THE INFLUENCE OF THERMOCHROMIC GLAZING PARAMETERS ON ENERGY SAVING AND COMFORT CRITERIA USING MOMENT-INDEPENDENT MEASURE

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The Influence of Thermochromic Glazing Parameters on Energy Saving and Comfort criteria Using Moment-Independent Measure

Aim of the study

Identify the influence of thermochromic glazing parameters for office buildings in hot climates using dynamic building simulations and sensitivity analysis techniques

Background

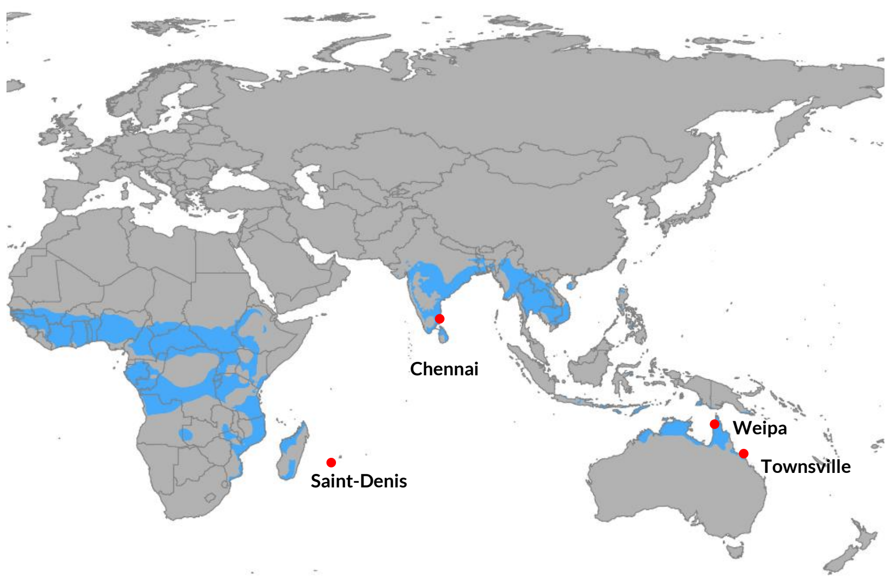
Thermochromic glazing (TC) :
Has the capability to modulate its thermo-optical properties dynamically and reversibly when a change in its temperature occurs

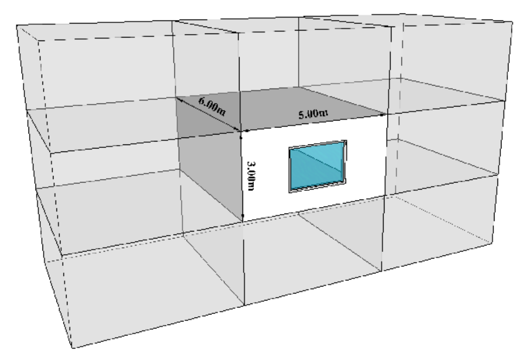
TC glazing

TC glazing for building application

- Has to be doped with other metals to improve its properties: (Li and al., 2012)
  - Transition temperature
  - Visible Transmittance
  - Solar modulation
- Has a potential to:
  - Reduce energy consumption (Hoffmann et al., 2014)
  - Improve thermal and visual comfort (Costanzo and al., 2016)
- Has a greater efficiency for hot climates (Saeli and al., 2010)

Methodology





Office building configuration

- Thermal and daylighting simulations with EnergyPlus
- Sensitivity analysis method with a Python code with the SAlib
- Analysis on several indexes and on 4 locations (hot tropical climates)

Sensitivity Analysis

Moment-Independent Measure (Borgonovo, 2007):

The assessment of "the influence of the entire input distribution on the entire output distribution without reference to a particular moment of the output"

INPUT VARIABLES	SYMBOL	RANGE	UNIT	PROBABILITY
Building Orientation	BO	0-360	°	Continuous; Uniform
Window to Wall Ratio	WWR	5-99	%	Continuous; Uniform
Insulation Thickness	θ_{ins}	0.01-0.7	m	Continuous; Uniform
Weather File	wea	1-4	-	Discrete; Uniform
Switching Temperature	T_s	5-70	°C	Continuous; Uniform
Switching Temperature range	ΔT_s	1-50	°C	Continuous; Uniform
Solar Transmittance Max	$\tau_{sol,max}$	0.3-0.9	-	Continuous; Uniform
Solar Transmittance range	$\Delta\tau_{sol}$	0.01-0.5	-	Continuous; Uniform
Visible Transmittance Max	$\tau_{vis,max}$	0.3-0.9	-	Continuous; Uniform
Visible Transmittance range	$\Delta\tau_{vis}$	0.01-0.5	-	Continuous; Uniform
Number of states	state	2-20	-	Discrete; Uniform

4096 simulations were performed

Model Outputs

Normalized output indexes

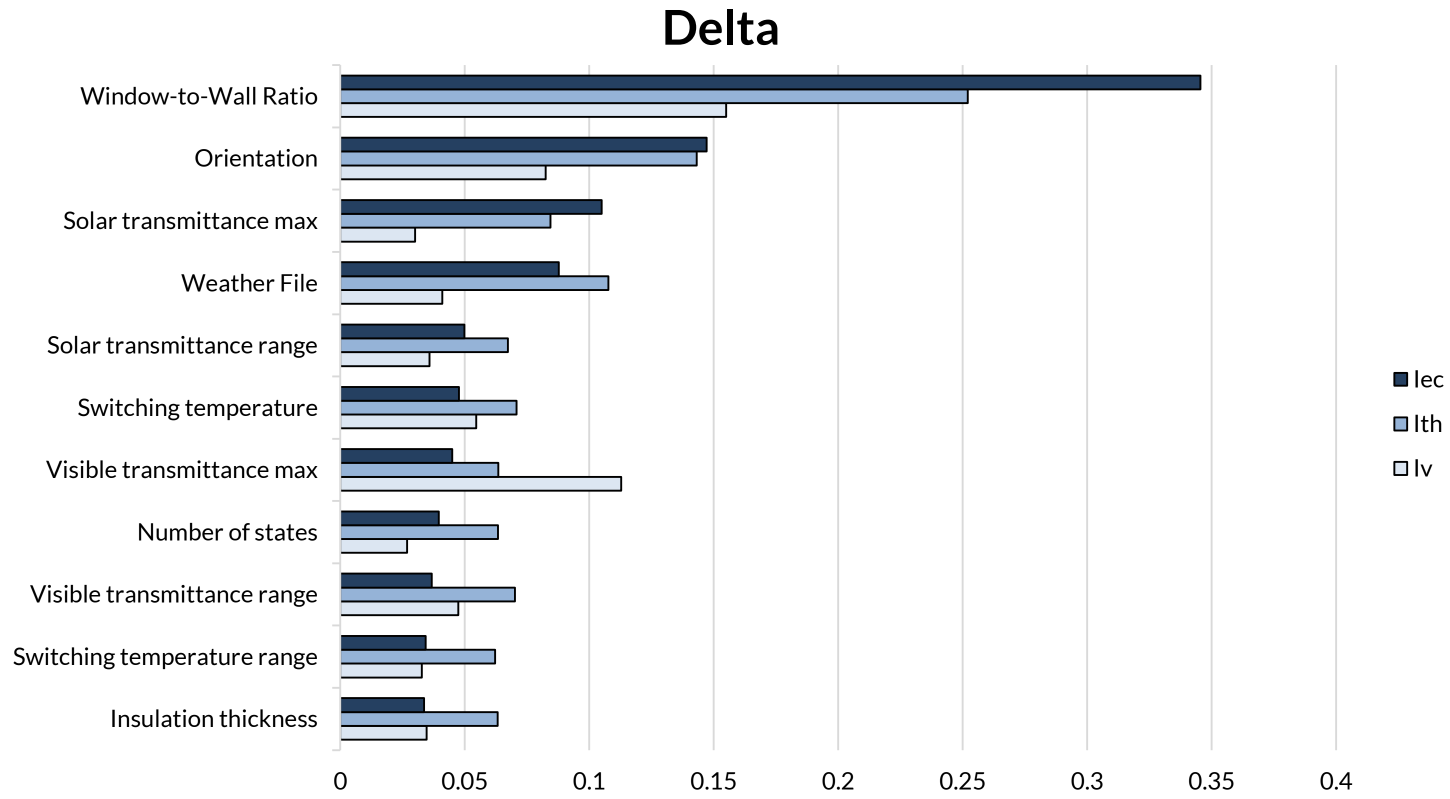
Energy consumption index (I_{ec}):
- Sum of the final energy consumed in one year
- Cooling and artificial lighting

Thermal comfort index (I_{th}):
- % of time when the operative temperature is below $26°C$

Visual comfort index (I_v):
- % of time when the illuminance reference points are between 300 and 2000 lux

Results

Delta

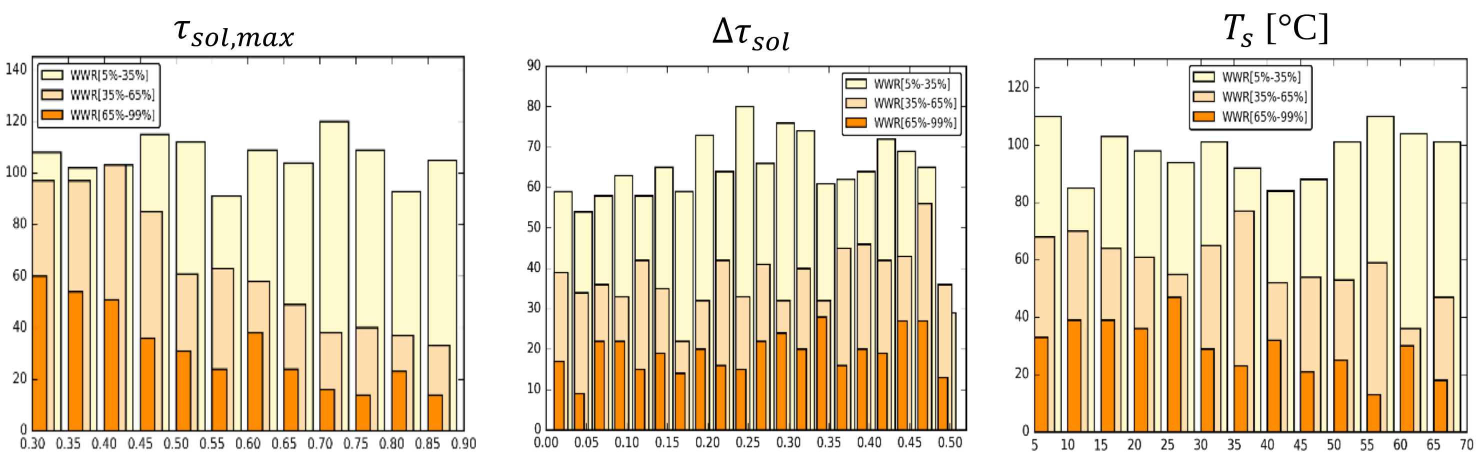


Distribution of input parameters

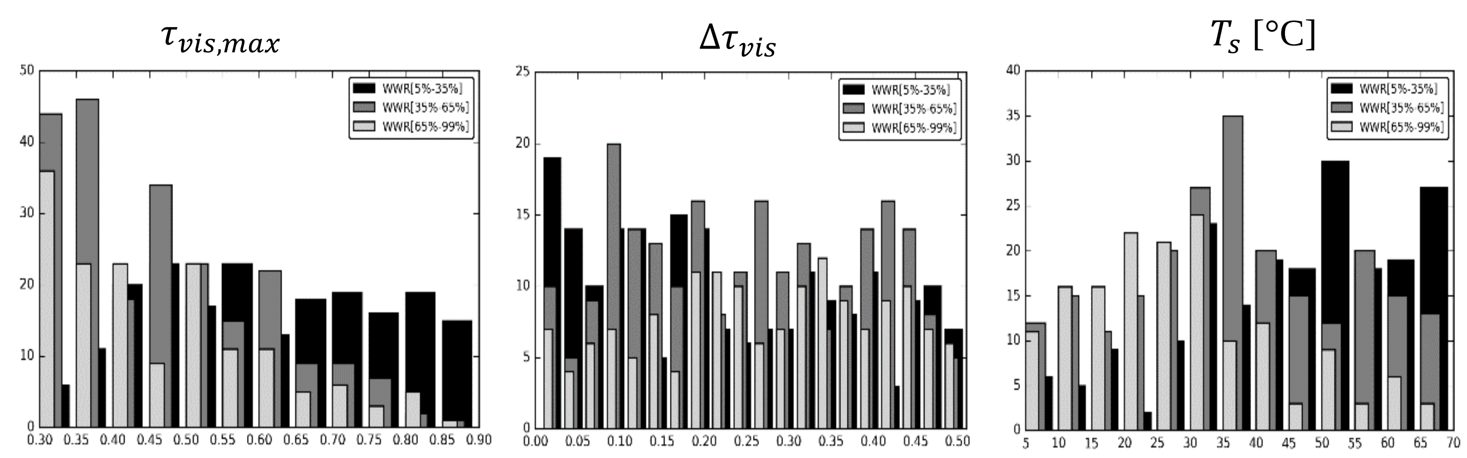
- Filtering model outputs according to a criteria
- Sorting given inputs by glazing size (small, medium, large)

WWR[5% - 35%[
WWR[35% - 65%[
WWR[65% - 99%]

Energy consumption: [0; 0.40]



Visible comfort: [0.70; 1]



References

Borgonovo, E., 2007. A new uncertainty importance measure. Reliab. Eng. Syst. Saf. 92, 771–784.
Costanzo, V., Evola, G., Marletta, L., 2016. Thermal and visual performance of real and theoretical thermochromic glazing solutions for office buildings. Sol. Energy Mater. Sol. Cells 149, 110–120.
Hoffmann, S., Lee, E.S., Clavero, C., 2014. Examination of the technical potential of near-infrared switching thermochromic windows for commercial building applications. Sol. Energy Mater. Sol. Cells 123, 65–80.
Li, S.-Y., Niklasson, G.A., Granqvist, C.G., 2012. Thermochromic fenestration with VO2-based materials: Three challenges and how they can be met. Thin Solid Films, 7th International Symposium on Transparent Oxide Thin Films for Electronics and Optics (TOEO-7) 520, 3823–3828.
Saeli, M., Piccirillo, C., Parkin, I.P., Binions, R., Ridley, I., 2010. Energy modelling studies of thermochromic glazing. Energy Build. 42, 1666–1673.

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Article accepted in the Australasian Building Simulation Conference
15 – 16 November 2017 – Melbourne

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