

Vidros e eficiência energética em edifícios no Brasil

Prof. Dr. Fernando Simon Westphal

Universidade Federal de Santa Catarina
Departamento de Arquitetura e Urbanismo
Laboratório de Conforto Ambiental

fernando.sw@ufsc.br



IEA SHC Task 50: 6° Workshop com a Indústria
"Soluções Avançadas de Iluminação para Retrofit de Edifícios"

Brasília, 28 de setembro de 2015

Topics

- ❑ Energy end-use: commercial buildings
- ❑ Trends in the façades design in Brazil
- ❑ Selective glazing systems in use
- ❑ Barrier to increase daylight integration
- ❑ Case studies

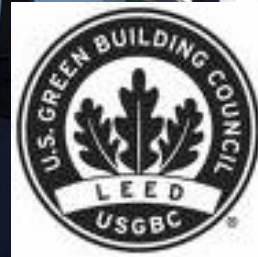
Introduction

Recent building simulation experience

Certificação LEED

Eldorado Business Tower

São Paulo
Gafisa & São Carlos
128 000 m²



LEED-PLATINUM

Certificação LEED

Pátio Victor Malzoni

São Paulo
Victor Malzoni | Brookfield
175.000 m²



LEED-SILVER



Certificação LEED

Infinity Tower

São Paulo
Método
75.700 m²



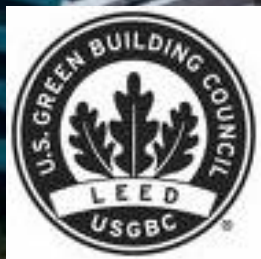
LEED-GOLD



Certificação LEED

Edifício Jatobá

São Paulo
Engelborm / Bratke & Collet
18.000 m²



LEED-SILVER

Torre Santander

São Paulo
WTorre
67.397 m²



LEED-SILVER



Certificação LEED

Morumbi Corporate Towers

São Paulo
Multiplan
142.500 m²



LEED-GOLD



Certificação LEED

Centro Empresarial Senado

Rio de Janeiro
W Torre
185.463 m²



LEED-SILVER

Certificação LEED

Ventura Corporate Towers

Rio de Janeiro
Tishman Speyers
170.000 m²



LEED-GOLD



Energy end-use

Architecture of office buildings in Brazil: trends

- ❑ Business needs:
 - ✓ Aesthetical requirements (transparent façades)
 - ✓ Increase the construction speed
 - ✓ O&M costs
- ❑ Design and product especification are essential
- ❑ Building simulation is the key

Challenges:
to assure high performance buildings and attend business needs

Glazed façades in Brazil

Commercial buildings

- ❑ Walls: steel framing
- ❑ Window-to-wall ratio between **40% to 60%**
- ❑ Laminated glass with SHGC between **25% to 40%**
- ❑ Visible transmittance between **25% to 45%**

ECO-Berrini (SP)



Morumbi Corporate (SP)



Non-operable Windows
(noise issues)

HVAC

Views to exterior

High performance glazing system



Ed. Bela Paulista (Antigo Horácio Lafer) | São Paulo

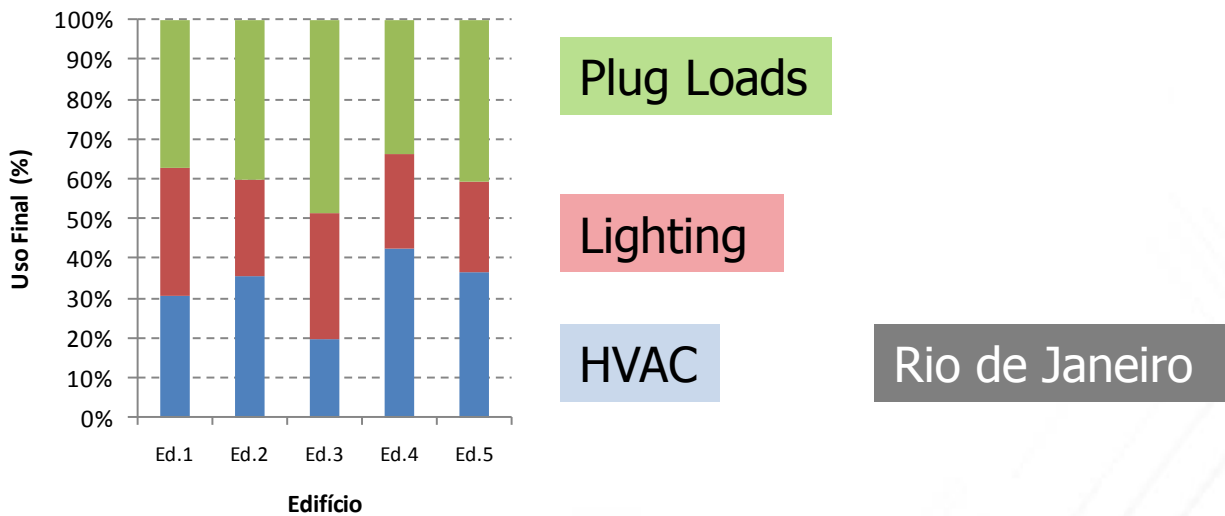
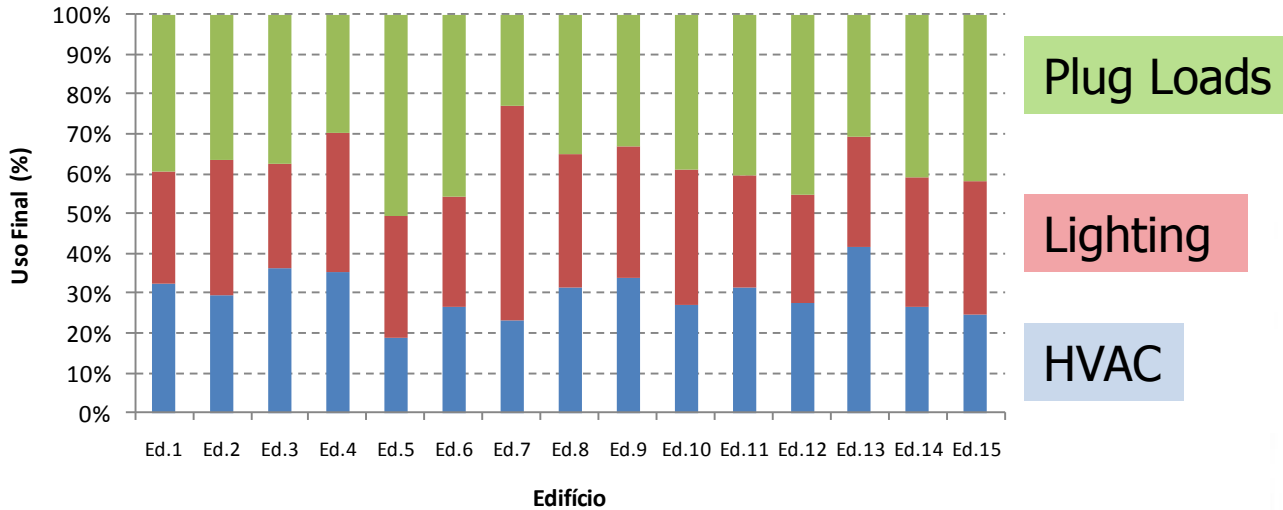


Ed. Paulista 1100 (Antigo Elijass Gliksmanis) | São Paulo



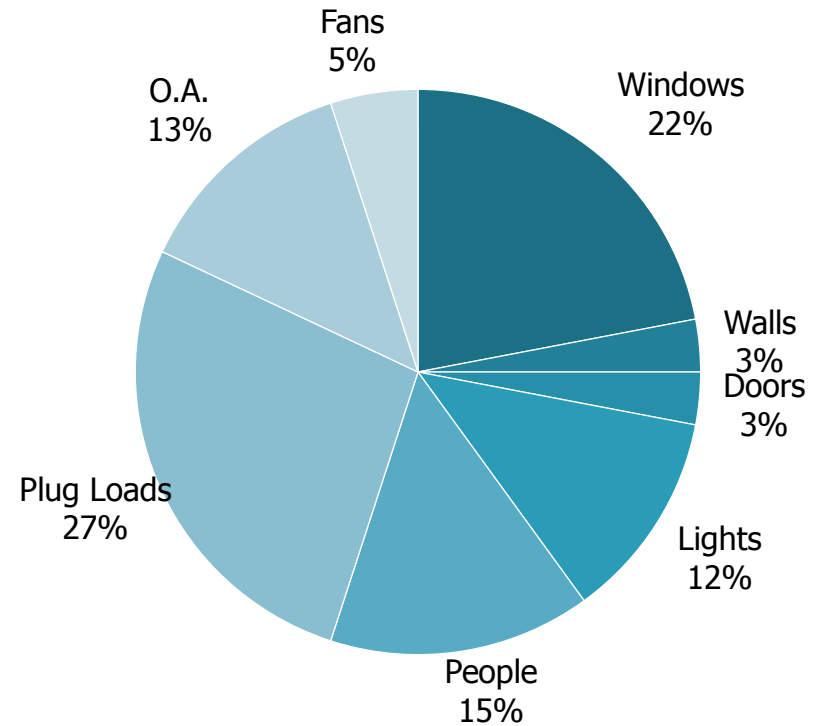
FONTE: Mariano, 2012

Energy End-Use: Office Buildings



Typical thermal loads composition

COOLING COIL PEAK					CLG SPACE PEAK	
Peaked at Time:		Mo/Hr: 2 / 17			Mo/Hr: 2 / 17	
Outside Air:		OADB/WB/HR: 86 / 75 / 126			OADB: 86	
	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0	0	0
Skylite Cond	0	0	0	0	0	0
Roof Cond	0	0	0	0	0	0
Glass Solar	1,039,698	0	1,039,698	13	1,039,698	24
Glass/Door Cond	603,082	75,518	678,600	9	603,082	14
Wall Cond	57,481	188,378	245,859	3	57,481	1
Partition/Door	204,773	0	204,773	3	204,773	5
Floor	-906,301	0	-906,301	-11	-906,301	-21
Adjacent Floor	0	0	0	0	0	0
Infiltration	0	0	0	0	0	0
Sub Total ==>	998,733	263,896	1,262,629	16	998,733	24
Internal Loads						
Lights	664,745	262,514	927,259	12	664,745	16
People	1,097,158	67,199	1,164,357	15	579,666	14
Misc	1,938,839	224,765	2,163,604	27	1,938,839	46
Sub Total ==>	3,700,741	554,478	4,255,219	54	3,183,249	75
Ceiling Load	62,666	-62,666	0	0	62,666	1
Ventilation Load	0	0	1,062,487	13	0	0
Adj Air Trans Heat	0	0	0	0	0	0
Dehumid. Ov Sizing	0	0	0	0	0	0
Ov/Undr Sizing	0	0	0	0	0	0
Exhaust Heat	0	-20,841	-20,841	0	0	0
Sup. Fan Heat	0	0	485,956	6	0	0
Ret. Fan Heat	0	2	2	0	0	0
Duct Heat Pkup	0	0	0	0	0	0
Underflr Sup Ht Pkup	0	0	906,301	11	0	0
Supply Air Leakage	0	0	0	0	0	0
Grand Total ==>	4,762,141	734,868	7,951,752	100.00	4,244,649	100.00

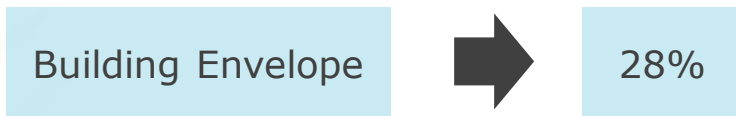
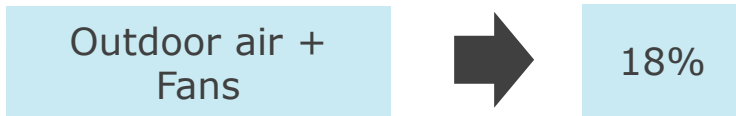
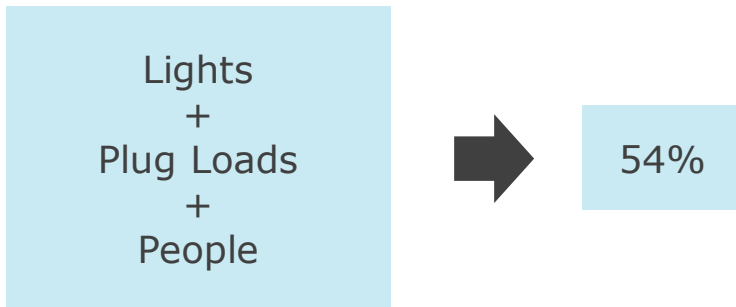


Software Trace 700
 Fonte: TEKNIKA Projetos

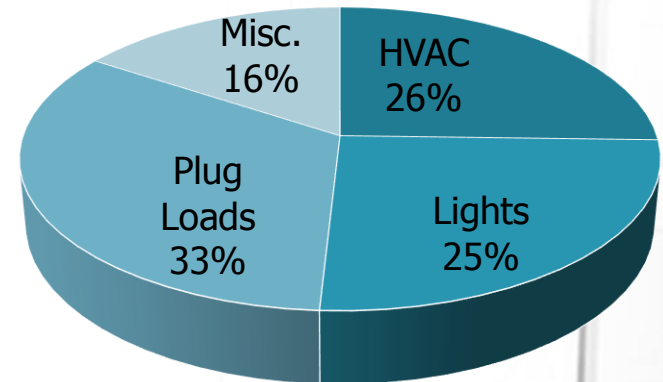
Energy End-Use: Office Buildings



Cooling load:



Energy End-Use in São Paulo:



28% of the cooling load is affected by the façade → 6,25%
25% of the annual electricity correspond to HVAC

Selective glazing systems

Opção	Visible transmittance	Visible reflectance – ext	Visible reflectance - int	SHGC	Light to Heat Gain Index
#1	0,16	0,34	0,31	0,27	0,59
#2	0,19	0,32	0,25	0,29	0,66
#3	0,33	0,26	0,19	0,27	1,22
#4	0,35	0,25	0,19	0,35	1,00
#5	0,58	0,09	0,07	0,49	1,18

Project	ECO Berrini São Paulo
SHGC	40%
VT	42%
VRe	20%



Project	ECO Berrini São Paulo
SHGC	40%
VT	42%
VRe	20%











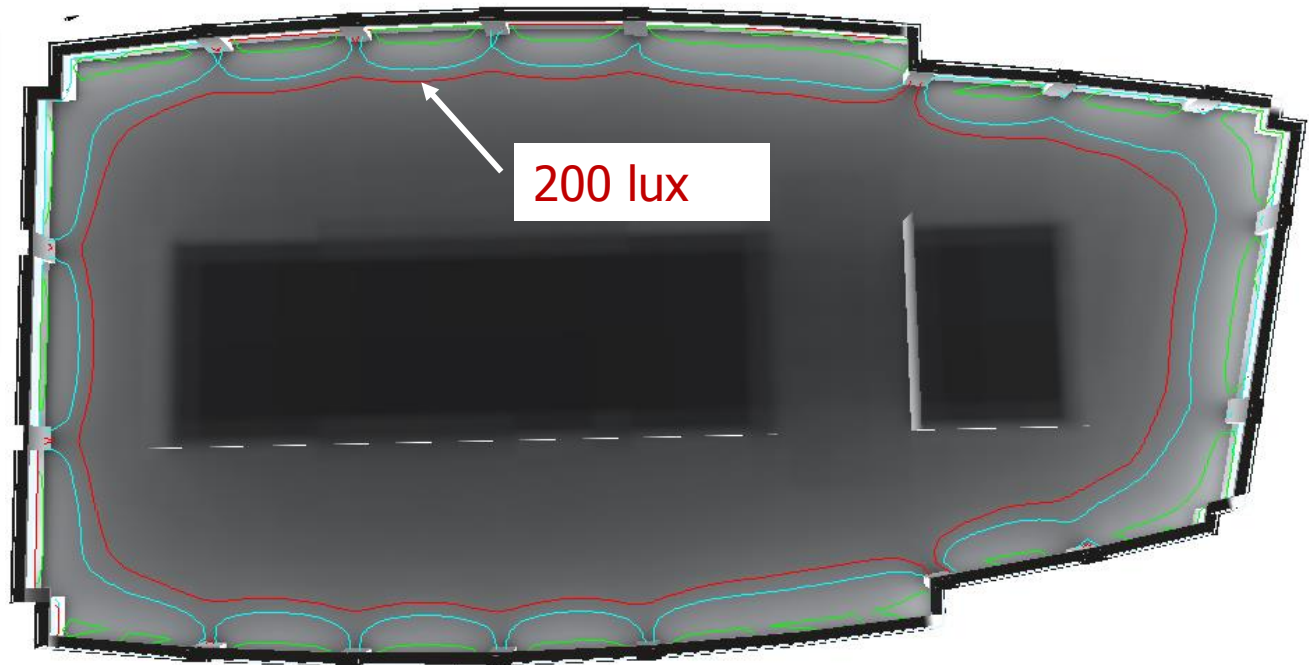
Simulação – Luz natural

- ❑ Very deep office spaces (11 m)
- ❑ Limited potential to harvest daylighting
- ❑ Sensors are in the tenant scope

Isolines workplane

1. Value	<input type="text" value="700.0"/>	lx	<input type="color" value="#00FF00"/>
2. Value	<input type="text" value="270.0"/>	lx	<input type="color" value="#00FFFF"/>
3. Value	<input type="text" value="200.0"/>	lx	<input type="color" value="#FF0000"/>

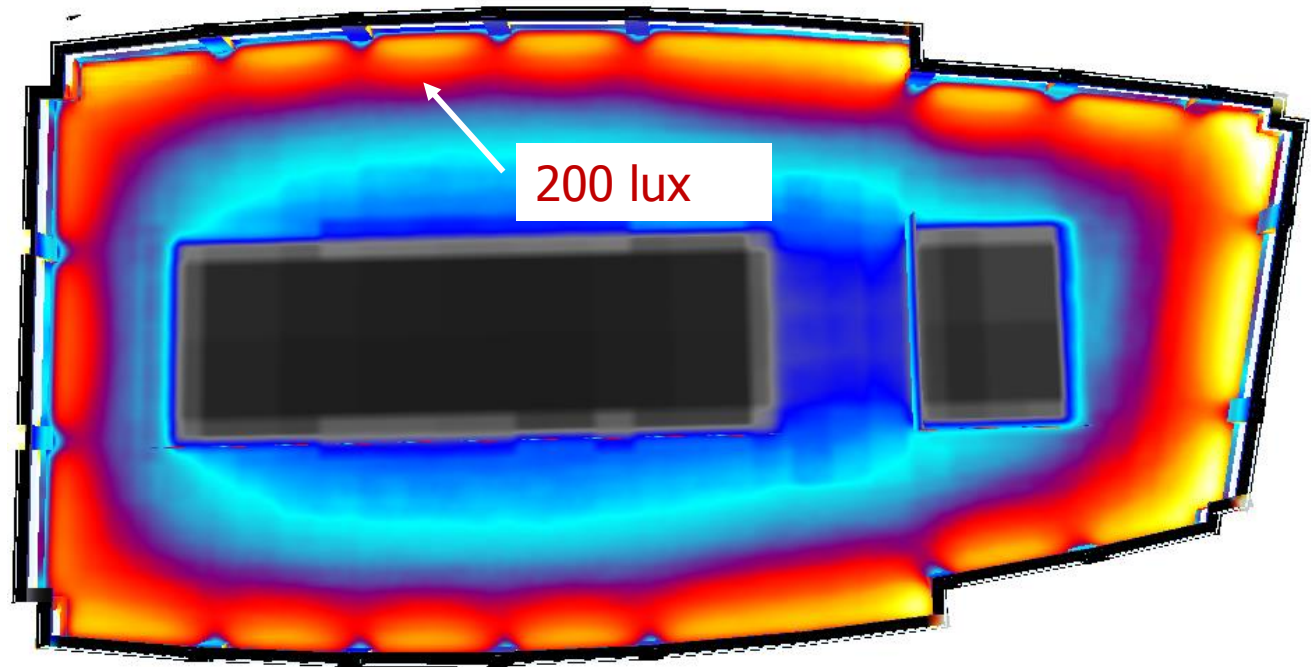
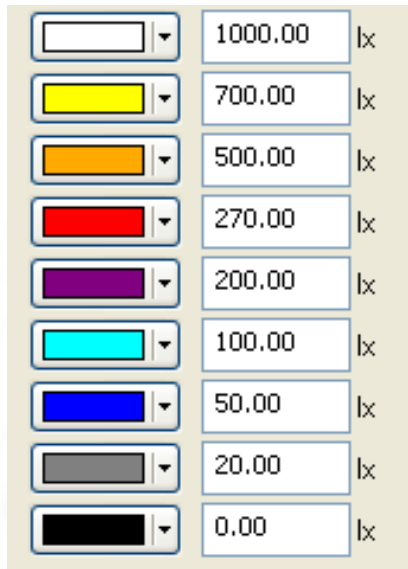
Enter the value 0 in an input box to deactivate the respective isoline.



Dialux simulation

Simulação – Luz natural

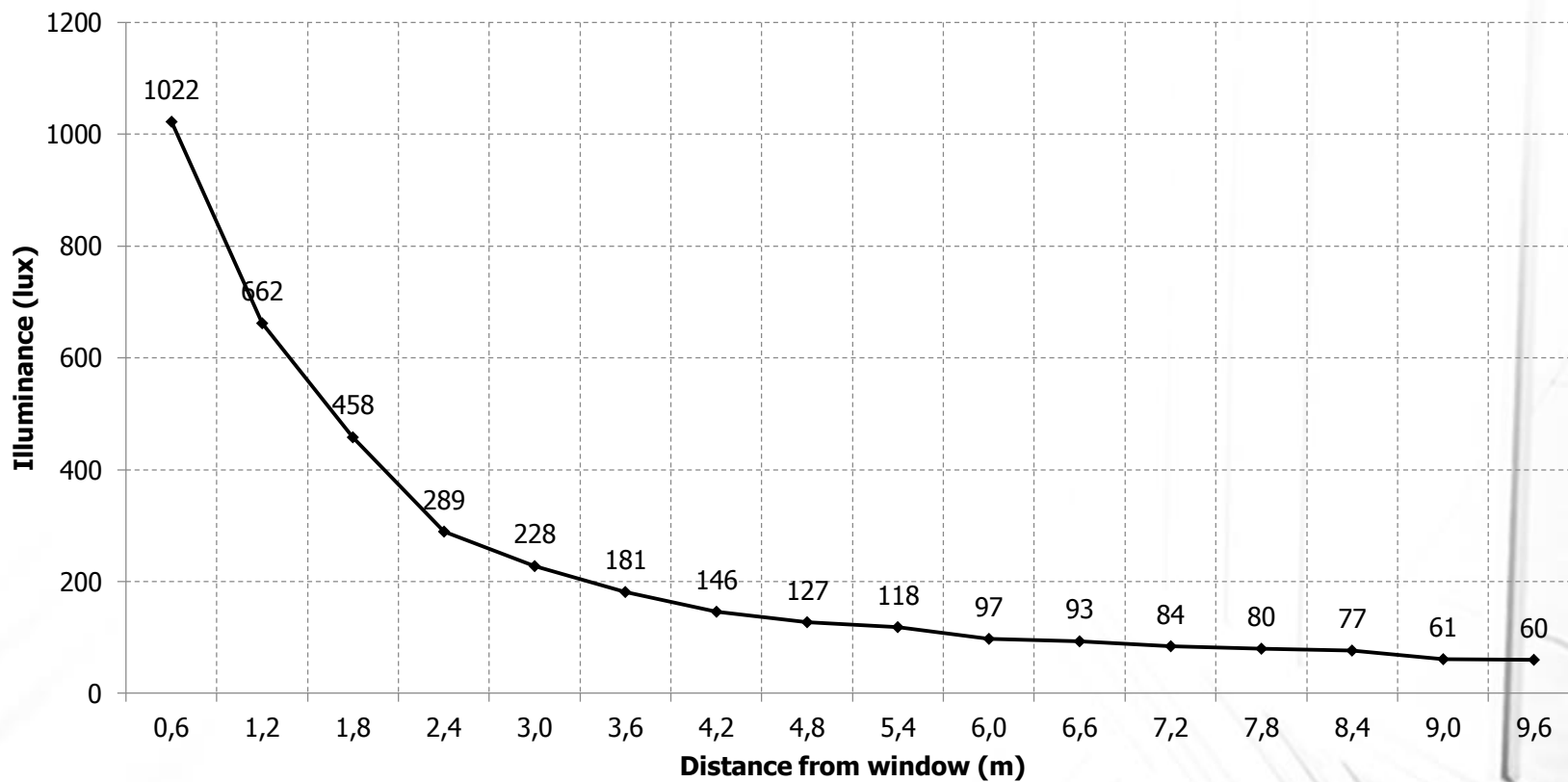
- ❑ Very deep office spaces (11 m)
- ❑ Limited potential to harvest daylighting
- ❑ Sensors are in the tenant scope



Dialux simulation

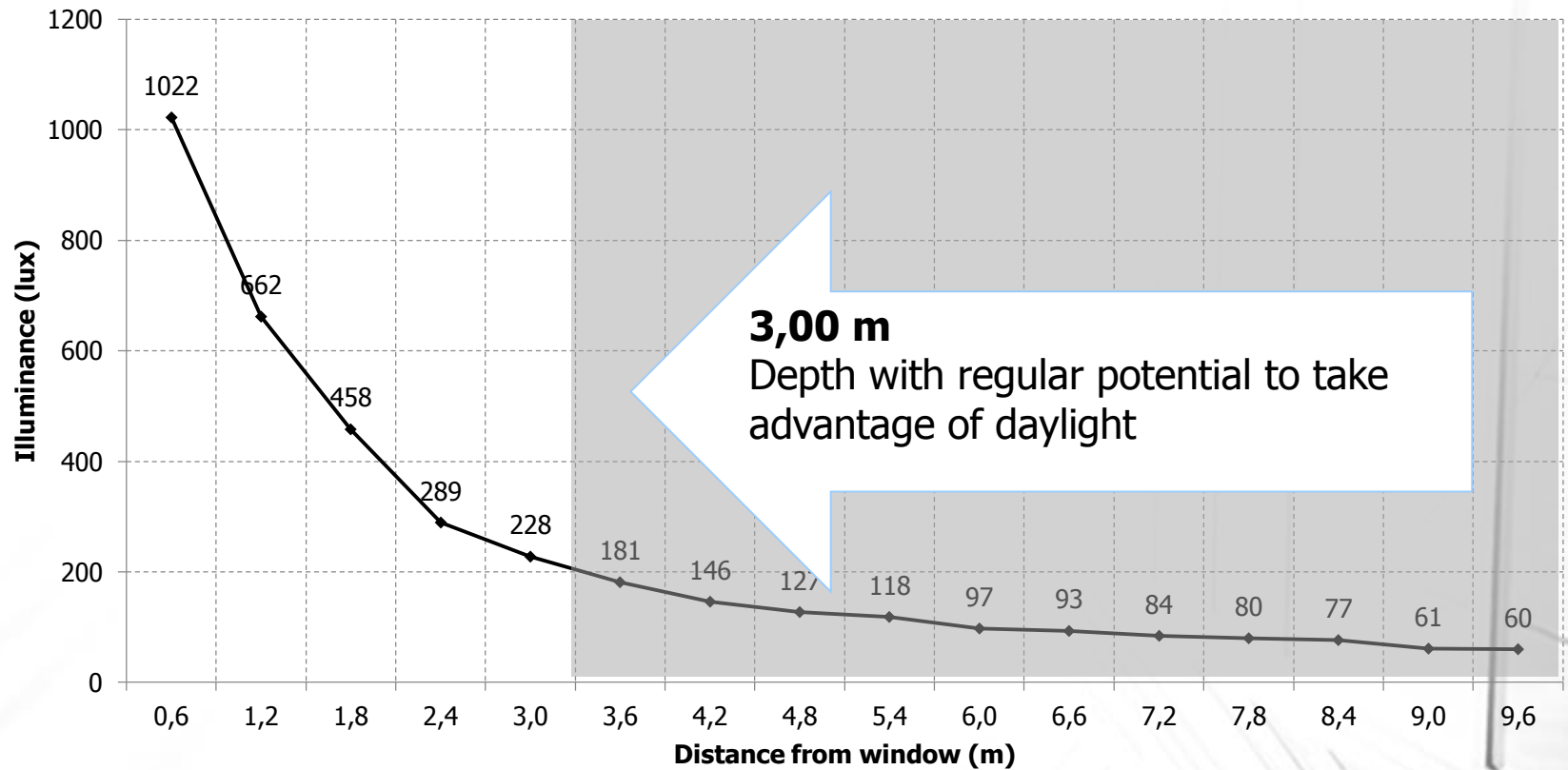
Simulação – Luz natural

Daylight levels profile

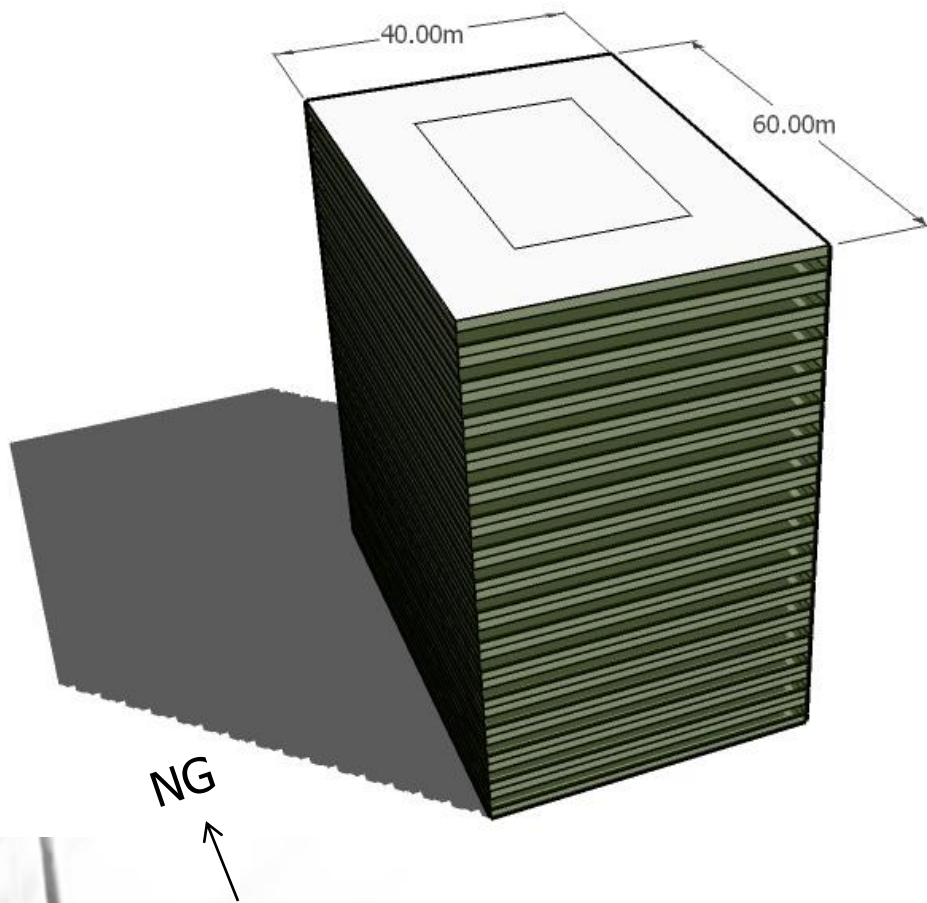


Simulação – Luz natural

Daylight levels profile



Building energy consumption database for parametric analysis



Office building

20 floors

48.000 m² total area

16.000 m² façade area

Fully glazed façade

No shading

Software EnergyPlus

7 Brazilian cities

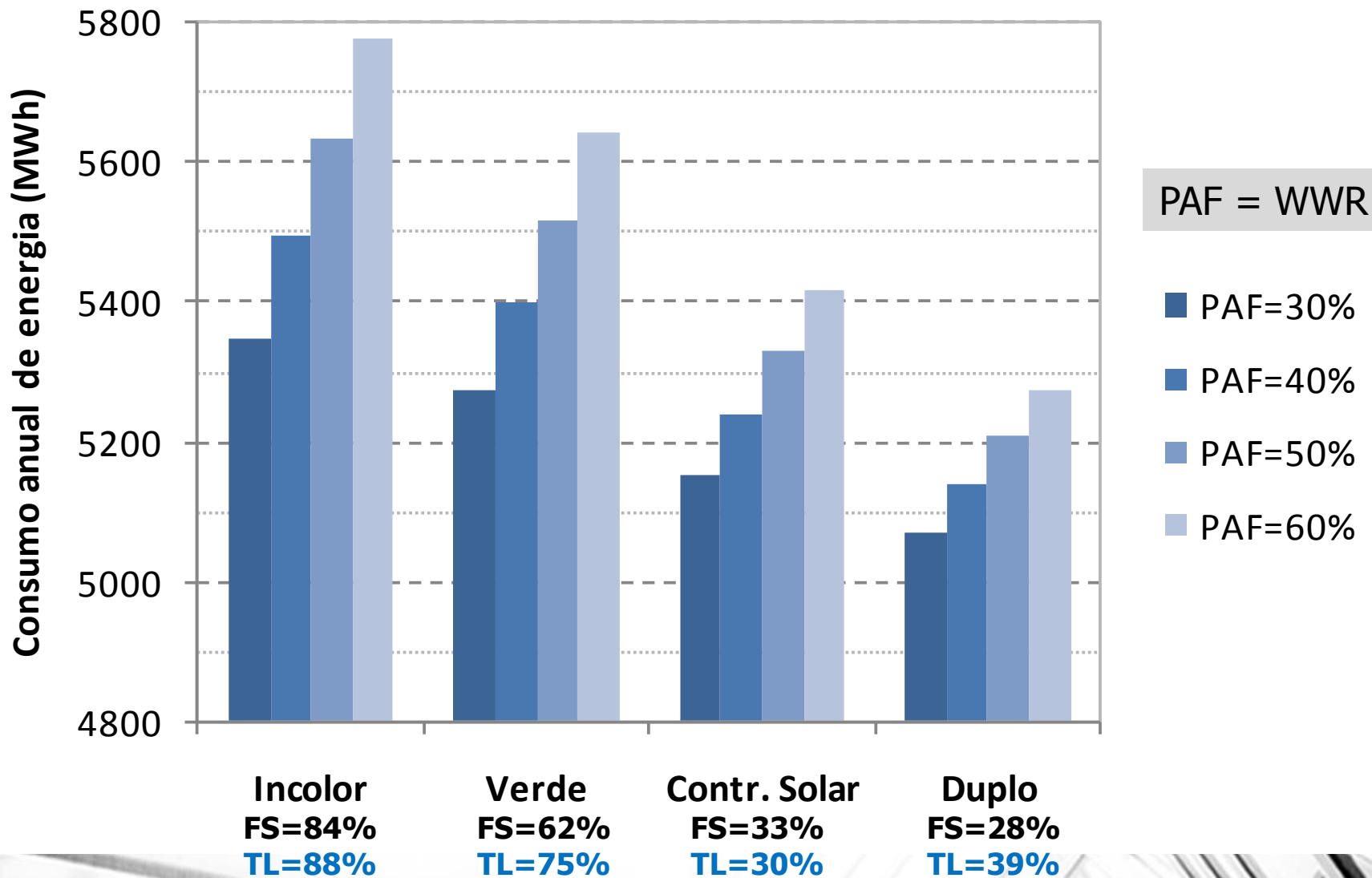
Estudos de caso por simulação: Vidros utilizados



Propriedade	Clear Glass	Green	Solar control glazing system	Insulated glass unit
SHGC	0.84	0.62	0.33	0.28
U-value (W/m ² .K)	5.60	5.60	5.60	1.88
Visible transmittance	0.88	0.75	0.30	0.39
Light to heat gain index	1.05	1.21	0.90	1.45

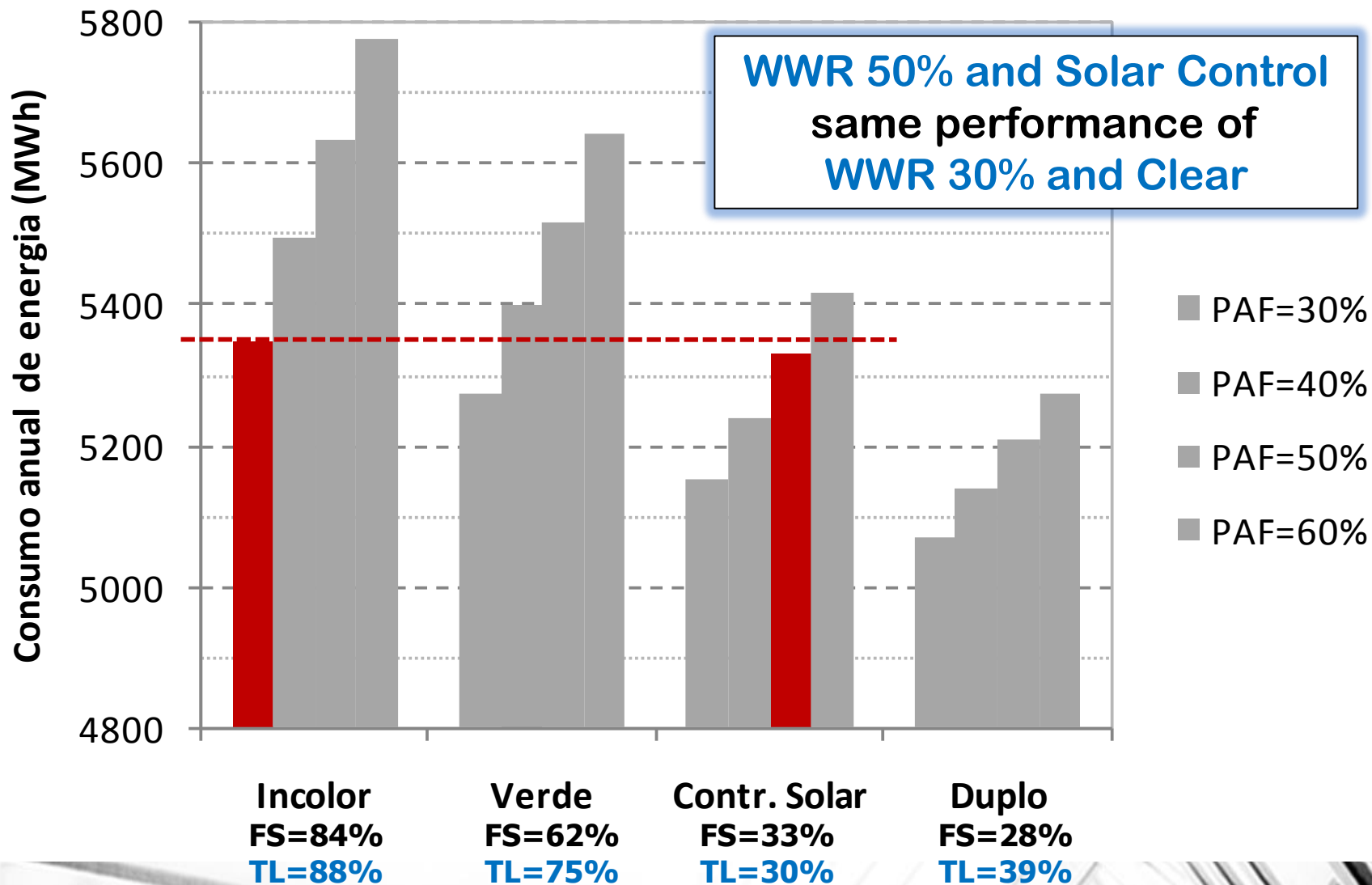
Estudo de caso por simulação

Clima: São Paulo



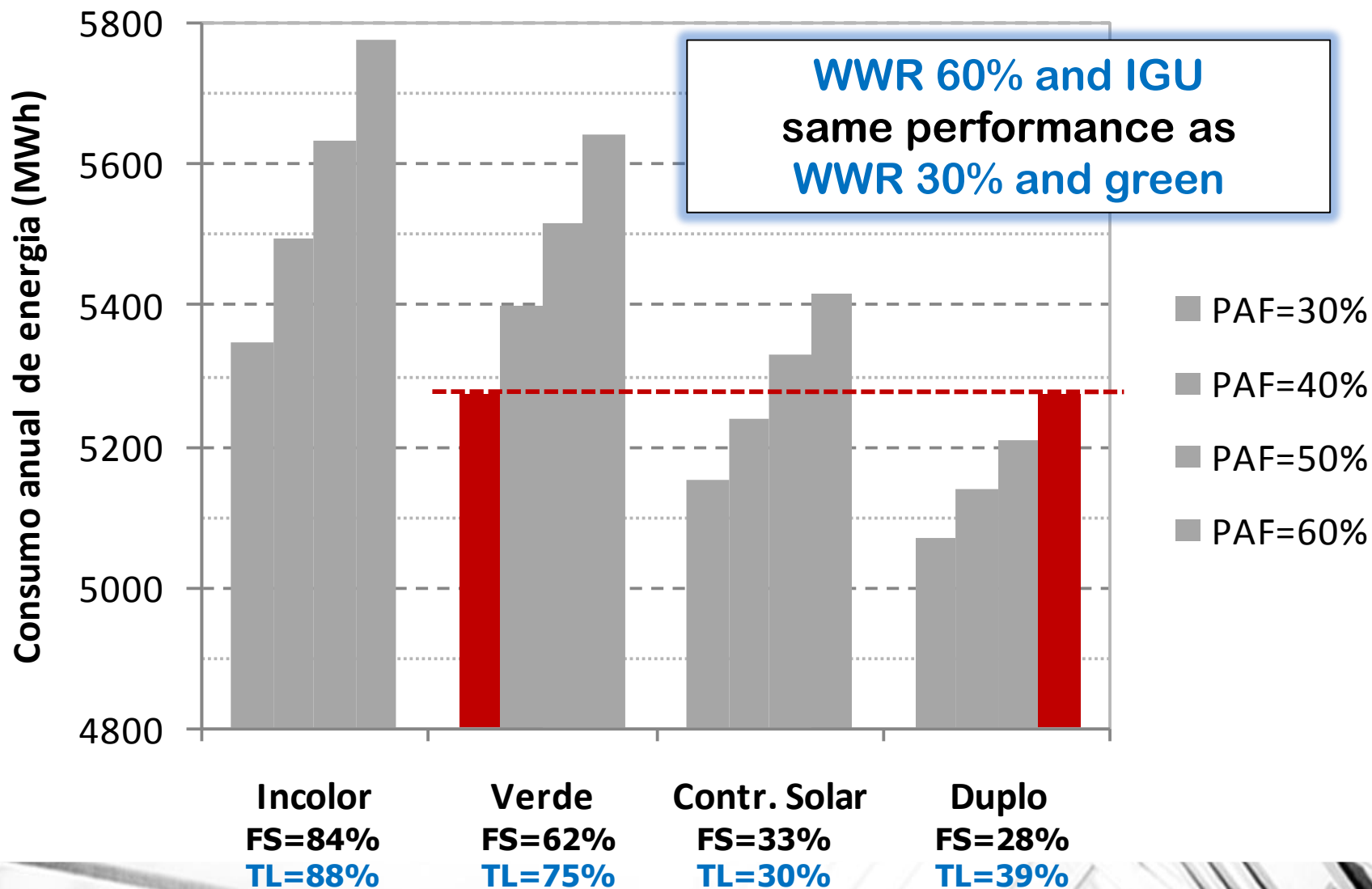
Estudo de caso por simulação

Clima: São Paulo

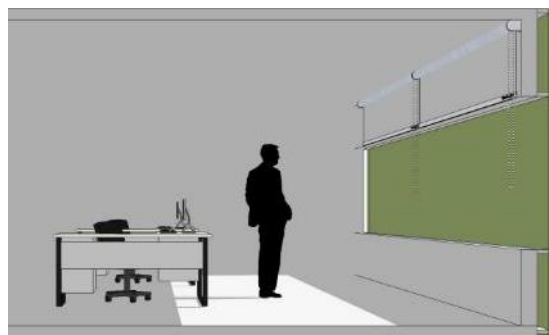


Estudo de caso por simulação

Clima: São Paulo



Comparativo: WWR 40%



Ar Condicionado: 1084 TR
Consumo: 5400 MWh



Ar Condicionado: 995 TR
Consumo: 5239 MWh

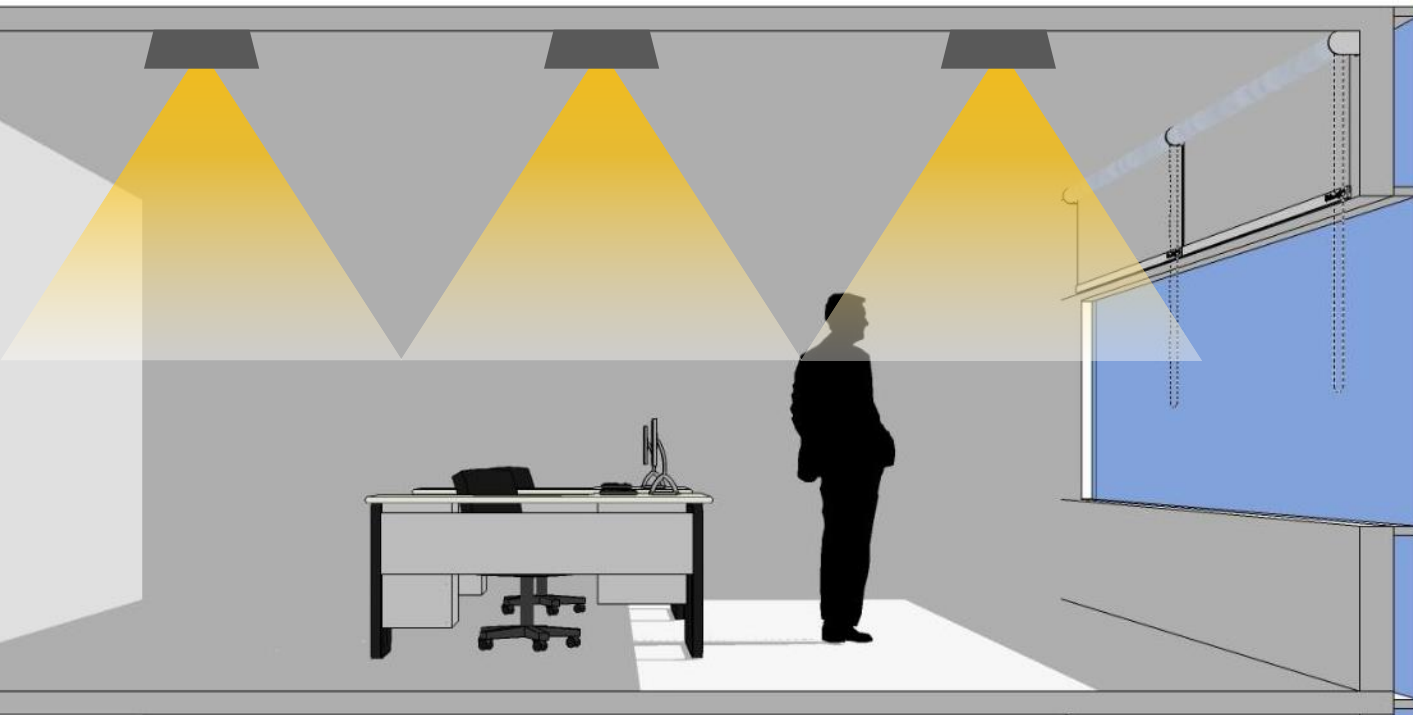
Economia no A.C.	R\$ 534 mil
Economia de energia	R\$ 56 mil
Economia/m ² de vidro	R\$ 83 + R\$ 9/ano



Ar Condicionado: 875 TR
Consumo: 5137 MWh

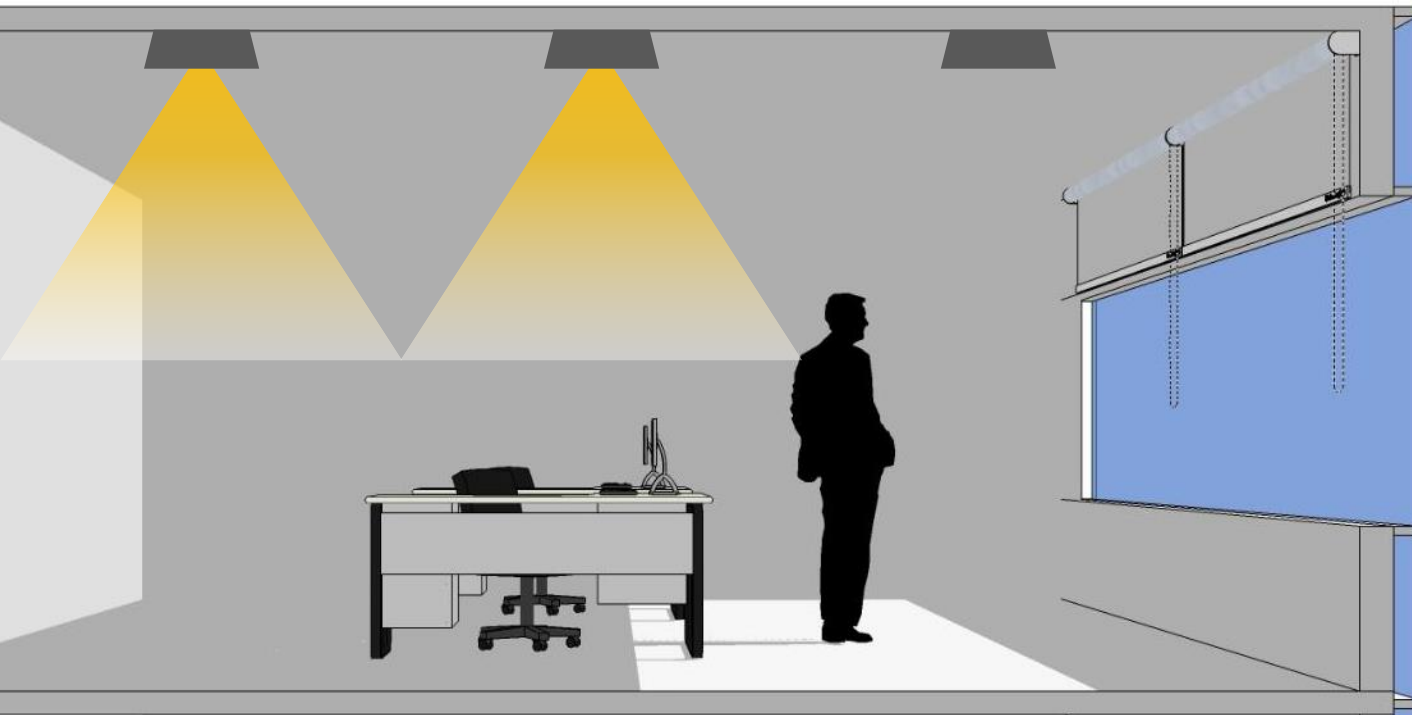
Economia no A.C.	R\$ 1.254 mil
Economia de energia	R\$ 92 mil
Economia/m ² de vidro	R\$ 195 + R\$ 14/ano

Daylight integration



Daylight integration

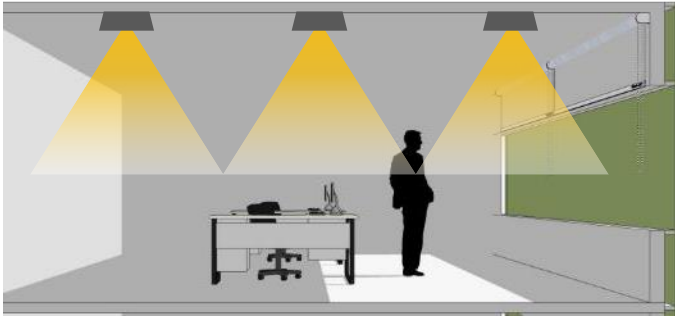
Estratégia de desligamento automático das luminárias próximas à fachada



Comparativo: Aproveitamento da Luz Natural

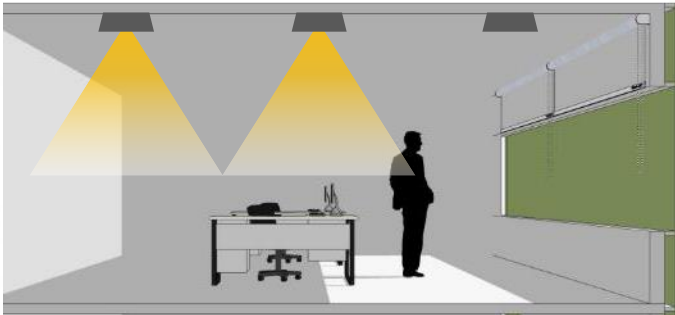


Annual electricity



5207 MWh

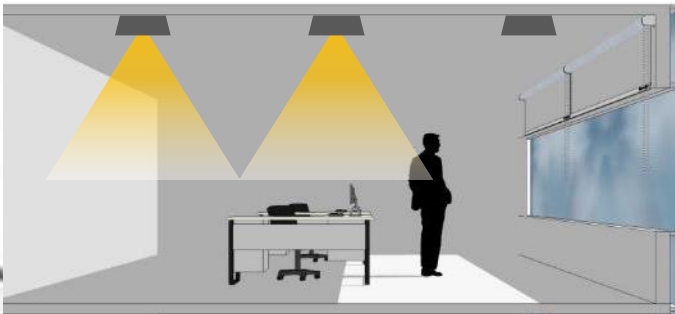
**Green glass with
interior shading**



5071 MWh

-2,6%
- R\$ 47 mil

**Green glass with
interior shading+
daylight**



4964 MWh

-4,7%
- R\$ 85 mil

**Solar control with
interior shading+
daylight**

Web tool: Parametric analysis – 5,800 cases

www.eneconsultores.com.br/site_antigo/abividro/

ABIVIDRO

Comparativo de desempenho energético entre diferentes soluções de fachada.

	Modelo 1	Modelo 2
Cidade:	Brasília ▼	Brasília ▼
Orientação:	N-S ▼	N-S ▼
Spandrel Glass:	Não ▼	Não ▼
Plenum isolado:	Não ▼	Não ▼
Parede:	Alvenaria ▼	Alvenaria ▼
Persianas:	Sem persianas ▼	C/ pers + luz natural ▼
PAF:	30% ▼	50% ▼
Vidro::	Incolor comum ▼	Duplo c/ câmara ar ▼

Calcular

Web tool: Parametric analysis

www.eneconsultores.com.br/site_antigo/abividro/calcular.php

ABIVIDRO

Comparativo de desempenho energético entre diferentes soluções de fachada.

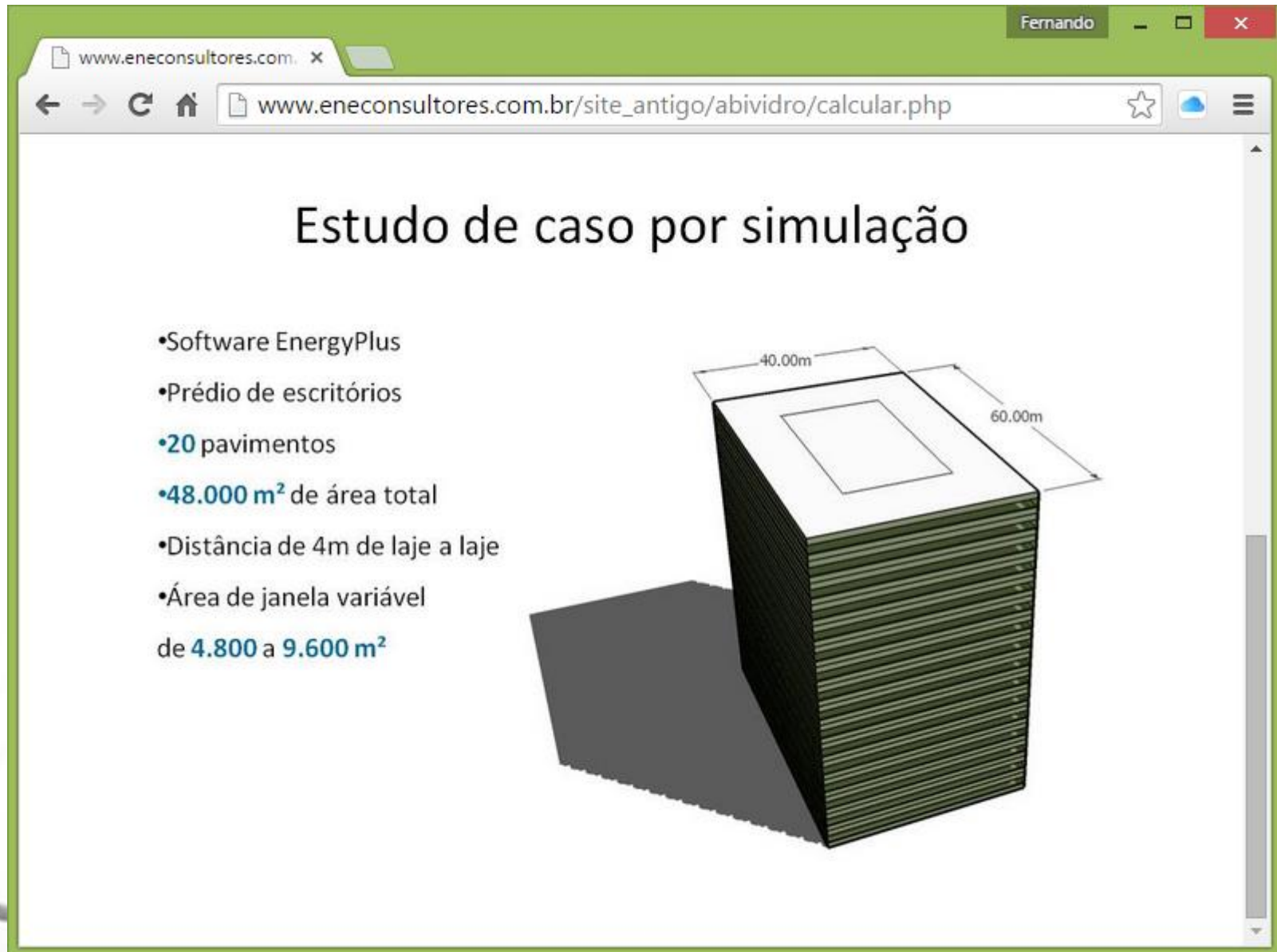
Cidade:	Brasília	Brasília	
Orientação:	N-S	N-S	
Spandrel glass:	Não	Não	
Plenum isolado:	Não	Não	
Parede:	Alvenaria	Alvenaria	
Persiana:	Sem persianas	C/pers + luz natural	
PAF:	30%	50%	
Vidro:	Incolor comum	Duplo c/ câmara ar	Economia:
Consumo (kWh):	5396120	5027760	6.8%
Capacidade (TR):	779	642	17.6%
Custo Anual (R\$):	1349030	1256940	6.8%

Economia no custo anual com energia: R\$ 92.090

Economia na instalação de AC : R\$ 822.000

Voltar

Web tool: Parametric analysis

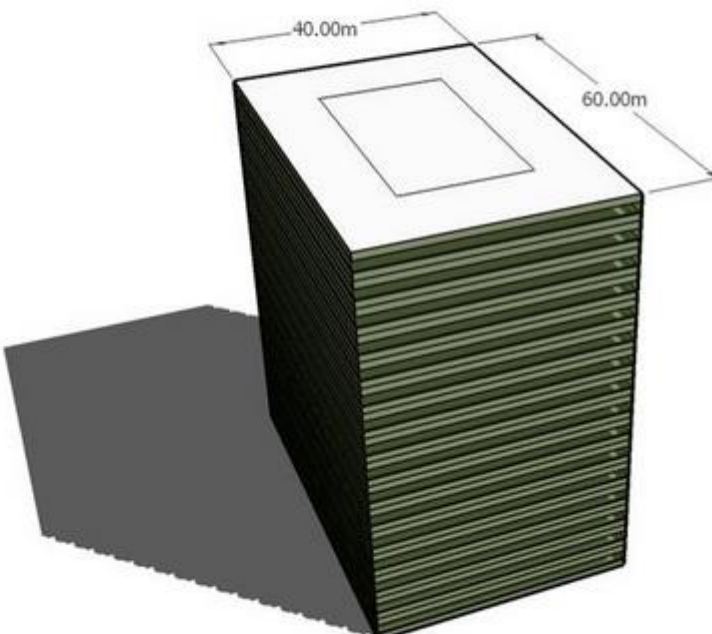


www.eneconsultores.com. x

www.eneconsultores.com.br/site_antigo/abividro/calcular.php

Estudo de caso por simulação

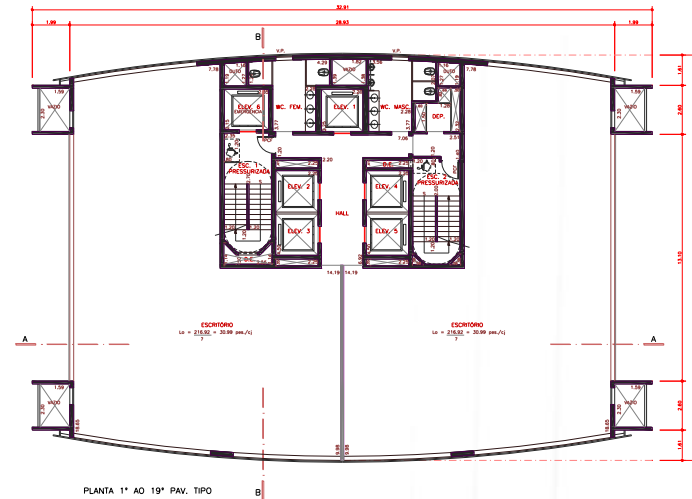
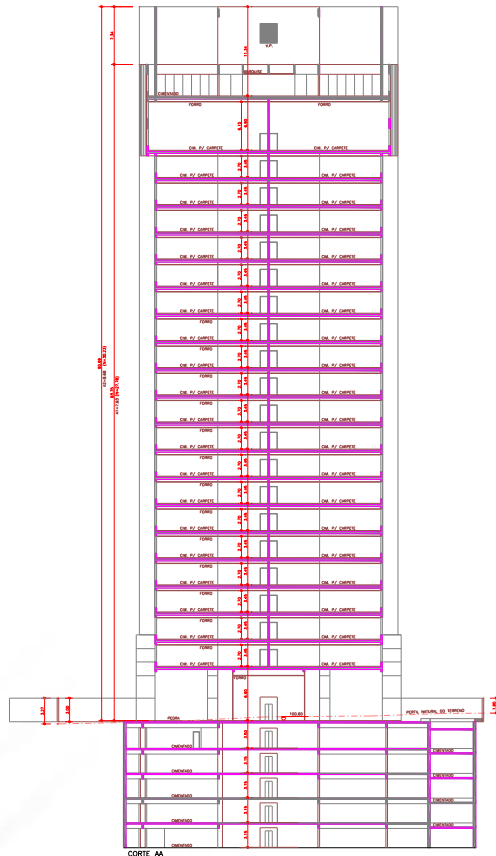
- Software EnergyPlus
- Prédio de escritórios
- 20 pavimentos
- 48.000 m² de área total
- Distância de 4m de laje a laje
- Área de janela variável de 4.800 a 9.600 m²



40.00m

60.00m

Case study: office building



Parâmetro	Descrição
Área total construída	11.942 m ²
Área condicionada	9.038 m ² (76% do total)
Número de pavimentos	20
Altura de laje a laje	3,45 m
Área de janela nas fachadas	3.008 m ² (50% das paredes dos ambientes climatizados)

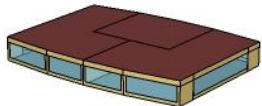
Simulation software: EnergyPlus

- ❑ Economic analysis for different types of glass
- ❑ Focus on energy savings for cooling
- ❑ Building located in São Paulo
- ❑ Analysis carried out for other 5 cities

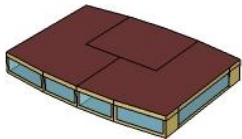


20° pavimento

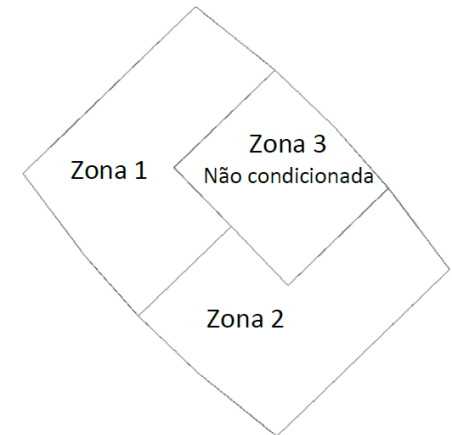
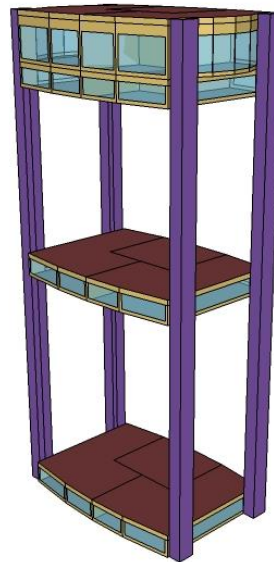
19° pavimento



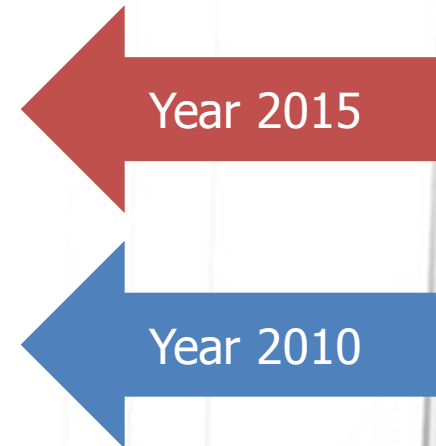
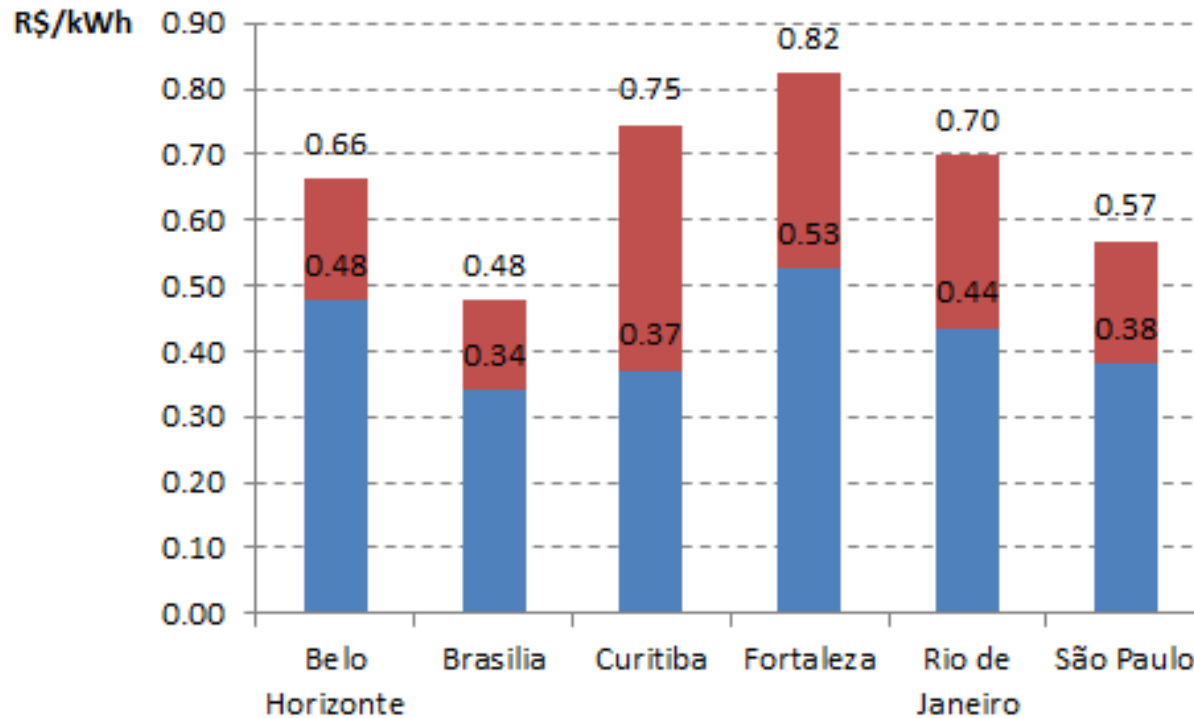
2° ao 18° pavimentos (x17)



1° pavimento

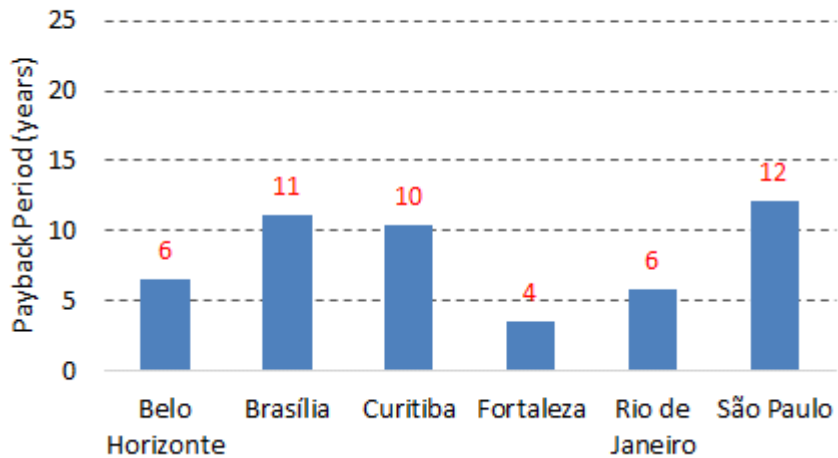


Energy tariff

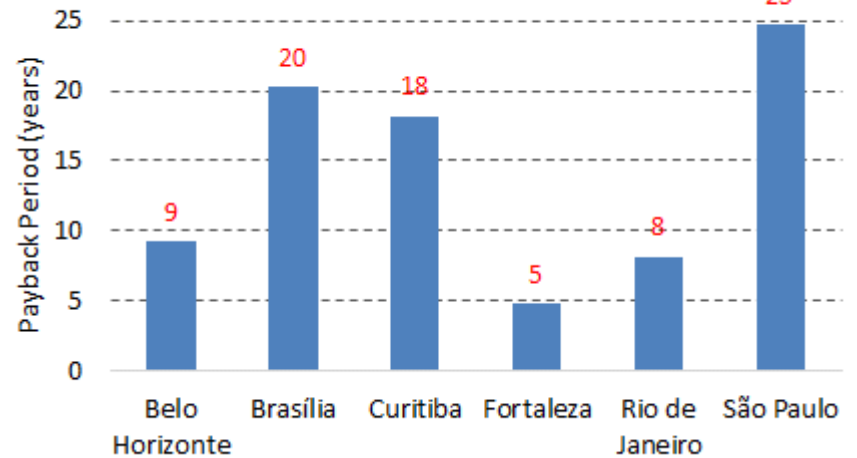


Results: economic analysis

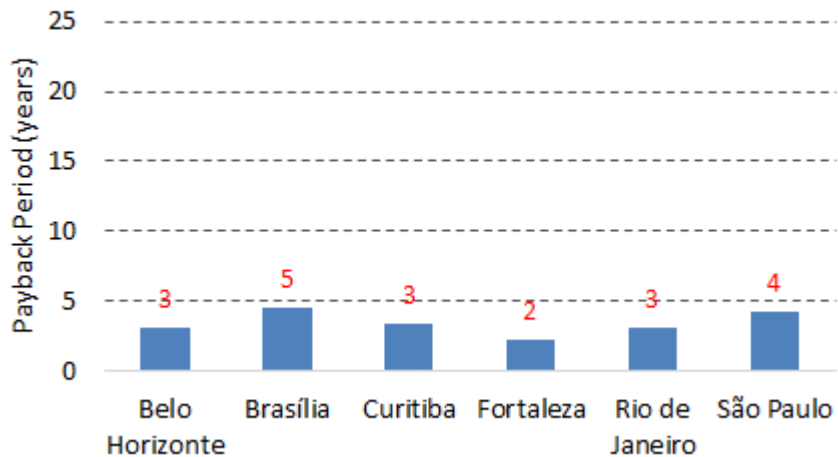
Insulated Glass - SHGC 18% | VT 13%



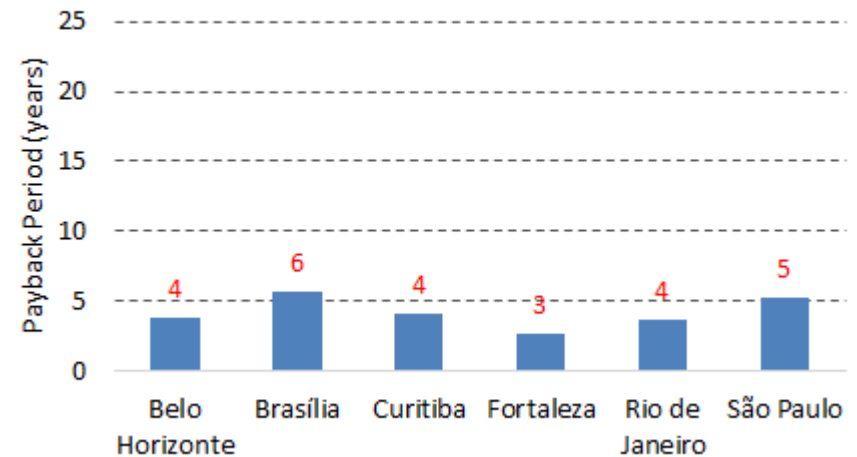
Insulated Glass - SHGC 33% | VT 29%



Laminated Glass - SHGC 30% | VT 16%

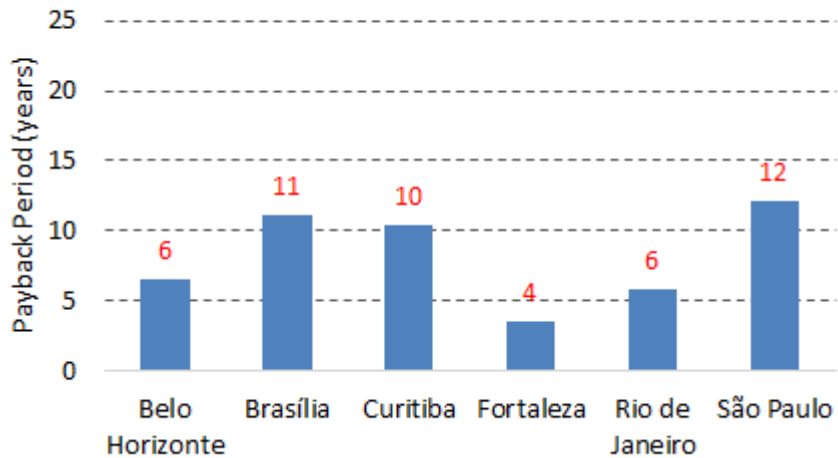


Laminated Glass - SHGC 43% | VT 33%

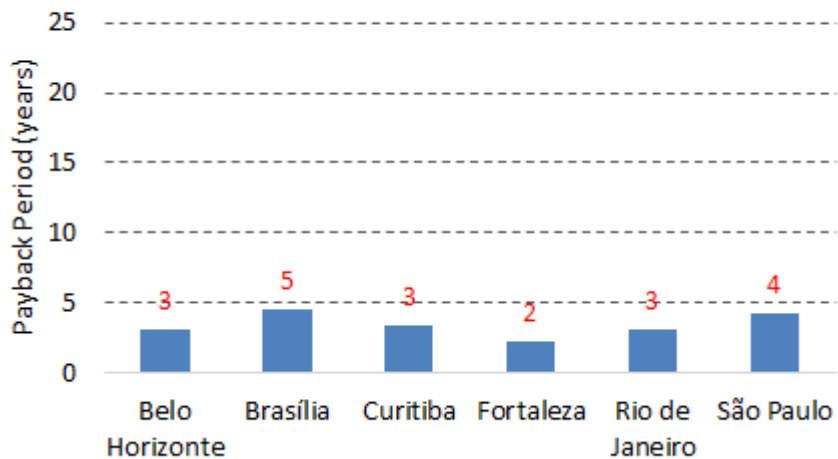


Results: economic analysis

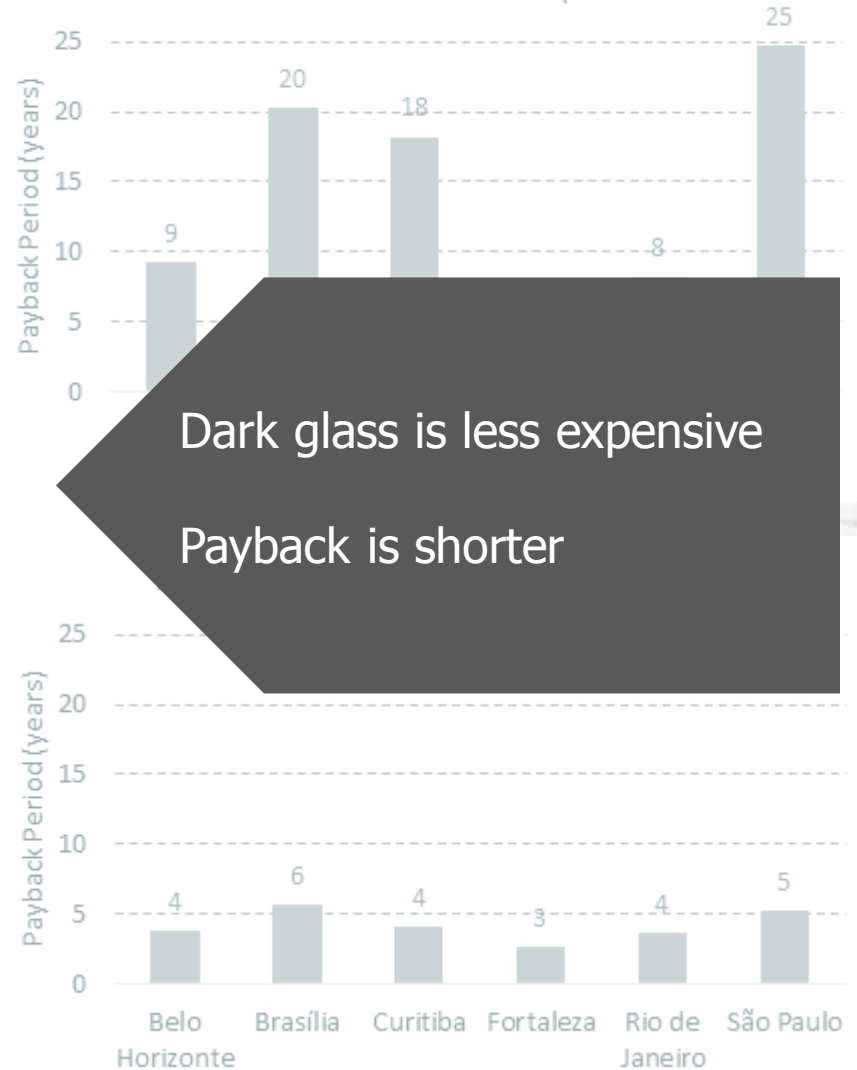
Insulated Glass - SHGC 18% | VT 13%



Laminated Glass - SHGC 30% | VT 16%

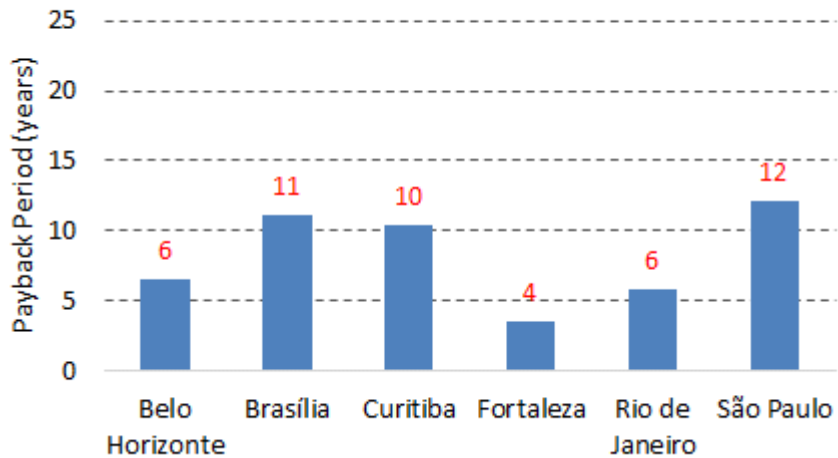


Insulated Glass - SHGC 33% | VT 29%

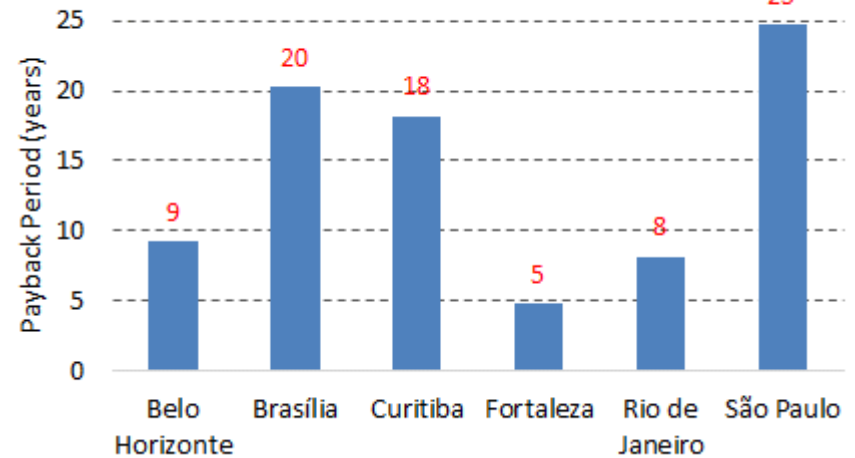


Results: economic analysis

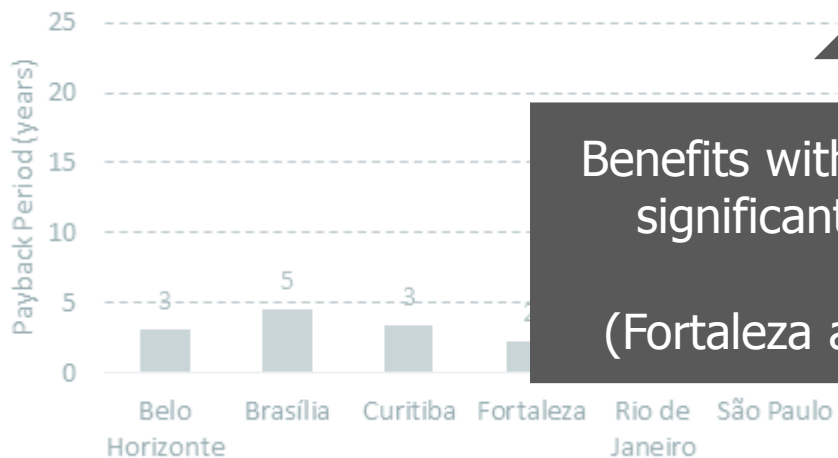
Insulated Glass - SHGC 18% | VT 13%



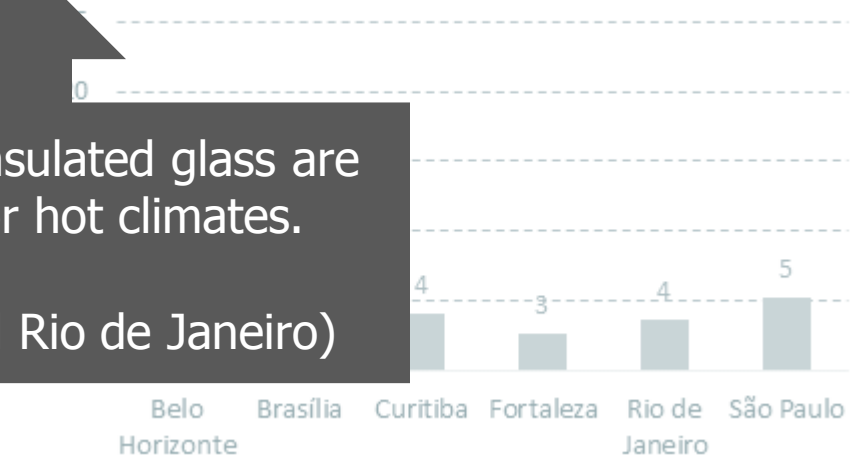
Insulated Glass - SHGC 33% | VT 29%



Laminated Glass - SHGC 30% | VT 16%



Laminated Glass - SHGC 43% | VT 33%



Benefits with insulated glass are significant for hot climates.

(Fortaleza and Rio de Janeiro)

Prédio dos Diários Associados | Rio de Janeiro

Oscar Niemeyer
1949



Tombado em 1988 pelo Município

Fernando

Sede de Diários Associados x

oglobo.globo.com/rio/sede-de-diarios-associados-vai-virar-predio-d

O GLOBO MENU RIO BUSCAR CLIQUE E ASSINE

Sede de Diários Associados vai virar prédio de escritórios

Imóvel na Zona Portuária, projetado por Niemeyer, foi vendido e ganhará um anexo

POR LUIZ ERNESTO MAGALHÃES

07/07/2014 6:00 / atualizado 07/07/2014 20:32

f t g+



O edifício dos Diários Associados: imóvel, está desocupado - Agência O Globo / Antonio Scorza

Prédio dos Diários Associados | Rio de Janeiro



Prédio dos Diários Associados | Rio de Janeiro



Remoção de
caixilhos e
vidros para
substituição



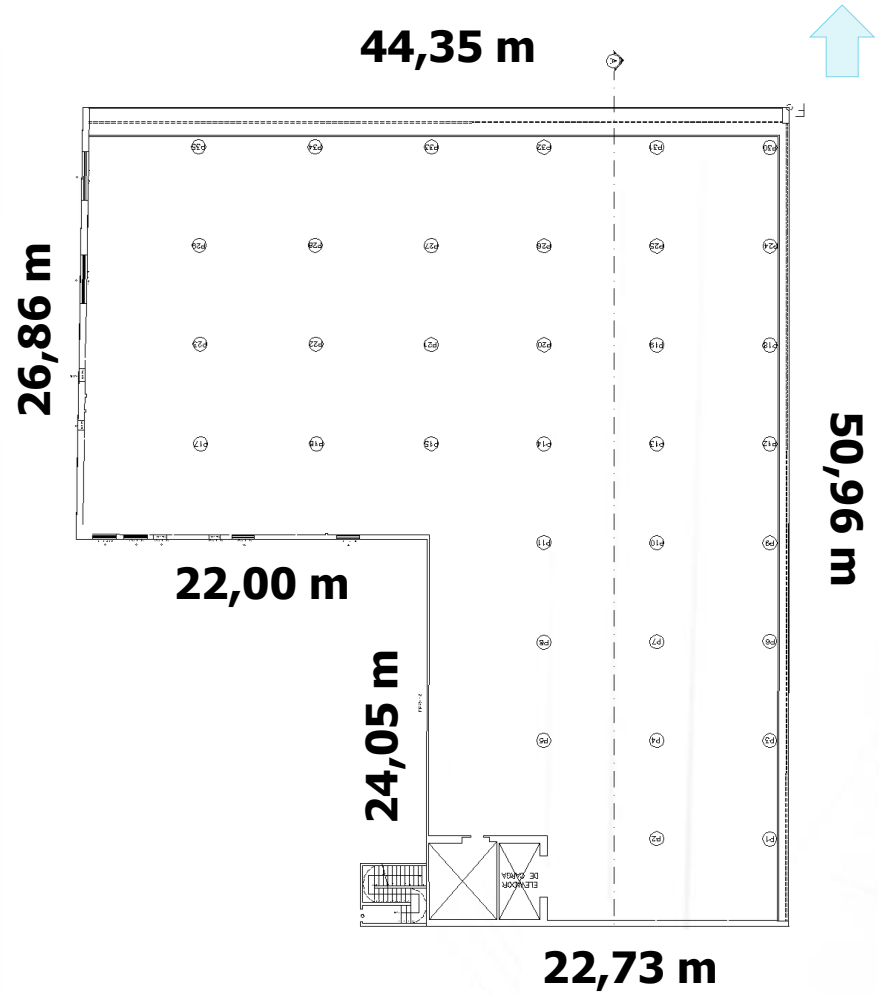
Glazing systems

Glass	Visible transmittance	SHGC
Clear	88%	82%
Green	75%	62%
SHGC 36 VT 54	54%	36%
SHGC 23 VT 14	14%	23%

- Daylight simulation (Ecotect)
- Energy simulation (EnergyPlus)

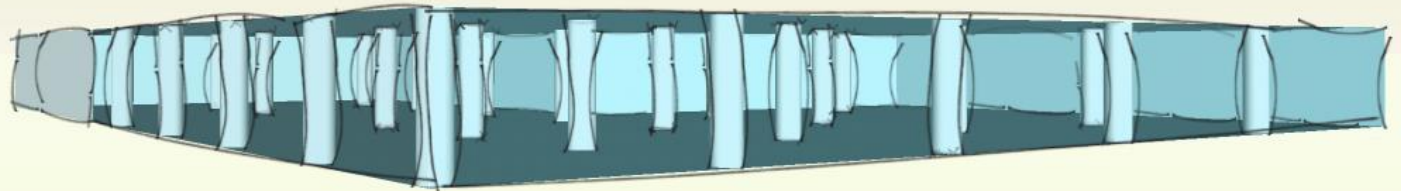
Prédio dos Diários Associados | Rio de Janeiro

Pavimento tipo
Planta geral

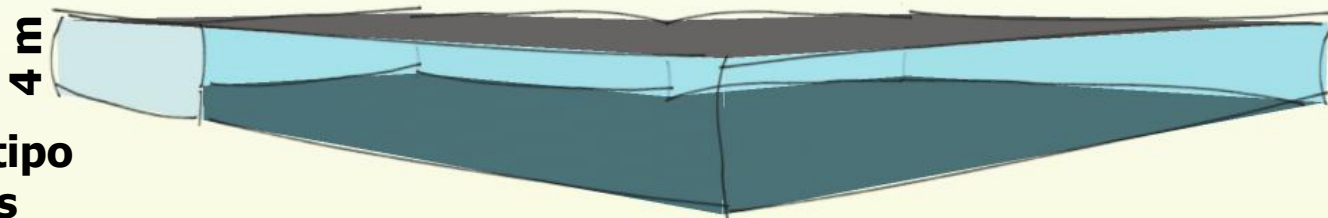
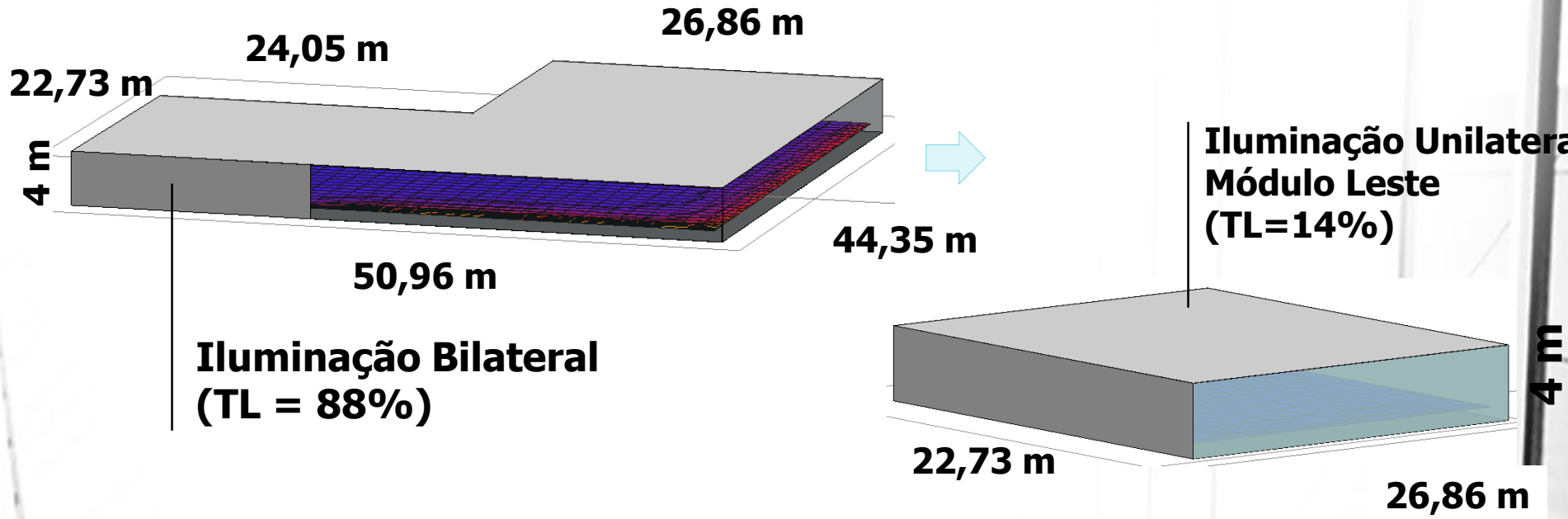


Pavimento tipo
Com colunas

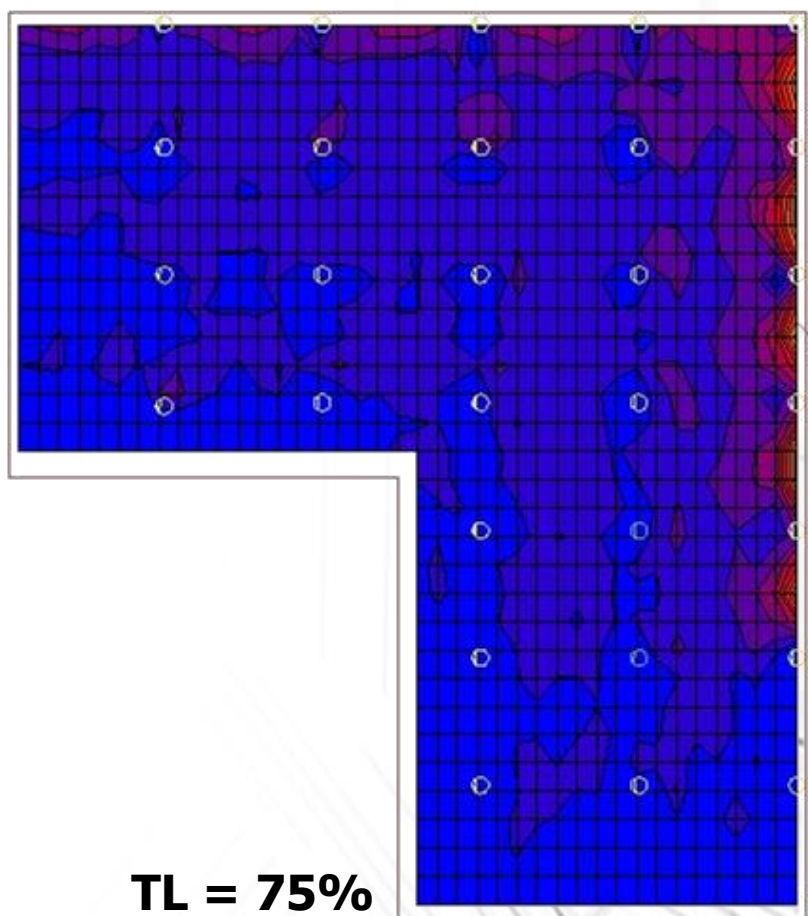
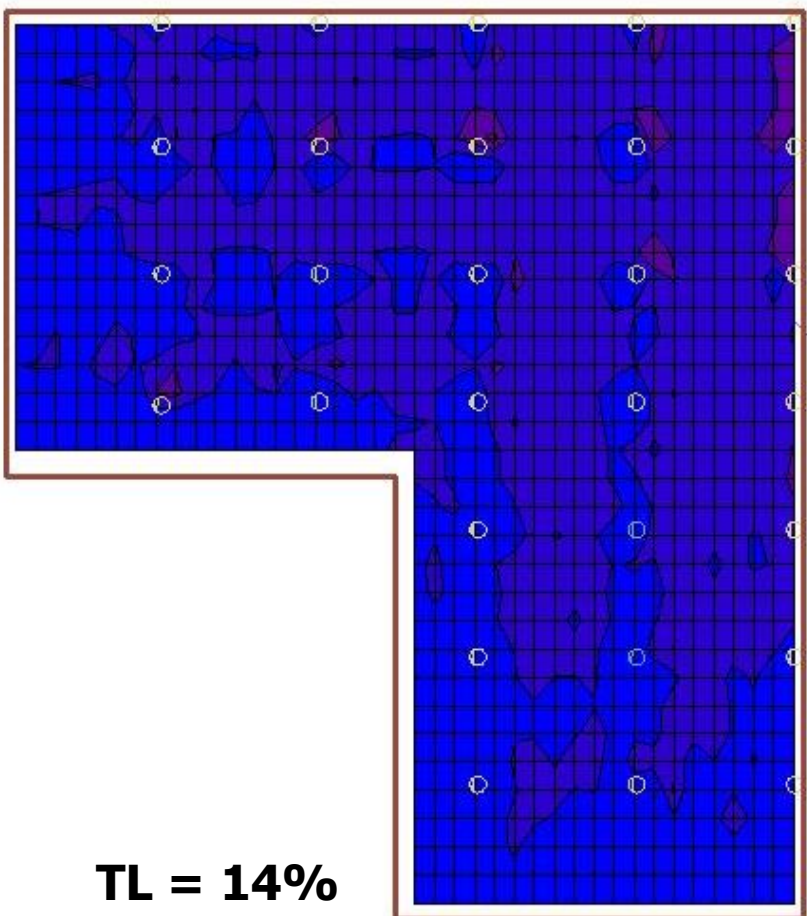
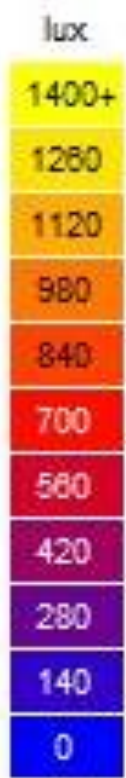
4 m



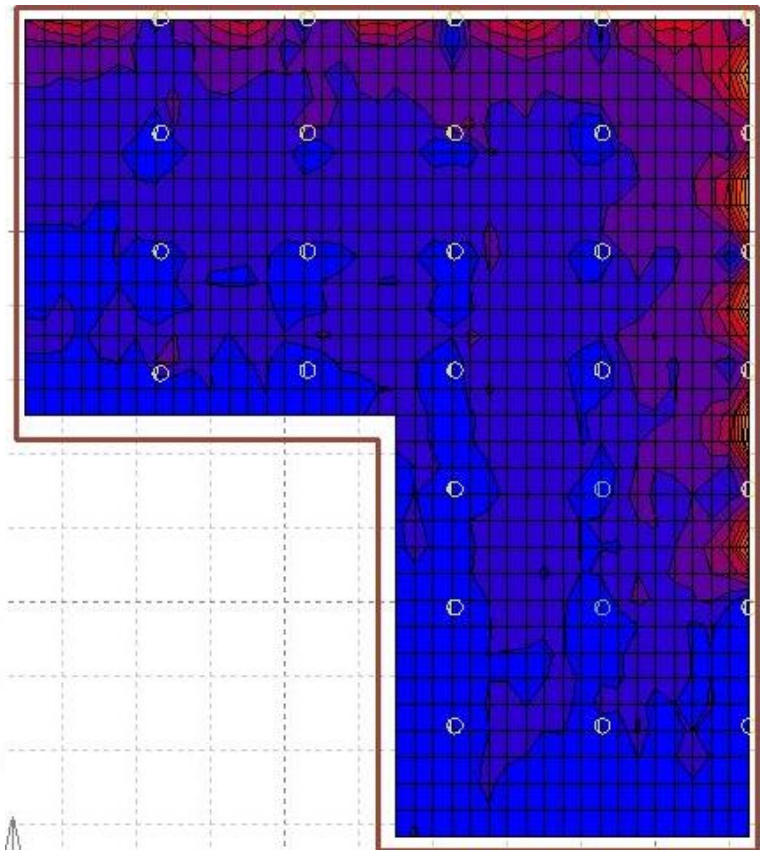
Vidros de controle solar
Distribuição da luz natural
Geometrias Avaliadas



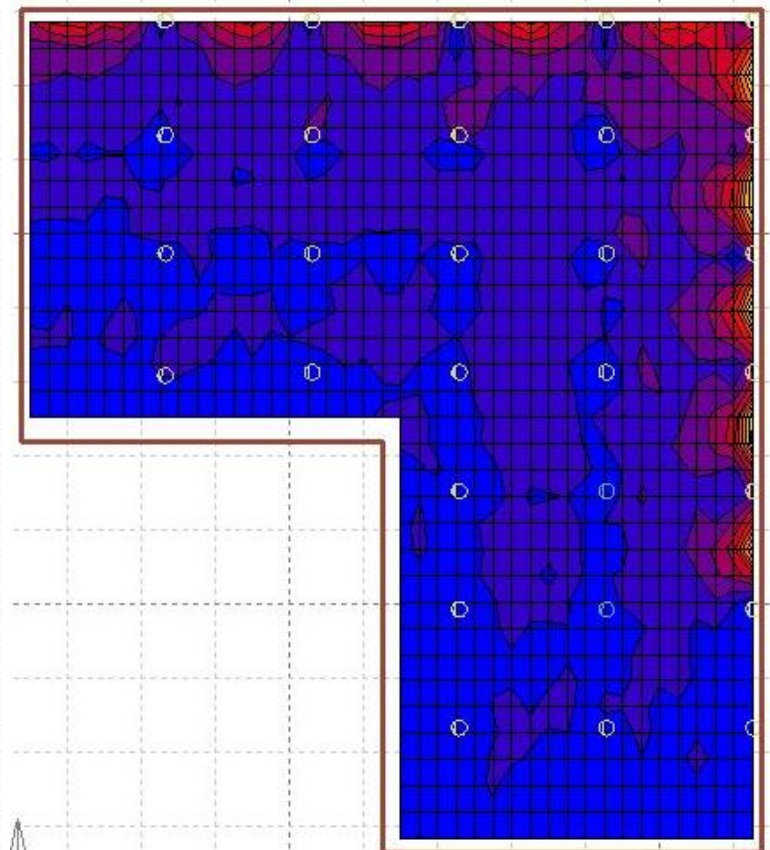
Vidros de controle solar
Abertura Bilateral
Distribuição da luz natural



Vidros de controle solar Abertura Bilateral Distribuição da luz natural



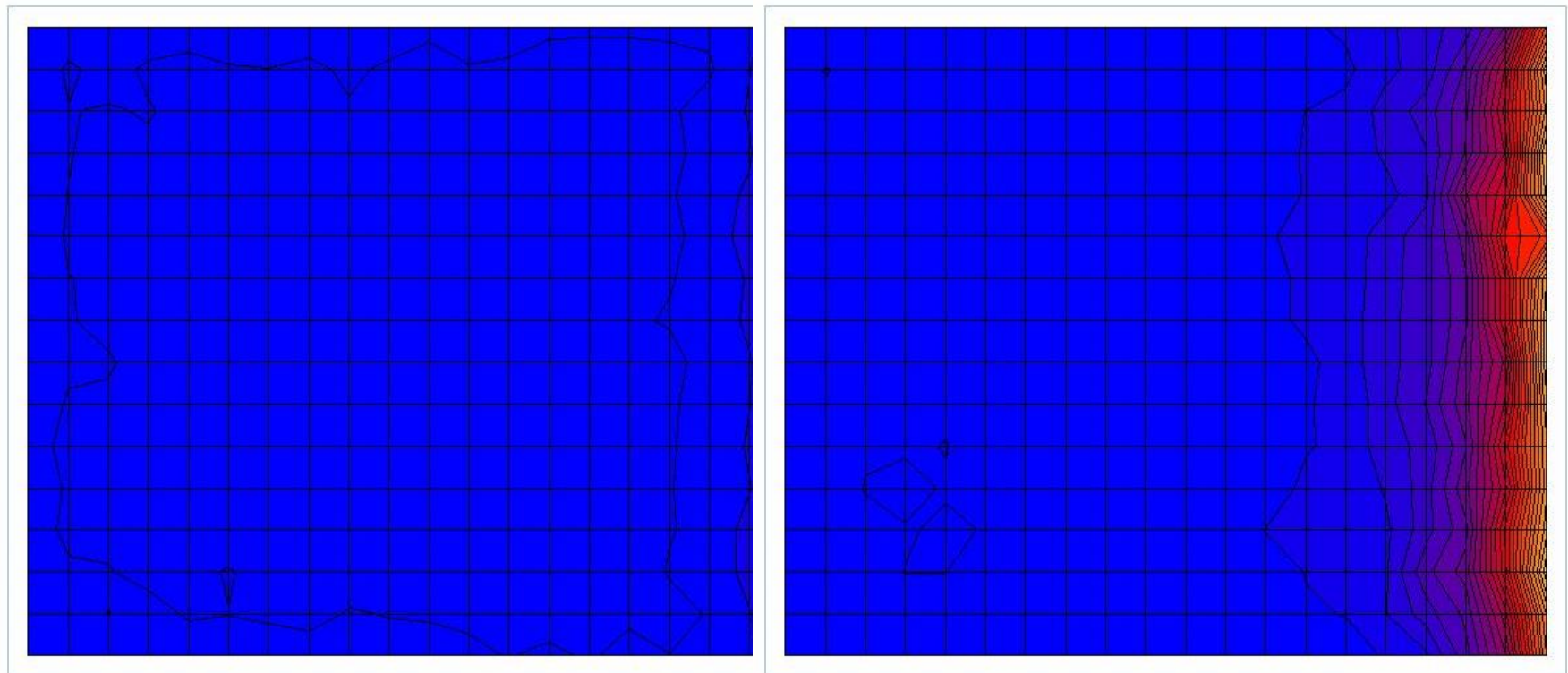
TL = 54%



TL = 88%

Ed. na Rua Livramento | Rio de Janeiro

Vidros de controle solar Abertura Unilateral Distribuição da luz natural

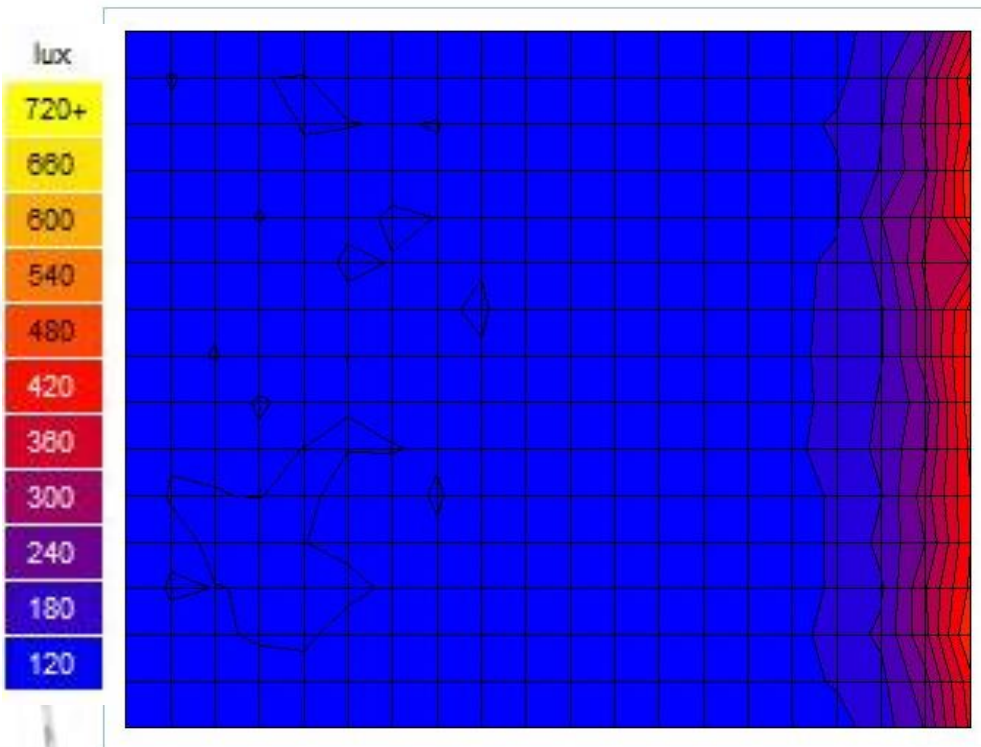


TL = 14%

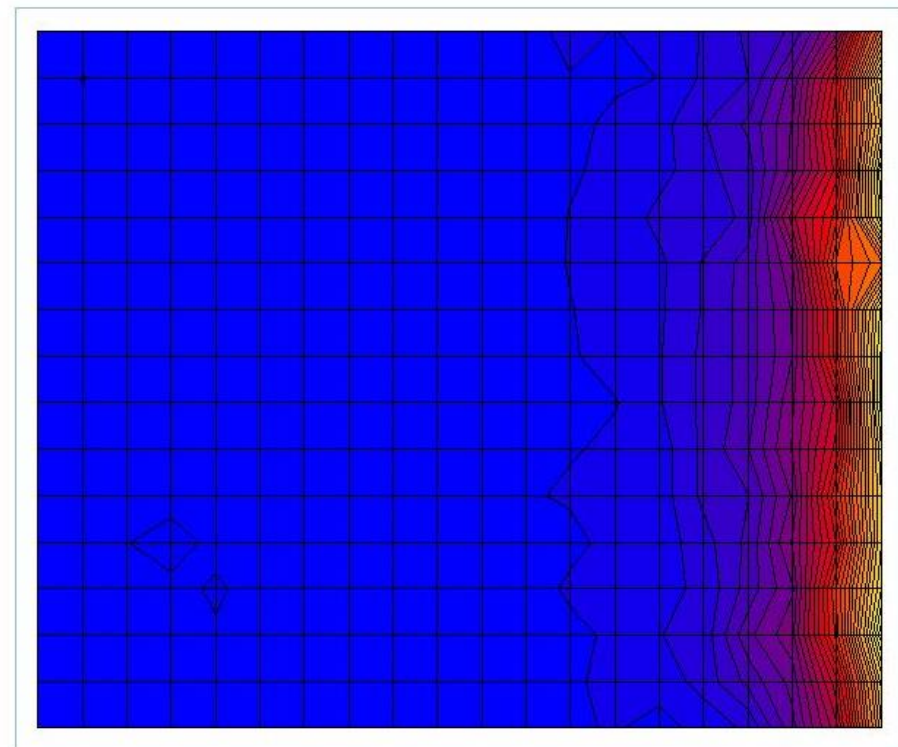
TL = 75%

Ed. na Rua Livramento | Rio de Janeiro

Vidros de controle solar Abertura Unilateral Distribuição da luz natural



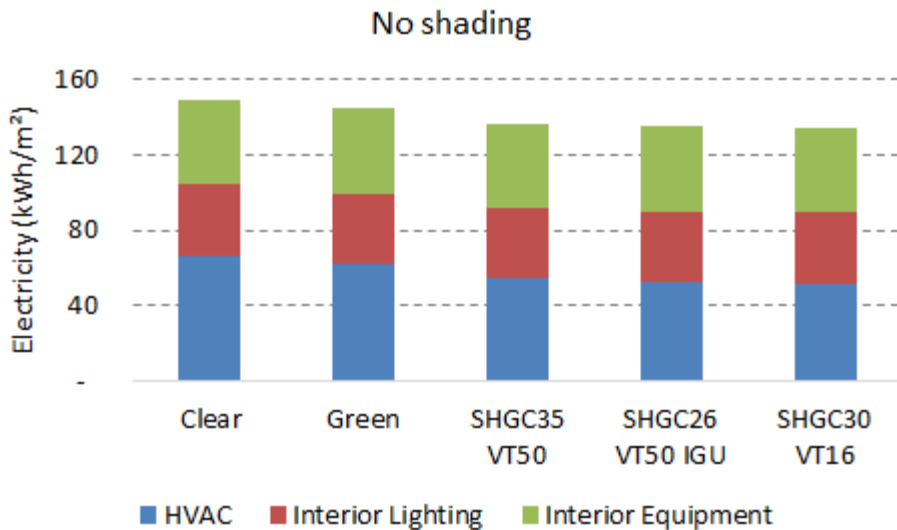
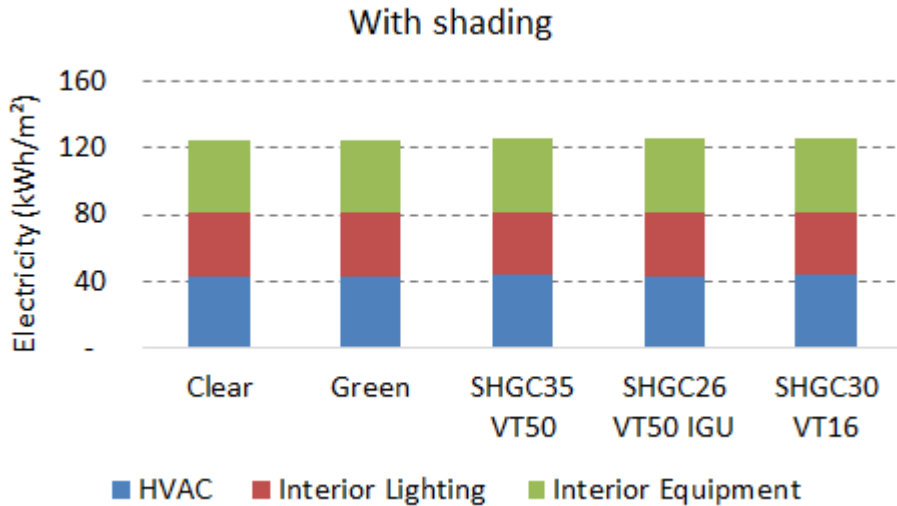
TL = 54%



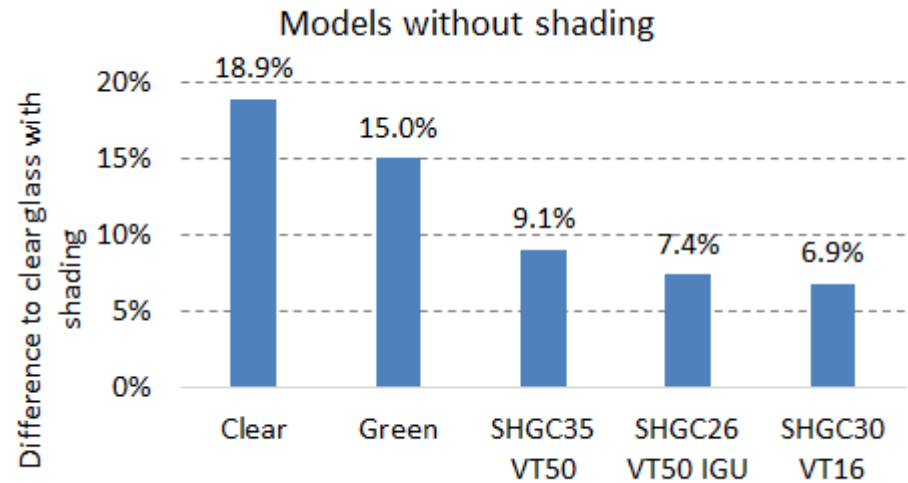
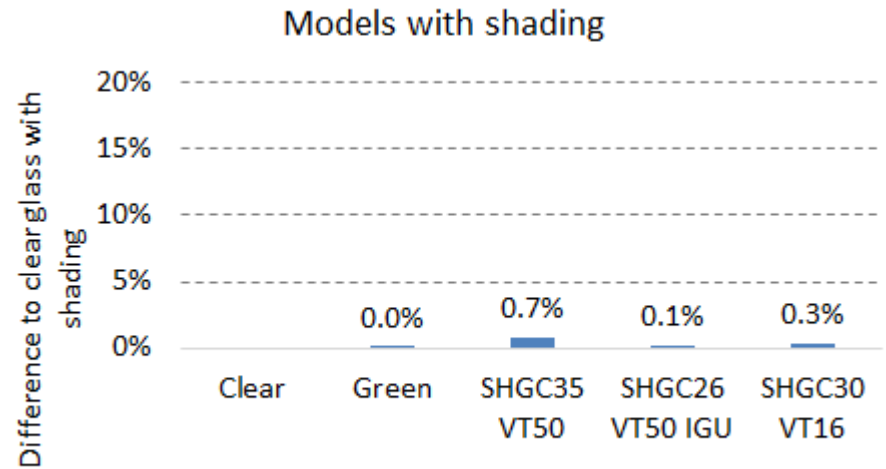
TL = 88%

Energy analysis: no daylight integration

Energy consumption (kWh/m²)



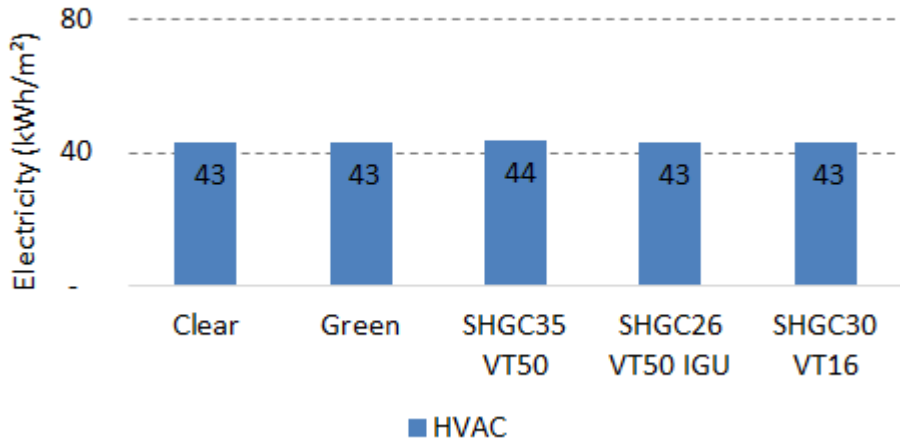
Difference to "Clear glass with shading"



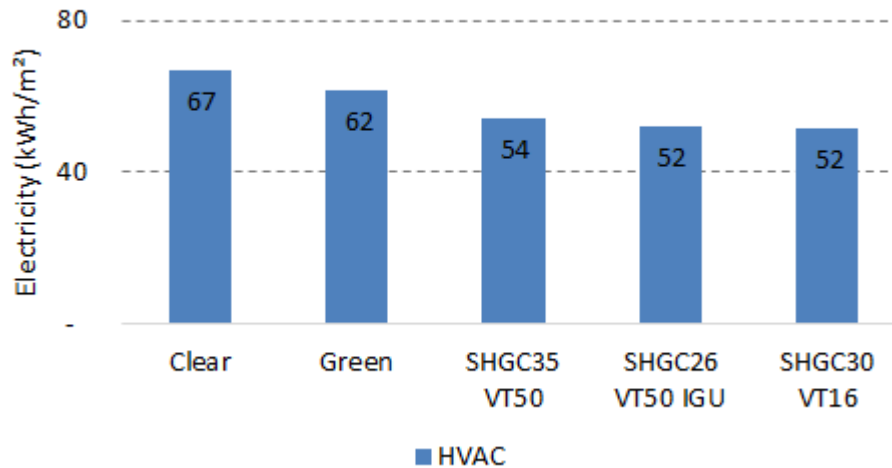
HVAC energy analysis: no daylight integration

Energy consumption (kWh/m²)

Models with shading

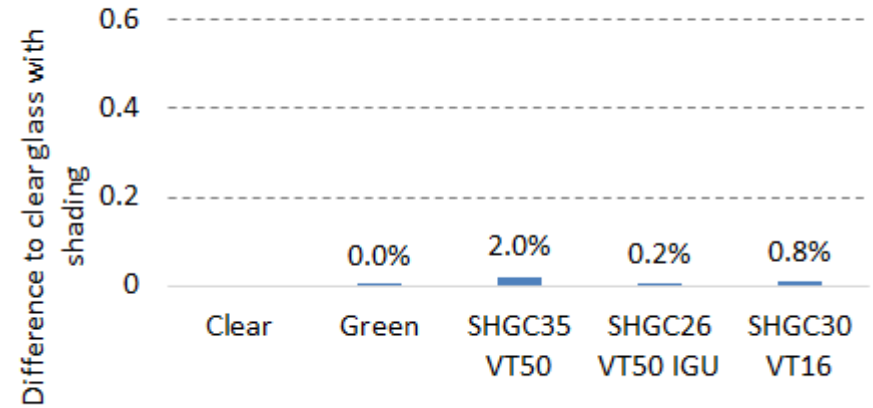


Models without shading

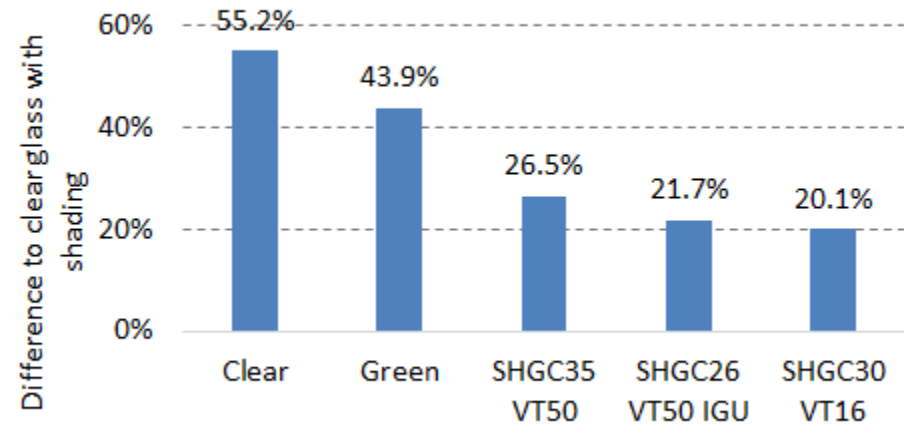


Difference to "Clear glass with shading"

Models with shading



Models without shading



Innovation in Design



Fritted glass: for glare control



Fritted glass: for glare control



Fritted glass: patterns



2256: 20% Cobertura
Listras 3 x 13 mm



2973: 30% Cobertura
Listras 3 x 7 mm



2030: 40% Cobertura
Listras 3 x 5 mm



2002: 50% Cobertura
Listras 3 x 3 mm



2604: 60% Cobertura
Listras 3 x 2 mm



2050: 50% Cobertura
Listras 6 x 6mm



2032: 50% Cobertura
Listras 13 x 13 mm



2013: 50% Cobertura
Listras 25 x 25 mm

Série de Bolas



5065: 20% Cobertura
Bolas 3 mm



5959: 30% Cobertura
Bolas 3 mm



5006: 40% Cobertura
Bolas 3 mm



5960: 50% Cobertura
Bolas 3 mm



5961: 60% Cobertura
Bolas 11 mm



5023: 60% Cobertura
Bolas Vazias 3mm



Simulation on-site for retrofit purposes

Transparent PV modules into laminated glass





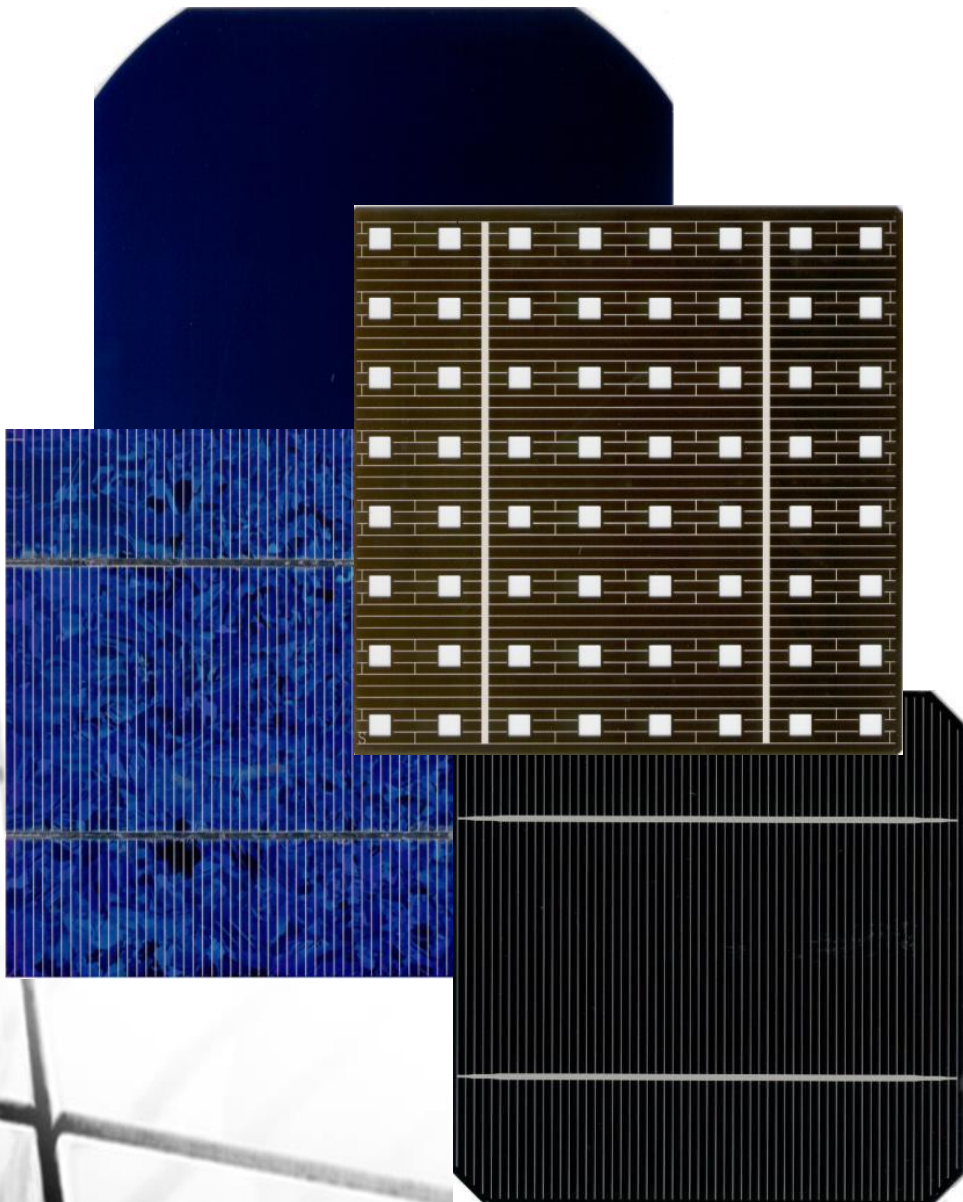








PV cells variation

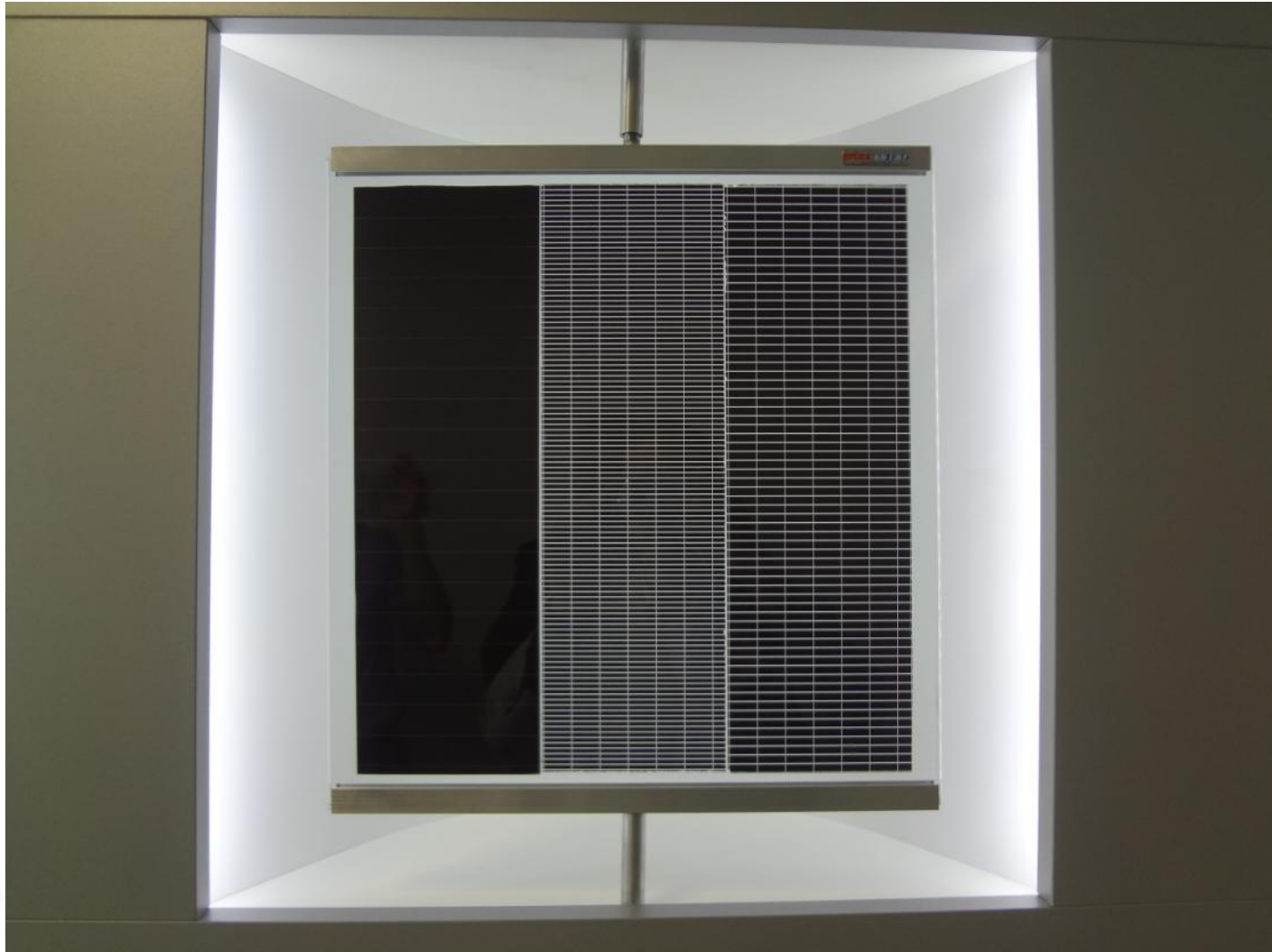


- Tipo
- Transparência
- Cor
- Caixa de conexão
 - Tipo
 - Posição

PV patterns X glass specification range

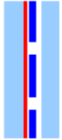
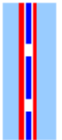
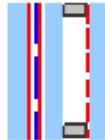
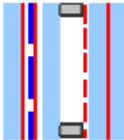
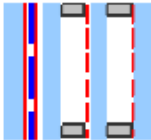
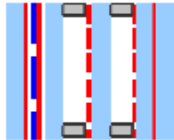
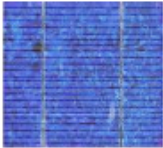





PV modules transparency



PV with fritted glass



el. Power W / m ²	Celltype	Thinglass Modules		VSG	VSG-Iso 1.1	VSG 2-Iso 1.1	VSG-Iso 0.5	VSG 2-Iso 0.5
								
128 W/m ²		3,6 €/Wp 399 €/m ²		4,6 €/Wp 502 €/m ²	5,3 €/Wp 580 €/m ²	6,2 €/Wp 675 €/m ²	6,6 €/Wp 718 €/m ²	7,1 €/Wp 777 €/m ²
135 W/m ²		3,6 €/Wp 421 €/m ²		4,5 €/Wp 528 €/m ²	5,2 €/Wp 606 €/m ²	6,0 €/Wp 701 €/m ²	6,4 €/Wp 744 €/m ²	6,9 €/Wp 803 €/m ²
105 W/m ²		5,1 €/Wp 485 €/m ²		5,9 €/Wp 567 €/m ²	6,8 €/Wp 645 €/m ²	7,7 €/Wp 740 €/m ²	7,9 €/Wp 753 €/m ²	8,8 €/Wp 842 €/m ²
155 W/m ²		4,4 €/Wp 636 €/m ²		5,2 €/Wp 746 €/m ²	5,6 €/Wp 805 €/m ²	6,3 €/Wp 900 €/m ²	6,4 €/Wp 913 €/m ²	7,0 €/Wp 1002 €/m ²

Ref.: Ertex Solar (Austria)

Final remarks

A indústria brasileira oferece produtos de alto desempenho

Necessitamos capacitar o mercado:

Arquitetos

Consultores

Projetistas de instalações de AC

Processadoras e distribuidoras de vidro

Especificadores

E o consumidor final

Cada projeto e clima exigirá uma solução diferente

Talvez o consumidor final ainda não tenha percebido a evolução tecnológica

Vidros e eficiência energética em edifícios no Brasil

Prof. Dr. Fernando Simon Westphal

Universidade Federal de Santa Catarina
Departamento de Arquitetura e Urbanismo
Laboratório de Conforto Ambiental

fernando.sw@ufsc.br



ABIVIDRO

IEA SHC Task 50: 6° Workshop com a Indústria
"Soluções Avançadas de Iluminação para Retrofit de Edifícios"

Brasília, 28 de setembro de 2015