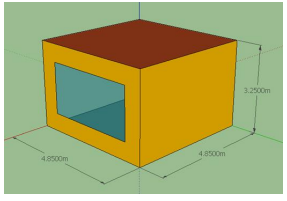
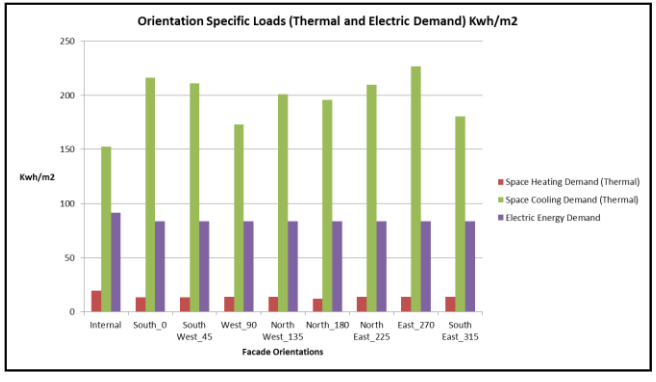
A Tool for Designing better Buildings

Parametric modeling- Thermal simulation- Regression analysis



180	180	180	180	180	180
90	Int	Int	Int	Int	270
90	Int	Int	Int	Int	270
0	0	0	0	0	0



By
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1st August 2014

Transsolar Mentor: Pratik Raval

Storyline

- *Introduction*
  - *Central Idea*
  - *Climate Info*
- *Simulation*
  - *Assumptions*
  - *Framework*
  - *Results- selective*
- *Creating footprint*
- *Regression Analysis- Equation*
- *Sensitivity Analysis tool*
- *Way Forward*

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Office Buildings in India

Westernizing building designs, but energy guzzlers

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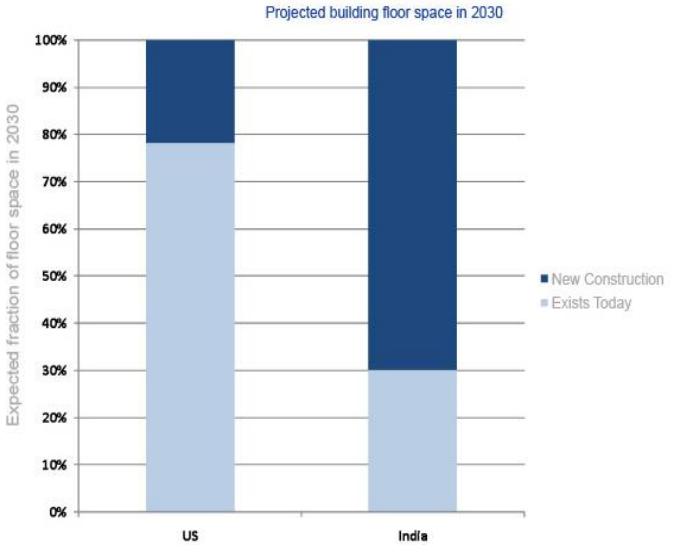
Issues and opportunities in Built Environment – Indian context



Source: Institute of Building Efficiency (IFBE), 2010

Issues:

- Adapting to **western building practices** (office spaces)
- Less **knowledge on climate responsive** strategies for building massing and design
- **System vs Design approach.**

Opportunity:

- Potential for huge new building stock in next 20-30 years (linked with economic growth) **70% new stock (85% Residential)** (IFBE, 2010)

"Architects and designers to be informed about the various building parameters and their effect on building energy at conceptual design stage" - create less energy demand and climate responsive designs.

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The Tool- Inform Designers on "Design and its impact on loads"

Pitch:

- Conceptual Design: Initial massing and climate responsive orientation and shading.
- Create **performance curves or sensitivity curves (effect of parameters on load)**
- Influence of basic building parameters on energy loads

Advantages:

- **Reduces the iterative changes** on design needed on a later design stage
- **Reduces the time and effort on Building Energy Simulation (BES)** at later design stages
- A quick tool to analyze the extent of **degree of closeness of building design to climate**

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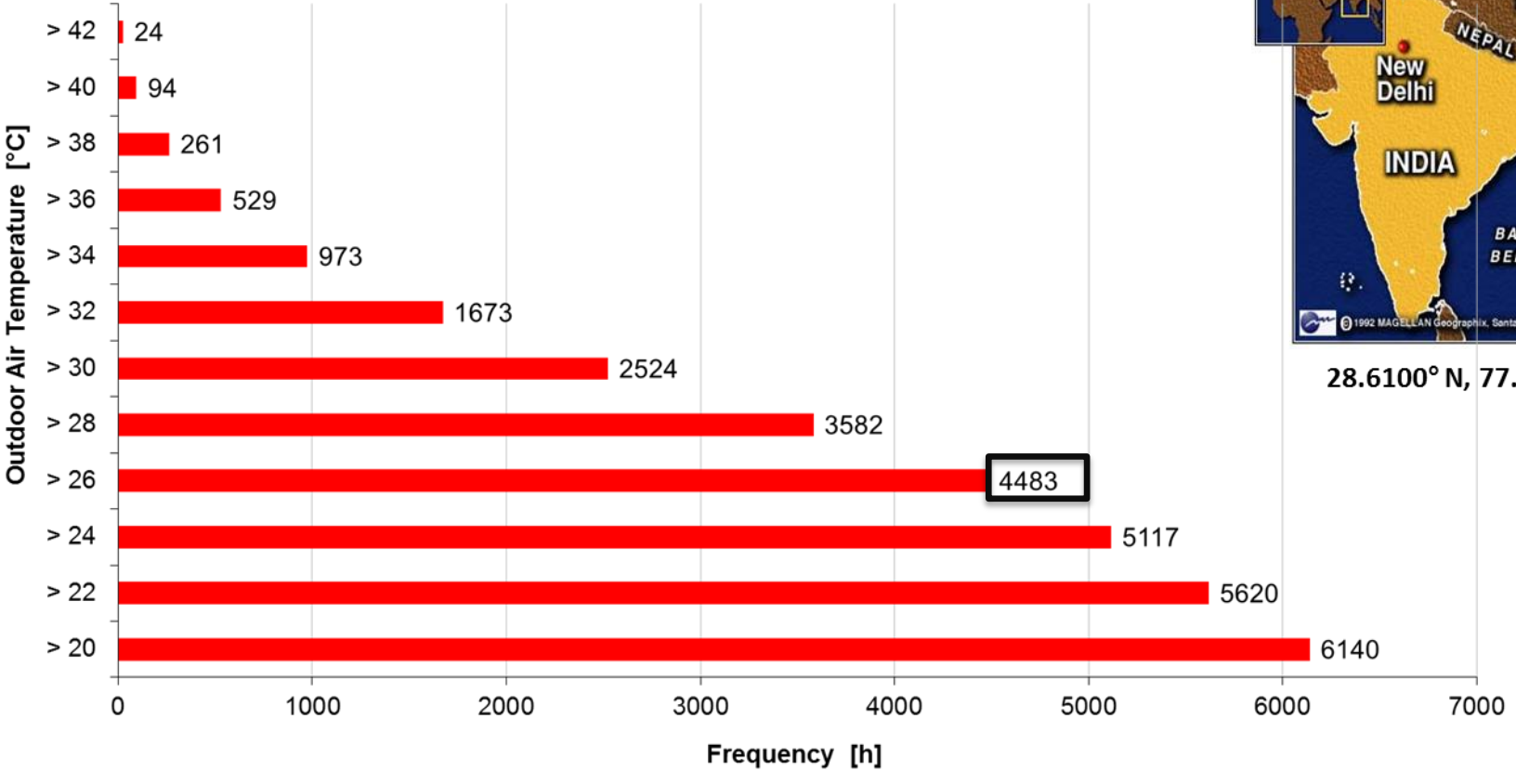
Outdoor Temperature Statistics

New Delhi, India (Composite Climate)



28.6100° N, 77.2300° E

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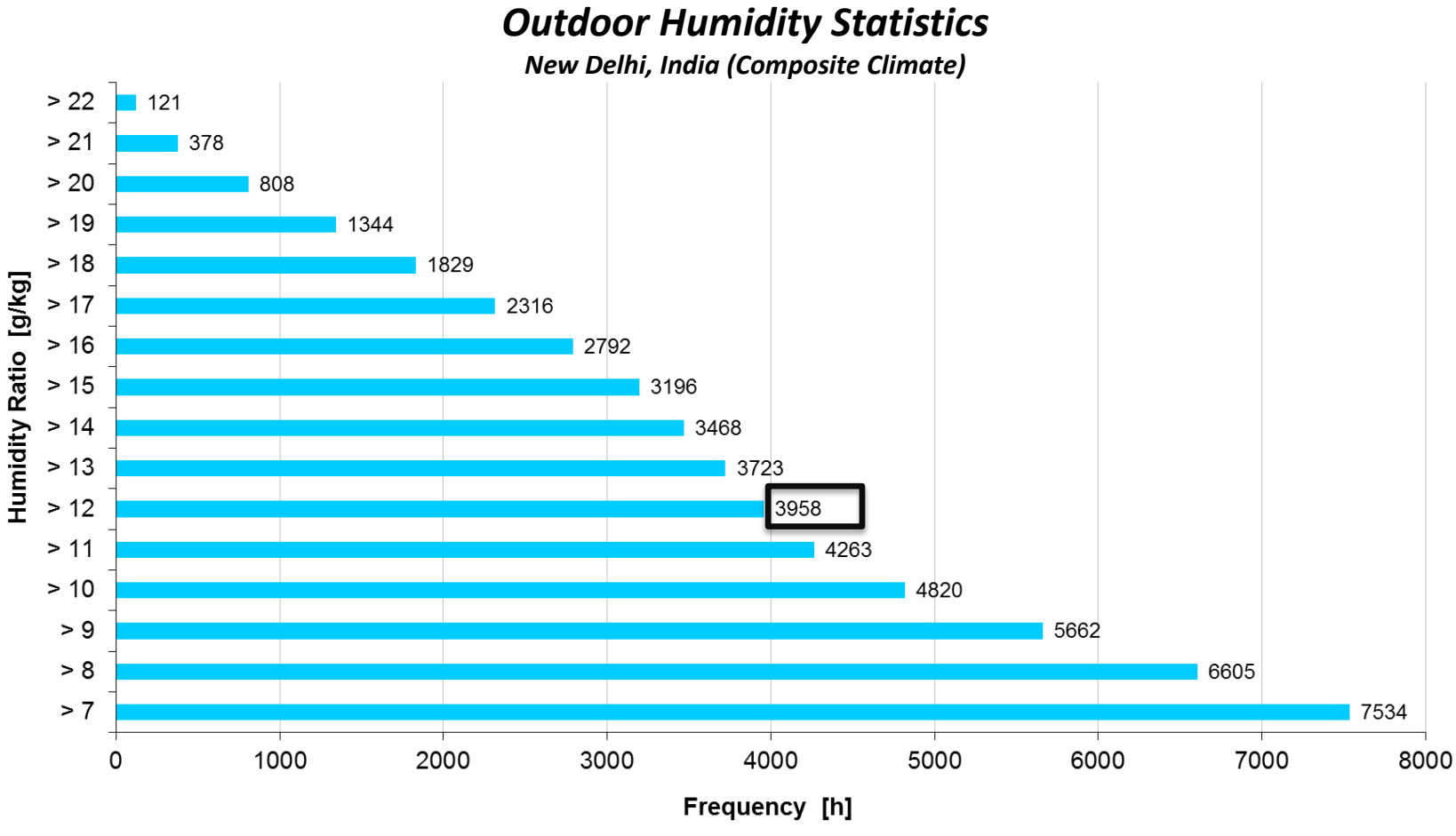

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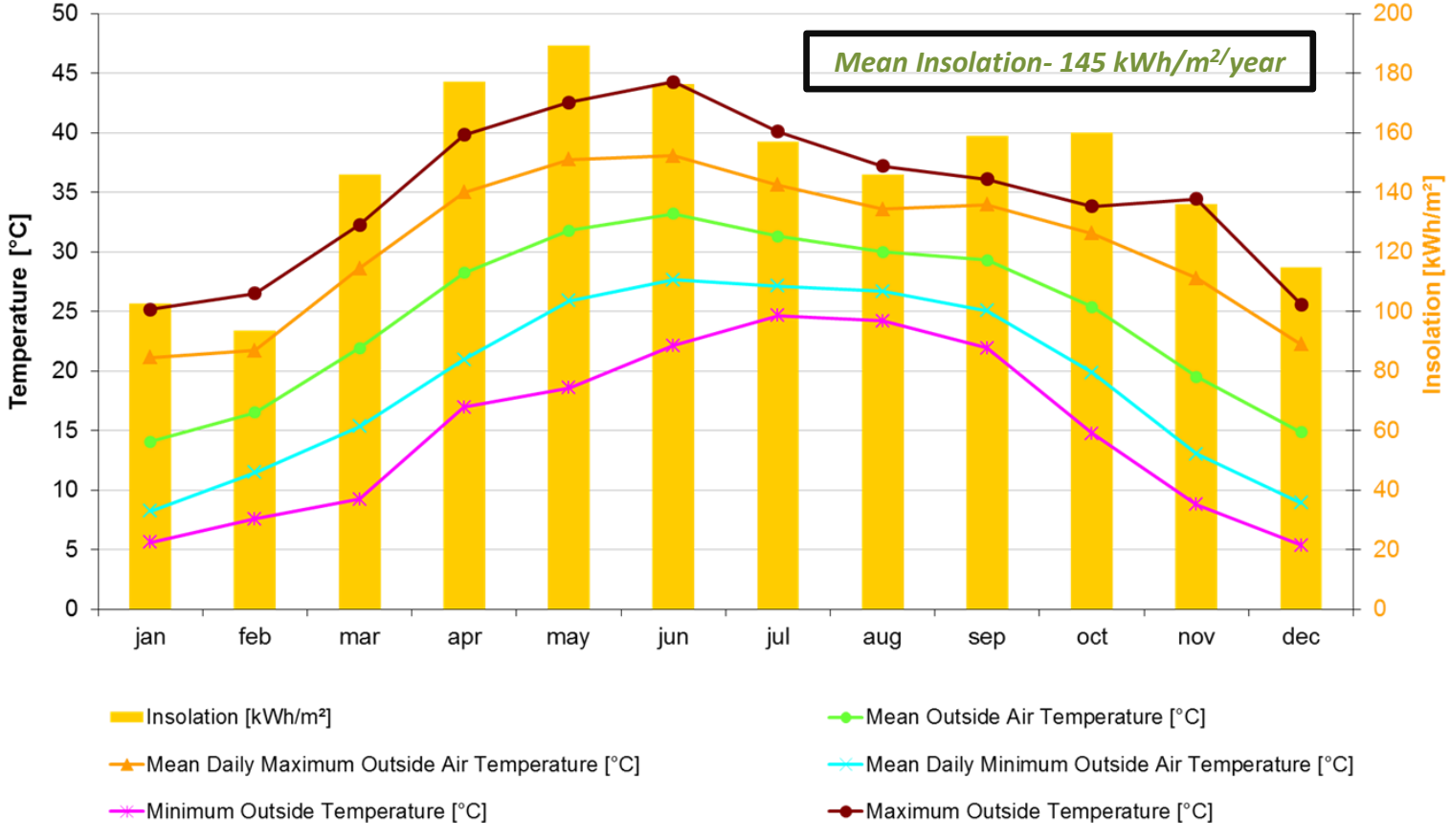
Solar Insolation Statistics

New Delhi, India (Composite Climate)



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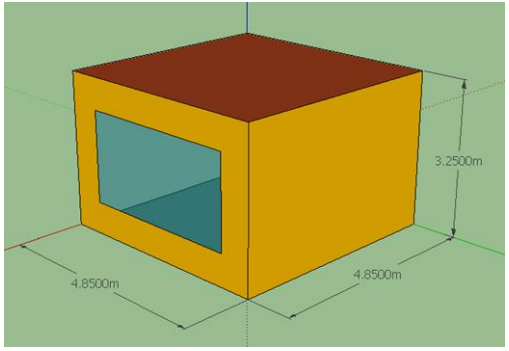
Geometry, Material and Operational parameters

Geometry:
4.85 X 4.85 X 3.25 m3
Shoe Box model



Opaque Façade: 0.219 m, U value- 0.250 W/m2K

Glazed Façade :
Option-1: Double- U Value-1.24 W/m2K, G value- 0.642
Option-2: Triple Façade- U Value-0.59 W/m2K, G value- 0.451

Base Operational Parameters:
(Deg Celsius)

Heating Set point- 20 ºC
Cooling set point- 26 ºC
Max ACH (Natural Ventilation)- 3 ACH
Mechanical Ventilation (Occupancy Schedule: 09-17 Hrs.)
Set point- 19 Winter, 22 Summer

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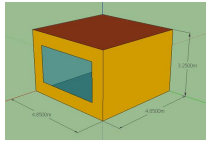
Variants Definition

Orientation	Shading Factor	Window to Wall Ratio	Glazing Type	Area (m2)/person
0	0	33	Double glazing with one low e	5
45	30	66	Triple glazing with 2 low e	10
90	60	100		
135	90			
180				
225				
270				
315				

8 ✖ 4 ✖ 3 ✖ 2 ✖ 2

8*4*3*2*2= 384 combinations

No of Variants (Each Climate) is 384



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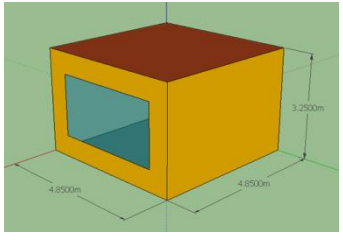
Project framework and post processing

Variation and Parameters definition

Base Energy Model



Design Parameters (Variations)

Orientation	Shading Factor	Window to Wall Ratio	Glazing Type	Area (m2)/person
0	0	33	Double glazing with one low e	5
45	30	66	Triple glazing with 2 low e	10
90	60	100		
135	90			
180				
225				
270				
315				

Parametric Design and Simulation

Parametric Design: Variants Generation → **Grasshopper- TRNSYS + DAYSIM Simulation**

VAM Outputs: Power Output (Heating, Cooling and Electricity)

Data Post Processing

Linear Regression Model: To generate equation for Heating, cooling and Electricity

Regression equation to Excel based tool for easy usage.

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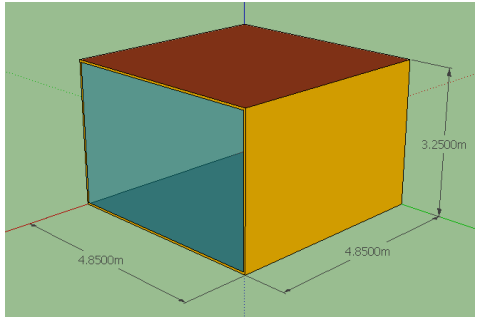
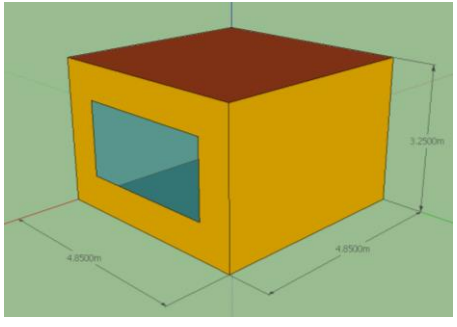
Building Parameter's Influence on Energy

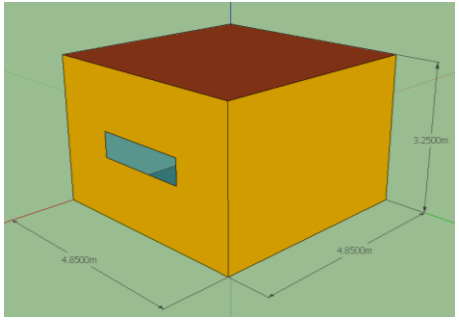
Window to Wall Ratio on Cooling Demand



Window to Wall Ratio :100%



Window to Wall Ratio :66 %



Window to Wall Ratio :33 %

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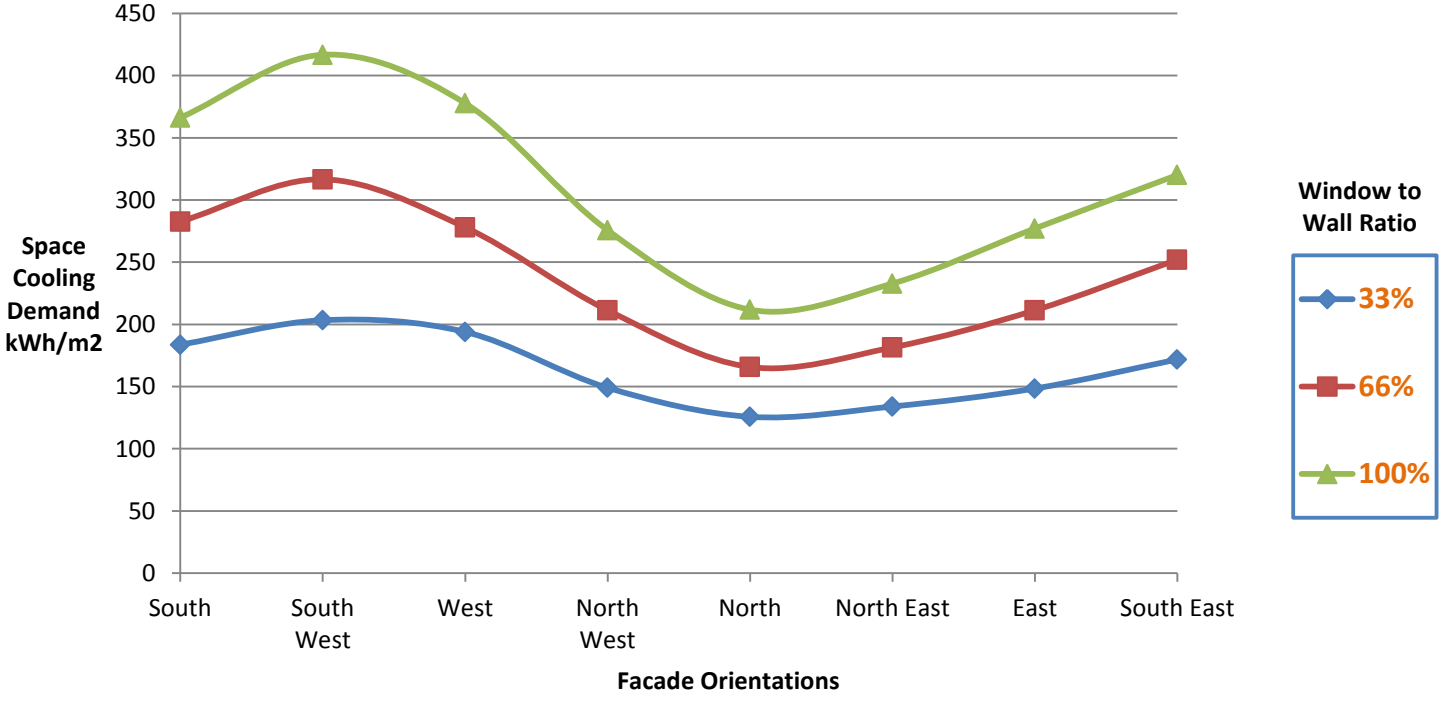
Window to Wall Ratio's influence on cooling demand (kWh/m2)

Shading Factor	Glazing Type	Area (m2)/person
0%	Double glazing with one low e	10



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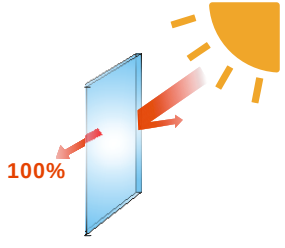
Building Parameter's Influence on Energy

Shading Factor on Cooling Demand

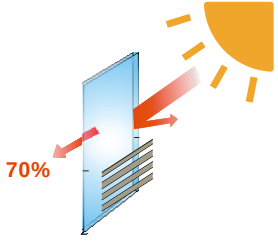
Window to Wall Ratio :100%

Window to Wall Ratio :66 %

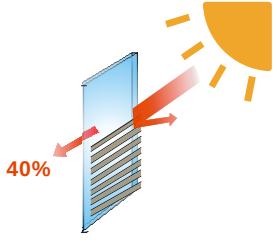
Window to Wall Ratio :33 %



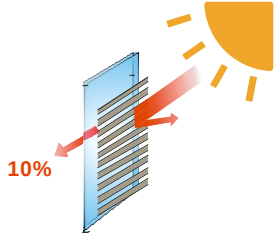
Shading Factor- **0%**



Shading Factor- **30%**



Shading Factor- **60%**



Shading Factor- **90%**

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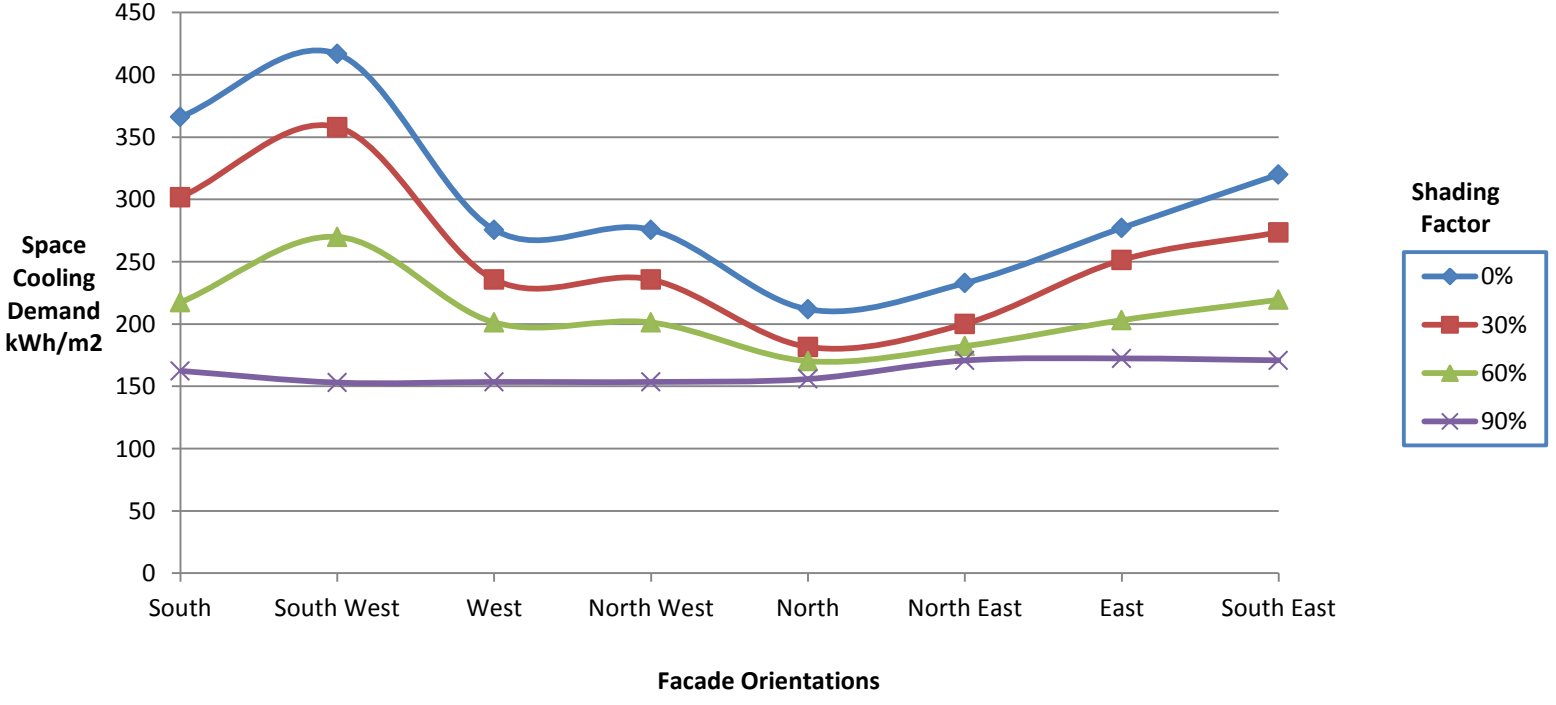
Shading Factor's influence on cooling demand (kWh/m2)

Window to Wall Ratio	Glazing Type	Area (m2)/person
100%	Double glazing with one low e	10



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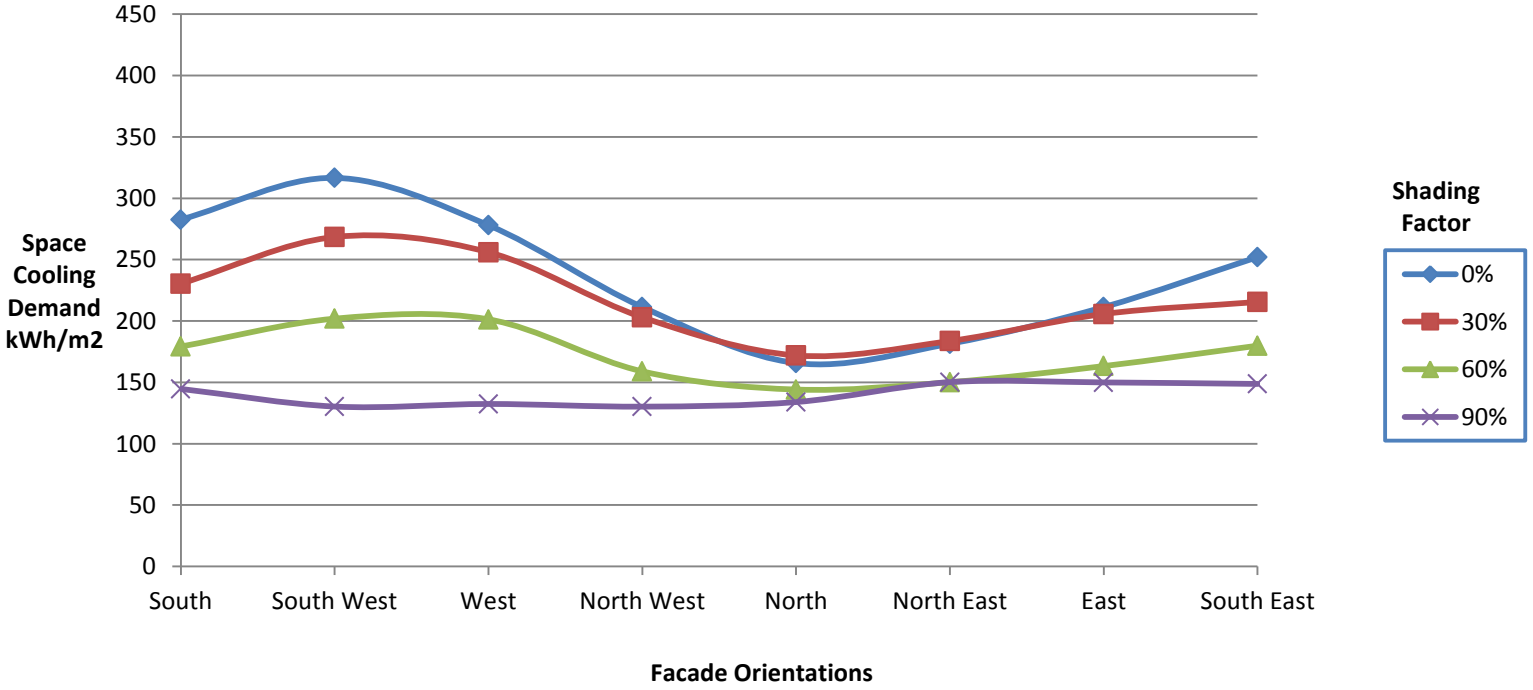
Shading Factor's influence on cooling demand (kWh/m2)

Window to Wall Ratio	Glazing Type	Area (m2)/person
66%	Double glazing with one low e	10



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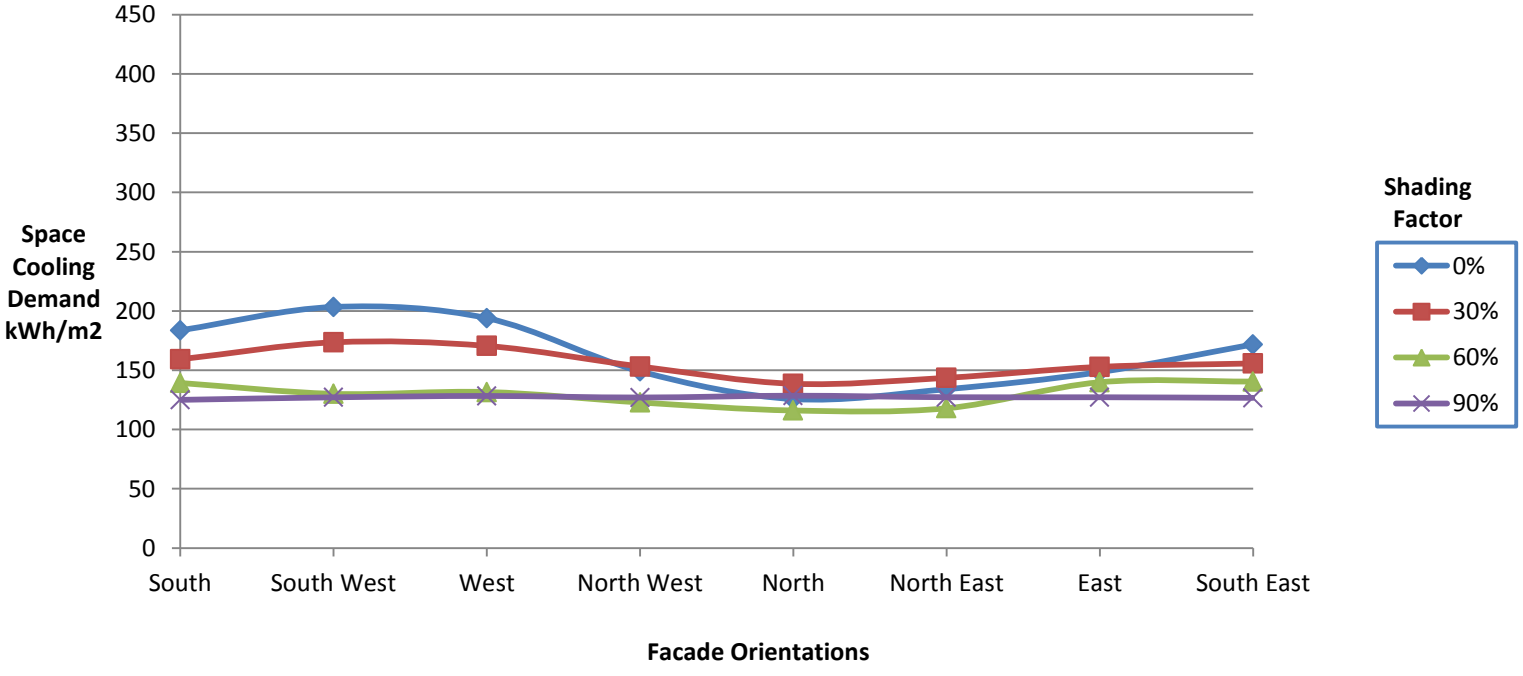
Shading Factor's influence on cooling demand (kWh/m2)

Window to Wall Ratio	Glazing Type	Area (m2)/person
33%	Double glazing with one low e	10



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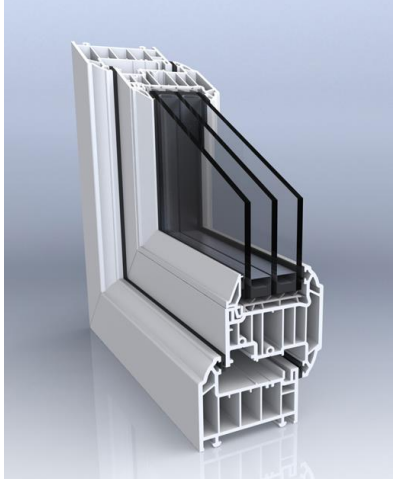
Building Parameter's Influence on Energy

Glazing Type on Cooling Demand

Double Glazing
U Value-1.24 W/m2K



Triple Glazing
U Value-0.59 W/m2K

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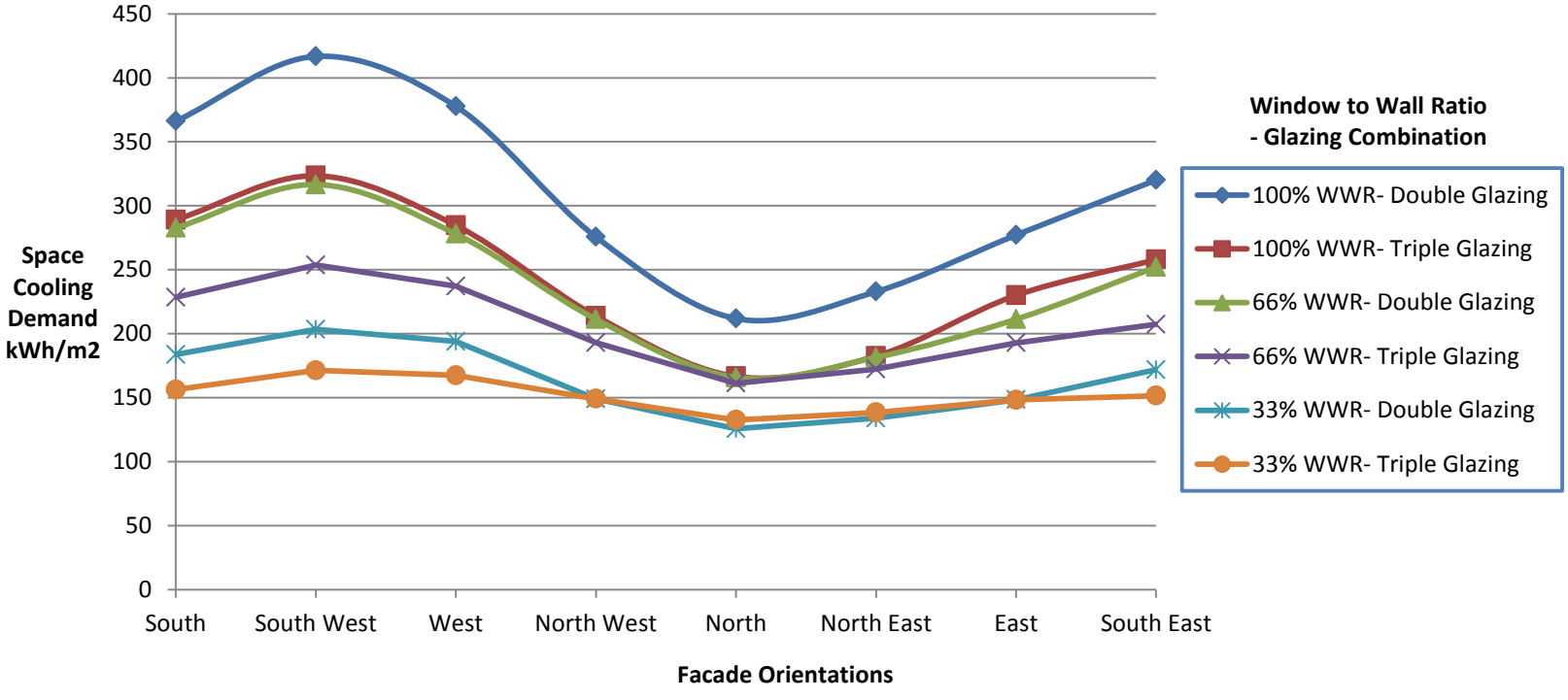
Glazing Type influence on cooling demand (kWh/m2)

Shading Factor	Area (m2)/person
0%	10



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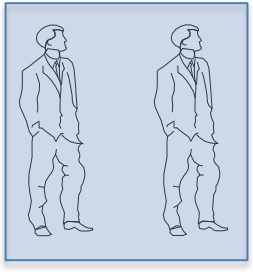
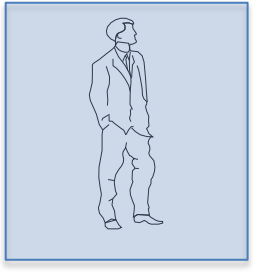
Building Parameter's Influence on Energy

Area/ Person on Cooling Demand



5 sqm/Person



10 sqm/Person

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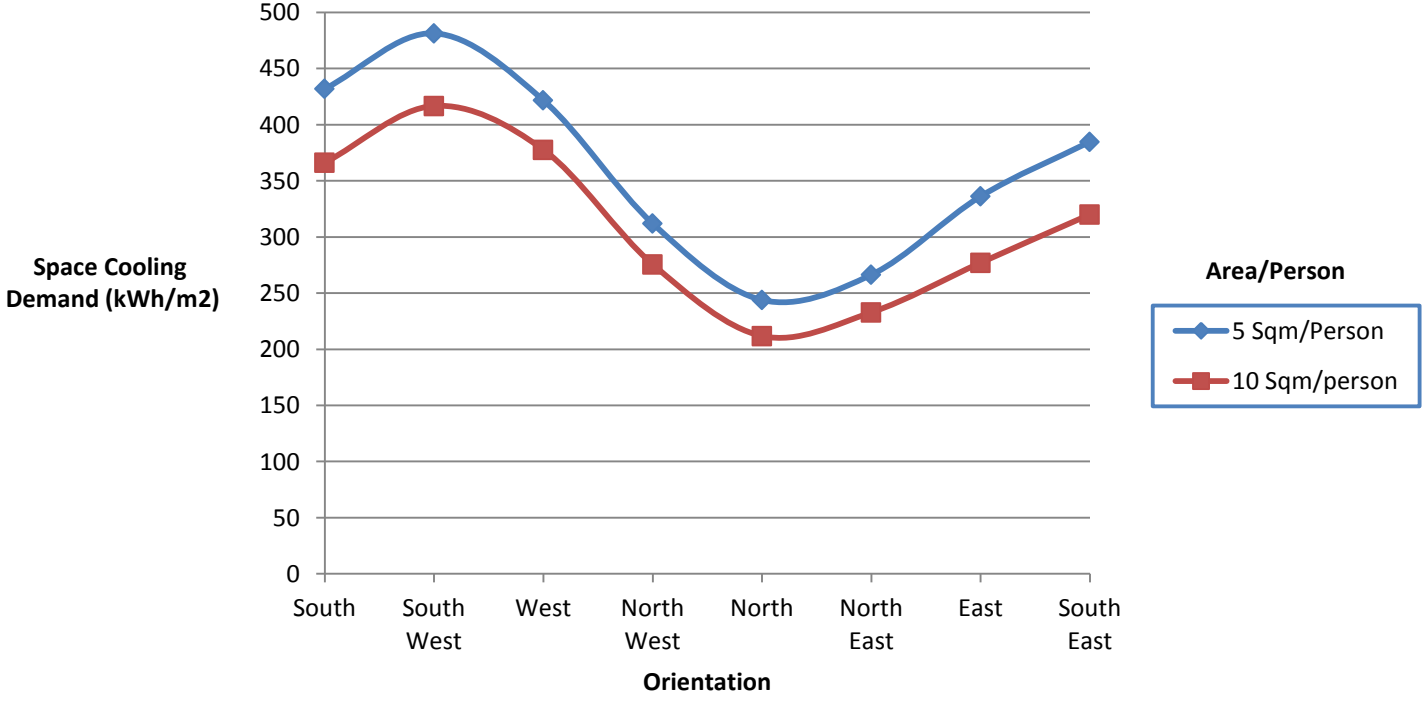
Area/ Person influence on cooling demand (kWh/m2)

Shading Factor	Window to Wall Ratio	Glazing Type
0	100%	Double glazing with one low e



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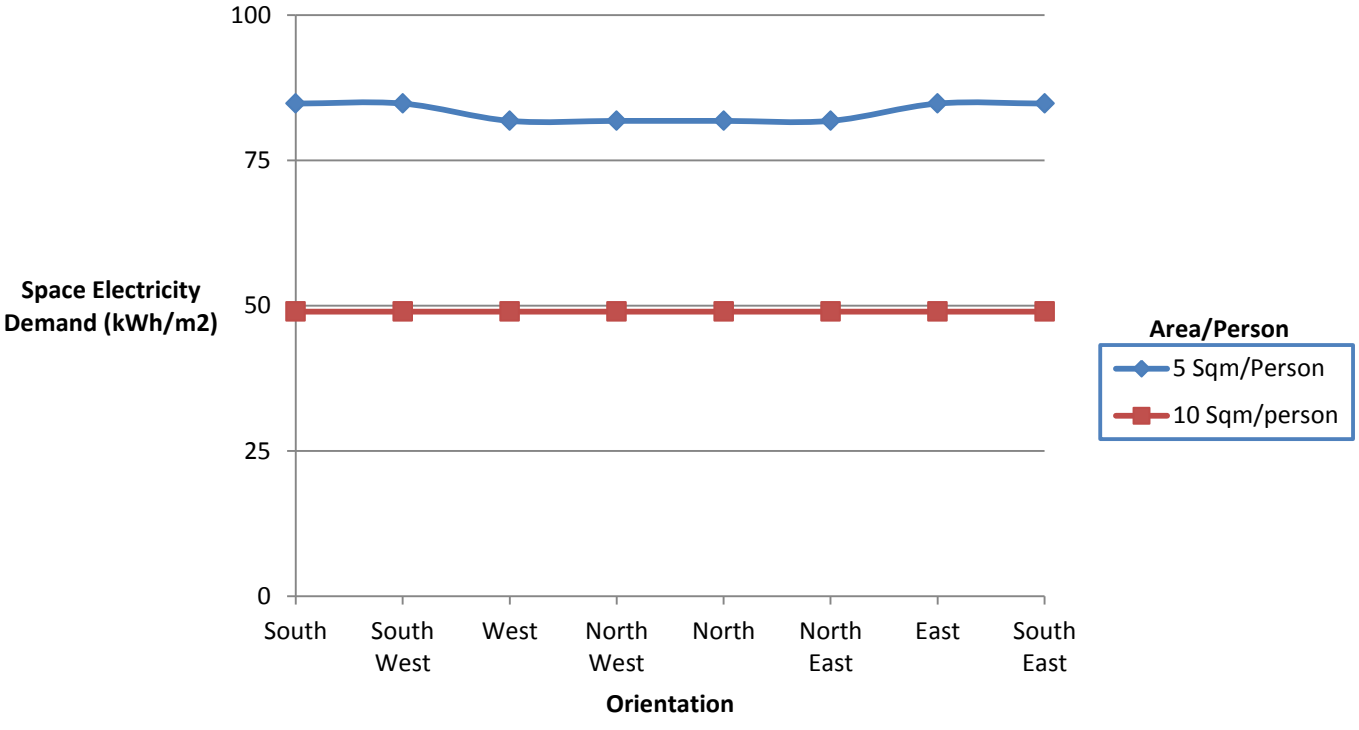
Area/ Person influence on electricity demand (kWh/m2)

Shading Factor	Window to Wall Ratio	Glazing Type
0	100%	Double glazing with one low e



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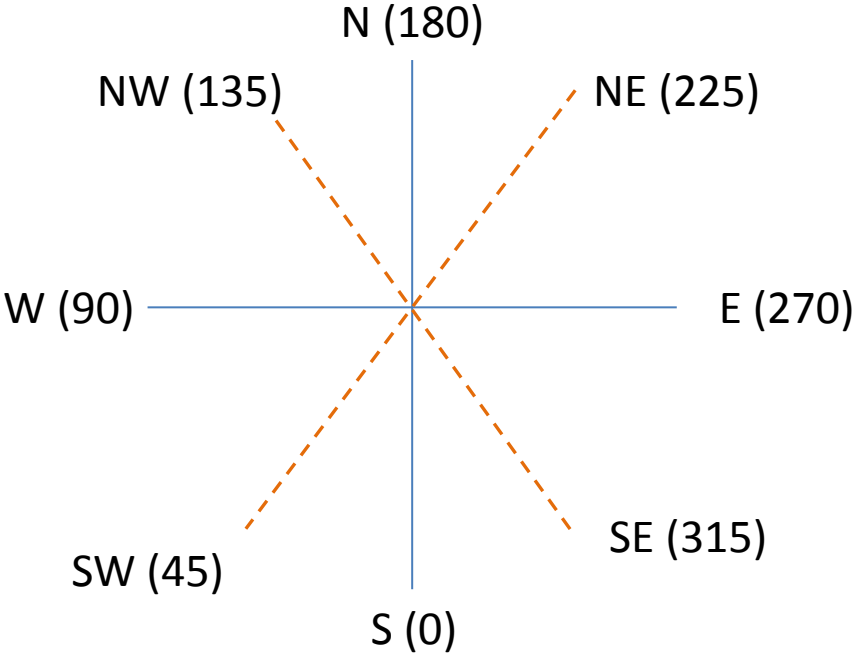
Building Parameter's Influence on Energy

Orientation *on Heating, Cooling (Thermal) and Electrical Demand*



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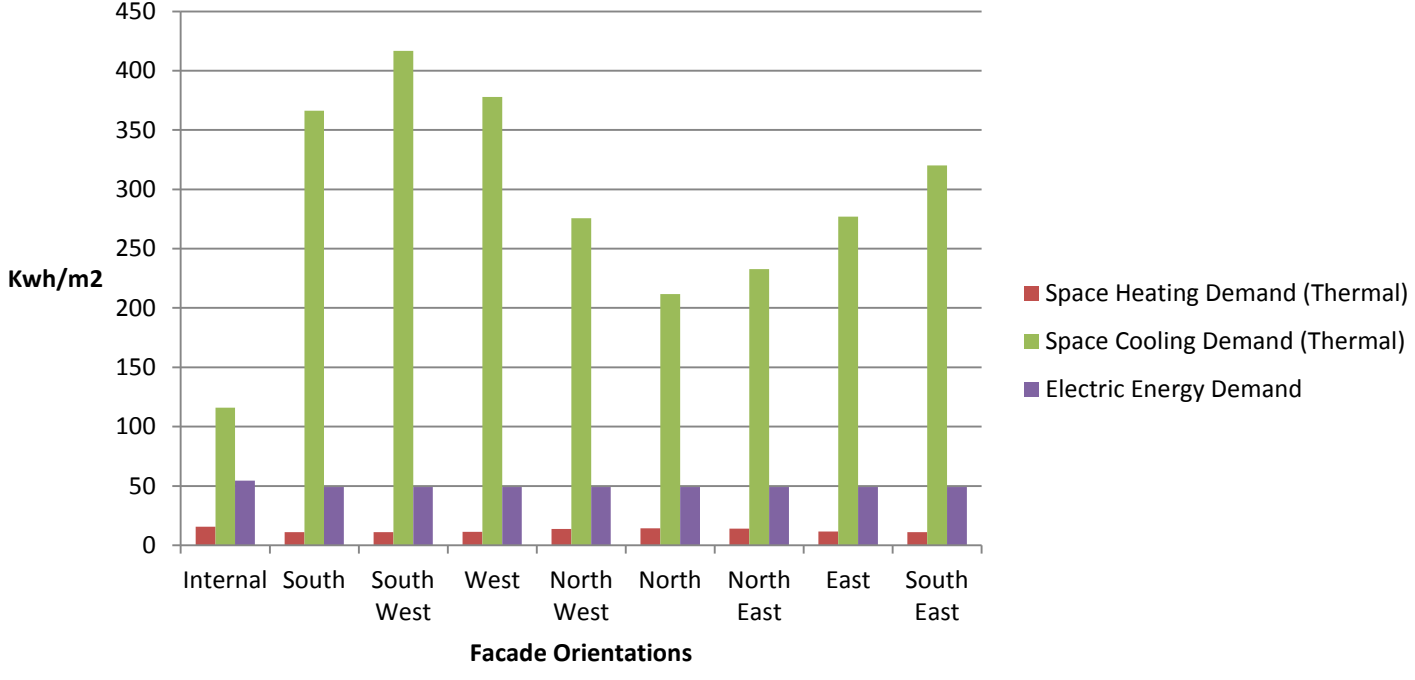
Orientation's influence on heating, cooling (Thermal) and electrical Demand (kWh/m2)

Shading Factor	Window to Wall Ratio	Glazing Type	Area (m2)/person
0%	100%	Double glazing with one low e	10



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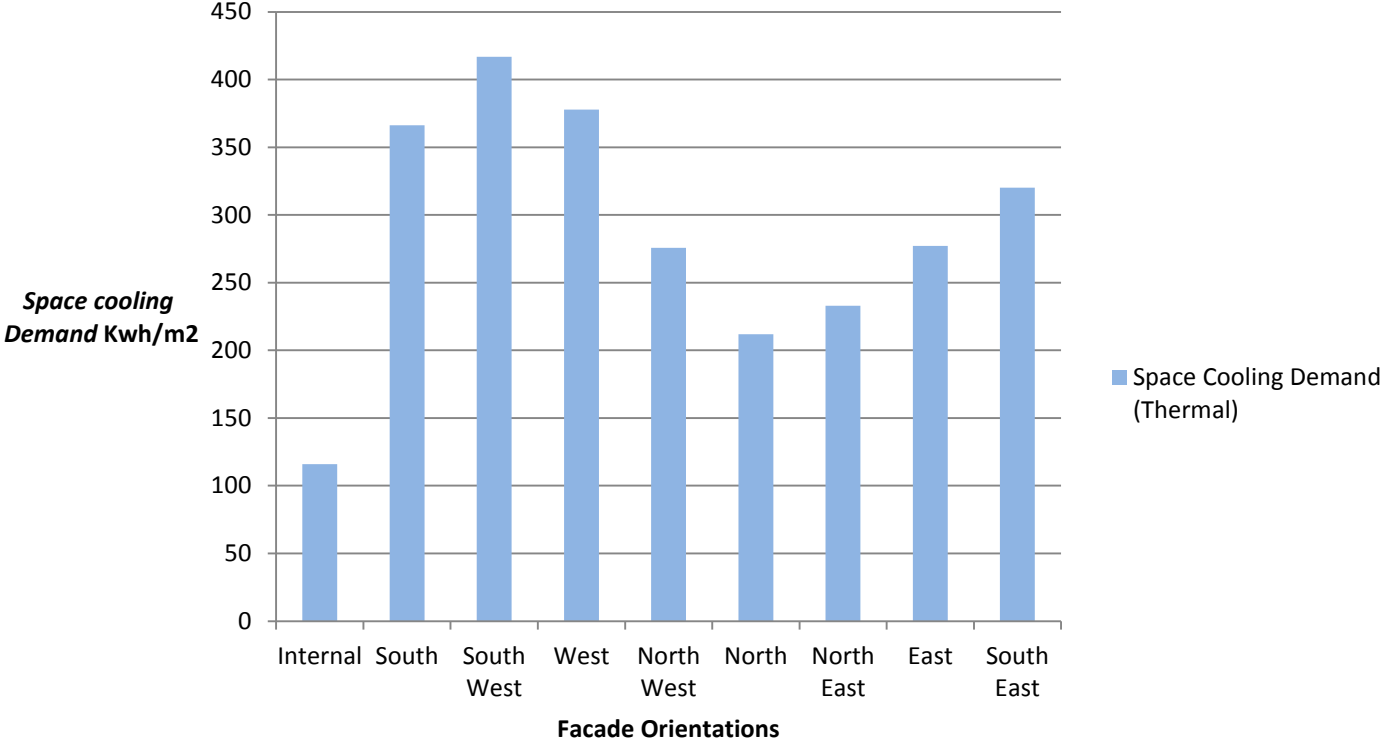
Orientation's influence on cooling Demand (Thermal) (kWh/m2)

Shading Factor	Window to Wall Ratio	Glazing Type	Area (m2)/person
0%	100%	Double glazing with one low e	10



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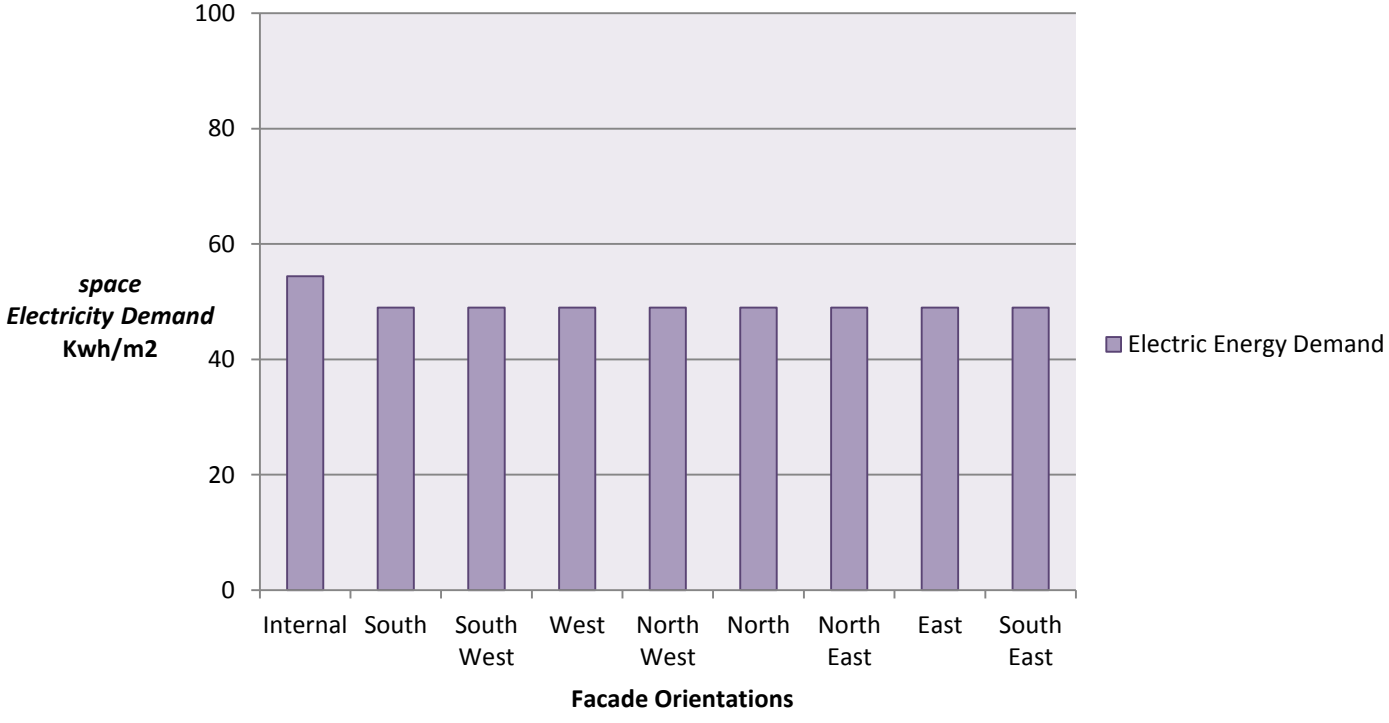
Orientation's influence on Electricity Demand (kWh/m2)

Shading Factor	Window to Wall Ratio	Glazing Type	Area (m2)/person
0%	100%	Double glazing with one low e	10



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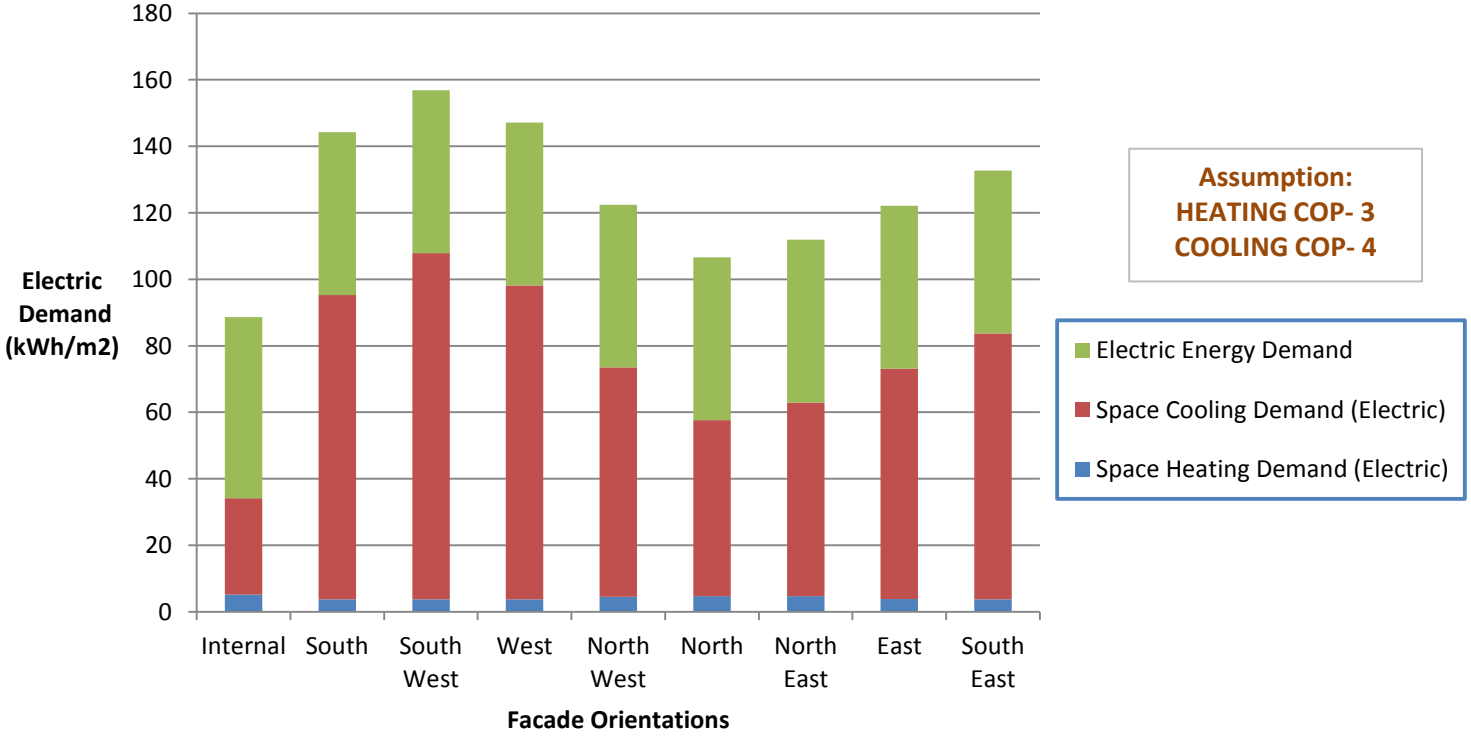
Orientation's influence on Combined Electric Energy Demand (kWh/m2)

Shading Factor	Window to Wall Ratio	Glazing Type	Area (m2)/person
0%	100%	Double glazing with one low e	10



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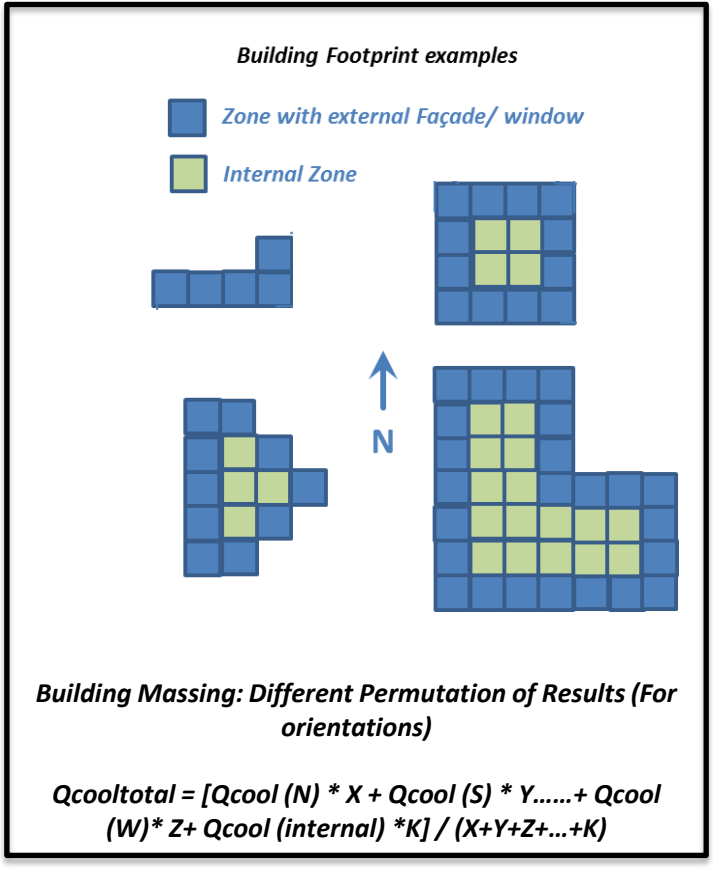
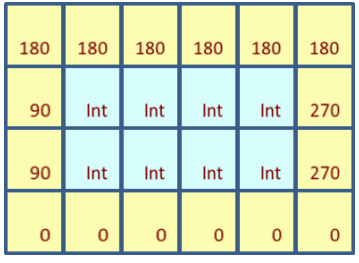
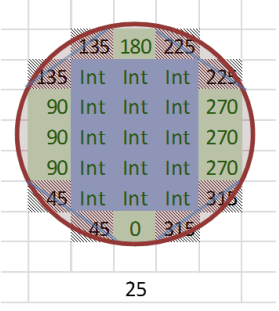
Building Footprints

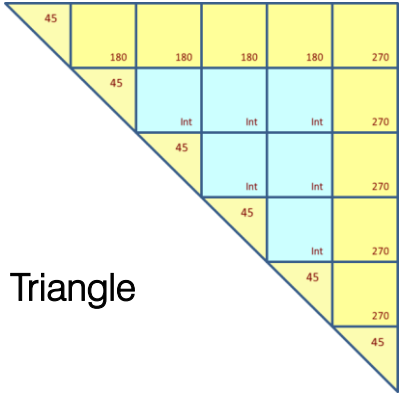




Rectangle/ Square



Circle



Triangle

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Regression Coefficients

External Zones

384

Simulation Run Results

Linear Regression Analysis

Dependent Variables

	Heating (Thermal)	*Cooling (Thermal)*	*Electric (Electric)*
Intercept	13.9467	221.7451	119.3328
Orientation	0.0016	-0.1135	-0.0001
Shade	0.0011	-0.9290	0.0003
WWR	-0.0016	1.2374	0.0006
Glazing	0.2057	42.8218	0.0501
Sqm/Person	-0.2974	-10.4469	-7.1224

Internal Zones

2

Simulation Run Results

Linear Regression Analysis

Dependent Variables

	Heating (Thermal)	*Cooling (Thermal)*	*Electric (Electric)*
Intercept	23.18775	249.74582	128.7594
Sqm/Person	-0.769254	-13.315802	-7.43292

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Regression Equation

	Heating (Thermal)	*Cooling (Thermal)*	*Electric (Electric)*
Intercept	13.9467	**221.7451**	119.3328
Orientation	0.0016	**-0.1135**	-0.0001
Shade	0.0011	**-0.9290**	0.0003
WWR	-0.0016	**1.2374**	0.0006
Glazing	0.2057	**42.8218**	0.0501
Sqm/Person	-0.2974	**-10.4469**	-7.1224

Cooling Demand (kWh/m2) = **221.745** + (**Orientation** * **-0.1135**) + (**Shading Factor** ***0.92903**)+(**Window to Wall Ratio** * **1.2374**)+(**Glazing** * **42.8218**)+ (**Sqm/person** * **-10.4469**)

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Regression Equations- External and Internal Zones

External Zone

Space Heating Demand (kWh/m2) = 13.9467 + (**Orientation** * 0.0016) + (**Shading Factor** *0.001148)+(**Window to Wall Ratio** * -0.0015527)+(**Glazing** * 0.2056)+(**Sqm/person** * -0.29736)

Space Cooling Demand (kWh/m2) = 221.74 + (**Orientation** * -0.113490) + (**Shading Factor** *0.092903)+(**Window to Wall Ratio** * 1.2373)+(**Glazing** * 42.8218)+(**Sqm/person** * -10.[illegible])

Space Electricity Demand (kWh/m2) = 119.33 + (**Orientation** * -0.0001[illegible]) + (**Shading Factor** *.000299)+(**Window to Wall Ratio** * 0.0006)+(**Glazing** * 0.0500[illegible])+(**Sqm/person** * -7.1225)

Not so simple to use!!! Can it be simplified??

Internal Zone

Space Cooling Demand (kWh/m2) =279.0139 + (**Sqm/Person** * -13.315)

Space Heating Demand (kWh/m2) =23.18775+ (**Sqm/Person** * -0.7693)

Space Electricity Demand (kWh/m2) =128.759 + (**Sqm/Person** * -7.4329)

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Sensitivity Analysis Tool

What is the Alternative way of presenting the result in a usable and interactive form ??

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Conclusion

Translate the inputs into an interactive Excel Sheet!!!

Tool Outputs:

- Influence of building parameter's on building energy- **Sensitivity of parameters**
- Interactive **Building footprint and load profile generation**
- **Real time demand statistics** as per dynamic user parameter inputs

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Way Forward

Immediate:

- Include **Daylighting simulation Input into Thermal Simulation**
- Include **more building parameters**
- Flexibility of zoning **(Internal/ External) for building footprints**

Long Term:

- Trying to include the **neighboring/ surrounding context for formulating the regression coefficients**
- **Include equations for Natural Ventilation and Daylighting potential**
- Analyze **comfort and loads** simultaneously

Danke

Q & A