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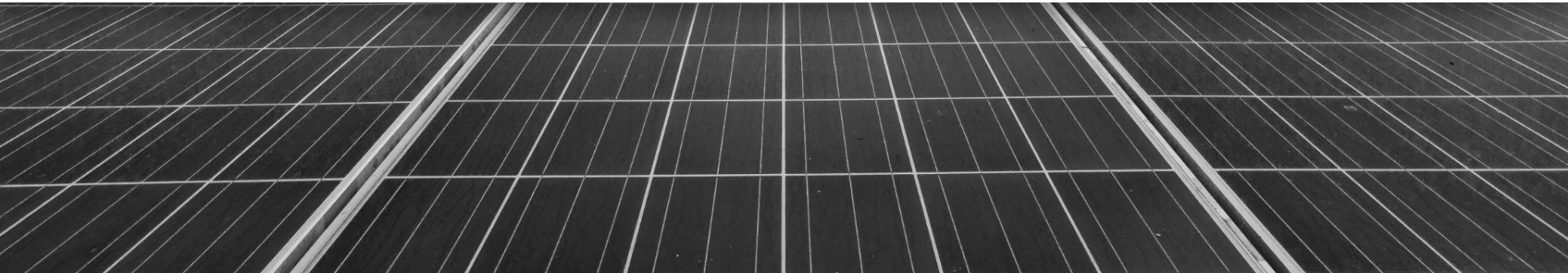
REHAU
Modelling Feedback



Introduction

This document provides performance modelling feedback on the measures a better design of the Rehau building fenestration .

The feedback covers daylight , thermal comfort and design consideration for the building fenestration

Process Based Design

START

SET TARGET

CLIMATE

REDUCE LOADS

Confirmation of passive design interventions being incorporated into the general architectural design

CONCEPT DESIGN

DETAILED DESIGN

Engineering services designed to take into consideration the improved passive design

SELECT TECHNOLOGY

ALTERNATIVE POWER & SYNERGIES

OPTIMISE OPERATIONS

The building is operated to meet its full potential

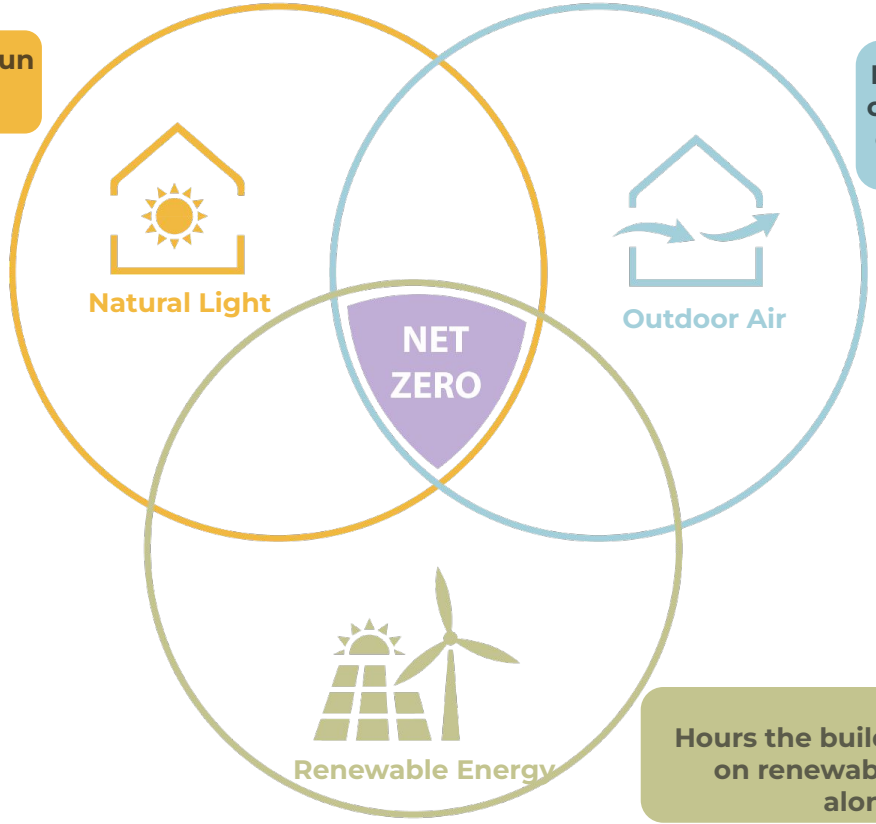
END

Set Targets - Net-Zero Energy

SET TARGET

Hours the building can run on natural light alone

Hours the building can run on outdoor air only (natural or mechanical ventilation)



Optimising passive design of the building reduces the amount of power needed for lighting and comfort. This often makes up 40 to 60% of a buildings energy use.

Due to the climate, the hours the building can run on outdoor air only, is expected to be significantly low.

With the reduced demand for energy, supply can be from renewable energy. Achieving this balance is crucial to achieving net-zero energy in operation.

Hours the building can run on renewable energy alone

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Process Based Design

Process Step	Planning Phase	Description
Set Targets	Inception	The overall target is to reduce carbon emissions . To achieve this, discrete targets for overall energy use are set. Based on these, interventions are prescribed to ensure adherence to these targets and the eventual renewable energy offset for projects meeting the targets.
Investigate Climate	Inception	Climate opportunities and challenges are captured in this document, project teams will have this document at project inception as a reminder of the passive design principles being followed.
Reduce Loads	Concept Design	The aim is to create a thermally comfortable building. This requires control of solar gains and reduction of heat gain building fabric. Interventions are aimed at achieving this goal. This is the first line of defence when it comes to low carbon emission buildings and removes reliance on efficient equipment to reduce the building carbon footprint.
Select Technology	Detailed Design	Engineering elements; lighting, hot water, heating and cooling are to be designed based on inputs that correlate to the optimised building fabric from the concept stage. Expected outcomes are provided in the document but engineers are still expected to do their detailed calculations to ensure the systems work to the required standards.
Alternative Power	Detailed Design	Renewable energy production based on the targets and expected operation are provided. Energy security or loadshedding requirements are also provided. These are outside of the net-zero requirements but presented here for completeness.
Optimise Operations	Post Occupation	All the steps above are to ensure the project has the potential to operate at low carbon footprint standards. However, the actual running of the building will determine if the building achieves the required standards. The guidelines make provision for metering to provide information during operations.

Set Targets - Introduction

Setting Targets is the first step in the integrated design process where the client goals around passive design and the designs teams response are merged.

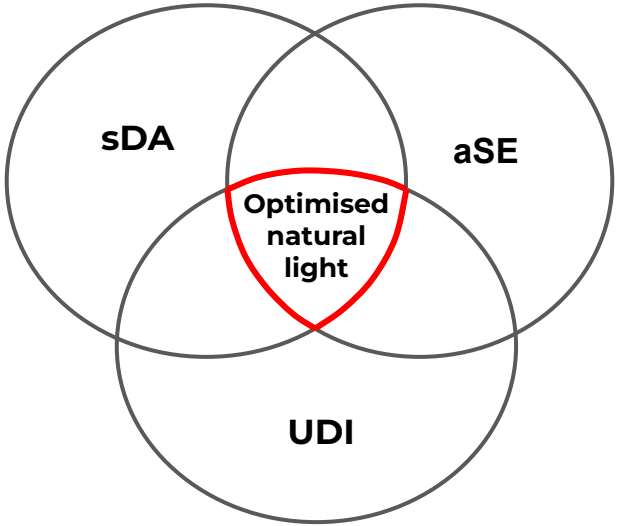
The following Targets are considered

- Daylight
- Thermal Comfort

Daylight

Balancing light and heat gain is key to ensuring mechanical cooling is not required to maintain comfort. Three important metrics are used. Natural light is optimised when performance metrics for all three lighting variables are met. This ensures a well lit area that does not create unwanted heat gains.

Spatial daylight autonomy (sDA) refers to the percentage of floor area where 200 lux is achieved for at least 50 percent of the workday.



The annual sunlight exposure (aSE) metric identifies the percentage of the floor area that receives intense daylight, exceeding 1000 lux, for more than 250 work hours every year.

Useful Daylight Illuminance (UDI) he level of daylight that can be introduced into a space without causing glare or disrupting the visual environment. Generally considered to be between 100 and 1000 lux

Thermal Comfort - Winter

✔ Complies with ASHRAE Standard 55-2020

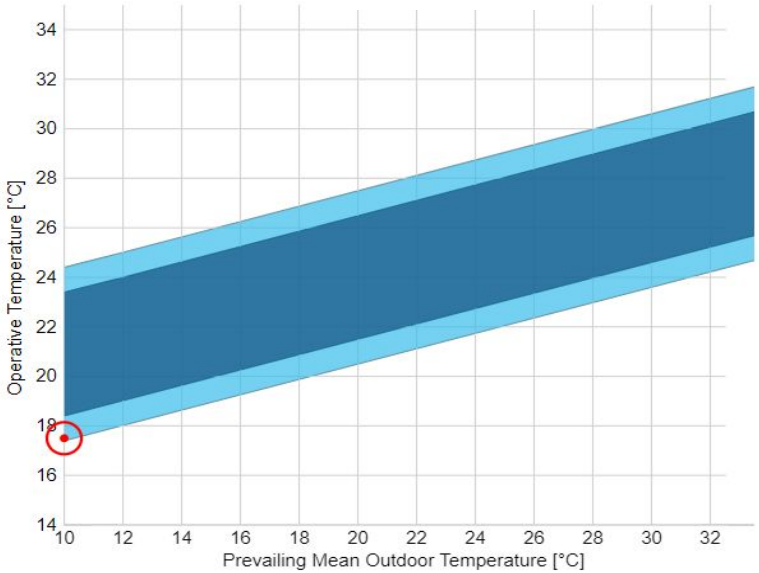
80% acceptability limits = Operative temperature: 17.4 to 24.4 °C

Comfortable

90% acceptability limits = Operative temperature: 18.4 to 23.4 °C

Too cool

Adaptive chart



Thermal Comfort - Summer

✔ Complies with ASHRAE Standard 55-2020

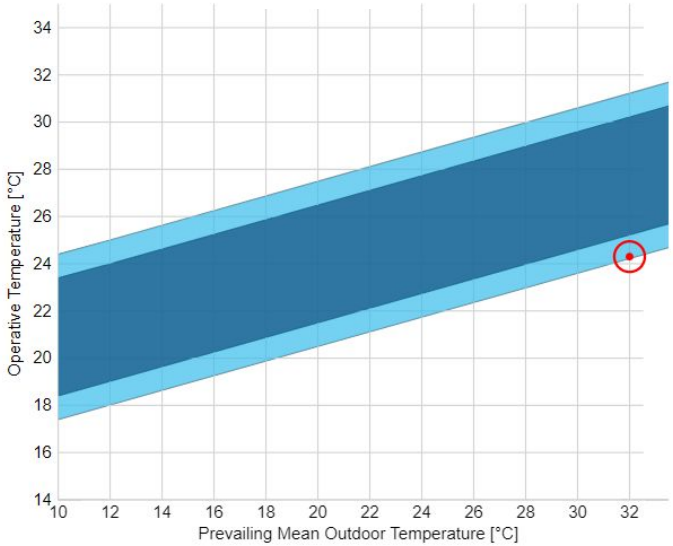
80% acceptability limits = Operative temperature: 24.2 to 31.2 °C

Comfortable

90% acceptability limits = Operative temperature: 25.2 to 30.2 °C

Too cool

Adaptive chart



INVESTIGATE CLIMATE

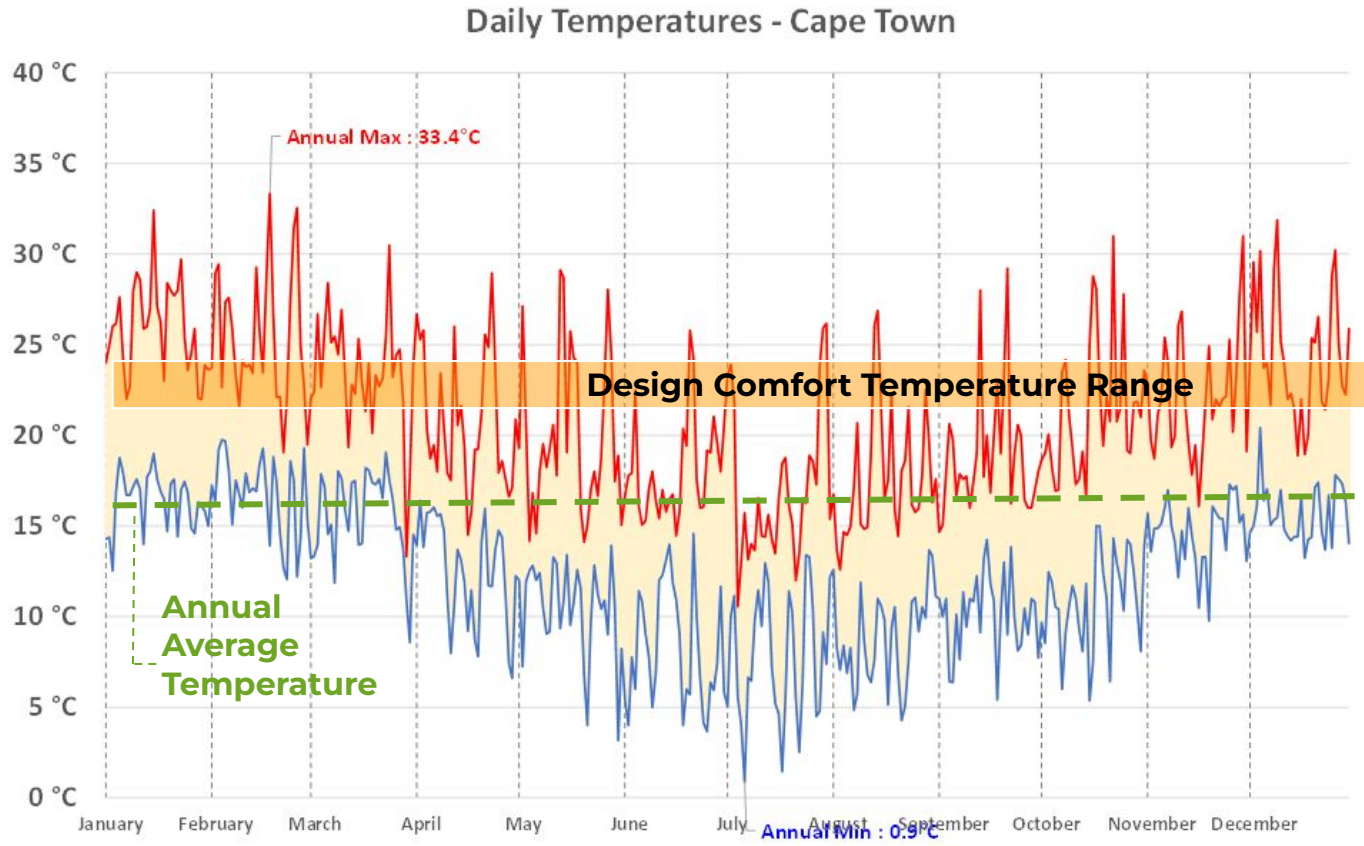
Understanding the climate helps make decisions with regards to the passive and active design elements

Comfort Temperature Range 22 -24 Deg C

Heating required to maintain comfort

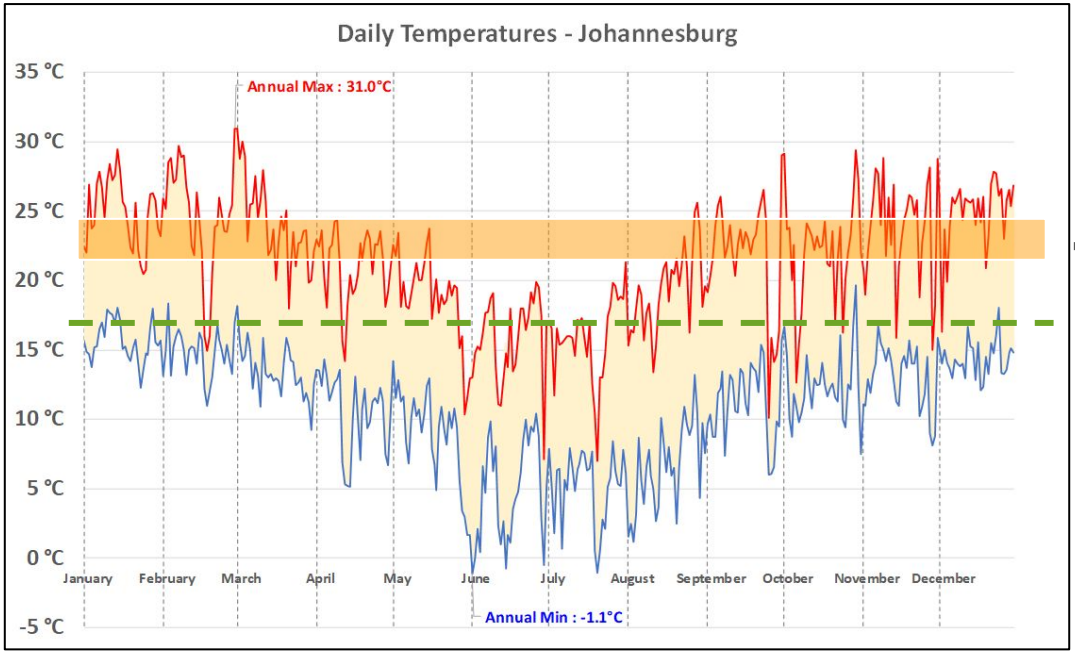
Average Temperature in Cape Town: 16.5 Deg C

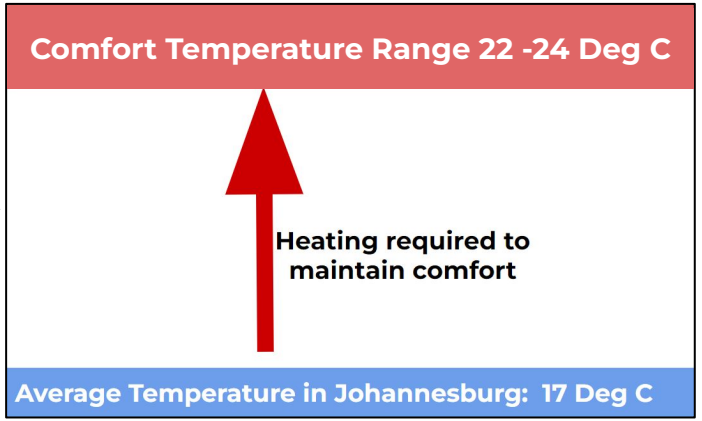
INVESTIGATE CLIMATE



The climate summary shows that for the bulk of the year cooling is not required. However , heating may be required.Controlling solar gains and reducing heat loss from the building will increase net-zero hours significantly.

INVESTIGATE CLIMATE

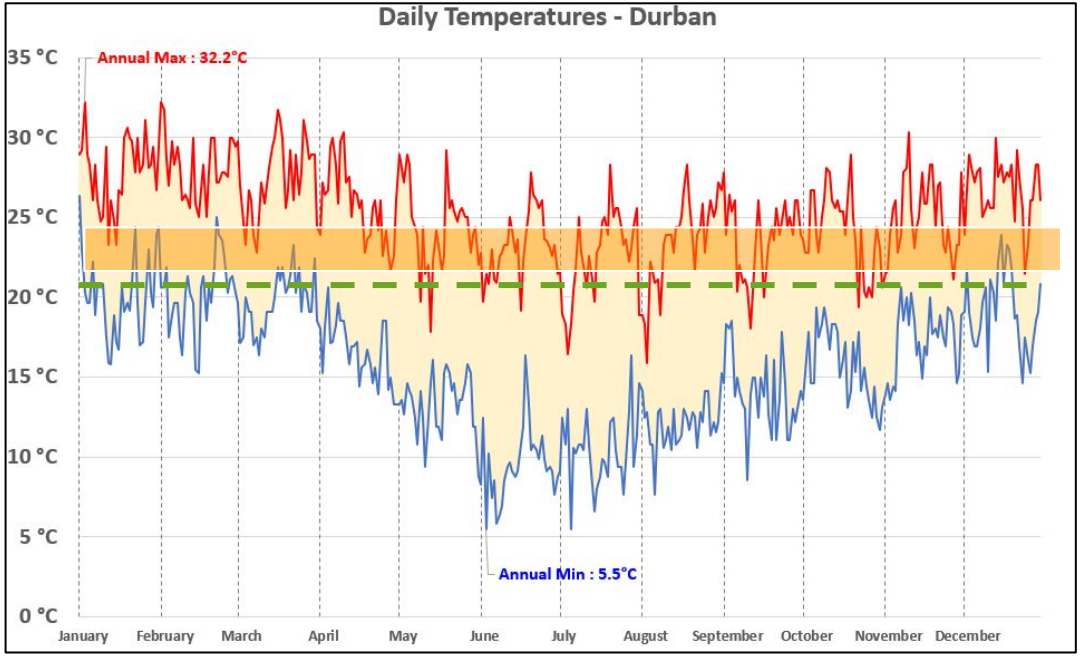


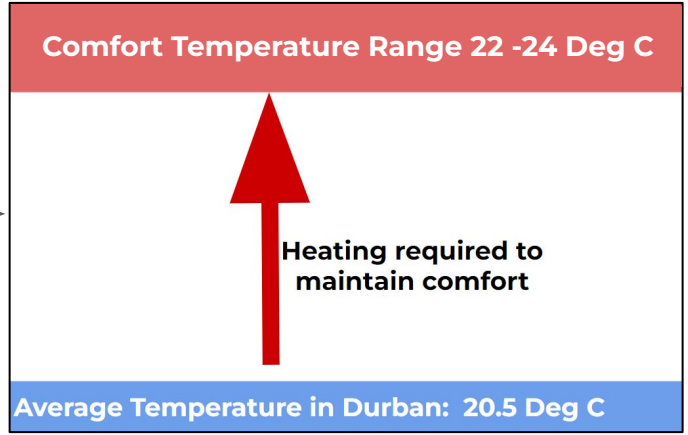


The climate summary shows that for the bulk of the year cooling is not required provided that solar gains are controlled. The average annual temperature across the year is significantly lower than the target comfort temperature. This indicates that active heating is required to maintain comfort during night time hours in particular. Controlling solar gains, reducing heat loss from the building will increase net-zero hours significantly.

INVESTIGATE CLIMATE

CLIMATE





The temperature data along with known high humidity means this region would require some level of artificial cooling during day time, particularly in offices. Active heating is unlikely to be required within the office type areas. Controlling solar gains, reducing heat loss from the building will increase net-zero hours significantly.

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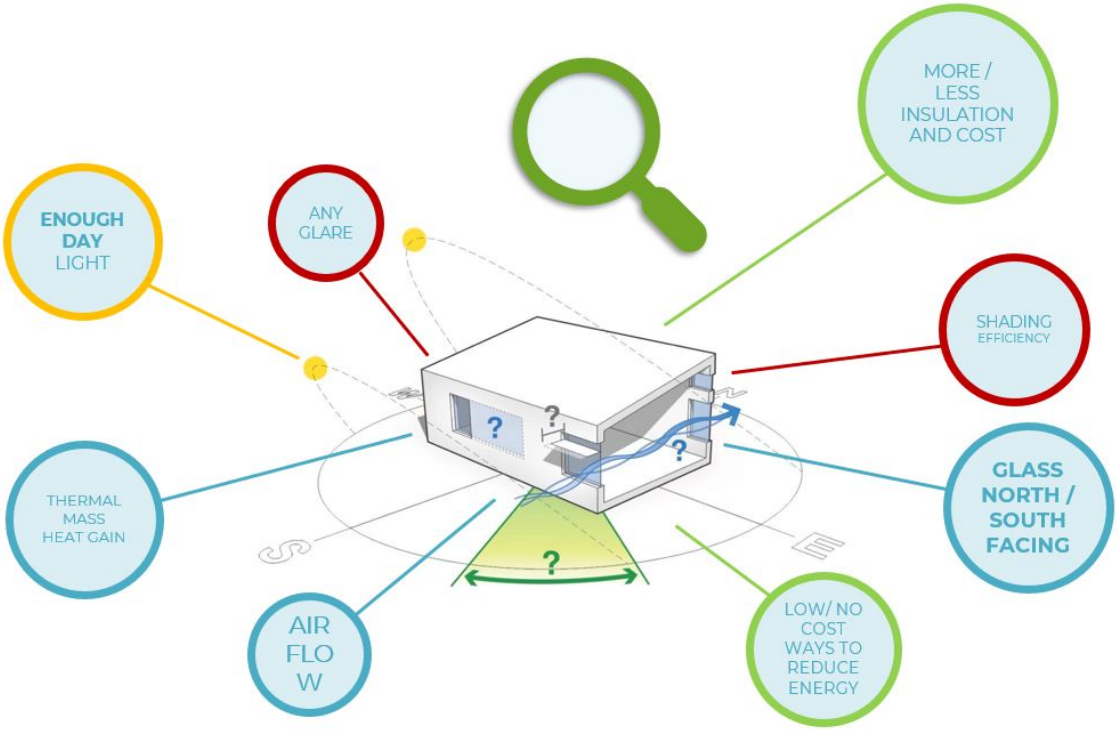
REDUCE LOADS



Targets tell you when to stop during optimisation

Modelling for design = Improving Passive Design

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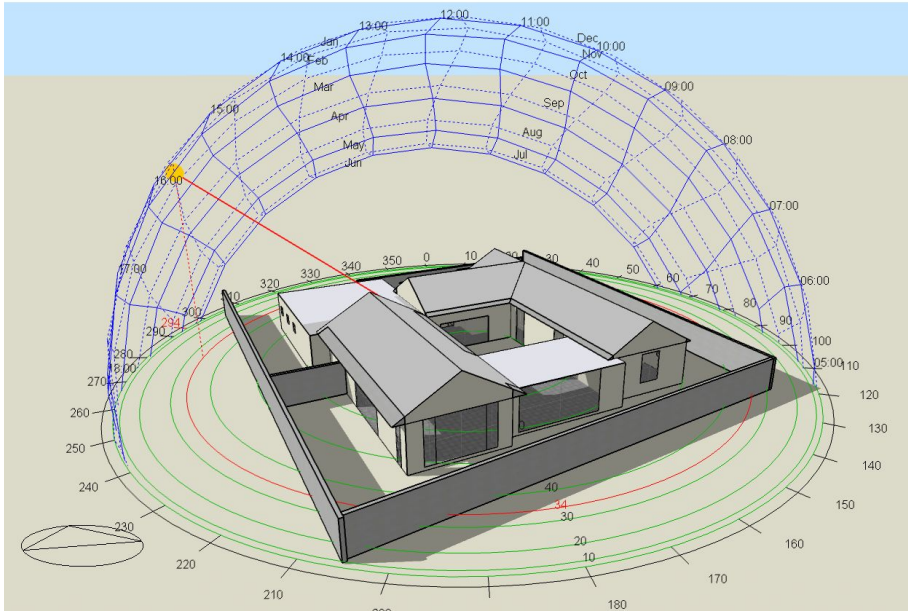
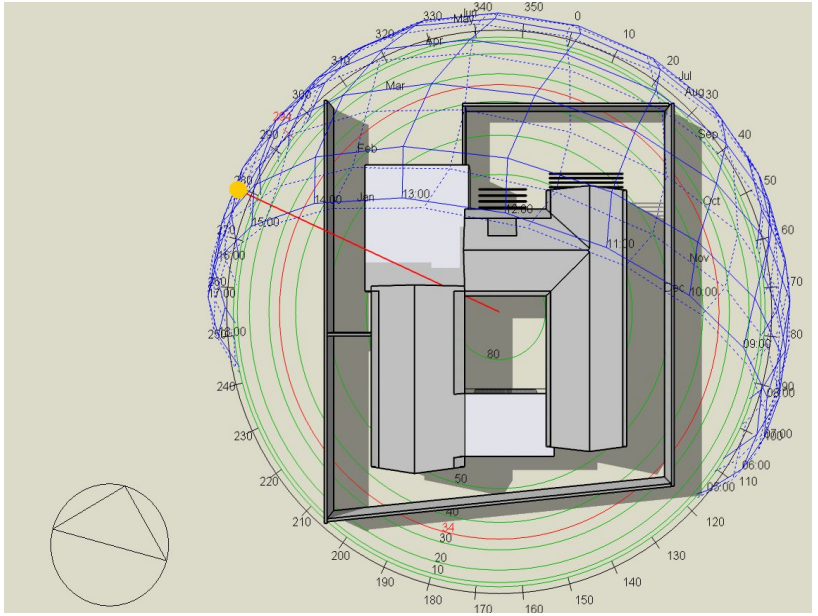
Passive Design - Simulation Model

The 3D model was modelled as per architect's drawings and includes all shading devices and correct orientation. The sun-path diagram is used to show the effect of shading at various times of the day specific to the building's location.





Glass Properties

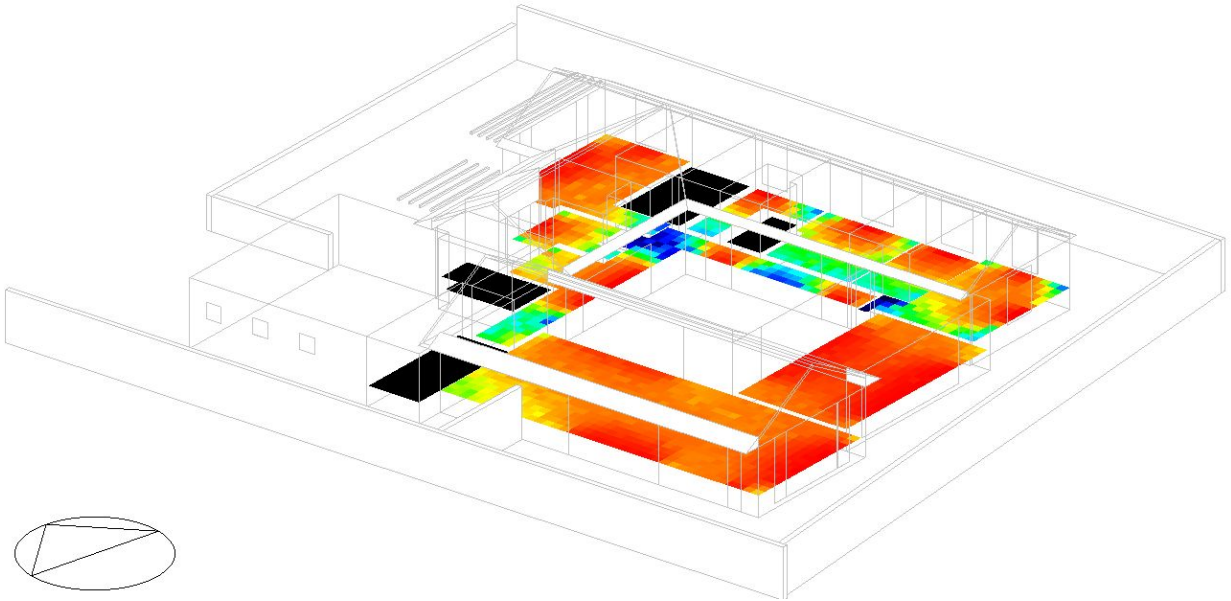
The physical properties of glass that impact daylight and thermal comfort within a building and should be taken into consideration when selecting a glass type.

Property	Description	Impact
U-value	How quickly conductive heat gains enter the space	Comfort, Energy
Solar Heat Gain Coefficient	What portion of the sun's energy enter the space	Comfort, Energy
Visible Light transmittance	How much natural light enters the space	Daylight

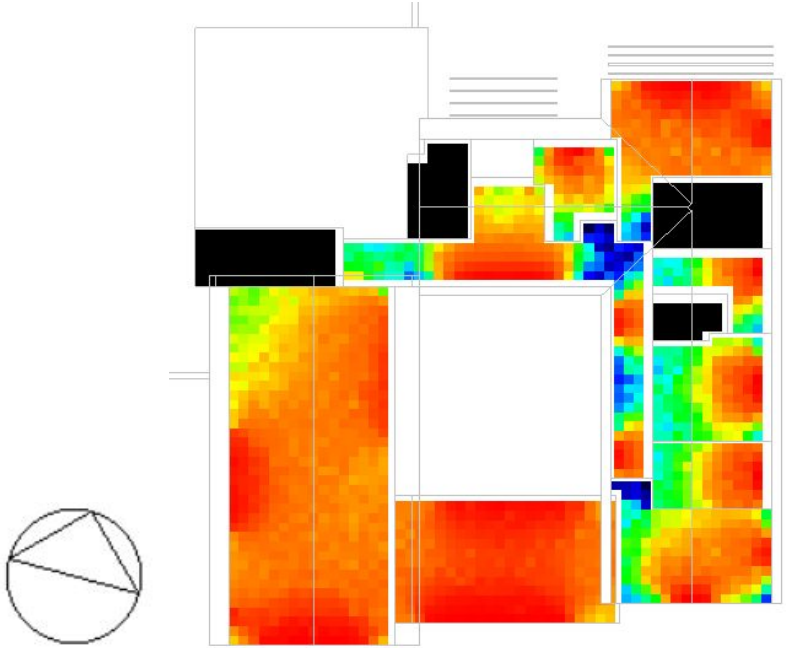
Simulation Results

Daylight

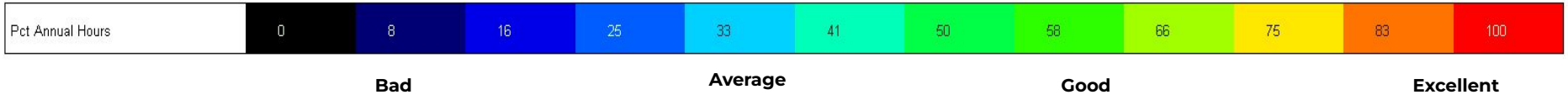
The percentage of the UA that has a Daylight Illuminance (DI) of at least 300 Lux, based on an annual dynamic simulation model, for 50% of the standard occupied hours (Daylight Autonomy (DA) incremental method)



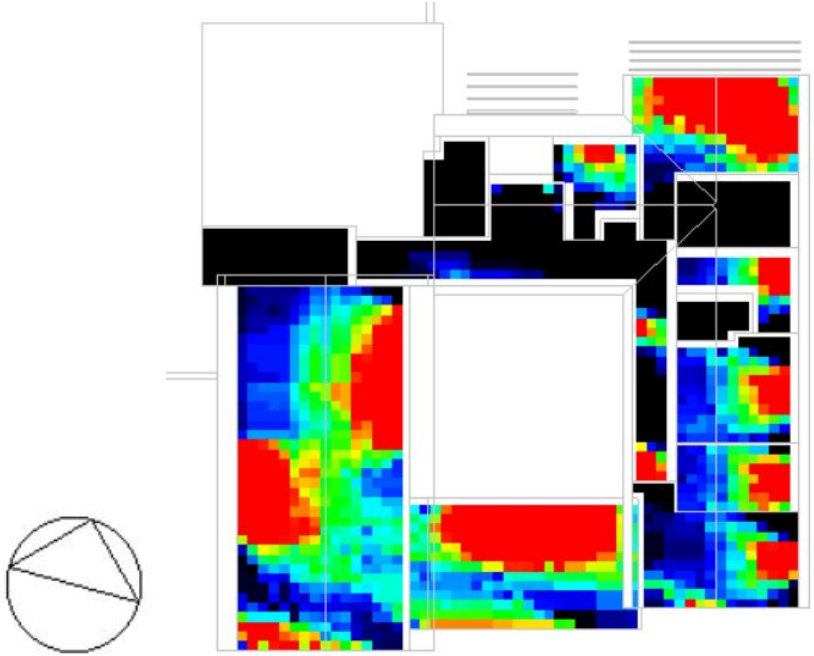
SDA - Daylight Autonomy



Spatial daylight autonomy (sDA) refers to the percentage of floor area where 200 lux is achieved for at least 50 percent of the workday. Higher sDA values indicates that a larger interior space receives at least 300 lux of daylight for at least 50 percent of the workday. Generally, sDA is calculated using a daylight simulation tool that computes the daylight levels in the space for every hour of the year. **The sDA maps shows that there are excellent levels of daylight throughout the house.**

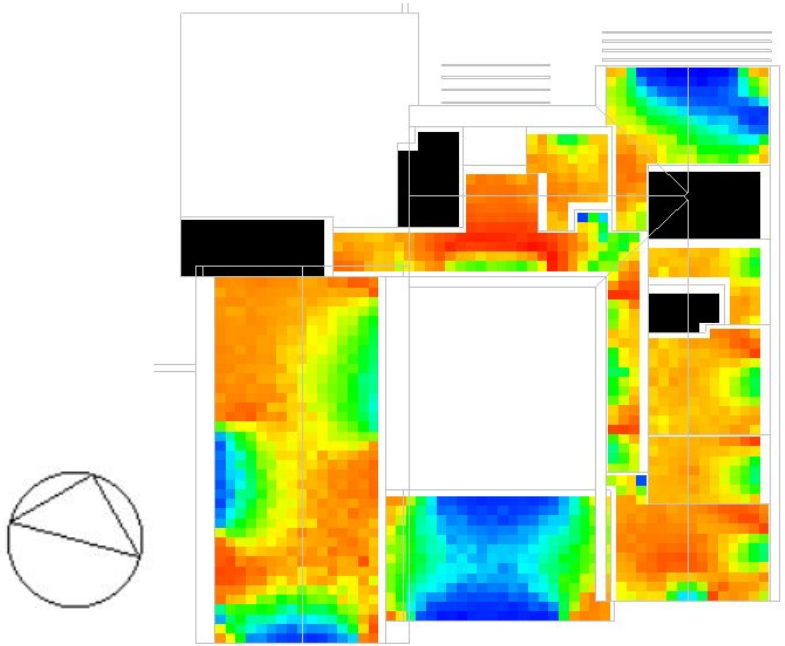


ASE - Solar Exposure



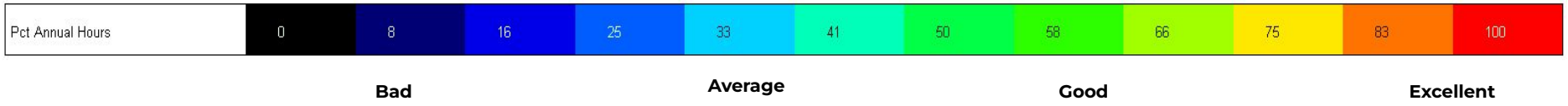
The annual sunlight exposure (aSE) metric identifies the percentage of the floor area that receives intense daylight, exceeding 1000 lux, for more than 250 work hours every year. a project must have a maximum aSE value of 10 percent. **There are high levels of sunlight exposure on perimeter zones, with high levels seen in the main bedroom and covered patio zones. This indicates that these zones may have issues with glare.**

UDI - Light Quality



Beyond identifying the exposure to intense daylight that a space receives, there is also a metric that measures the amount of useful daylight that a space receives. The idea of useful daylight revolves around the level of daylight that can be introduced into a space without causing glare or disrupting the visual environment. That range of useful, glare-free daylight is generally considered to be between 100 and 1000 lux at the workplane. **Useful daylight illuminance (UDI)** refers to the percentage of work hours where the illuminance from daylight in a space is between 100 and 1000 lux. **There are very good levels of useful daylight in the throughout the house with the exception of the main bedroom and covered patio which may experience issues with glare.**

The UDI results in conjunction ASE results provide evidence that the current shading device design in the main bedroom would need to be improved.



Daylight Summary

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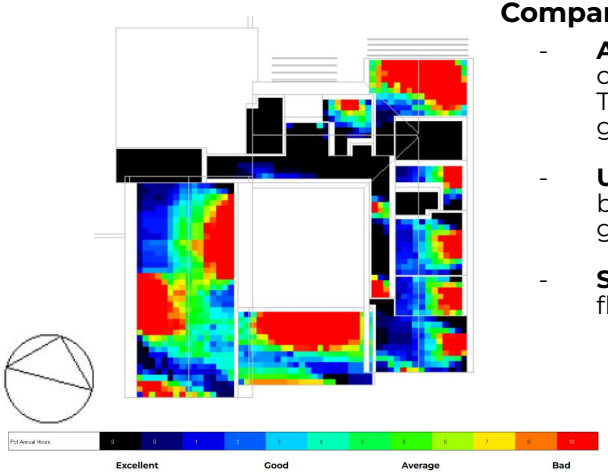
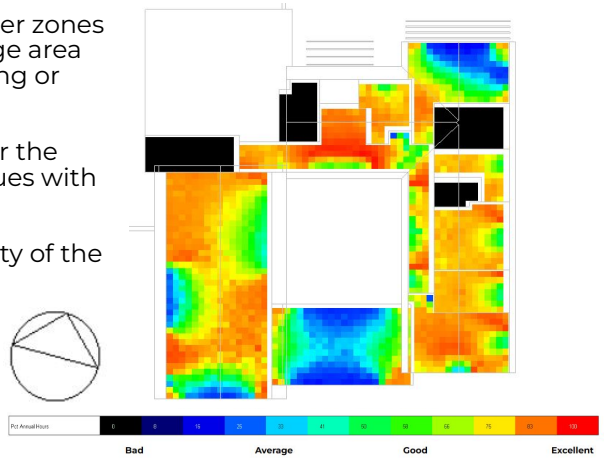
ASE



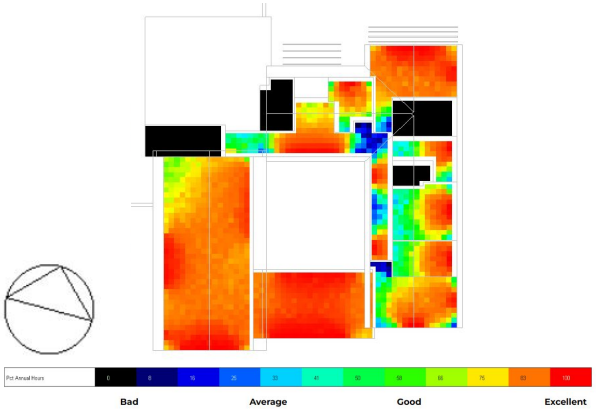
Comparison of SDA, ASE and UDI

- **ASE** shows high levels of sunlight exposure on perimeter zones of the main bedroom, covered patio, kitchen and lounge area These zones may have issues with glare. Internal shading or glass size adjustments will mitigate the issue.
- **UDI** shows very good levels of useful daylight except for the bedroom and covered patio which may experience issues with glare.
- **SDA** shows high levels of daylight autonomy for majority of the floor area .

UDI

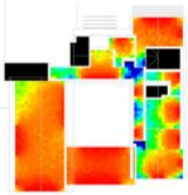
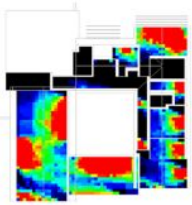
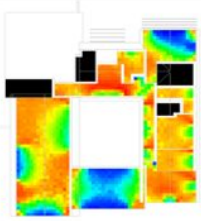
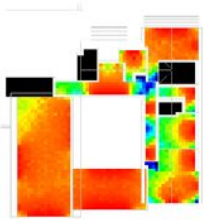
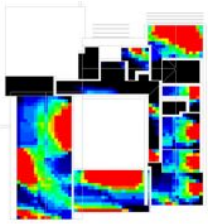
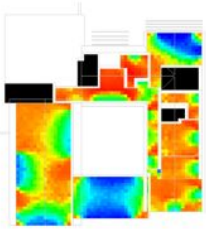
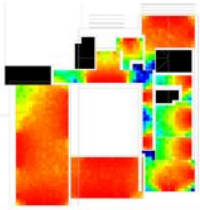
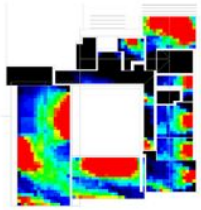
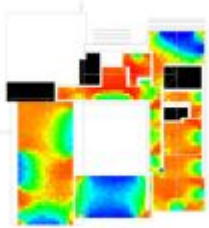


SDA



Based on initial modelling there are high levels of daylight entering the building.

Daylight Summary

Location	Daylight Metric		
	SDA	ASE	UDI
CPT			
JHB			
DBN			

SDA

ASE

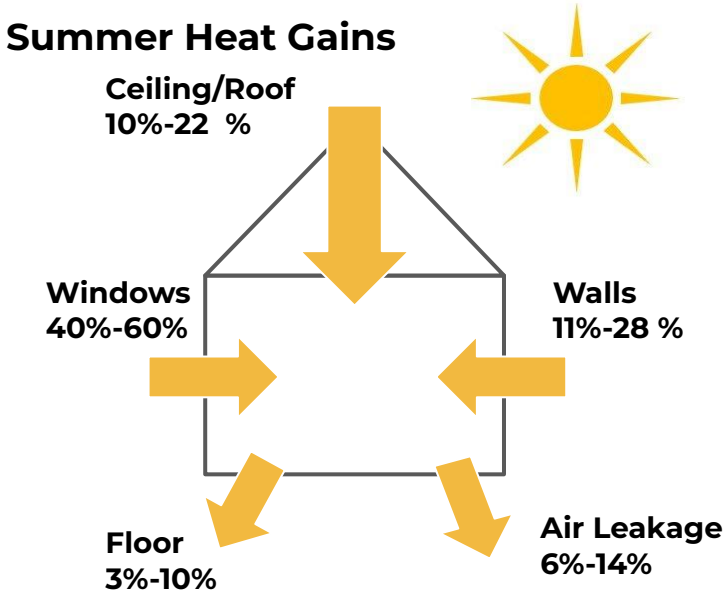
UDI

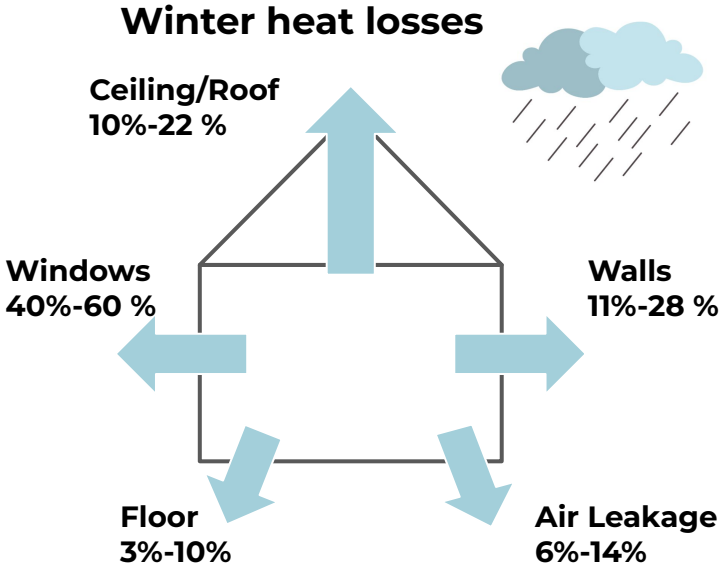
Comparison of SDA, ASE and UDI

- **SDA** shows high levels of daylight autonomy for majority of the floor area, in all three climate zones
- **ASE** shows high levels of sunlight exposure on perimeter zones of the main bedroom, covered patio, kitchen and lounge area. These areas may have issues with glare. shading or glass size adjustments is required in all three climate zones.
- **UDI** shows very good levels of useful daylight throughout the floor area with an average in the good-excellent range, in Cape Town and Johannesburg. In all three climate zones

Thermal Comfort

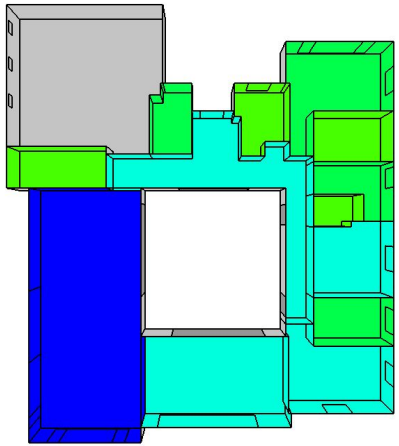
Heat gains and losses within a house occur from the ceiling, walls and windows. Key interventions to consider in order to control these gains and losses include consideration insulation and fenestration U-value .



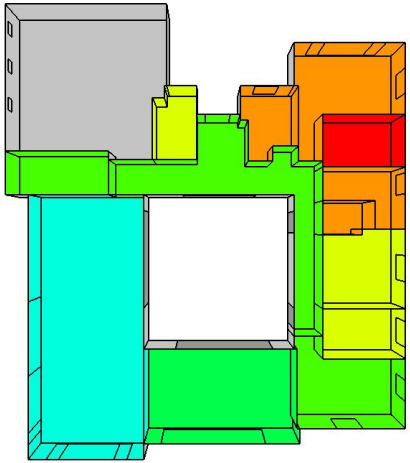


Impact of Insulation (Winter)-CPT

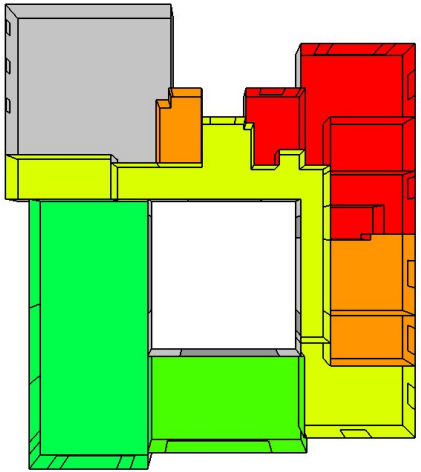
The graphic below depicts the impact of insulation during Winter (08:00 AM, 7 July). The building with insulation(as per drawings) is compared with the building without insulation.The window VLT and SHGC were kept constant. It can be seen that insulating the roof/ceiling and walls reduces heat losses resulting in increased internal air temperatures.



No Wall and Roof Insulation



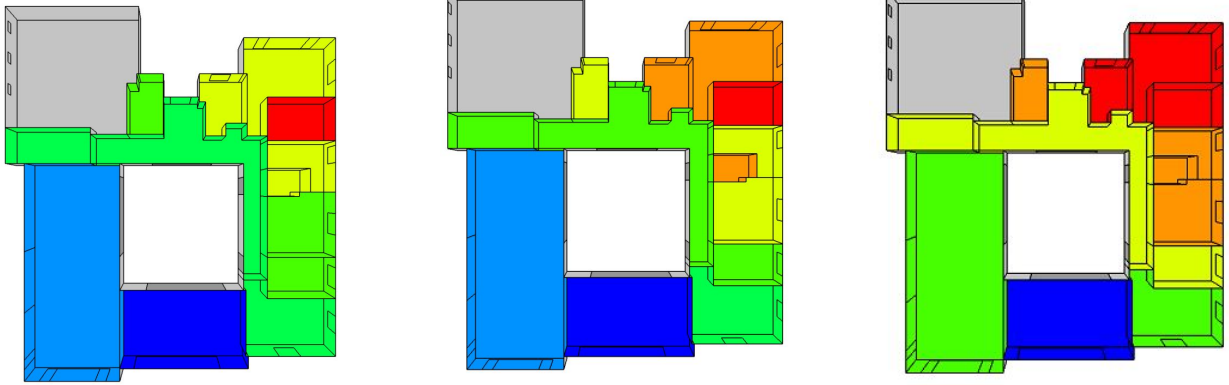
Roof Insulation Only



Roof and Wall Insulation

Impact of Fenestration U-Value (Winter)- CPT

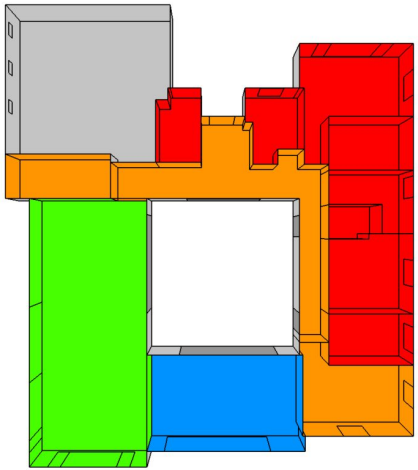
The air temperature maps below depict the impact of the window construction U-value in Winter (08:00 AM 7 July). The glass VLT and SHGC values were kept constant. It can be seen that improving the window construction U-value improves the buildings heat retention resulting in increased air temperatures. The Lounge and Kitchen zones have the lowest internal temperature.



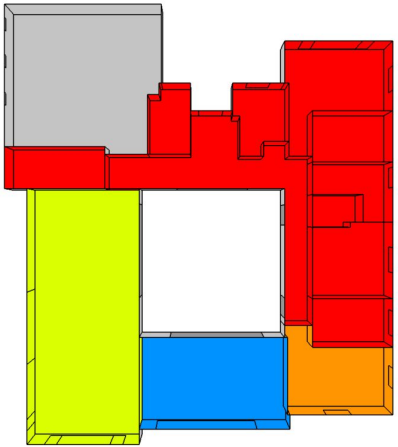
U=6.8 U=4.6 U=1.9

Impact of Fenestration U-Value (Winter)- CPT

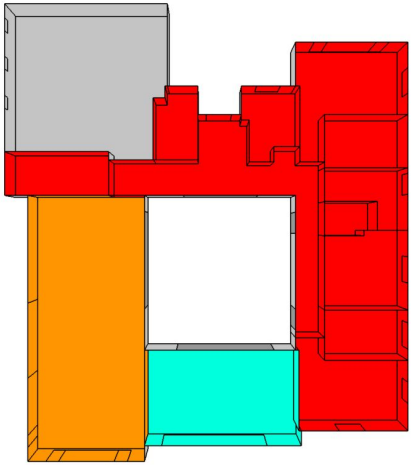
The temperature difference in the living room and kitchen space is depicted below at a higher resolution.



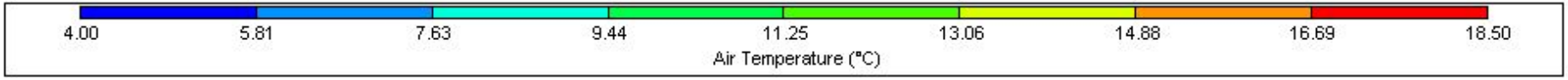
U=6.8



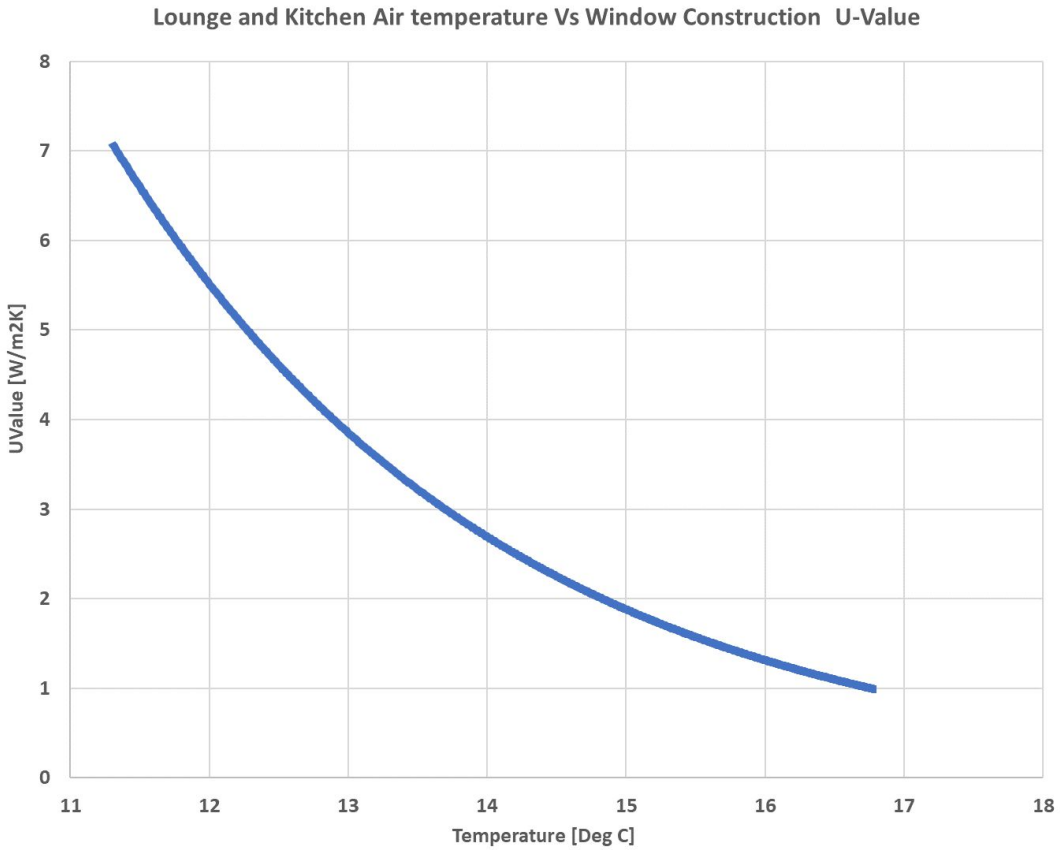
U=4.6



U=1.9



Impact of Fenestration U-Value (Winter)-CPT

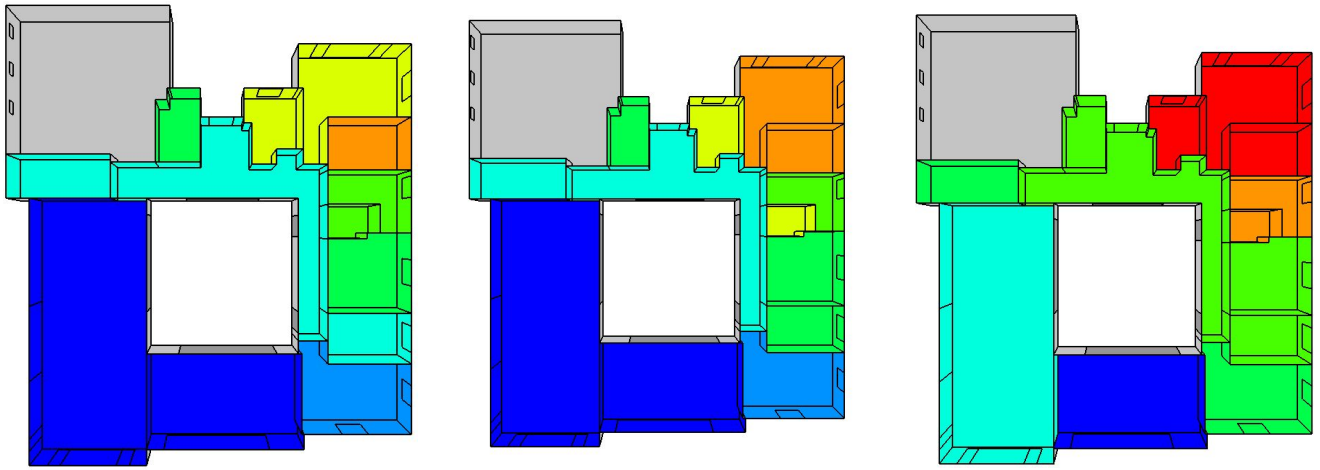


The Graph depicts the relationship between the Internal air temperature and the Construction U-value of the window for the Lounge and Kitchen Zones in Cape Town.

Internal temperatures range between 11.9 to 16.6 degrees celsius for fenestration Construction U-values of between 5.6 and 1.1 W/m2K

Impact of Fenestration U-Value (Winter) - JHB

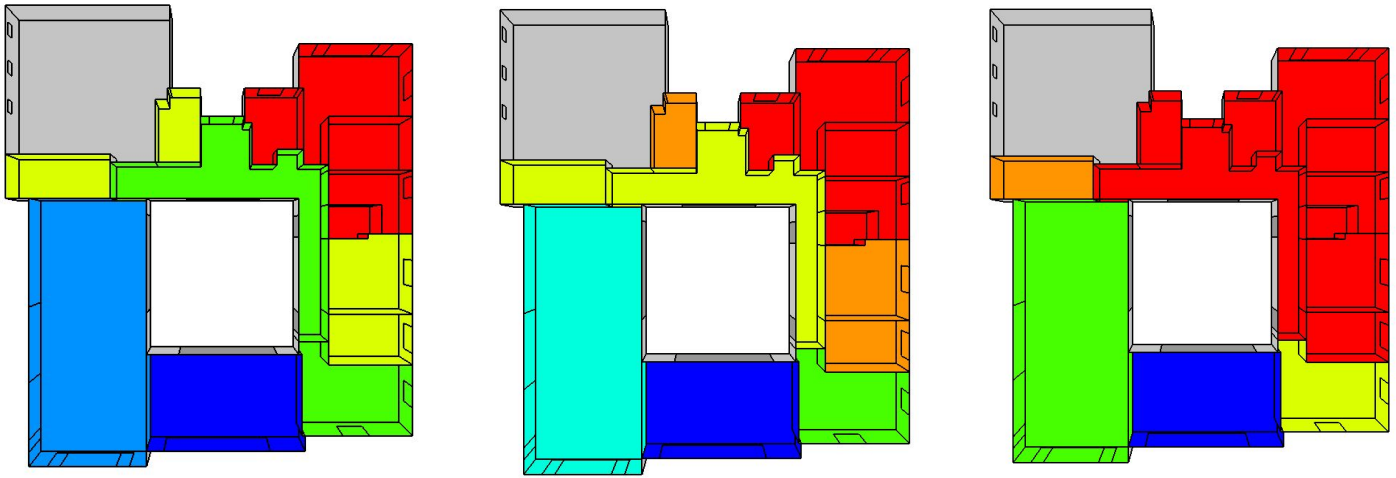
The air temperature maps below depict the impact of the window construction U-value in winter (08:00 AM 21 July). The glass VLT and SHGC values were kept constant. It can be seen that improving the window construction U-value improves the buildings heat retention resulting in increased air temperatures. The Lounge and Kitchen zones have the lowest internal temperature.



U=6.8 U=4.6 U=1.9

Impact of Fenestration U-Value (Winter) - JHB

The temperature difference in the living room and kitchen space is depicted below at a higher resolution

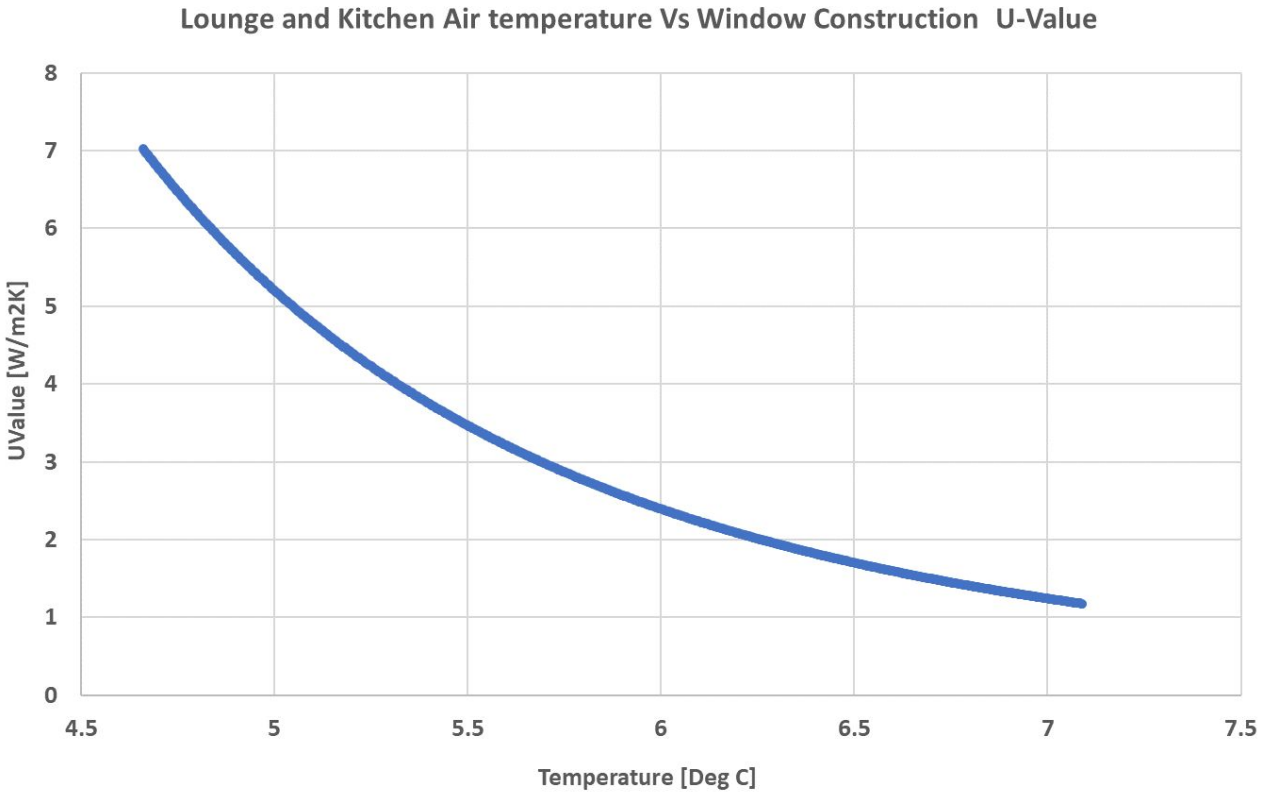


U=6.8

U=4.6

U=1.9

Impact of Fenestration U-Value (Winter) - JHB

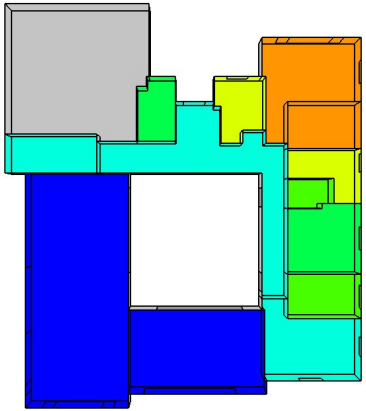


The Graph depicts the relationship between the Internal air temperature and the Construction U-value of the window for the Lounge and Kitchen Zones in Johannesburg

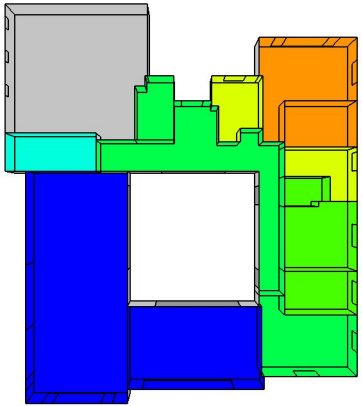
Internal temperatures range between 4.8 to 7.1 degrees celsius for fenestration Construction U-values of between 5.6 and 1.1 W/m2K

Impact of Fenestration U-Value (Winter) - DBN

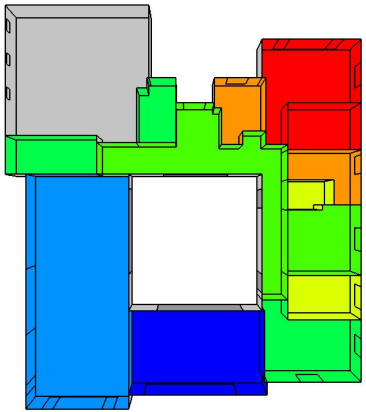
The air temperature maps below depict the impact of the window construction U-value in winter (08:00 AM 8 June). The glass VLT and SHGC values were kept constant. It can be seen that improving the window construction U-value improves the buildings heat retention resulting in increased air temperatures. The Lounge and Kitchen zones have the lowest internal temperature.



U=6.8



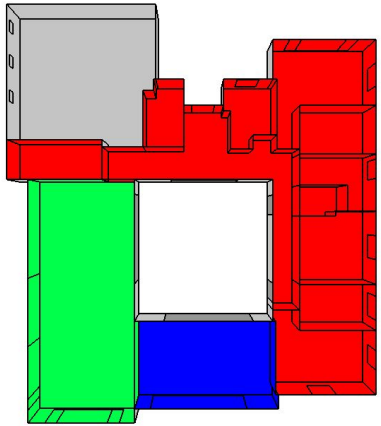
U=4.6



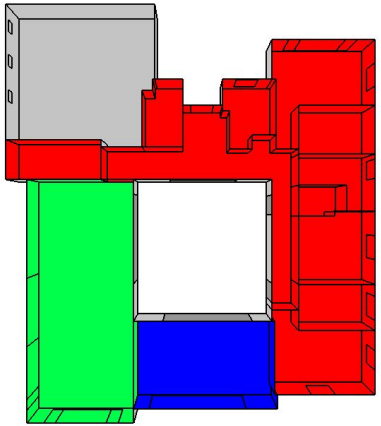
U=1.9

Impact of Fenestration U-Value (Winter) - DBN

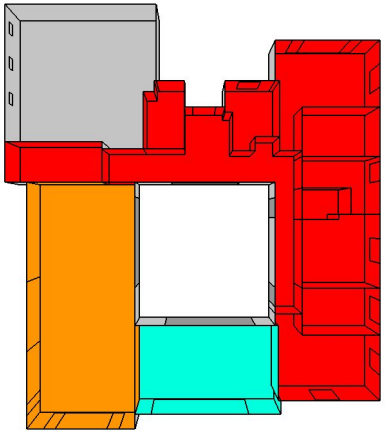
The temperature difference in the living room and kitchen space is depicted below at a higher resolution



U=6.8

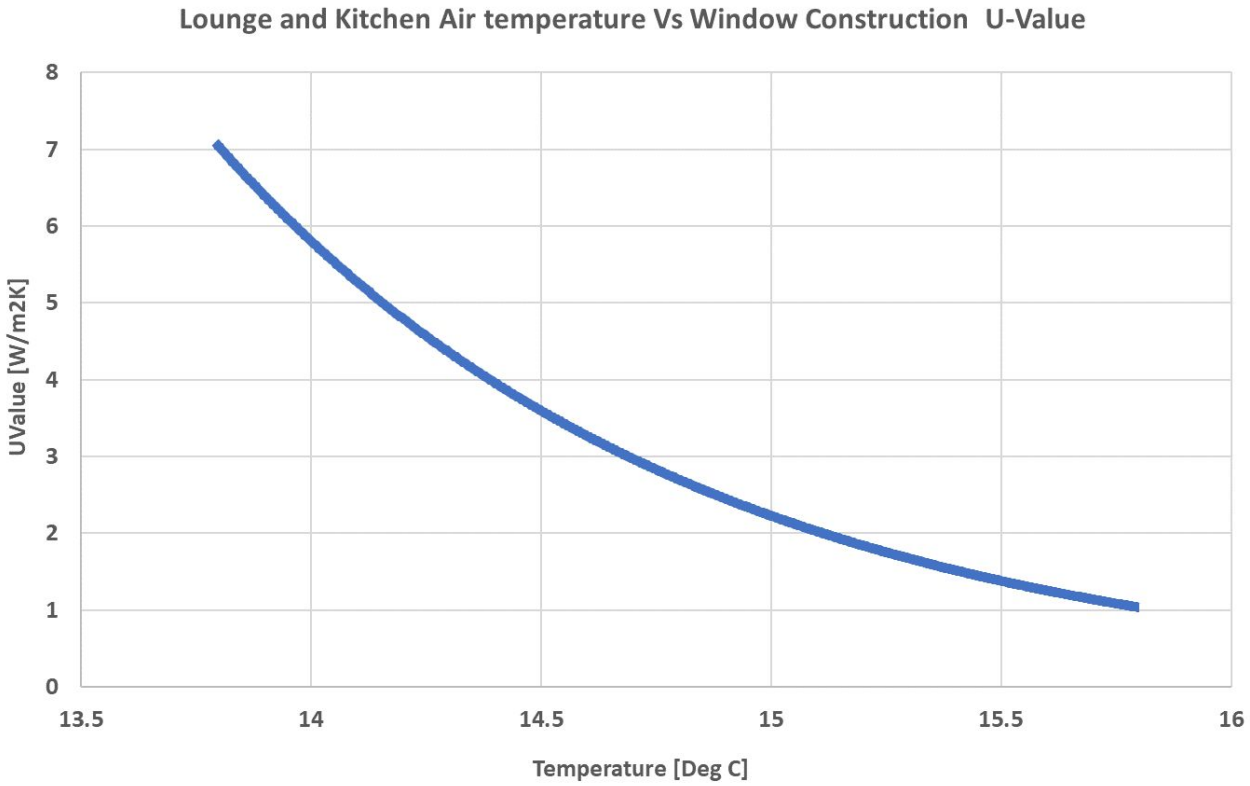


U=4.8



U=1.9

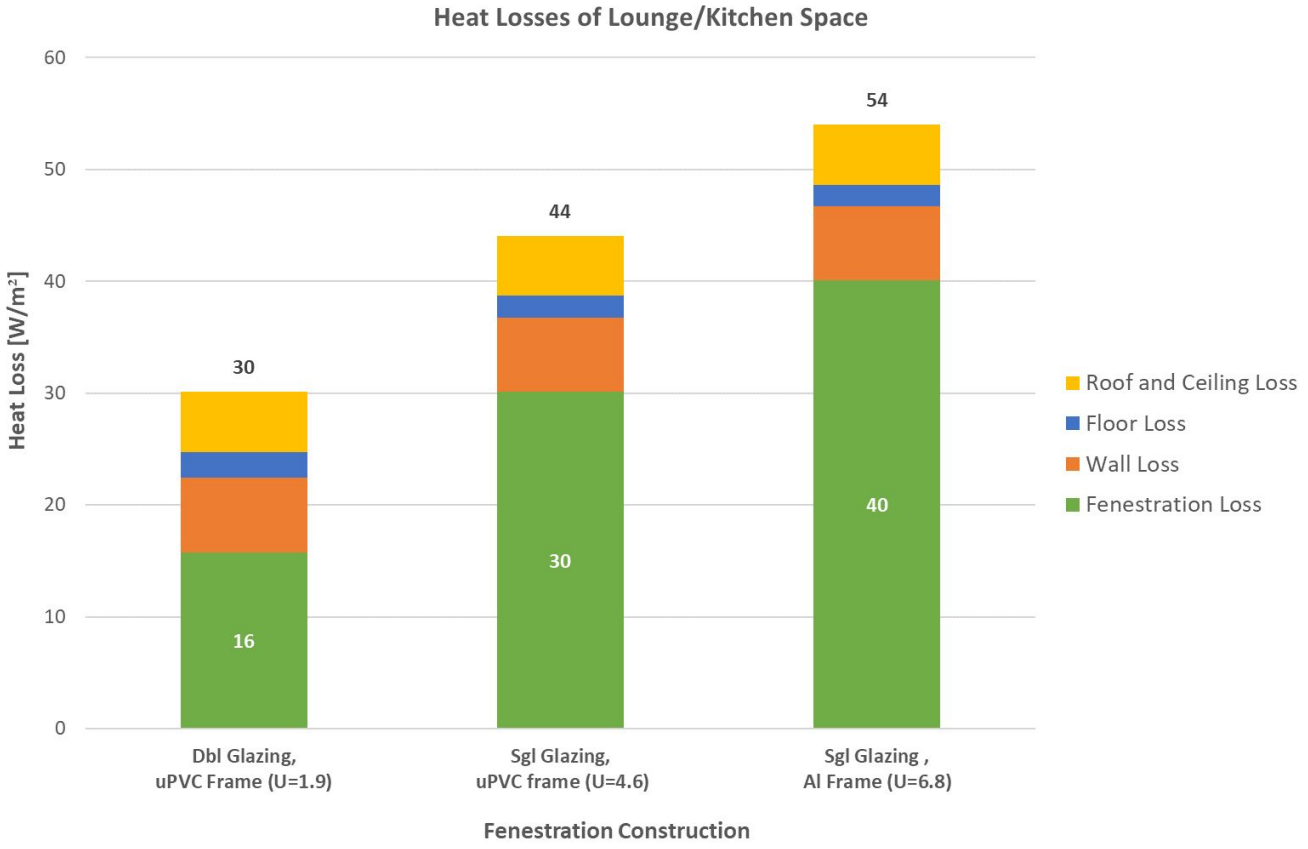
Impact of Fenestration U-Value (Winter) - DBN



The Graph depicts the relationship between the Internal air temperature and the Construction U-value of the window for the Lounge and Kitchen Zones In Durban

Internal temperatures range between 14 to 15.7 degrees celsius for fenestration Construction U-values of between 5.6 and 1.1 W/m2K

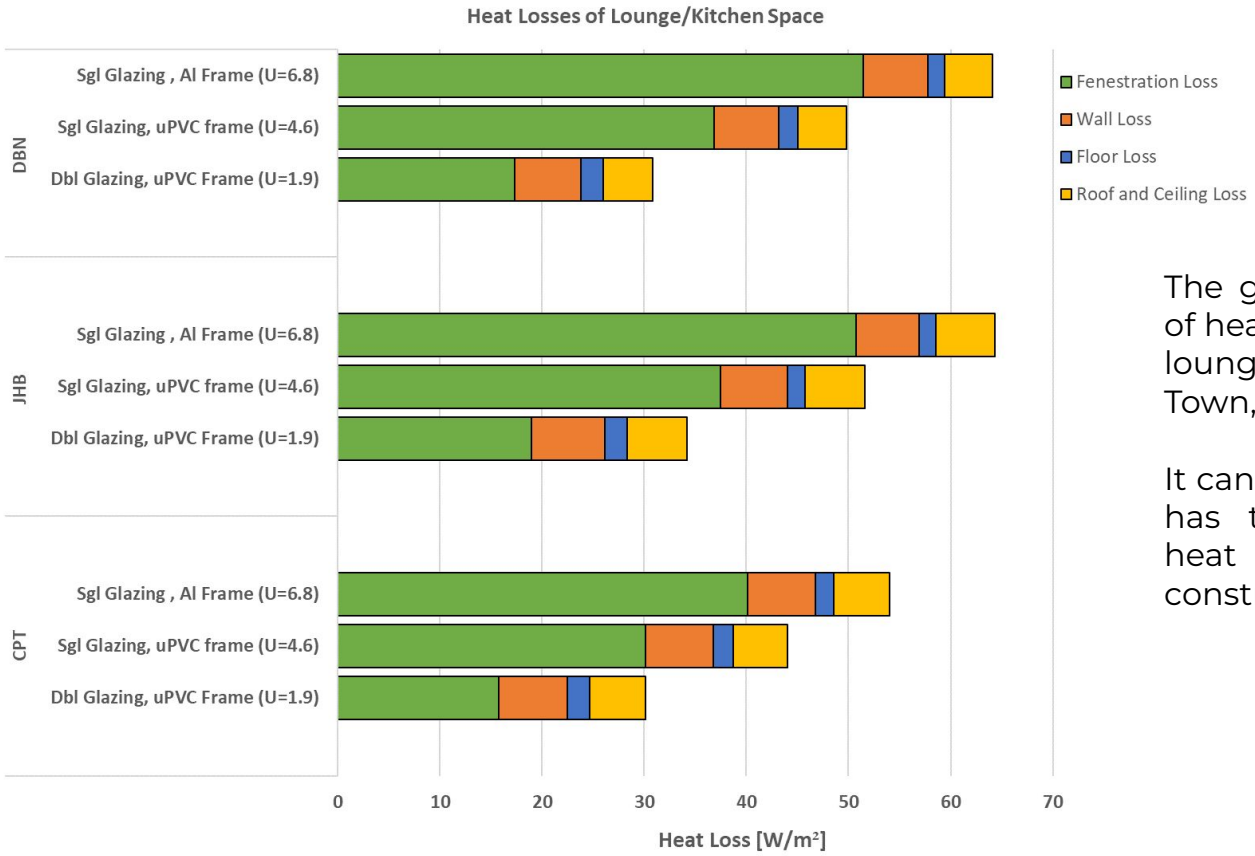
Fenestration Contribution To Heat Loss - CPT



The graph depicts the magnitude of heat losses from the Kitchen and lounge space in Winter in Cape Town

It can be seen that the fenestration has the highest magnitudes of heat loss at the different construction U-Values.

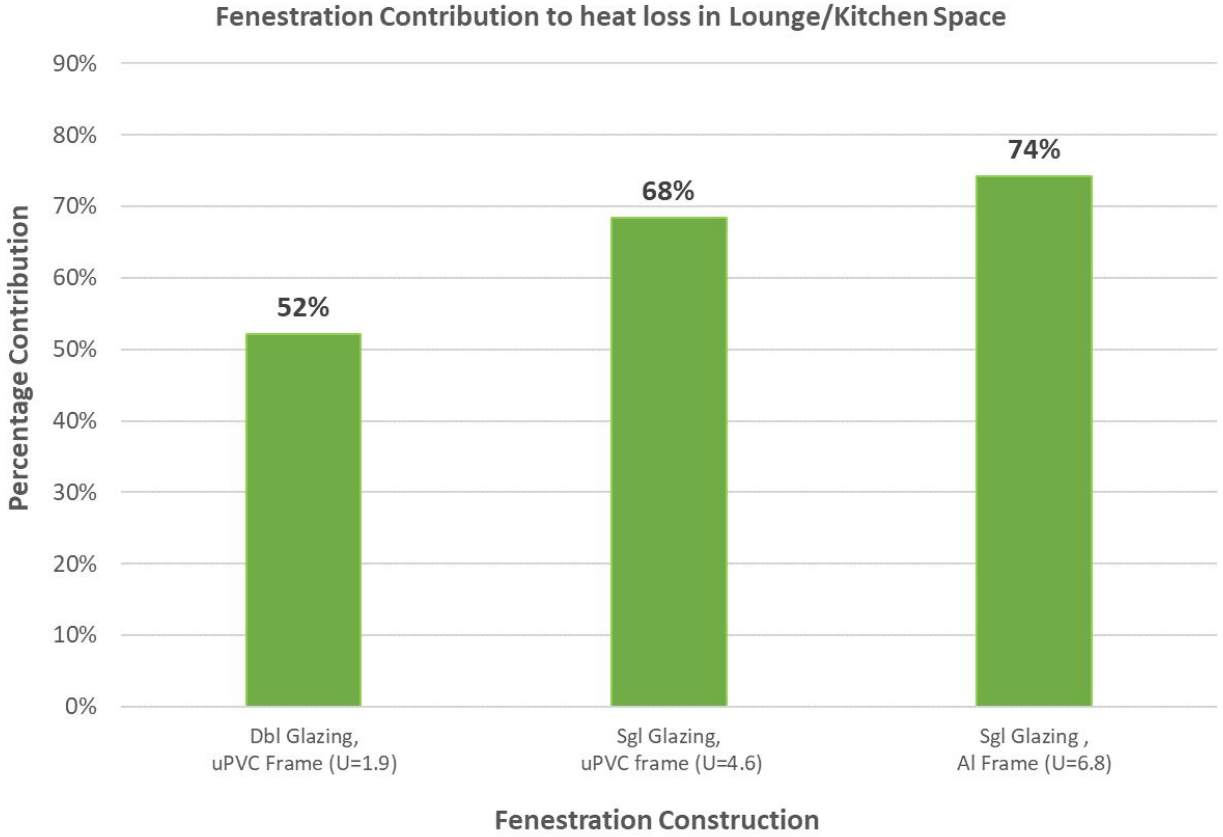
Fenestration Contribution To Heat Loss



The graph depicts the magnitude of heat losses from the Kitchen and lounge space in Winter in Cape Town, Johannesburg and Durban.

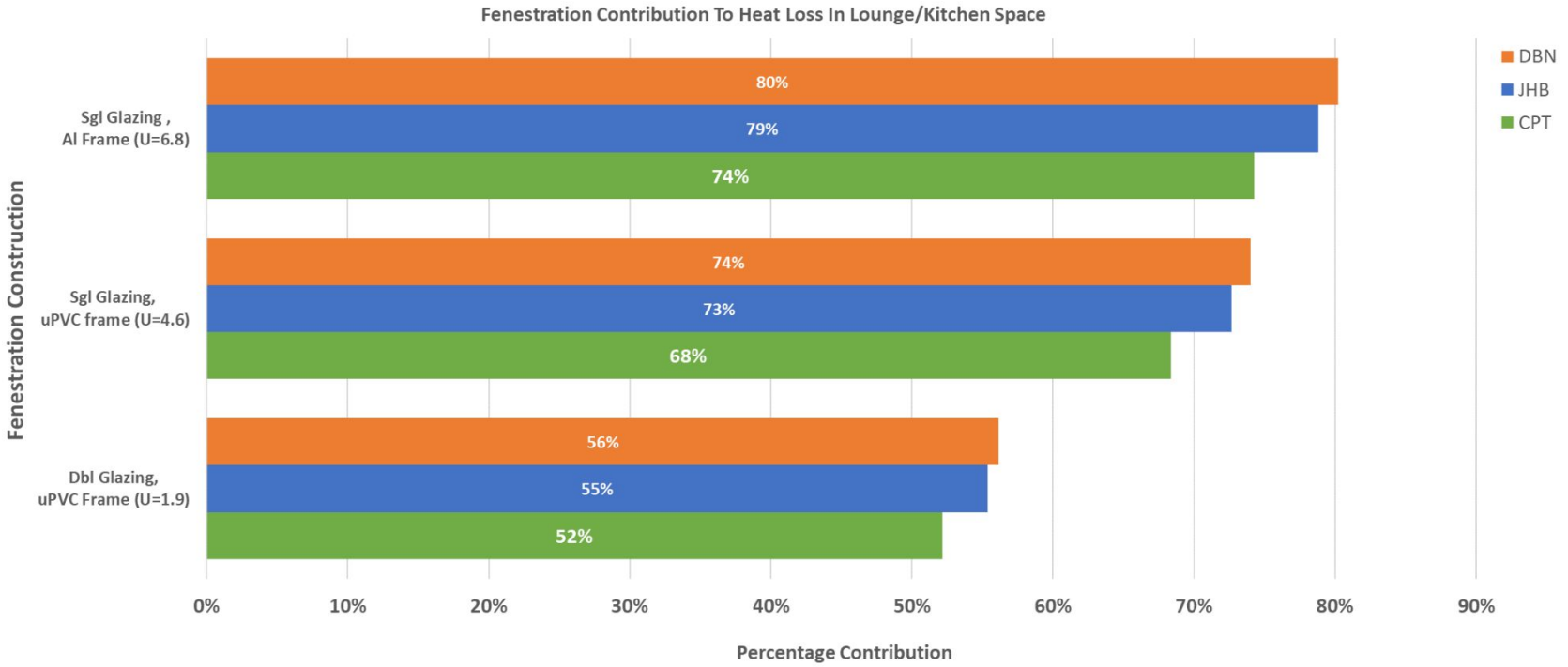
It can be seen that the fenestration has the highest magnitudes of heat loss at the different construction U-Values.

Fenestration Contribution To Heat Loss -CPT



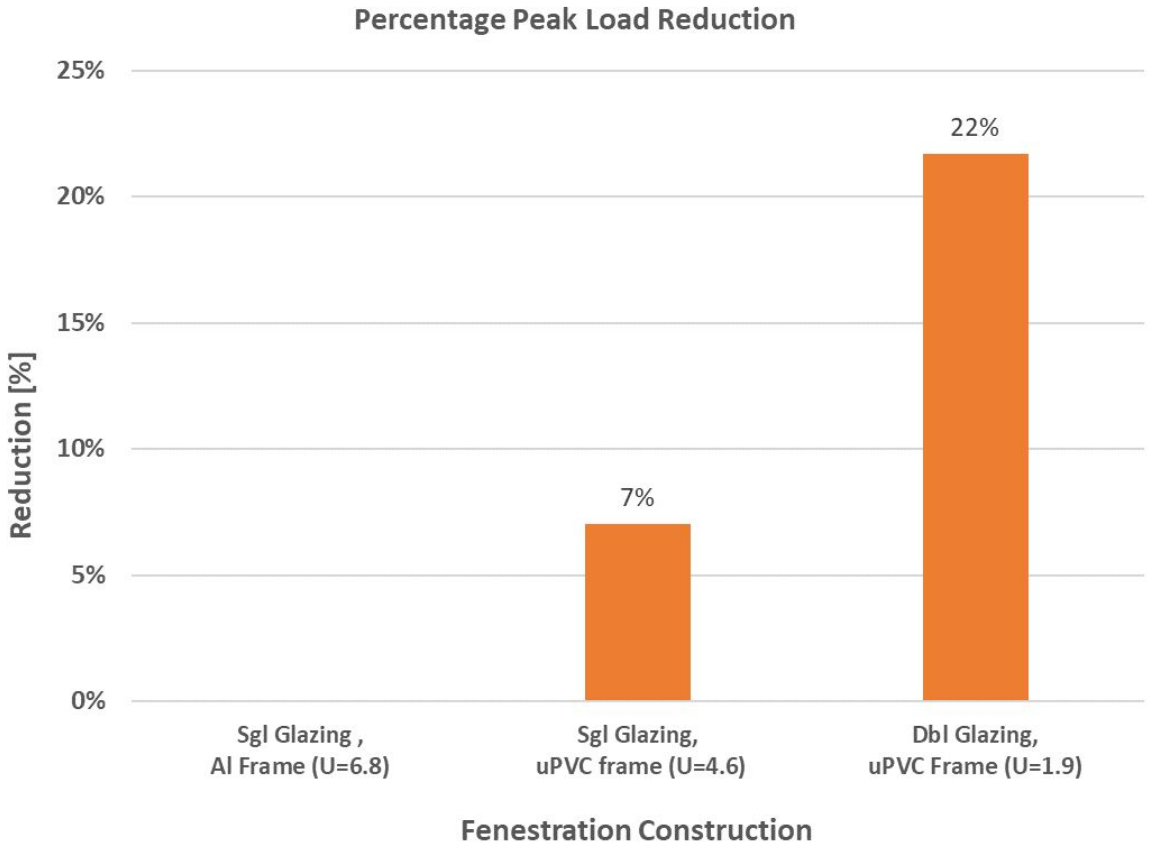
The graph depicts the contribution of heat losses through the fenestration as a percentage at different construction U-Values.

Fenestration Contribution To Heat Loss



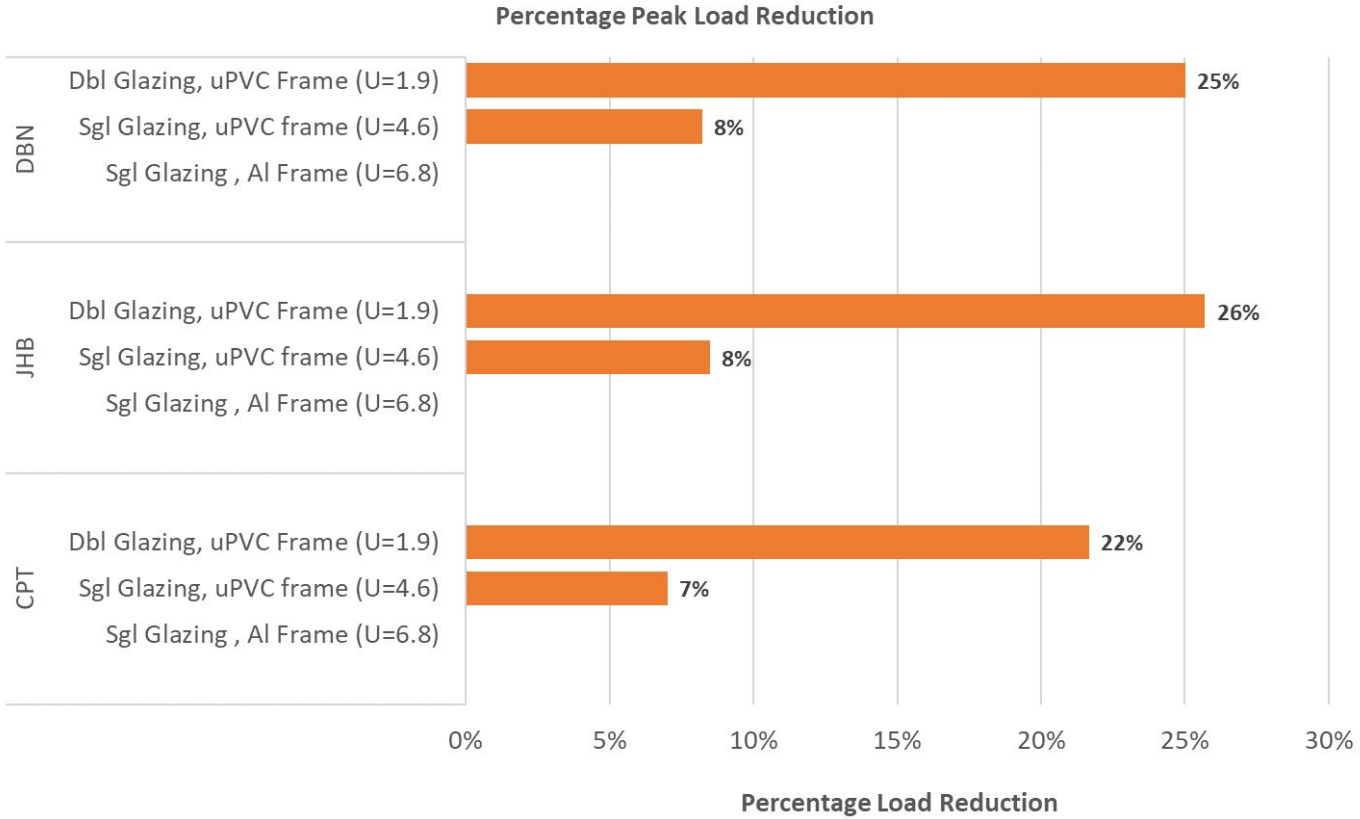
The graph depicts the contribution of heat losses through the fenestration as a percentage at different construction U-Values across Cape Town , Johannesburg and Durban.

Peak Heating Load Cape Town



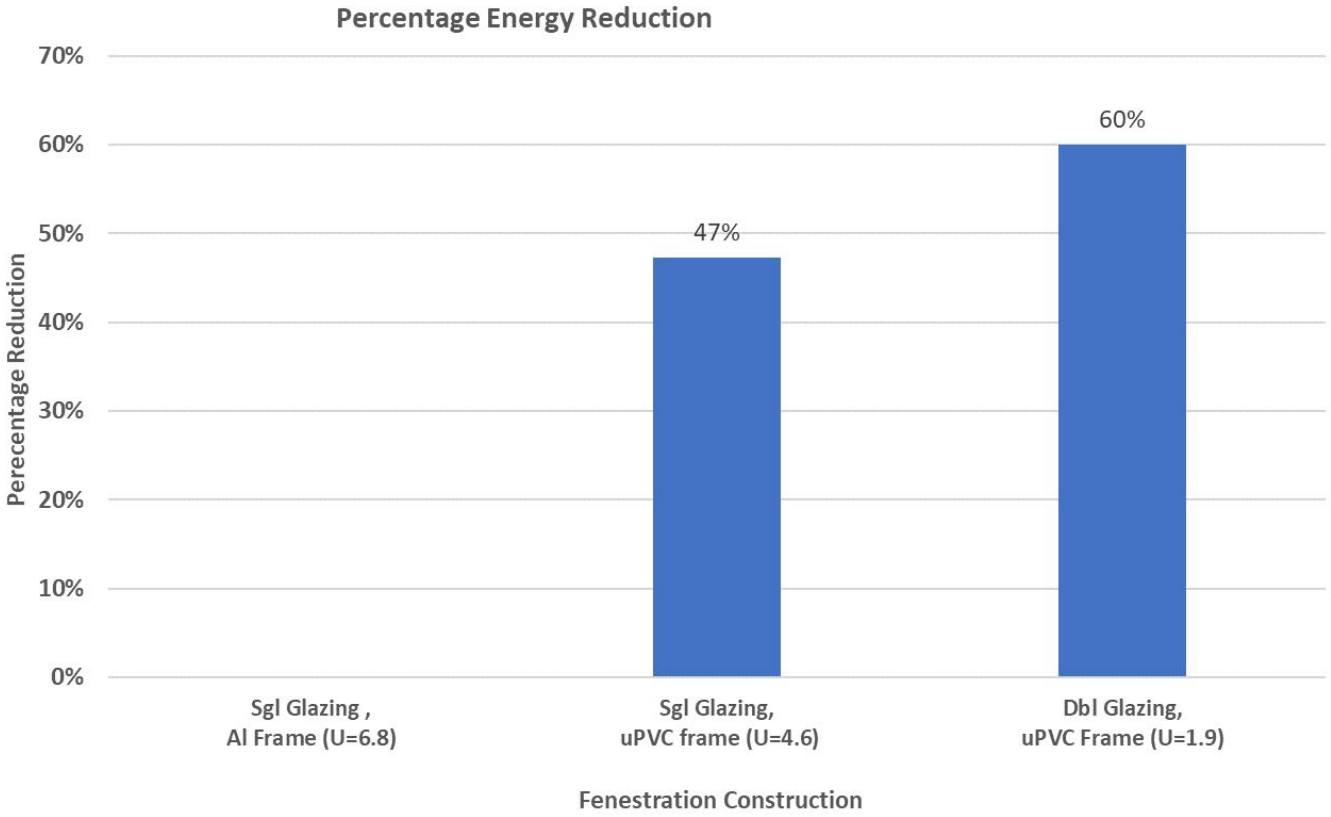
The reduction in the peak heating load throughout the house is depicted as a percentage at different construction U-Values.

Peak Heating Load



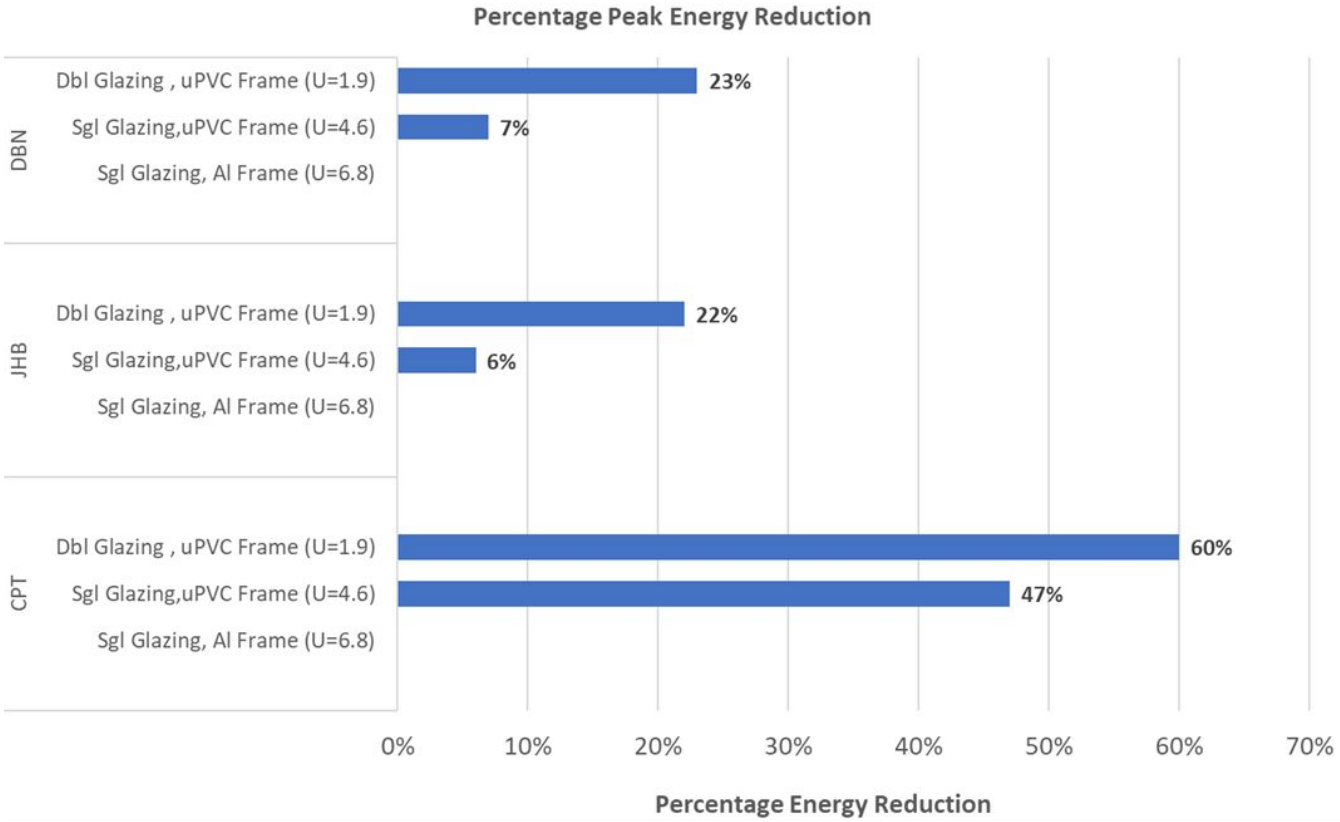
The reduction in the peak heating load throughout the house is depicted as a percentage at different construction U-Values in the different climate zones.

Heating Energy Reduction: Cape Town



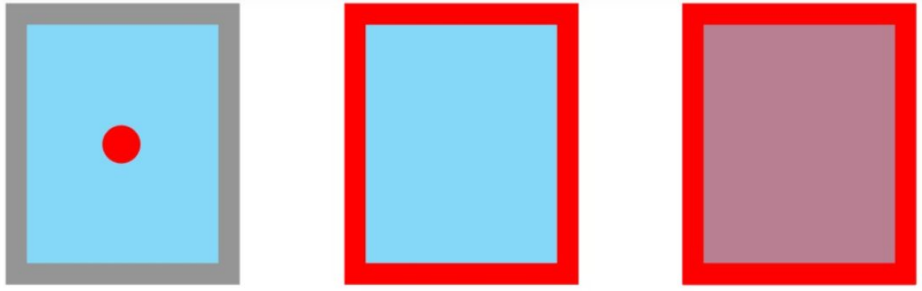
The reduction in the annual energy consumed from space heating in the house is represented as a percentage at the different construction U-values.

Heating Energy Summary



The reduction in the annual energy consumed from space heating in the house is represented as a percentage at the different construction U-values in Cape town , Johannesburg and Durban.

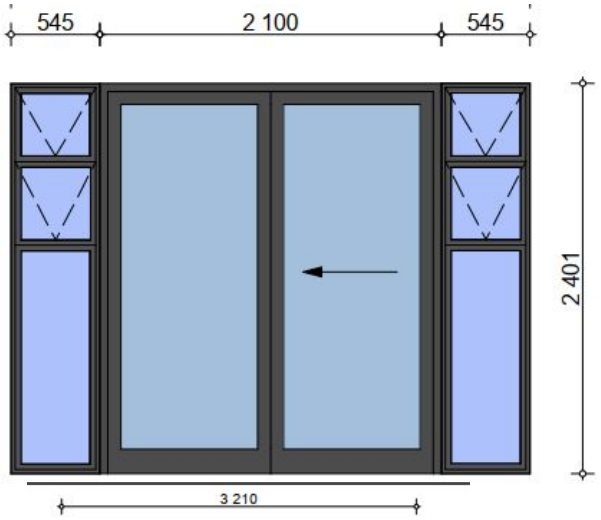
Mapping Industry Values

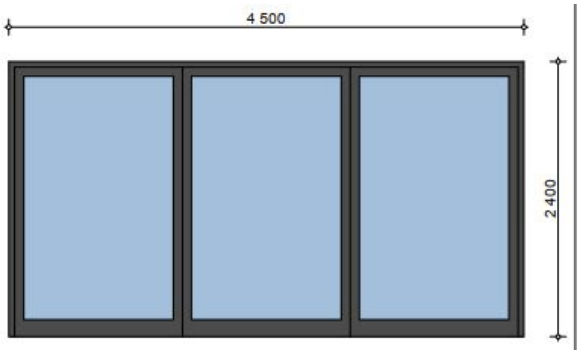


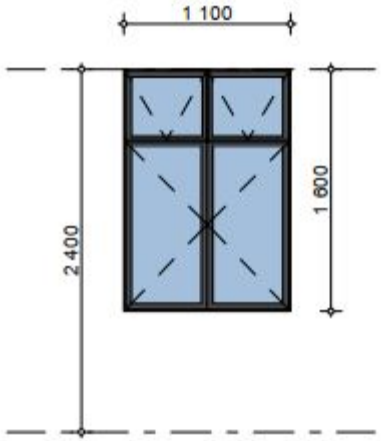
Values for glass and frame are entered separately

Window Frame Material	U-Value W/m2-K
Aluminium (no thermal break)	5.8
Aluminium (thermal break)	4.8
uPVC (Standard)	3.4
Wood	3.6
uPVC (REHAU)	1.1

Mapping Industry Values







Thank you!

Chilufya Lombe
Solid Green Consulting

www.solidgreen.co.za

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