DO WE NEED MORE FOSSIL FUEL?

Adaptive Solutions and Increasing Building Energy Savings

MOHAMED AMER HEGAZY
MAY 19TH 2015

MENTOR: CHRISTIAN FRENZEL

This project goes under

ight different steps.

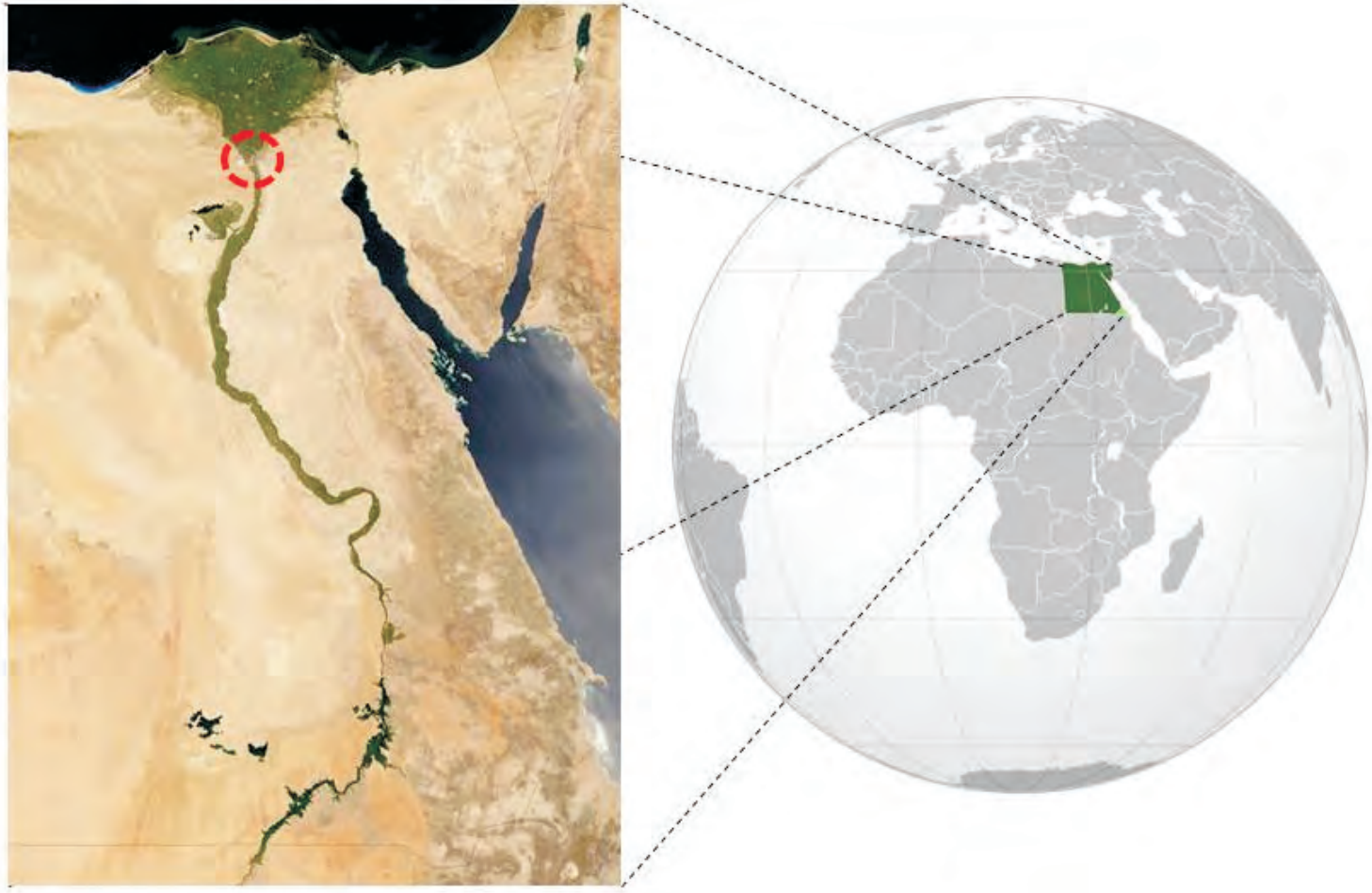
This project goes under eight different steps.

FACTS

Chapter One: The first step is about narrating some facts, by which my project and research were based on.

FACTS: EGYPT

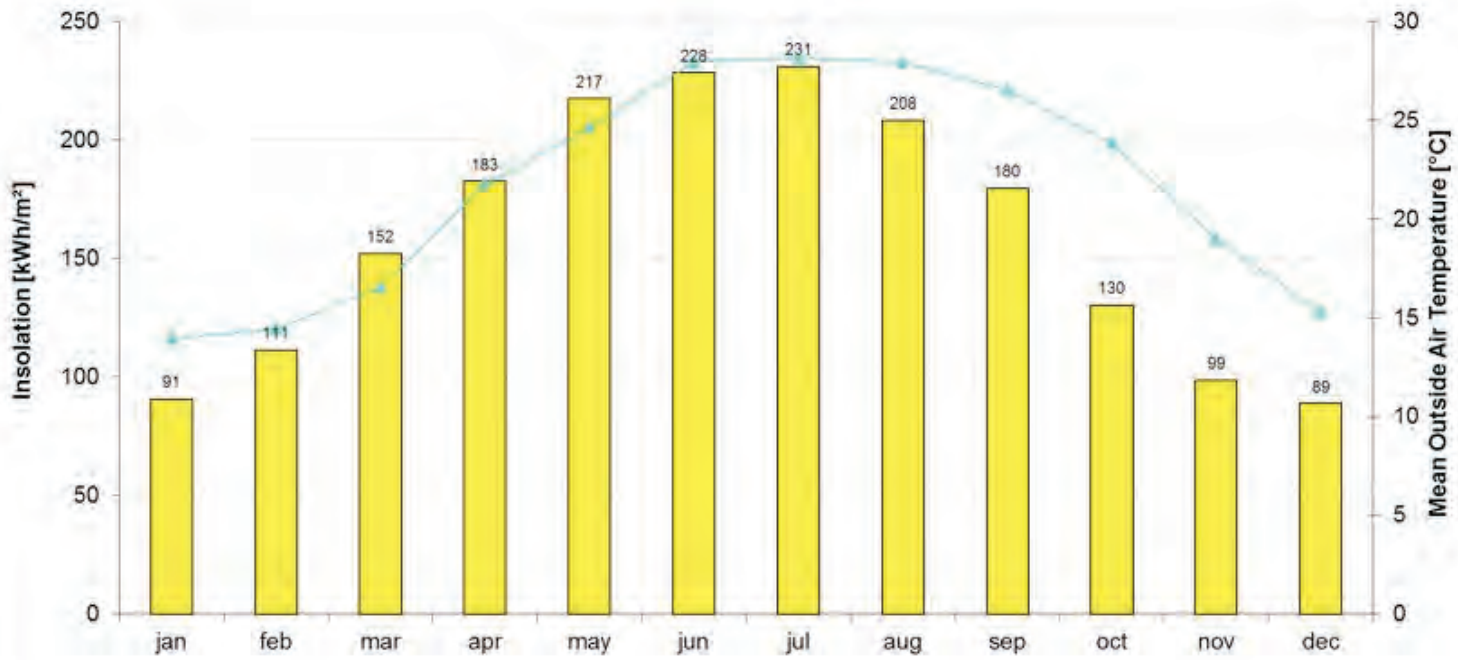
CAIRO



Egypt is located in north east africa, where cairo is my case study location.

FACTS: EGYPT

CAIRO – CLIMATE



Horizontal Insolation: 1919 kWh/m²/a
Yearly Mean Outside Temperature 21.7 °C
Nr. Of Hour With Outside Temperature Over 25 °C 2786 h
Nr. Of Hour With Outside Humidity Over 11.5 g/Kg 2362 h

Insolation [kWh/m²]

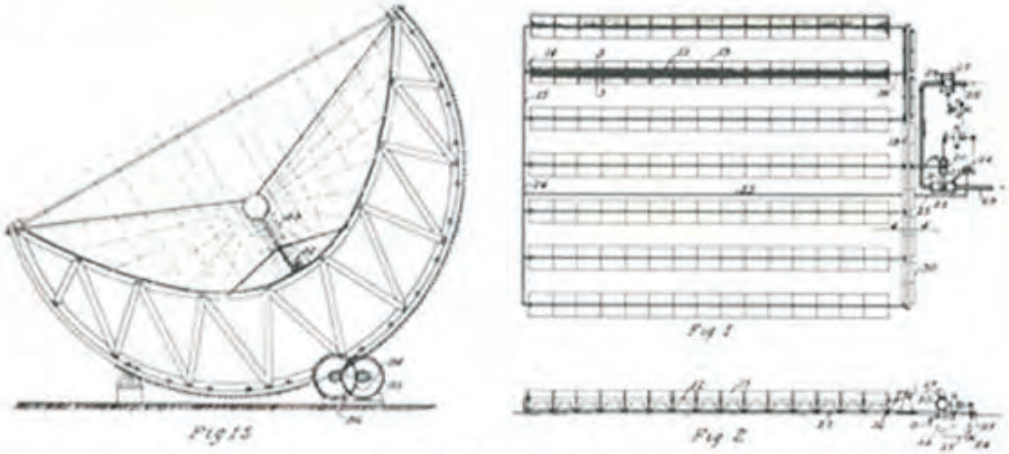
Mean Outside Air Temperature [°C]

Cairo is characterized by its cumulative high Insolation through out the year with more than 1900 kWh/m2/a

It lies in the northern hemisphere with a latitude 31 degrees, it has a dominant clear sky with higher insolation values during the summer

FACTS: EGYPT

CAIRO – CLIMATE

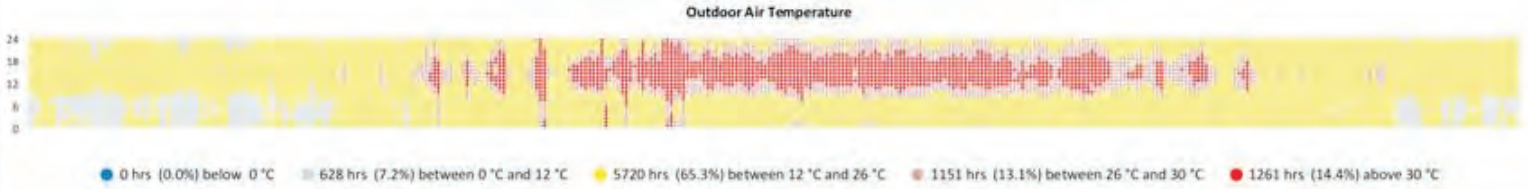


1912 – 1913

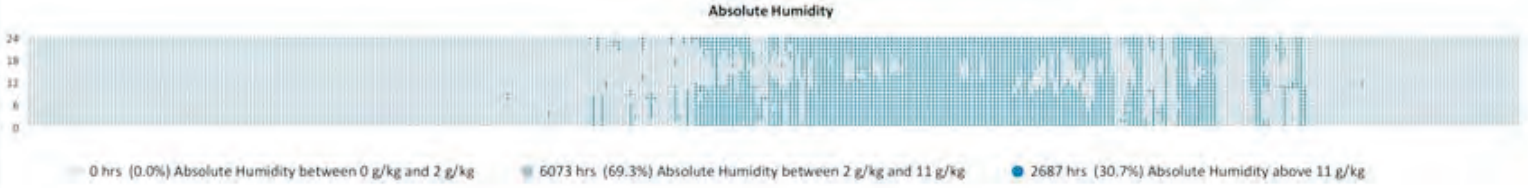
The first attempt in the world to use the sun in producing energy was in Egypt, Cairo.

FACTS: EGYPT

CAIRO – CLIMATE



65% between 12°C and 26°C



69% between 2g/kg and 11g/kg

Temperatures in Cairo should be moderate, with a 65% of the year period between 12 and 26 degree Celsius and 69% with humidity ranges between 2g/kg and 11g/kg, which gives better opportunity to depend on passive solution to achieve comfort.

FACTS: EGYPT

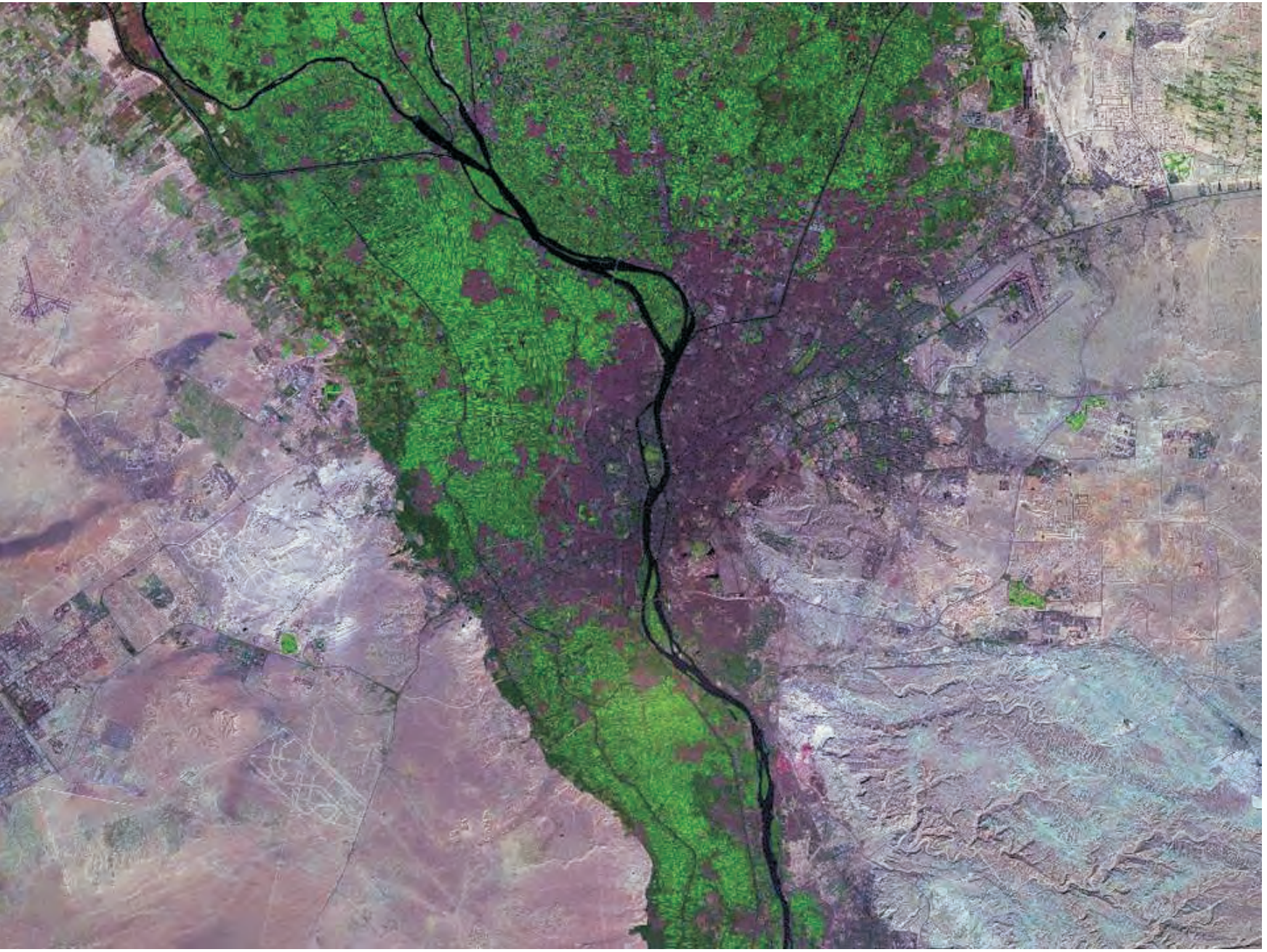
CAIRO – HISTORY

This is how houses in Cairo used to look like. Climatic approaches were highly considered in those buildings

FACTS: EGYPT

CAIRO – HISTORY

It used to be in good state till 60 years before, this is a picture of one of the last neighborhoods that were built 100 years ago.



However, since the 50's

. . . informalities and

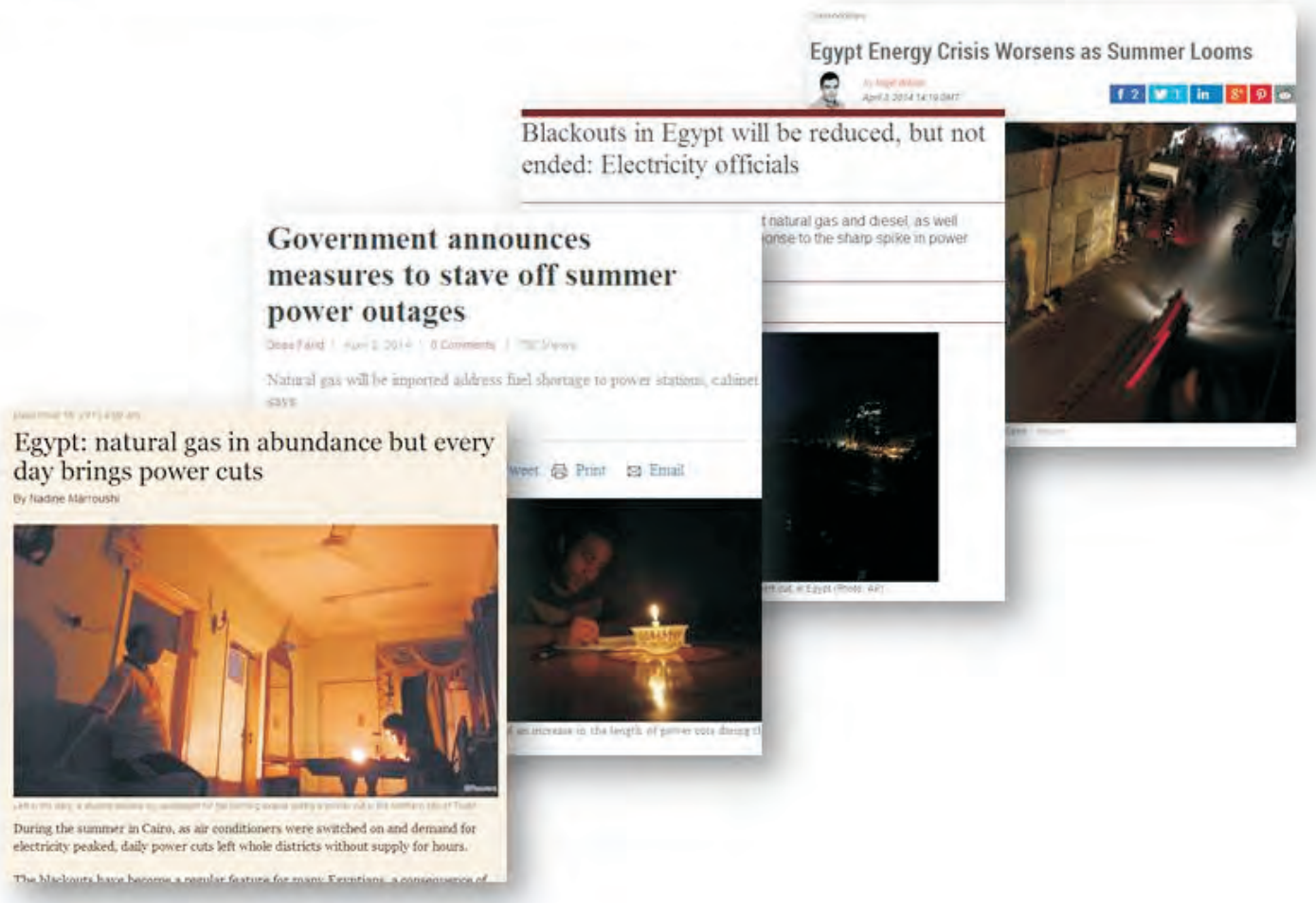
illegal expansions used to

take place.

This is how it looks like nowadays!

FACTS: ENERGY

CRISIS – BLACKOUTS



One of the recent problems the country faced was several blackouts due to over consumption of electricity and increasing use of AC's

That was one drive reason for me to propose my individual project.

FACTS
SUMMARY

Summary of the facts

- ENERGY CRISIS
- INCREASING DEMAND ON ENERGY
- GREAT POTENTIAL FOR PASSIVE SOLUTIONS

SELECTION

Chapter 2: Handles the criteria and process of selecting the case study.

SELECTION CRITERIA

- IN CAIRO
- MINIMUM 3 USERS IN THE HOUSE, MAXIMUM 5 USERS
- URBAN AREA
- TOP FLOOR APARTMENT
- TRUSTED HOUSHOLDS
- EASY TO MODEL

Five criteria were the base of the selection

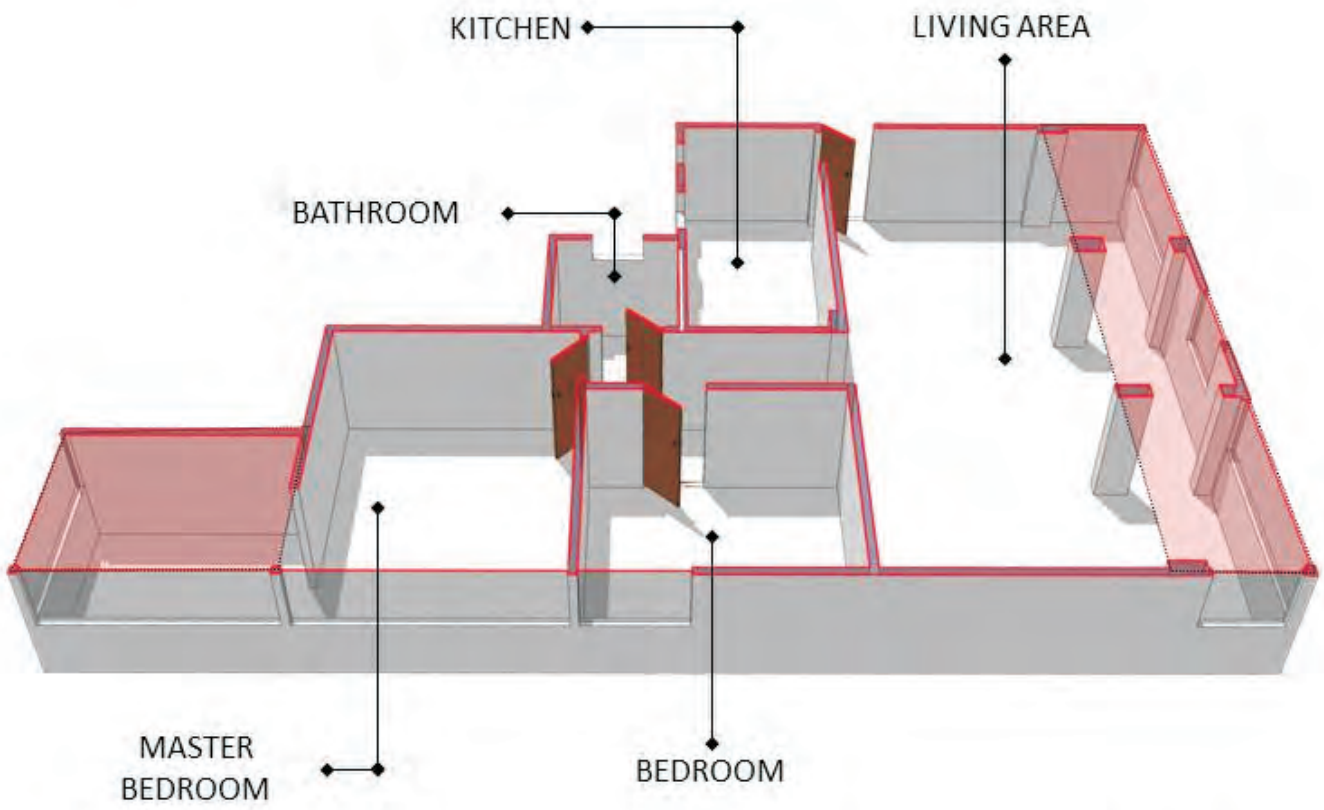
SELECTION CRITERIA

I have had at the beginning four possible options, based on the selection criteria, three were canceled

BASE CASE

Chapter 3: Handles the description of the base case

BASE CASE MODELLING

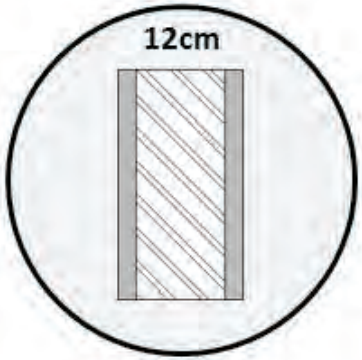


TOTAL AREA 120 m²

The base case is an apartment consists of one living area, two bedrooms, a kitchen and a bathrooms.

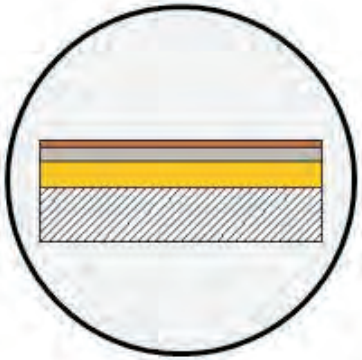
The red zones used to be balconies, but they are not at the moments and are included as interior zones.

BASE CASE MODELLING



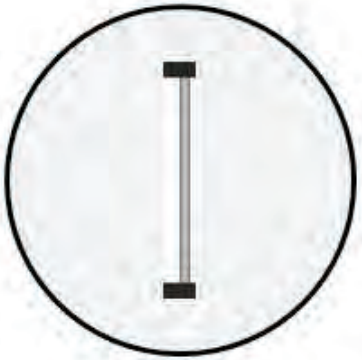
EXTERIOR WALLS

U-Value: 2.47 W/m²K



ROOF & SLABS

U-Value: 3.1 W/m²K



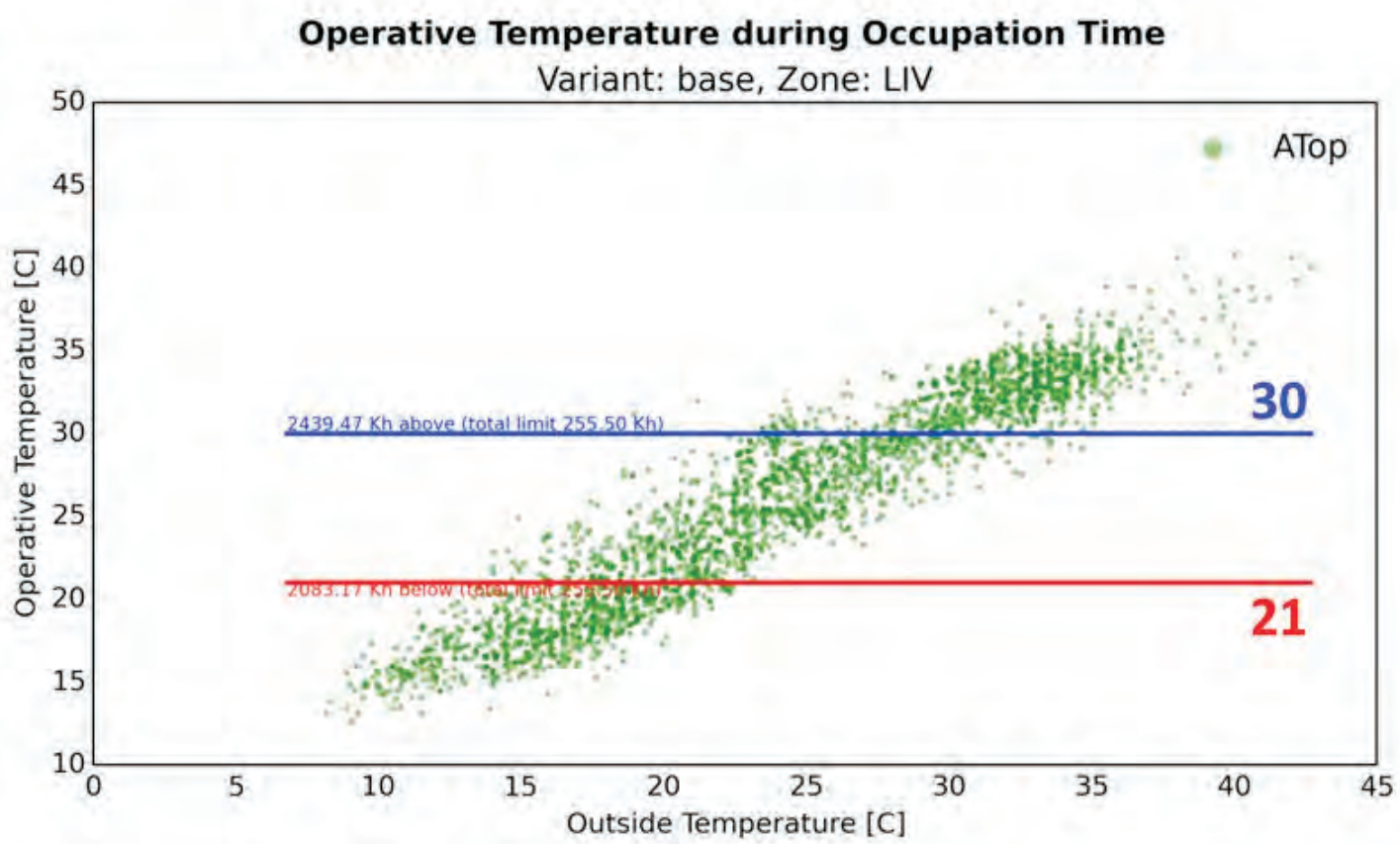
GLAZING

SHGC: 0.68
U-Value: 5.3 W/m²K

The base case material configurations

BASE CASE

MODELLING – COMFORT ZONE

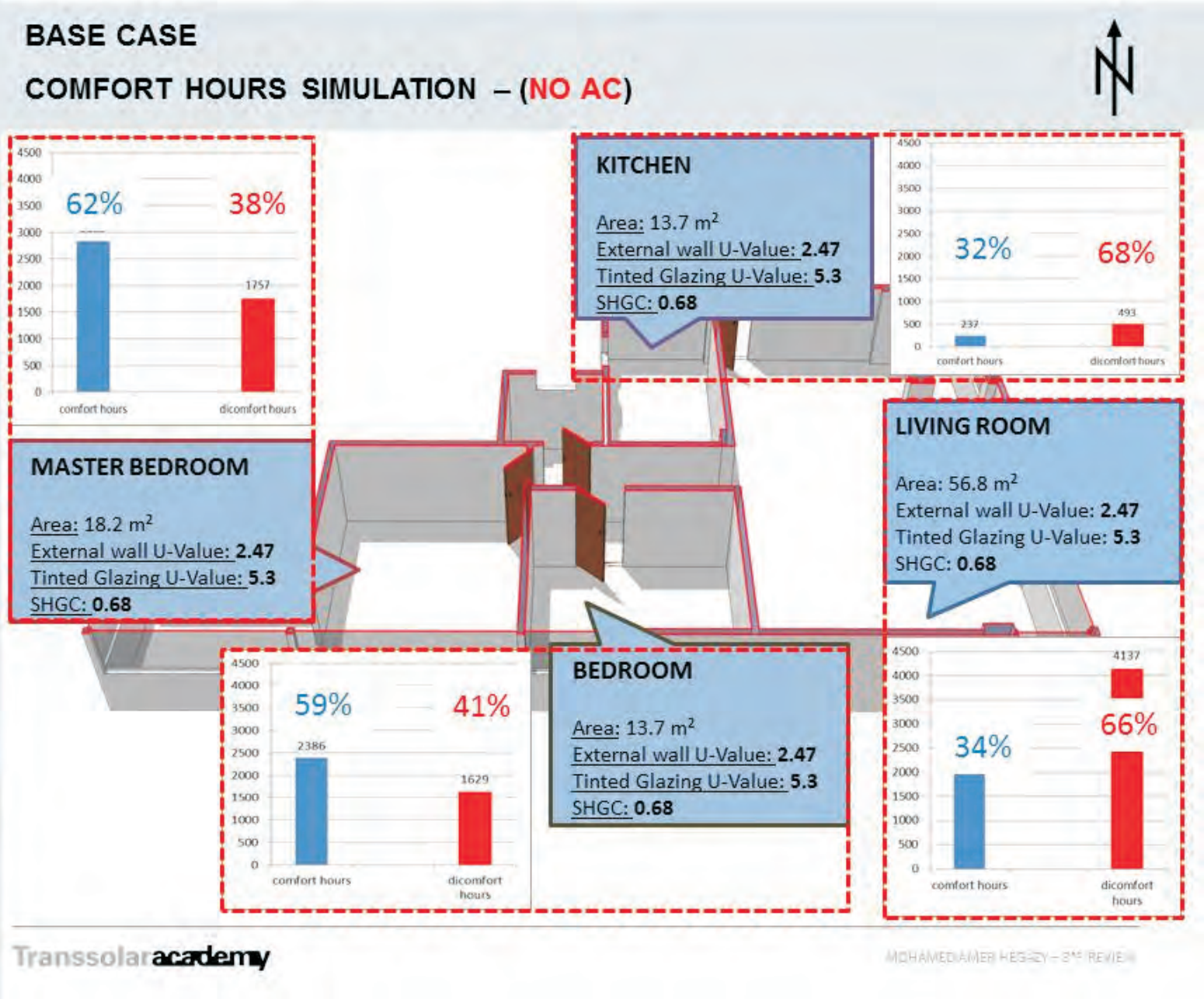


Energy Efficiency Code foe Residential Buildings, 2004

Several factors are contributing into assessing the thermal comfort.

However, to make it less complicated, all factors (clothing, metabolic rate, air speed, humidity) are considered a sort of adaptive in this case study (Or not considered in calculation), operative temperature were only considered to assess thermal comfort in this case.

Based on the Egyptian code, O. temperatures ranges from 21 till 30 are considered in the comfort zone.



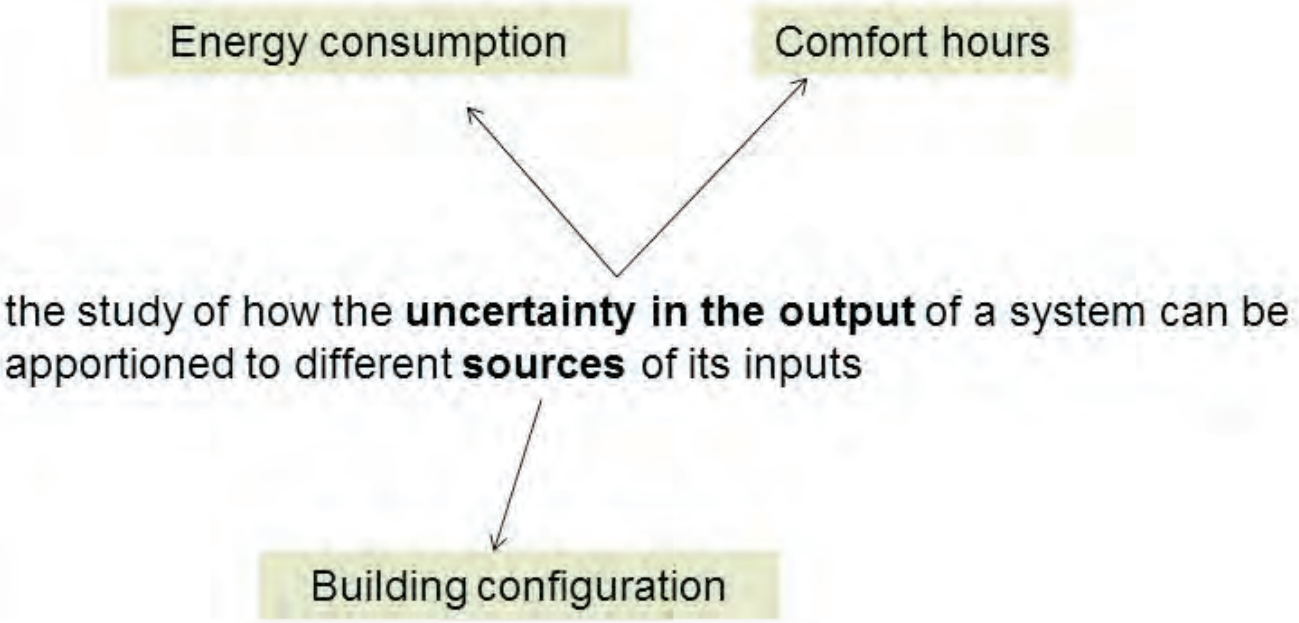
For the primary simulations, the number of comfort and discomfort hours were calculated to get an over view how far does the base case provide comfort to occupants.

SENSITIVITY

Chapter four: Sensitivity analysis is conducted to define the building configuration with the highest influence on comfort and energy consumption.

SENSITIVITY ANALYSIS

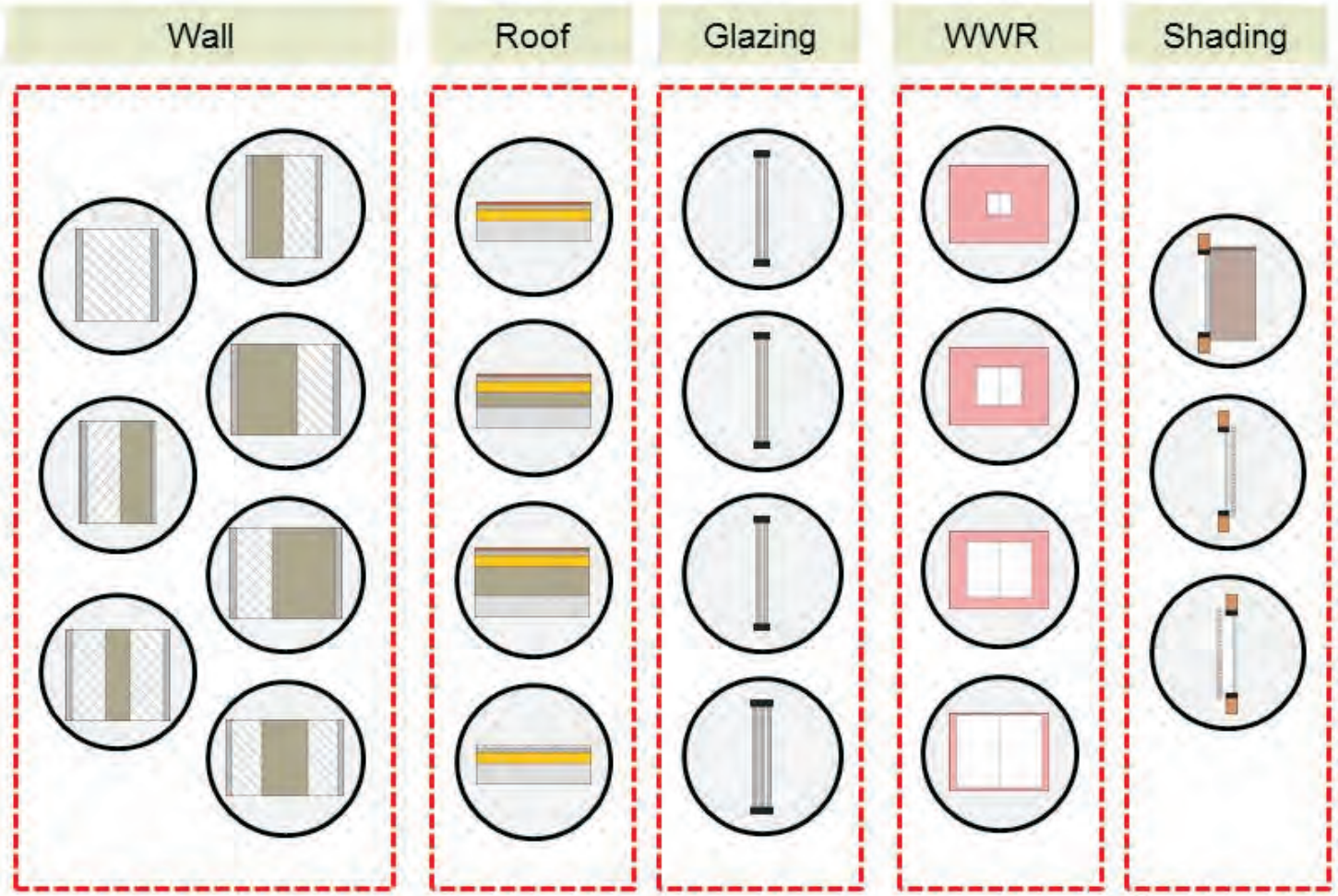
DEFINITION



Sensitivity analysis definition with a reference to the project condition.

SENSITIVITY ANALYSIS

VARIABLES – BUILDING ENVELOPE



The variables consisted in the sensitivity analysis are categorized into six MAIN variables (Wall, Roof, Glazing, Window to Wall Ratio (WWR), Shading and Occupancy), each one consists of SUB variables as shown in the slide.

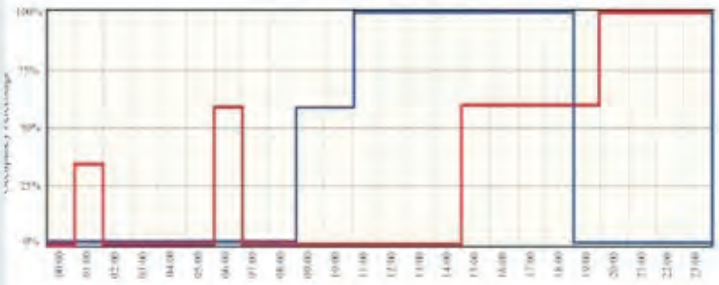
SENSITIVITY ANALYSIS

VARIABLES – SCHEDULES

LIVING ROOM

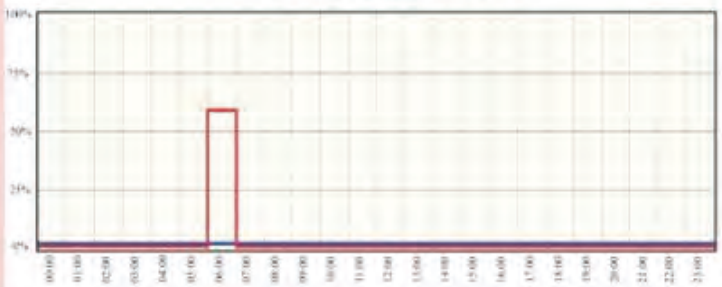
< 30C

TYPICAL SCHEDULE



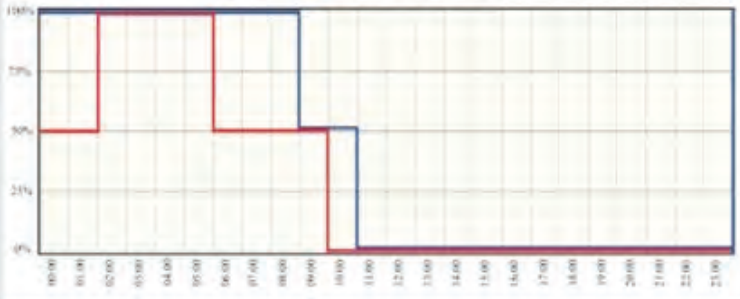
> 30C

ACTUAL SCHEDULE

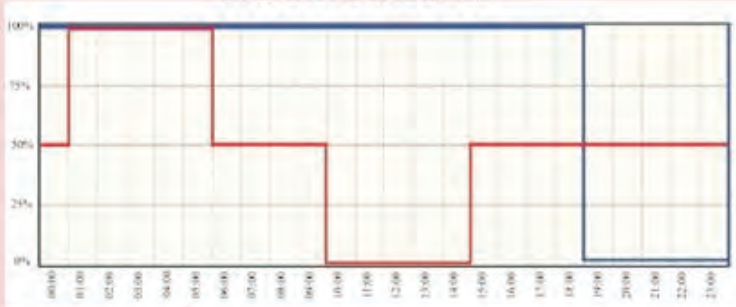


MASTER BEDROOM

TYPICAL SCHEDULE



ACTUAL SCHEDULE

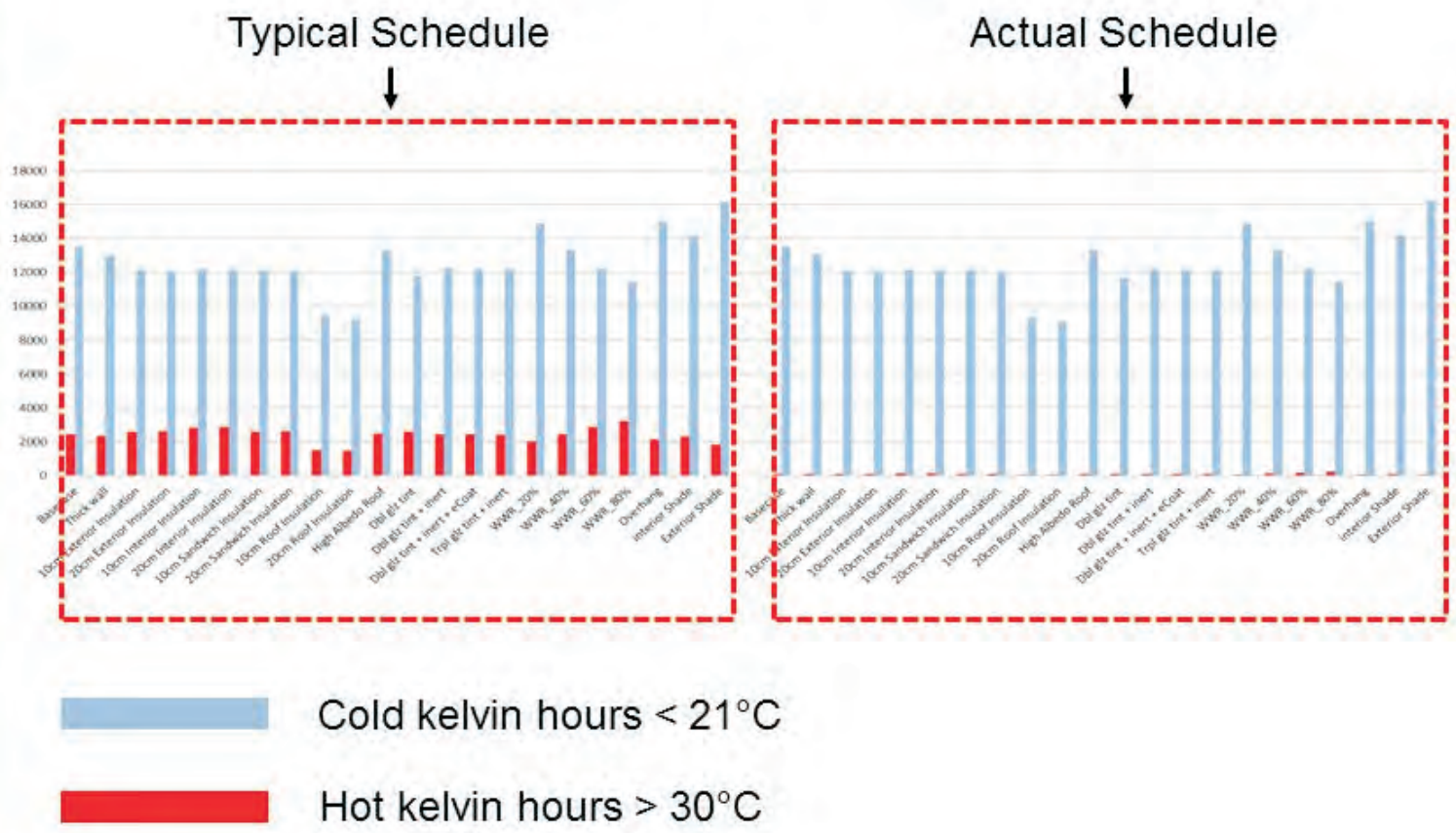


In this MAIN Variable (Occupancy) two SUB variables are defined:

1. Typical Schedule, which describes a static way of defining occupancy without any consideration of external factors affecting their living habits,
2. Actual Schedule, which describes a dynamic altering schedule based on operative temperature in the room. This is based on the fact that occupants change their living area from the living room to bedrooms when operative temperatures are higher than 30 degrees, that is because bedrooms have AC's while Living room does not have one.

SENSITIVITY ANALYSIS

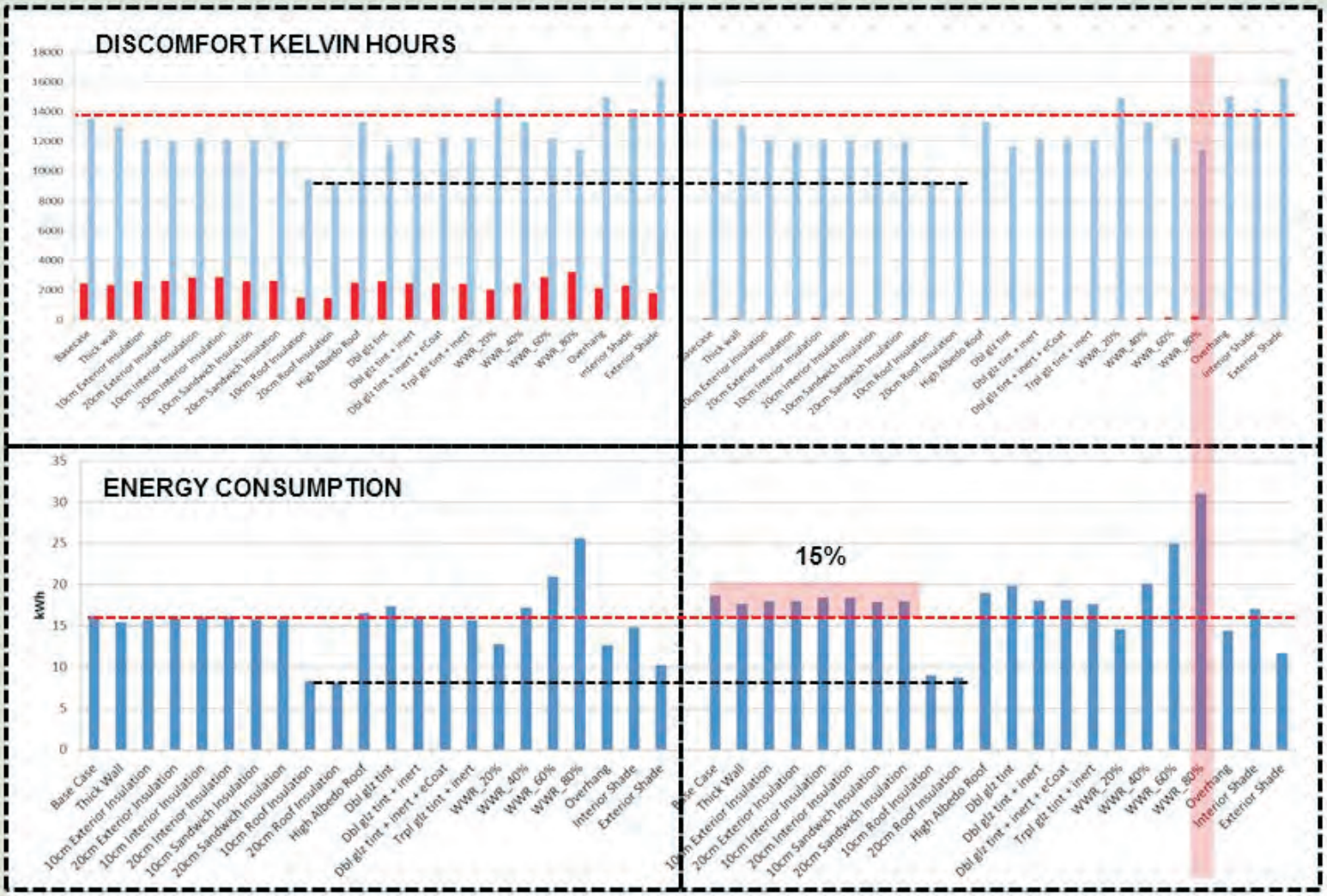
RESULTS



First, it was not expected to get less Hot kelvin Hours than the Cold Kelvin Hours, however, that is due to the fact that occupants tend to use AC's when temperatures get quite hot, while on the other hand, they do not have heating systems, which makes them get more cold hours than hot ones. Second, Actual Schedule represents the real case of not experiencing hot hours, due to the shifting of the using spaces in summer.

SENSITIVITY ANALYSIS

RESULTS



Transsolaracademy

MOHAMEDAMER HEGAZY – 3RD REVIEW

This is a comparison between Actual and Typical Schedules when it comes to comfort hours and energy consumption.

The most affecting variable is the roof configurations, then window ratios.

Wall configuration and glazing type have less effect.

SENSITIVITY ANALYSIS

REFLECTIONS

Summary!

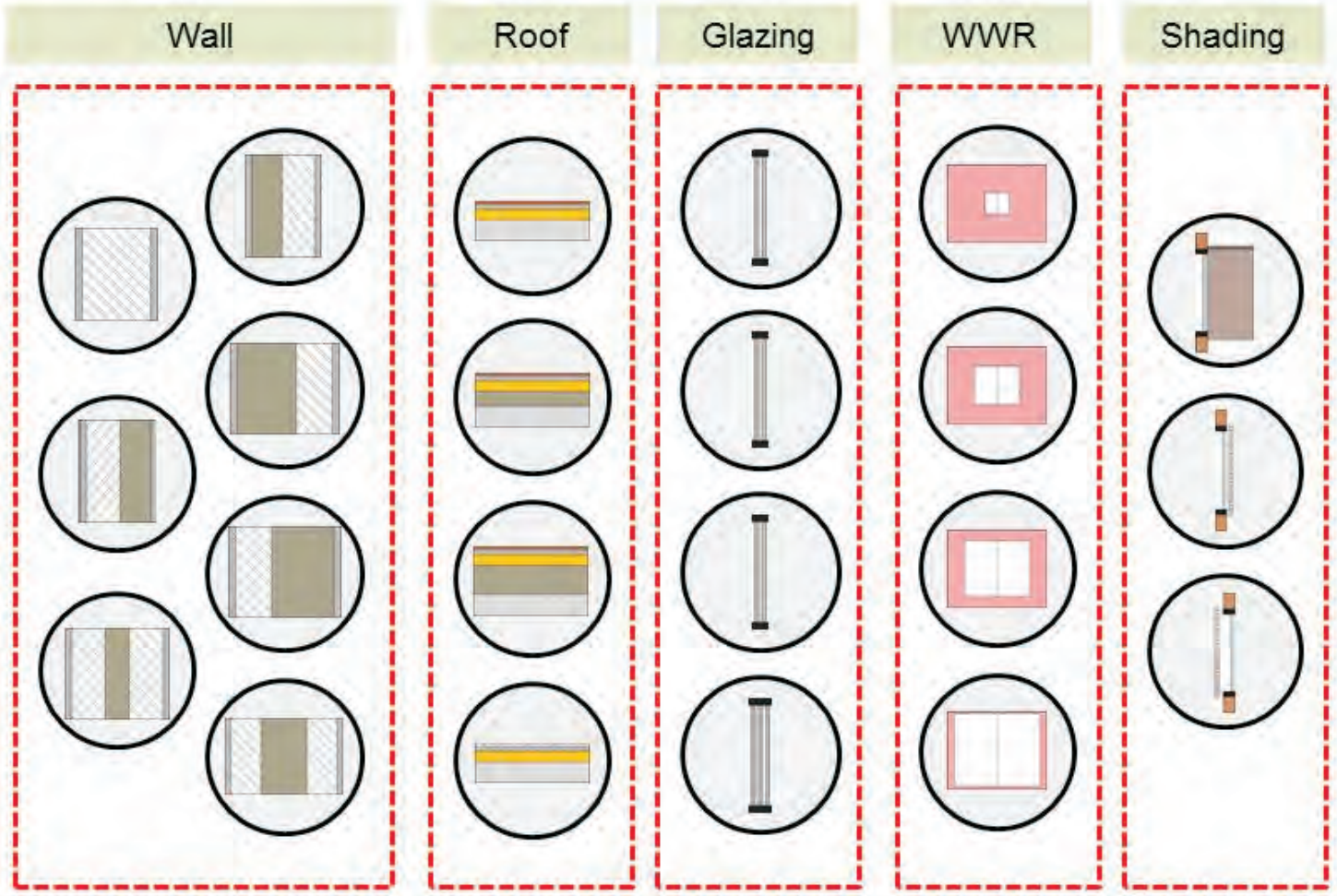
- Occupancy schedules can make difference in results with a value of 15% for energy consumptions for the base case
- Roof insulation has maximum impact
- Wall insulation and glazing type have minimum impact
- Glazed surfaces has more impact than opaque ones
- Need for heating as well as cooling

OPTIMIZATION

Chapter 5: Optimization is conducted to define the most efficient combination of variables that achieves the highest comfort with least energy consumption.

MULTI-OBJECTIVE OPTIMIZATION

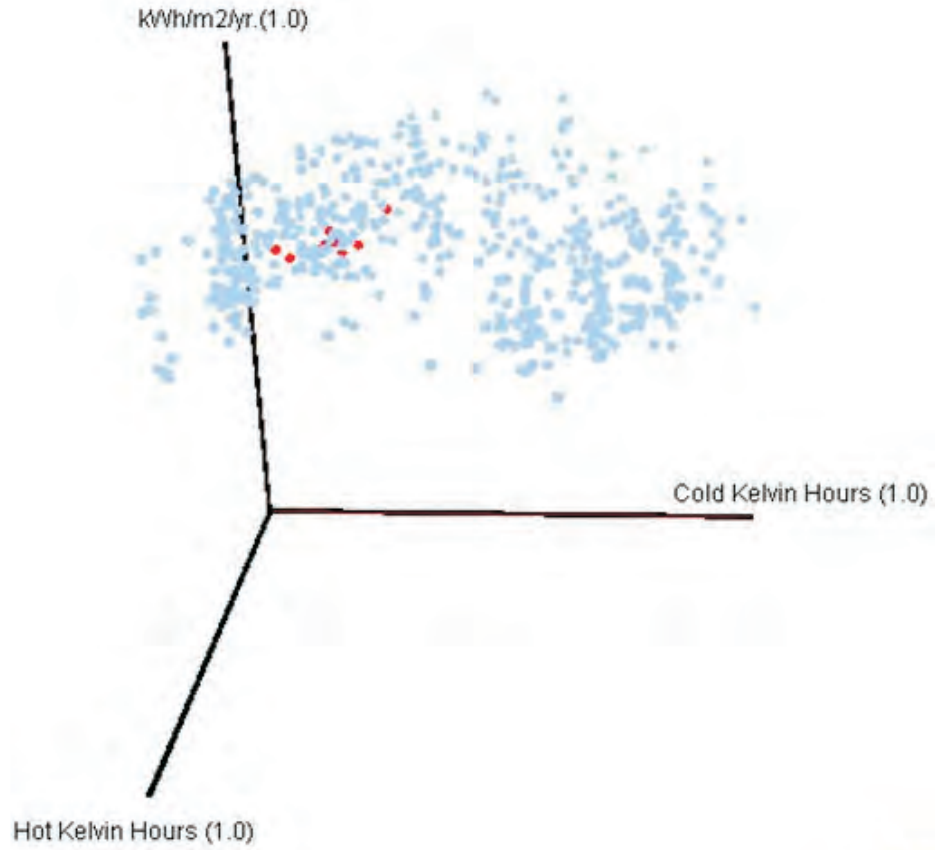
VARIABLES



Variables that were tested all together in the optimization. .

MULTI-OBJECTIVE OPTIMIZATION

READING RESULTS



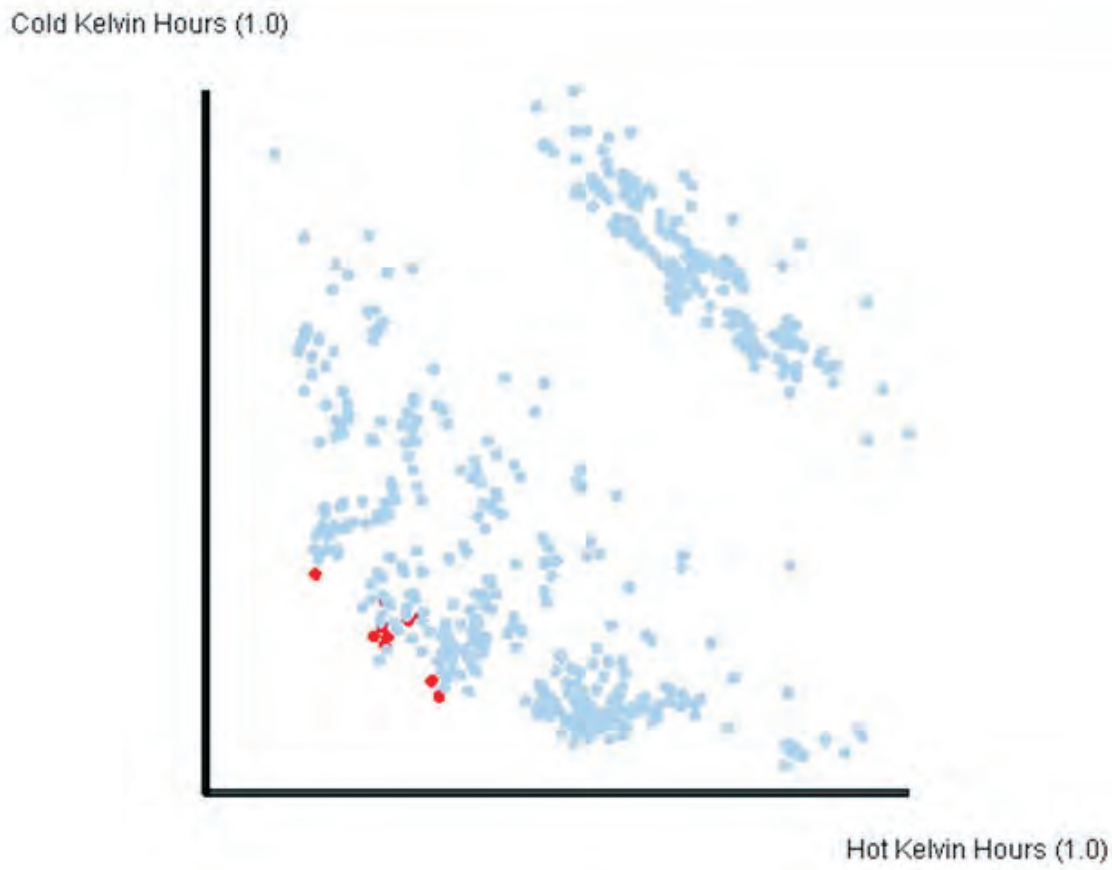
PERSPECTIVE

After more than 500 simulation runs, the results were compiled in one 3D diagram; each point represents one simulation run defined by its outcome in the three axes.

The red points represent the "Optimized" results, each has as far as possible the lowest value in each axis together.

MULTI-OBJECTIVE OPTIMIZATION

READING RESULTS

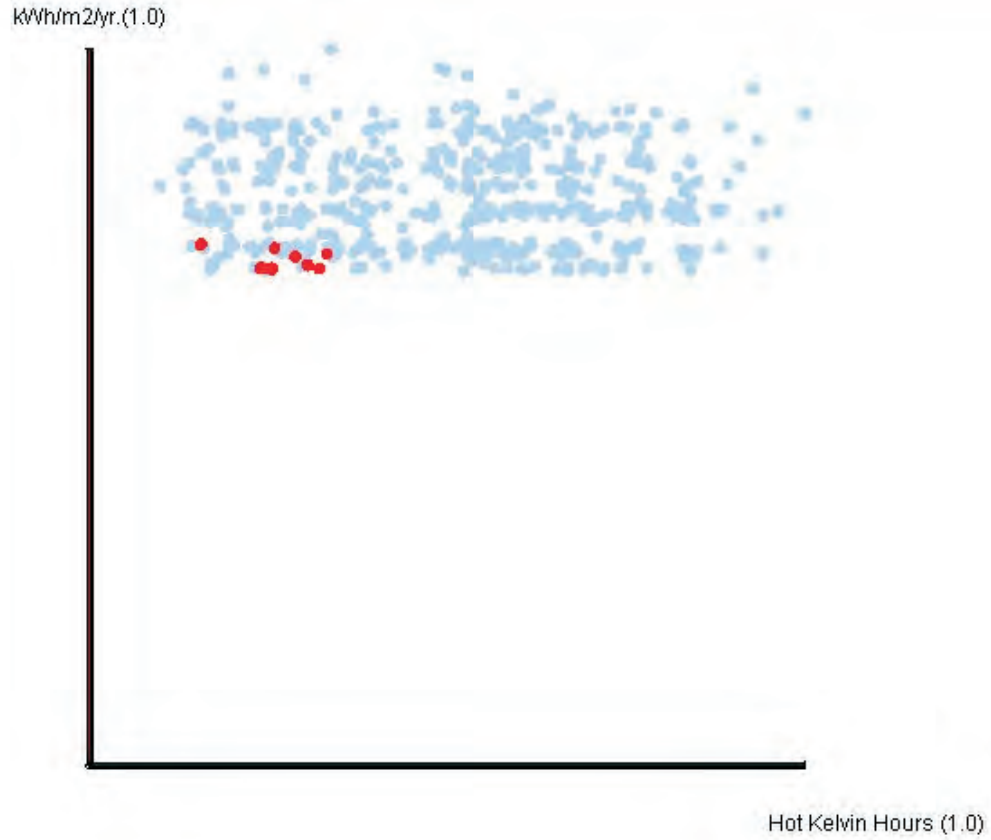


This is a 2D view, which means that a comparison is made between only two variables, Hot and Cold hours.

With as search after "Pareto frontier", more information can be got.

MULTI-OBJECTIVE OPTIMIZATION

READING RESULTS

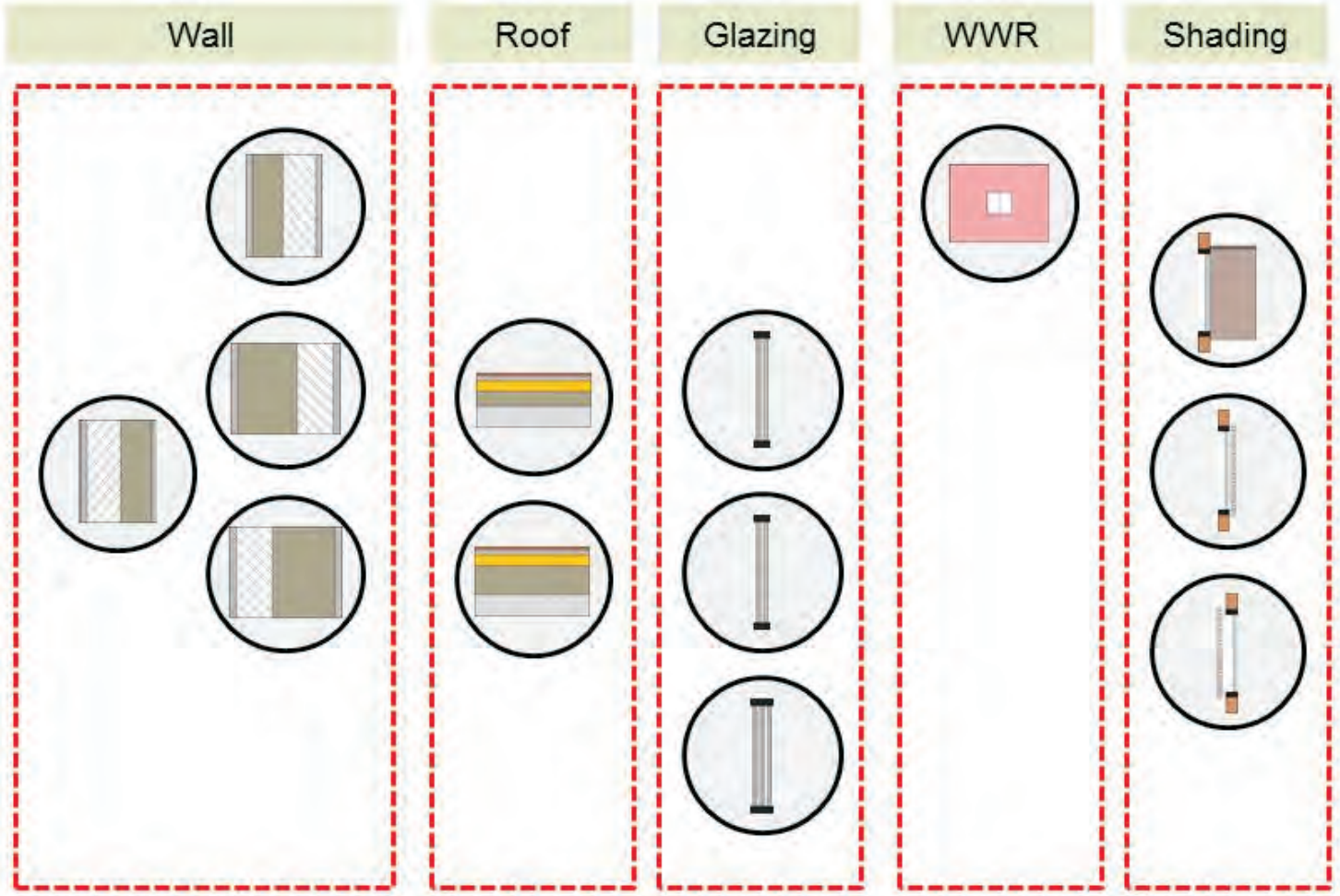


SIDE VIEW

Another 2D view shows the comparison between hot kelvin hours and energy consumption. The high constant amount of energy consumption is die to the constant value of electrical appliances used in the apartment, which is not affected with building configuration.

MULTI-OBJECTIVE OPTIMIZATION

READING RESULTS



Out of the total amount of variables some where chosen as a recommendation to be used for optimized results.

MULTI-OBJECTIVE OPTIMIZATION

REFLECTIONS

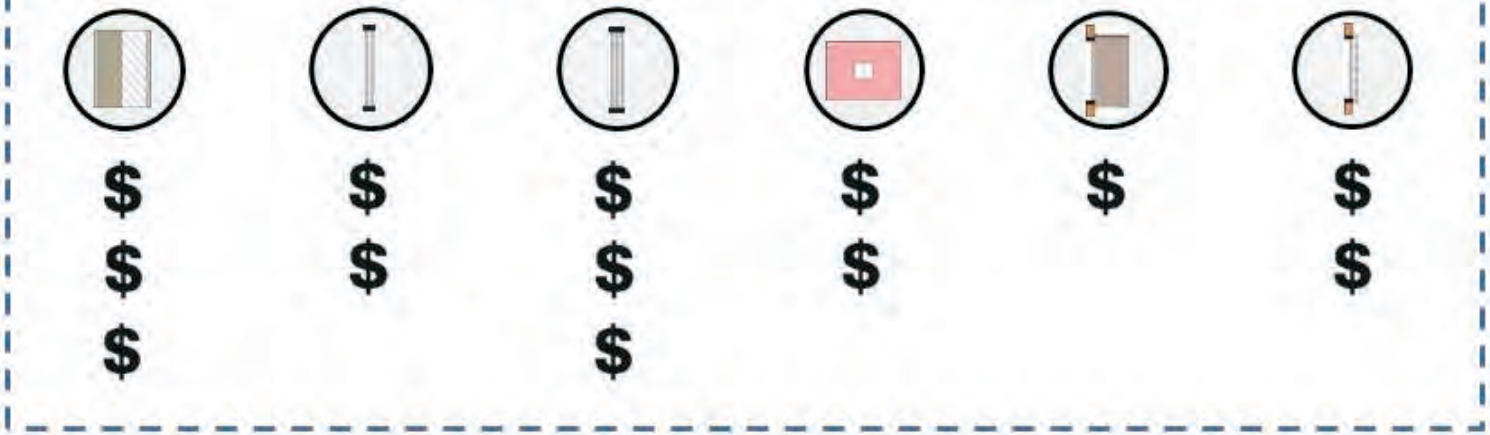
Summary!

- No big difference in results coming out of typical and actual occupancy schedules
- Useful to get more than one option / diversity of results
- Post processing can be adjusted to set a priority of choosing the optimized results

COST ANALYSIS & RETROFITTING

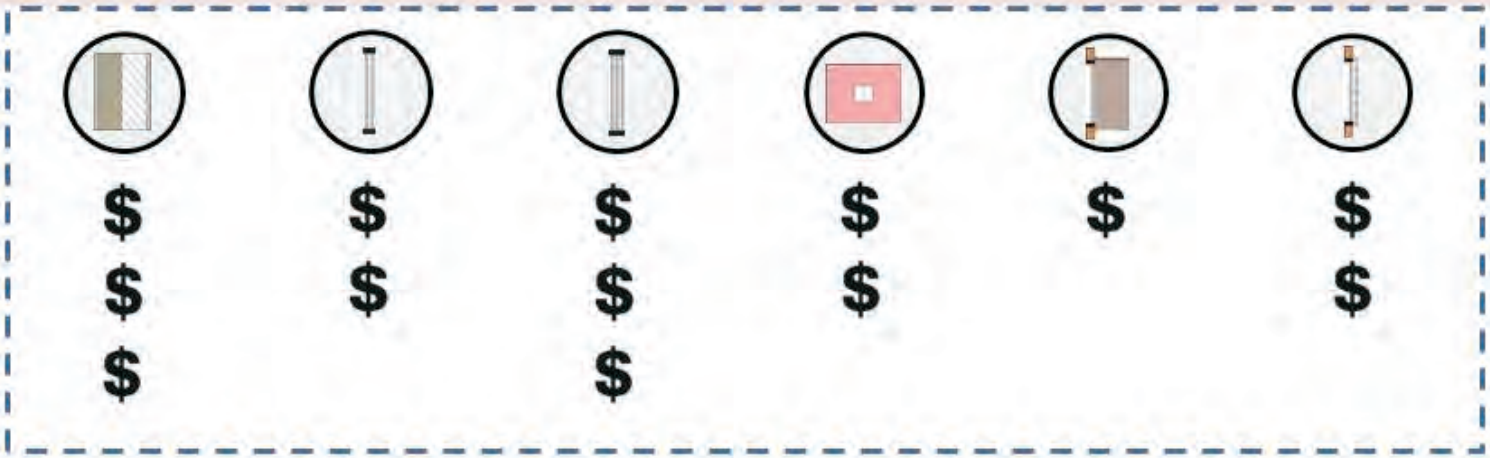
Chapter 6 & 7: were needed together to be able to decide on the final outcome

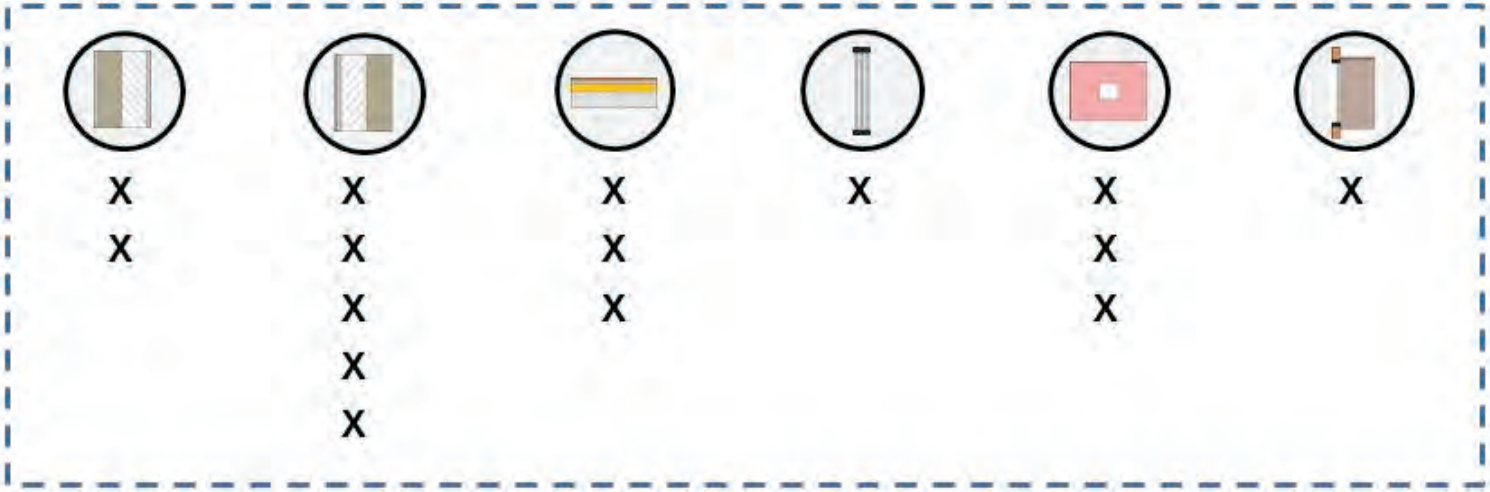
COST ANALYSIS & RETROFITTING



The price (material) of each type of variable was calculated based on the available information from the current Egyptian market

COST ANALYSIS & RETROFITTING



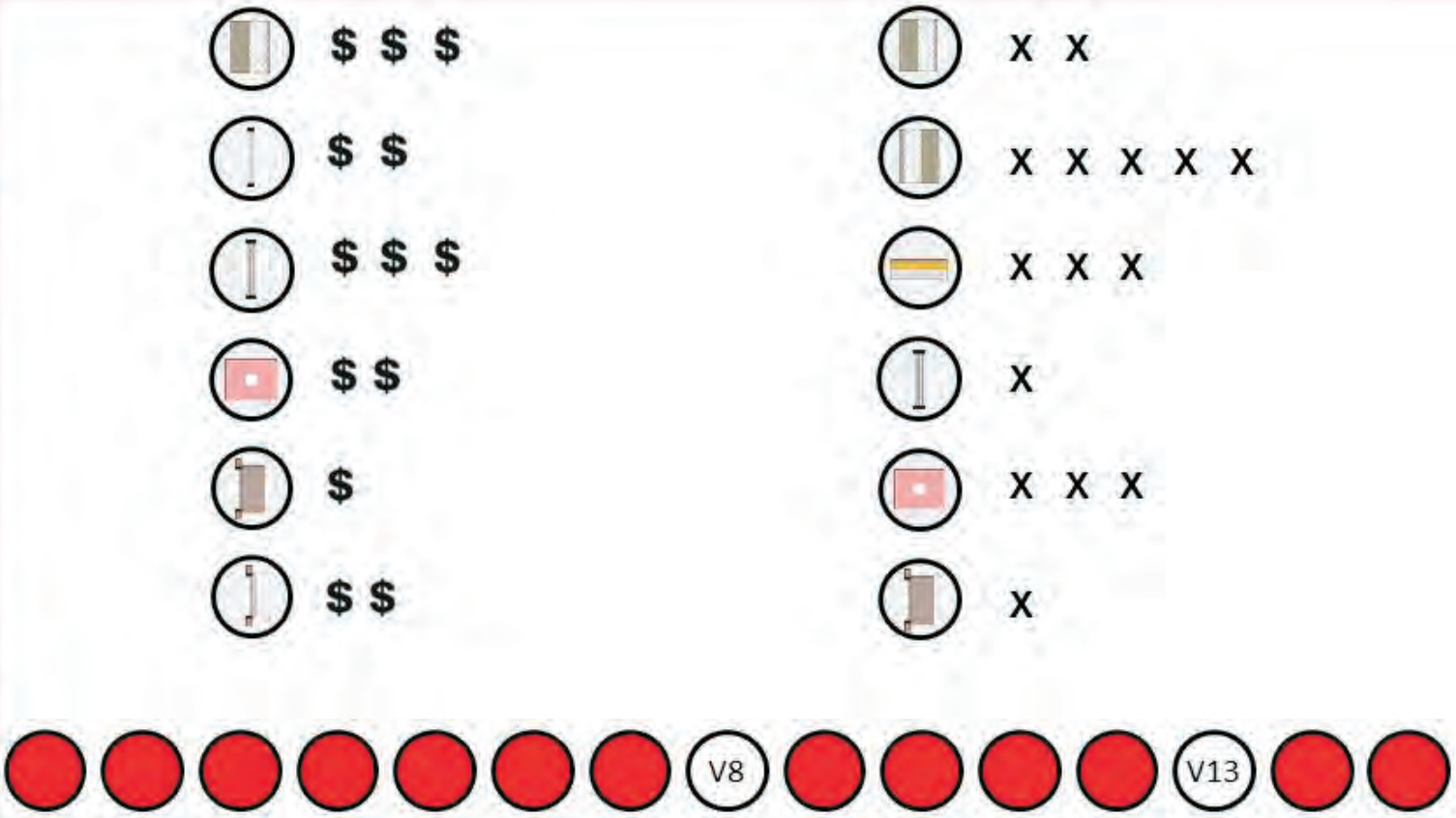


Each Variable was given a _subjective_ complexity factor, which defines how complex is it required to carry out this type of retrofitting strategy.

COST ANALYSIS & RETROFITTING

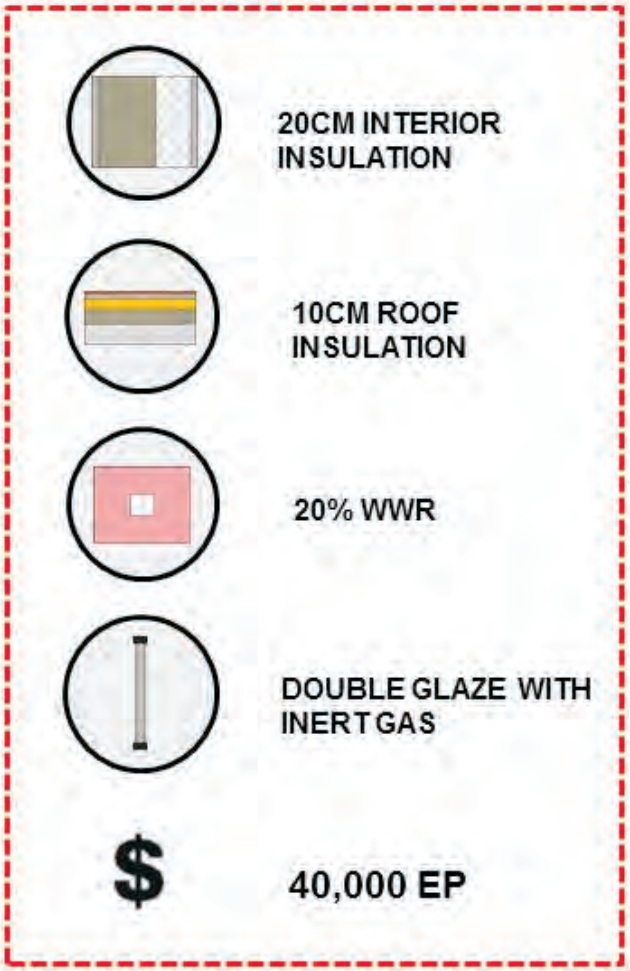
Given a 15 optimized variables options, cost and complexity factor . . .

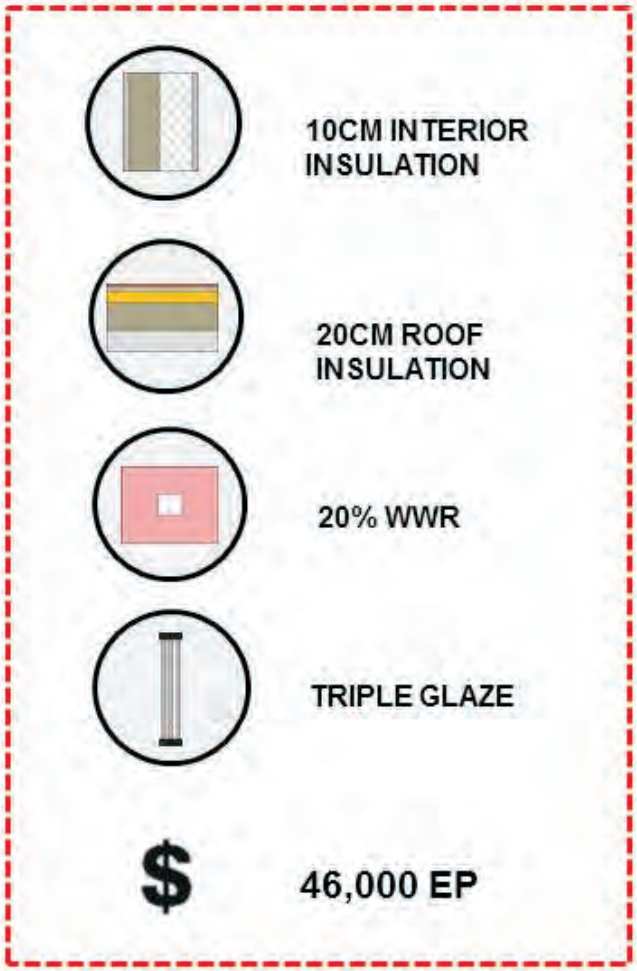
COST ANALYSIS & RETROFITTING



. . . two variables were selected.

COST ANALYSIS & RETROFITTING





here gives the specifications of each solution with the expected price.

COST ANALYSIS & RETROFITTING

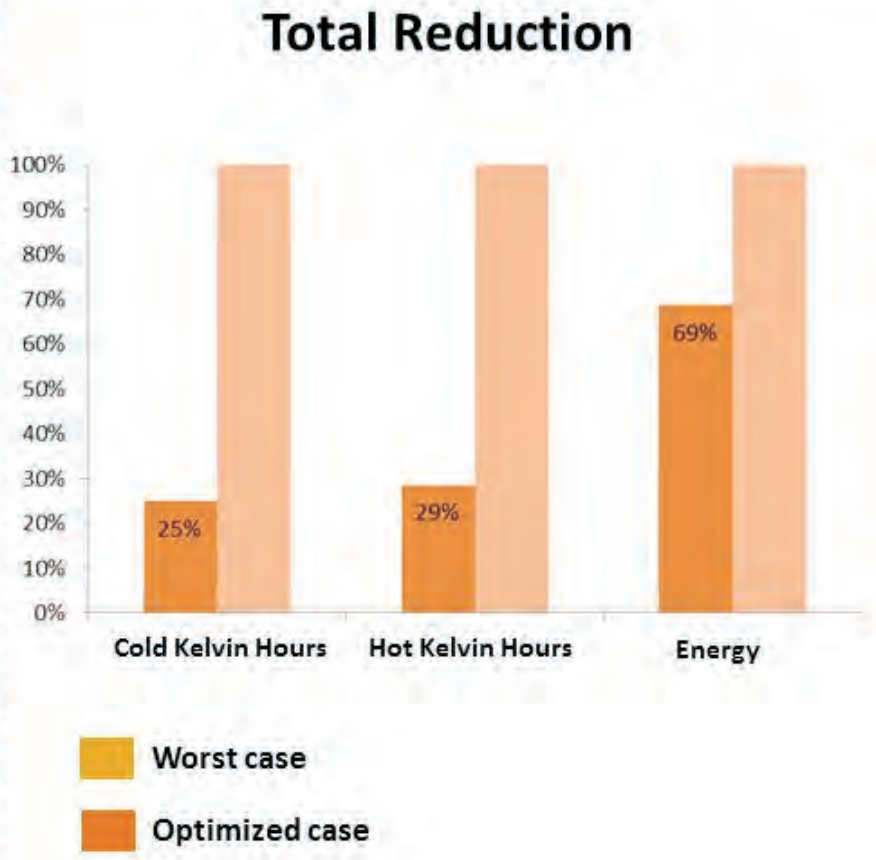
20CM INTERIOR INSULATION

10CM ROOF INSULATION

20% WWR

DOUBLE GLAZE WITH INERT GAS

$ 40,000 EP



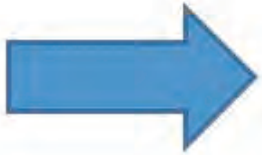
The lower price is selected as a sample of choice, while it is shown the achievements in the total reduction in energy consumption and increasing of comfort.

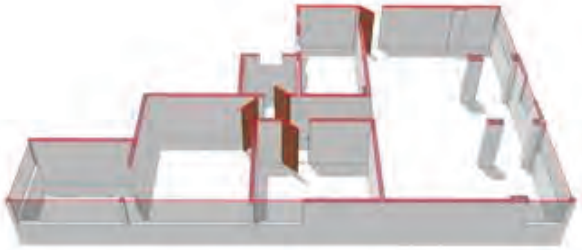
Chapter 8: is a rough attempt to estimate the area of PV panels needed to cover the electricity consumption after the optimization process.

Zero Energy Apartment

ZERO ENERGY APARTMENT

30 m2





6750
kWh/a

Payback Period 8 years

At the end, to cover the need of the whole apartment, roughly 30 m2 of PV is needed with a payback period of 8 years.

Do we need more fossil fuel?

YES ... & NO

In fact, there is not answer for this question. On the national level to be able to sustain without more fossil fuel, the solution comes beyond an apartment level, it needs a wide strategic level of planning. Yet, based on this project, the attempt is to find solution on an individual base, which means that every house hold should be able by the end to decide whether he/she would like to operate the apartment independently or not. Theoretically it is possible, but yet to able to accurately answer this question it needs to be realized and experimented for at least 12 months in row; One Year.

Hopefully that will come later . . .