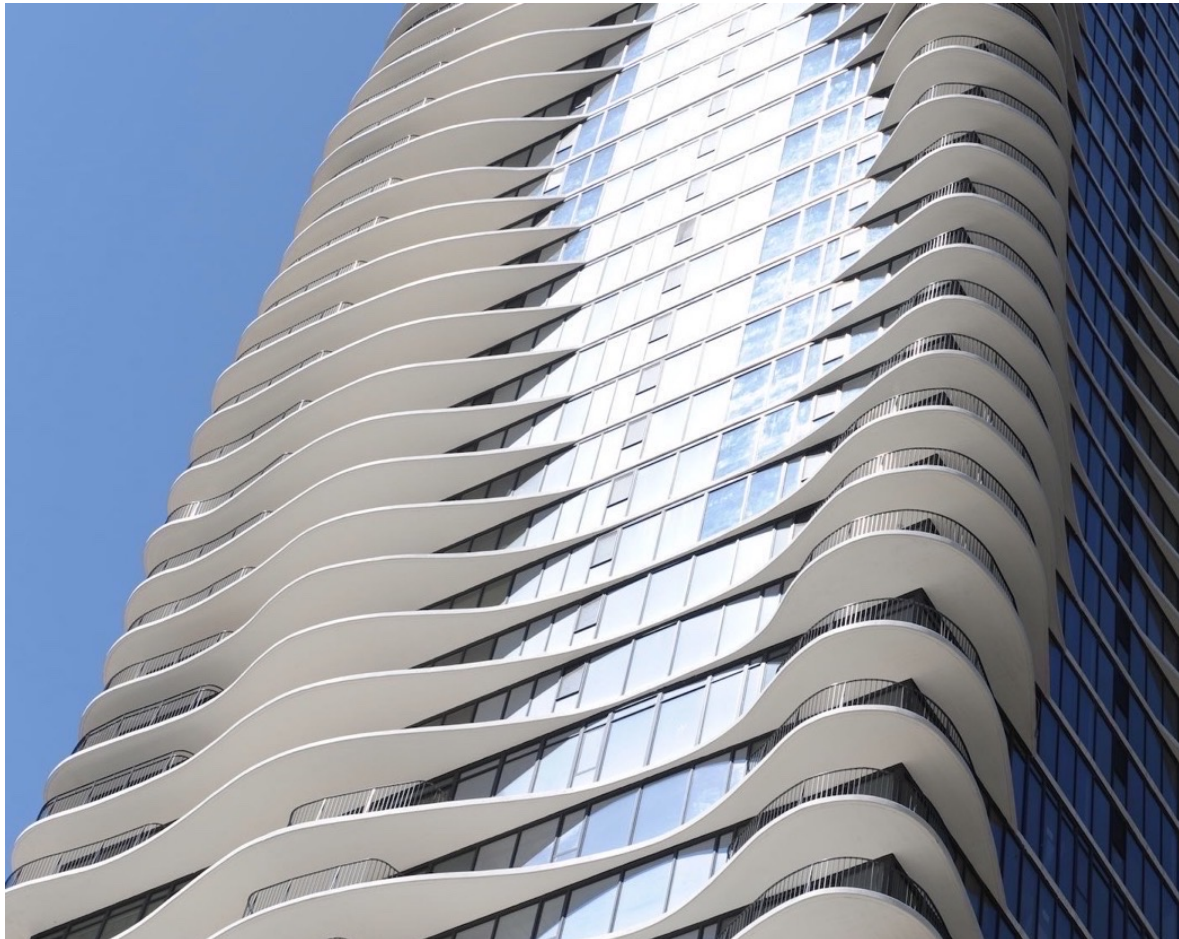
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LIMITES  
fenêtrage

BETBG



quoi déprécier ?

... *OtherEquipment + EMS*

[www.architecture.org/learn/resources/buildings-of-chicago/building/aqua](http://www.architecture.org/learn/resources/buildings-of-chicago/building/aqua)



BETBG

NREL / EnergyPlus Public

<> Code Issues 766 Pull requests 38 Discussion

## Thermal bridging #6509

Open aaron-boranic opened this issue on Mar 5, 2018 · 2 comments



aaron-boranic commented on Mar 5, 2018 · edited

Problem: EnergyPlus provides no method to describe thermal bridging for the same construction (e.g., wood stud and insulation cavity).

Solution 1: A very basic approximation would be to allow input for the same construction (e.g., wood stud and insulation cavity).

Solution 2: Develop adjustments to the conduction calculation for thermal bridges, similar to Psi factors.

# ADDENDA

## ANSI/ASHRAE/IES Addendum a ANSI/ASHRAE/IES Standard 90.1-2013

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**Table A10.1 Thermal Bridging Psi-Factors and Chi-Factors for Thermal Bridges (I-P)**

Class of Construction— Wall, above Grade	Thermal Bridge Type	Section	Unmitigated		Default		
			Psi-Factor Btu/(h·ft·°F)	Chi-Factor Btu/(h·°F)	Psi-Factor Btu/(h·ft·°F)	Chi-Factor Btu/(h·°F)	
<i>Steel framed and metal buildings</i>	Roof edge	5.5.5.1.1	0.450	N/A	0.140	N/A	
	Parapet	5.5.5.1.2	0.289		0.151		
	Intermediate floor to wall intersection	5.5.5.2.1	0.487		0.177		
	Intermediate floor balcony or overhang to opaque wall intersection	5.5.5.2.2	0.487		0.177		
	Intermediate floor balcony in contact with vertical fenestration	5.5.5.2.2	0.974		0.177		
	Cladding Support	5.5.5.3	0.314		0.217		
	Wall to vertical fenestration intersection	5.5.5.4	0.262		0.112		
	Other element and assembly intersections	5.5.5.5	N/A	1.73	N/A	0.91	
	<i>Mass (exterior or</i>	Roof edge	5.5.5.1.1	0.500			