Modernizing the Vietnamese Modern „Tube-House“
Higher Comfort - Lower Energy

Vu Hoang

With the support of: **Felix Thumm, Alejandra Cassis, Tommaso Bitossi**

Modernizing
the Vietnamese
Modern Tube-House

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Lower Enenery

by: Vu Hoang

with the support of:
Felix Thumm
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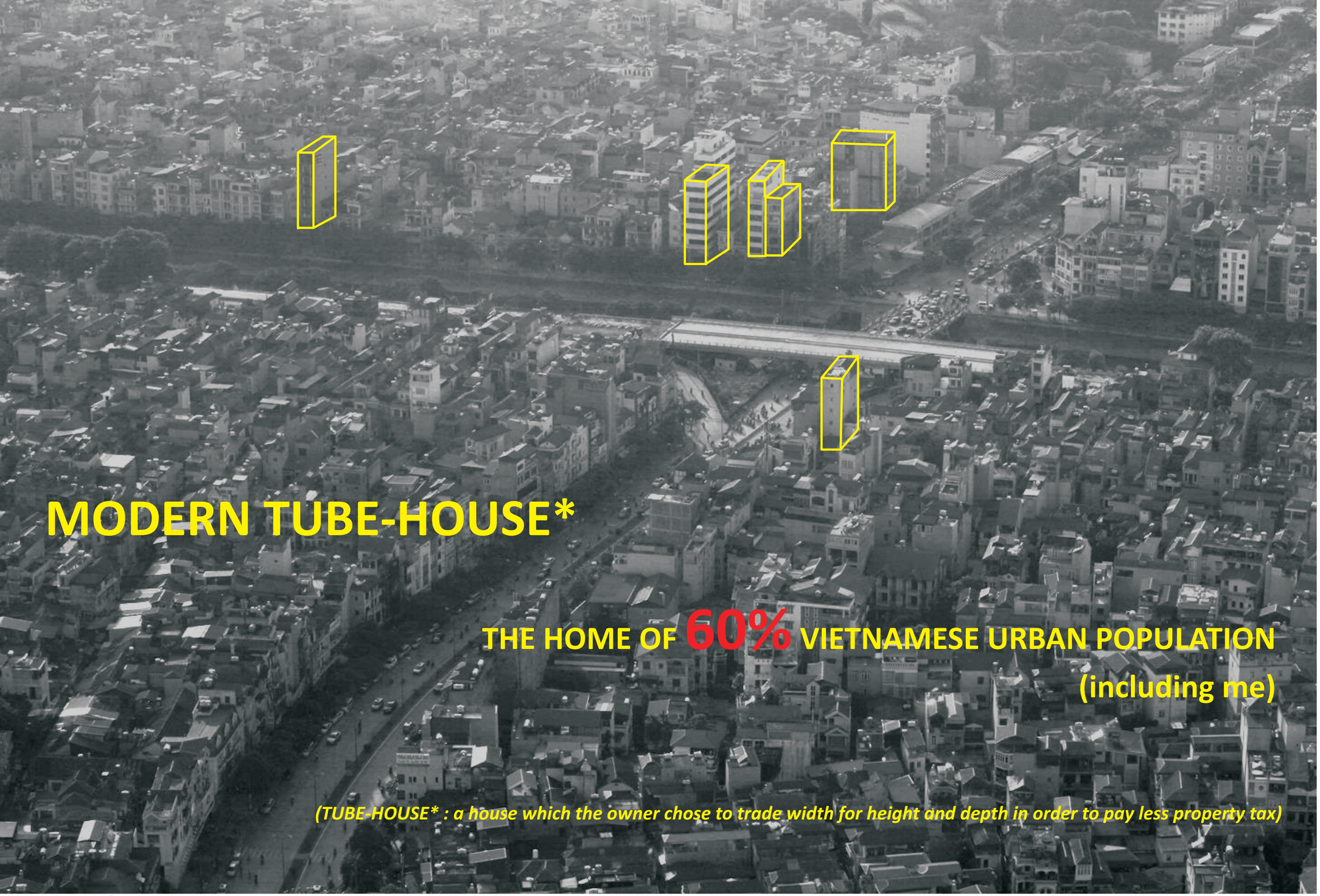
and Transsolar Academy



MODERN TUBE-HOUSE*

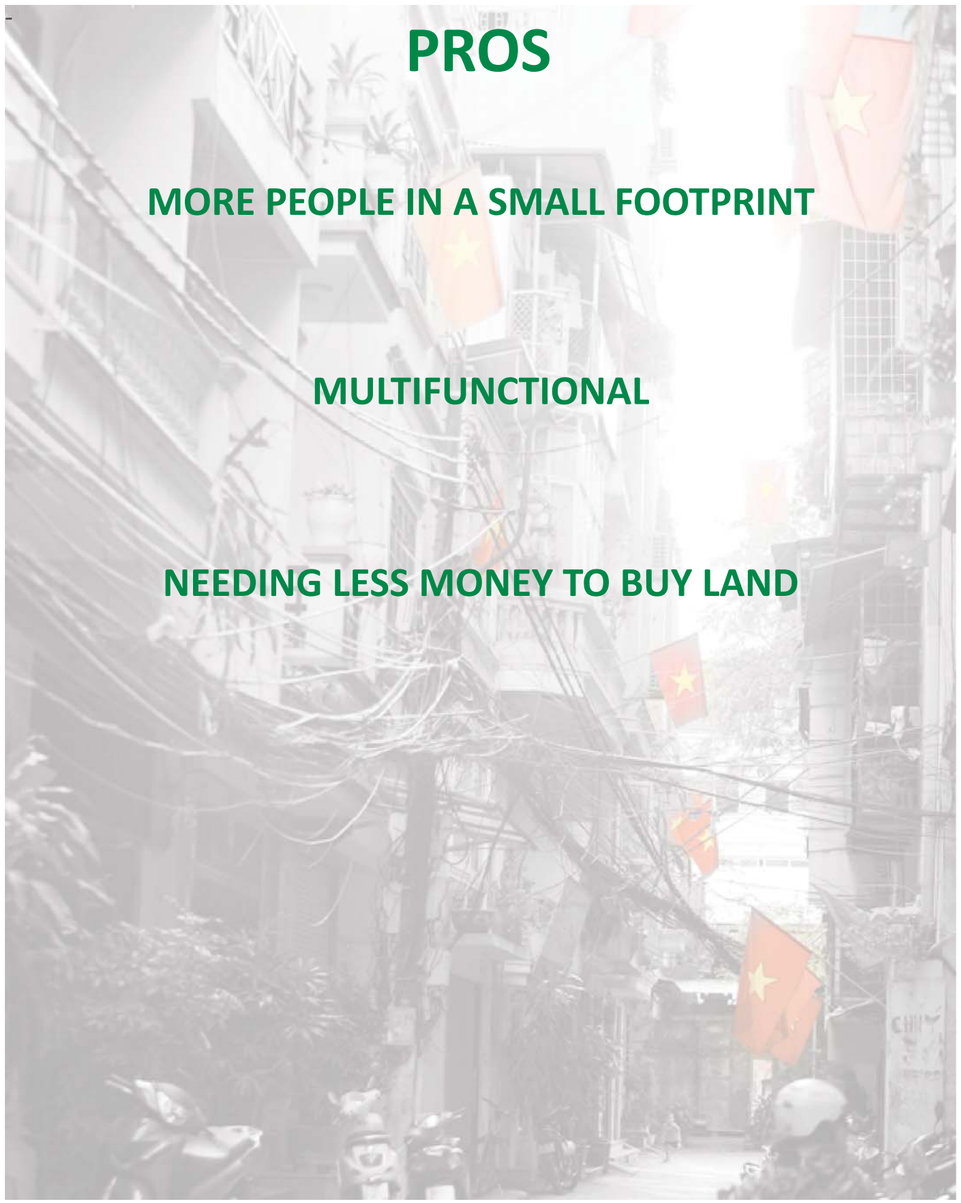
THE HOME OF 60% VIETNAMESE URBAN POPULATION (including me)

(TUBE-HOUSE : a house which the owner chose to trade width for height and depth in order to pay less property tax)*

As an unique solution to certain problems in urban developments, tube-house has become **the icon of Vietnamese urban environment.**

The project aims to upgrade the modern tube-house design using inspirations from traditional architecture, **connecting the past and future** while still **achieving higher comfort, lower energy.**

TUBE HOUSE: PROS AND CONS



PROS

MORE PEOPLE IN A SMALL FOOTPRINT

MULTIFUNCTIONAL

NEEDING LESS MONEY TO BUY LAND

CONS

TOO DENSED

COLD IN WINTER AND STILL HOT IN SUMMER (w. AC)

TOO DARK

INEFFICIENT

NO RELATION TO VENARCULAR ARCHITECTURE

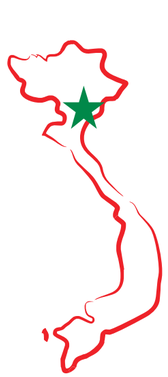
Despite being seen as an extreme measure, the tube-house itself brings flexibility in functionality.

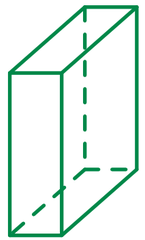
However, at the same time, inappropriate designs bring **bad performance in term of comfort and energy consumption.** And when being busy chasing functionality, sometime we **lose the touch on our own tradition.**

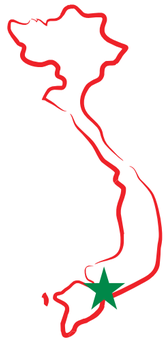
This is why I am here.

METHODOLOGY FOR HIGHER COMFORT, LOWER ENERGY

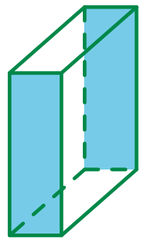
BASECASE



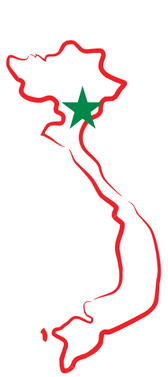


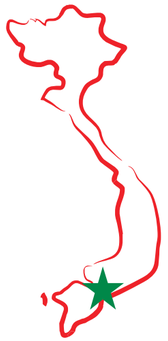


Add-ons

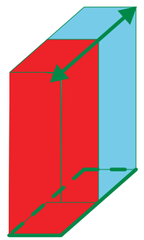


RETROFIT

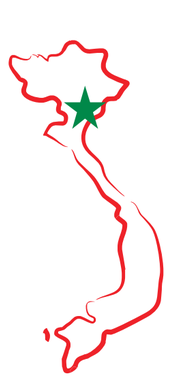


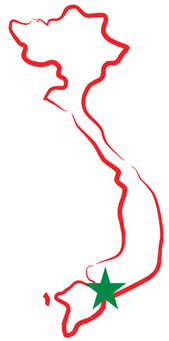


Re-shuffle



MODERNIZE





Note:

Hanoi

Hochiminh City

Cooling energy

Daylighting

PMV Comfort

The project is divided into three main assessments:

- **Present**
- **Retrofitted**
- **Modernized**

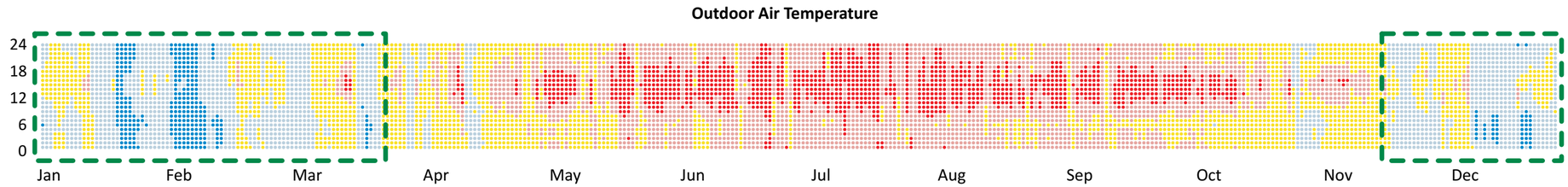
The criteria including:

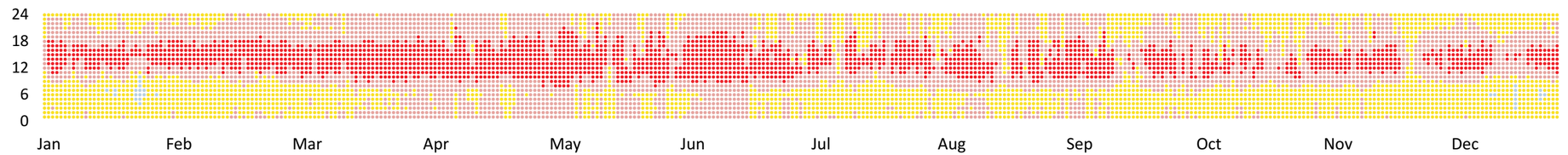
- **Daylight Availability**
- **Thermal Comfort**
- **Energy Consumption**

As the tube-house is so popular in Vietnam, **two different climates** are also taken into consideration.

CLIMATE ANALYSIS

Temperature



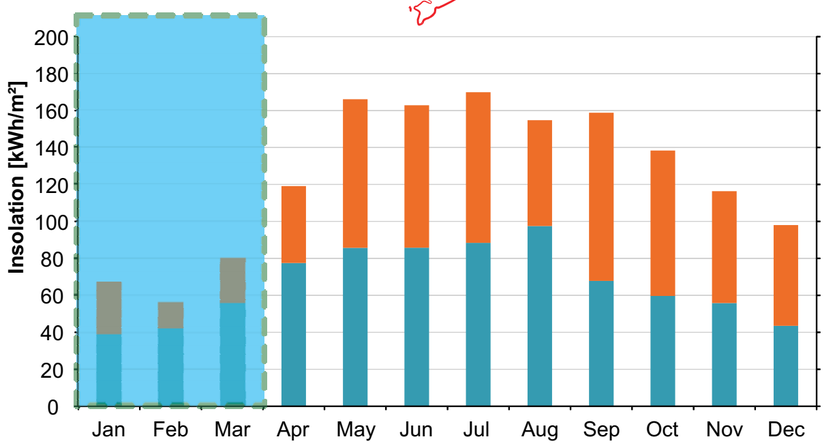


Below 10°C | Between 10 and 20°C | Between 20 and 26°C | Between 26 and 30°C | Above 30°C

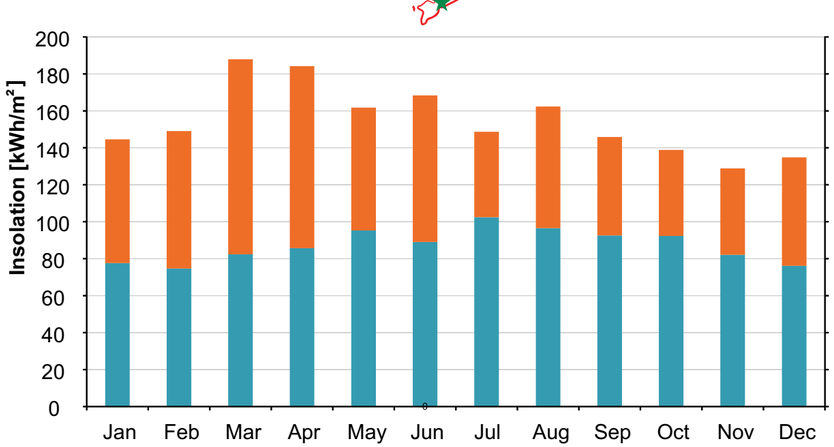
The locations are the two biggest cities in Vietnam.

Located in the North, **Hanoi** is the capital of Vietnam and has **humid subtropical climate** with fairly cold winter.

Solar Radiation on Horizontal Surfaces



Total 1488 kWh/m²/a | Diffuse Radiation 799 kWh/m²/a | Beam Radiation 689 kWh/m²/a

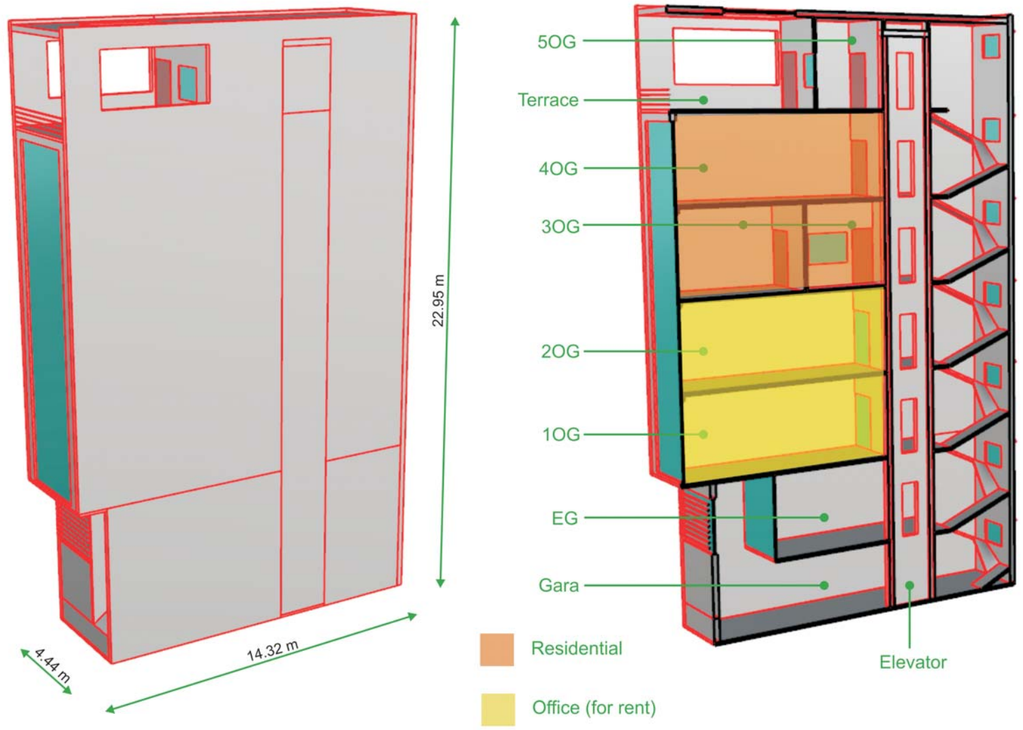


Total 1855 kWh/m²/a | Diffuse Radiation 1047 kWh/m²/a | Beam Radiation 809 kWh/m²/a

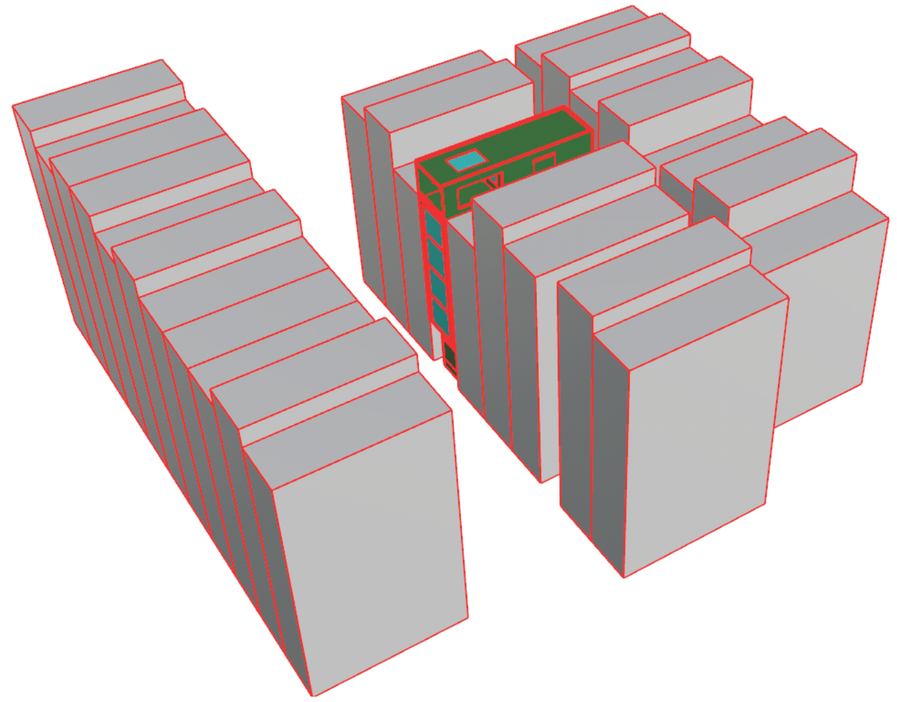
Meanwhile, **Hochiminh City** is the biggest city in the South of Vietnam with **tropical wet and dry climate** and higher level of solar radiation throughout the year.

TUBE HOUSE: CASESTUDY

Standalone



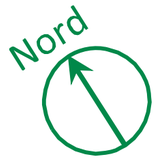
In Context



The casestudy chosen for this project is designed by my dad, which is an engineer.

In a way, this personal project is now even more personal.

Fun facts:
- Designed by my dad (a civil engineer)



BASECASE ASSESSMENT AND RETROFITTING

Daylight Availability

The first step would be assessing the performance of current design in term of

daylight availability, identifying the problems and then coming up with ideas to modify it.

DAYLIGHT AVAILABILITY

Metrics

- Daylight Autonomy (DA)

- Spatial Daylight Autonomy (sDA)

Assumptions

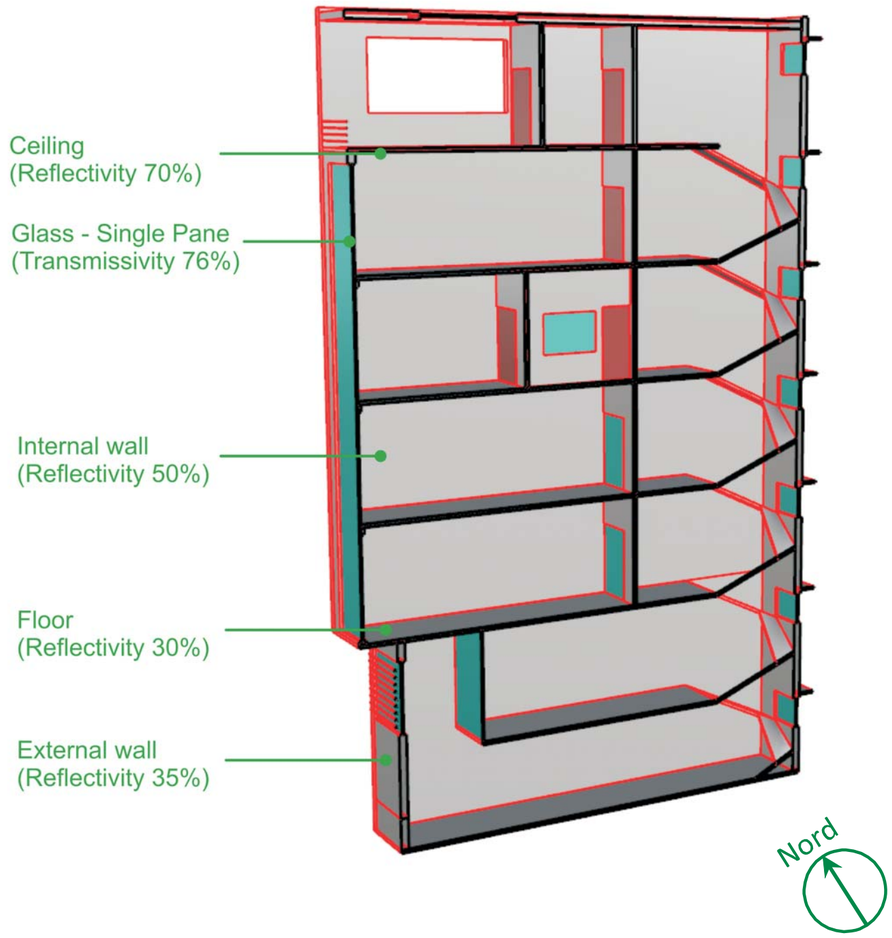
- Climatic data:

Hanoi

Hochiminh City

- Target illuminance: ***300 lux***

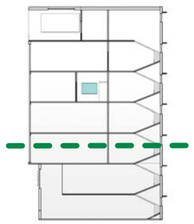
Boundary Conditions

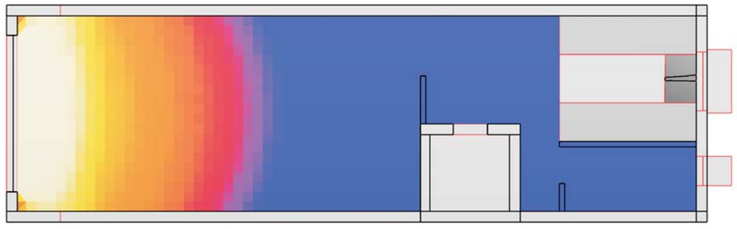


The metric used to assess daylight availability is **Daylight Autonomy** and **Spatial Daylight Autonomy**.

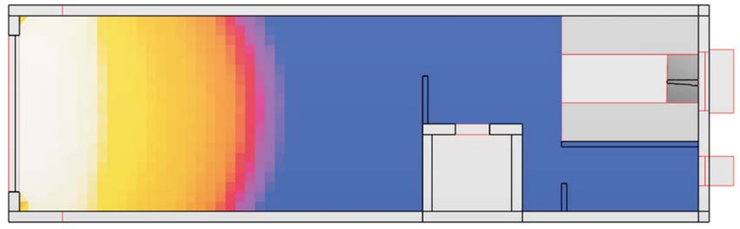
DAYLIGHT AVAILABILITY: BASECASE

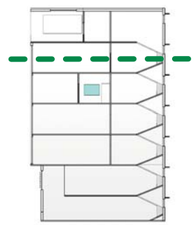
Nord

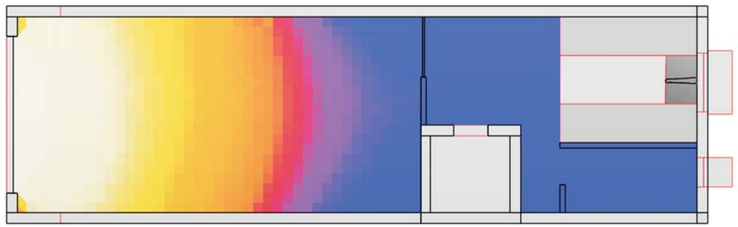


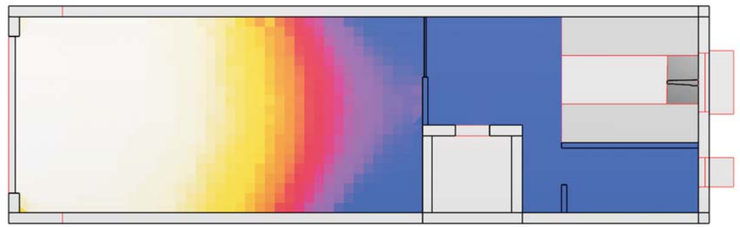


Non-uniform distribution of light

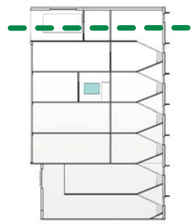


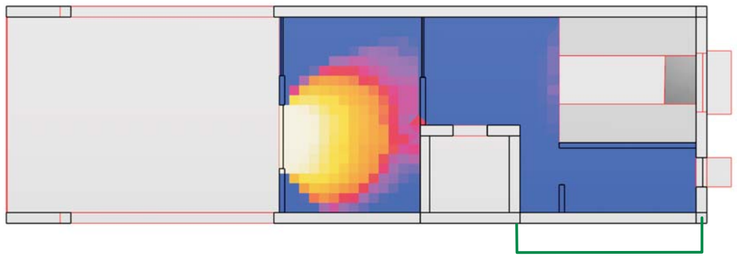




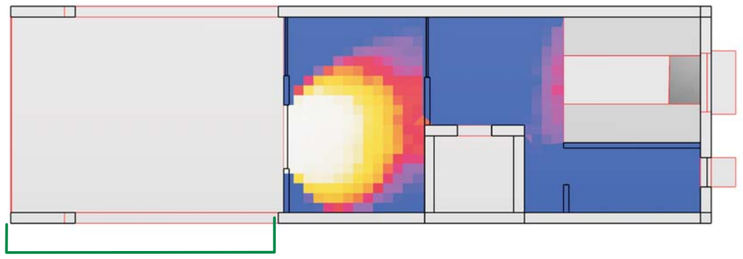


The room is too deep

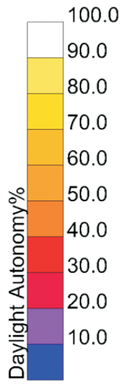




Limited daylight availability in back spaces



Not fully making used of spaces with better access to daylight



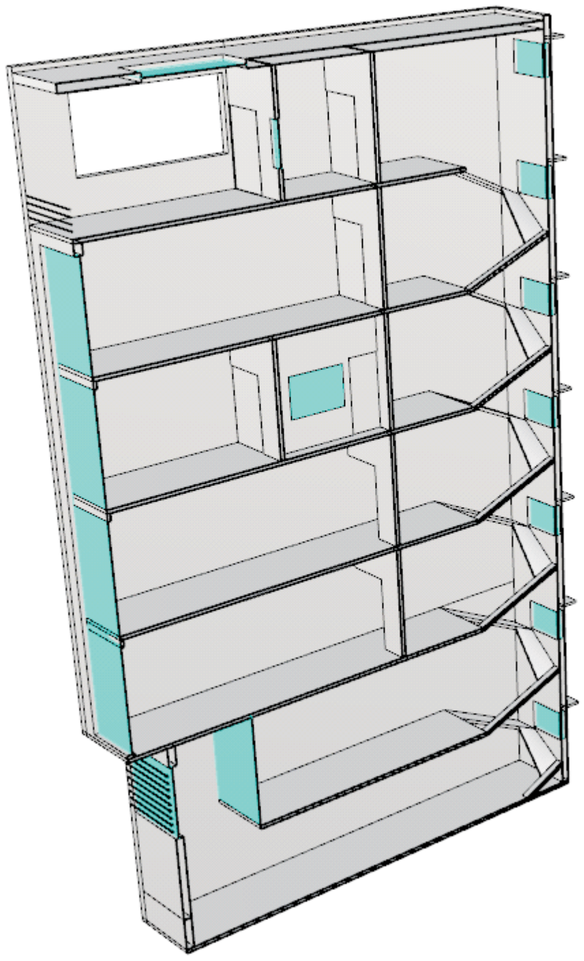
Based on the results, the problems with current tube-house design are identified.

The main reason why tube-house has such bad performance of daylight is due to

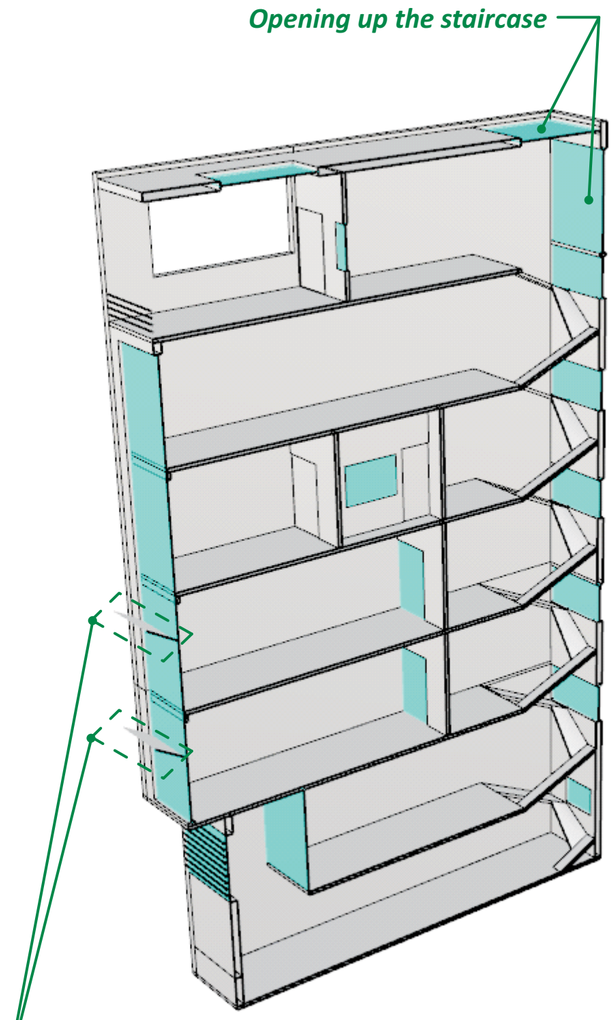
inappropriate arrangement of living spaces.

DAYLIGHT AVAILABILITY: RETROFITTING

Basecase



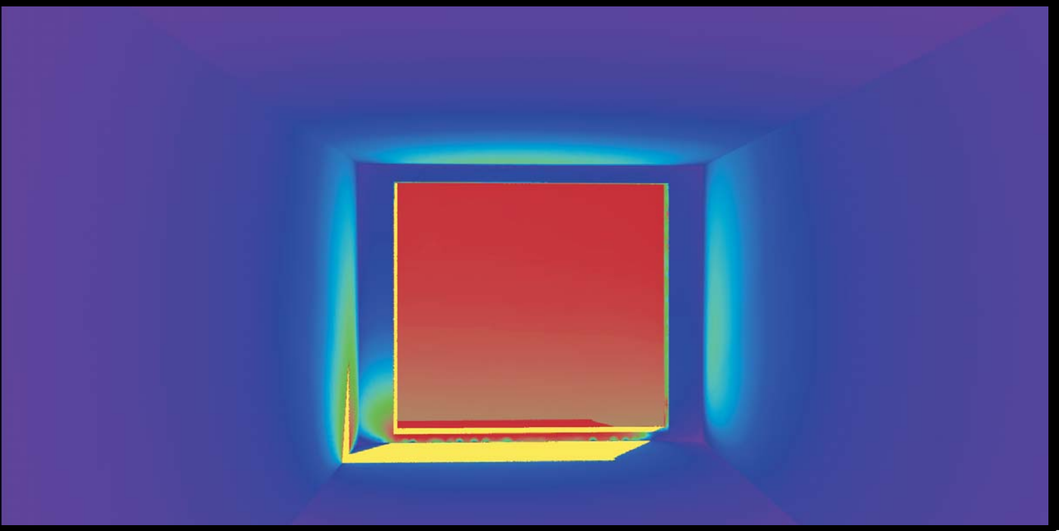
Retrofitting



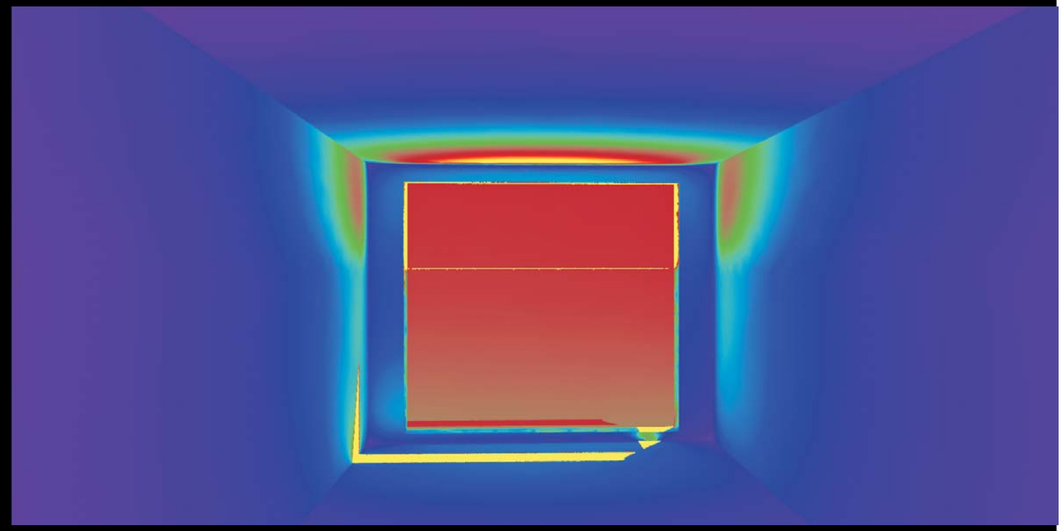
The main idea for retrofitting a tube-house is to improve the design without damaging the structure.

In oder to have a better daylight condition inside, proposed solutions including **opening up the staircase and back facade** while **adding lightshelf on the front facade to improve the uniformity of light.**

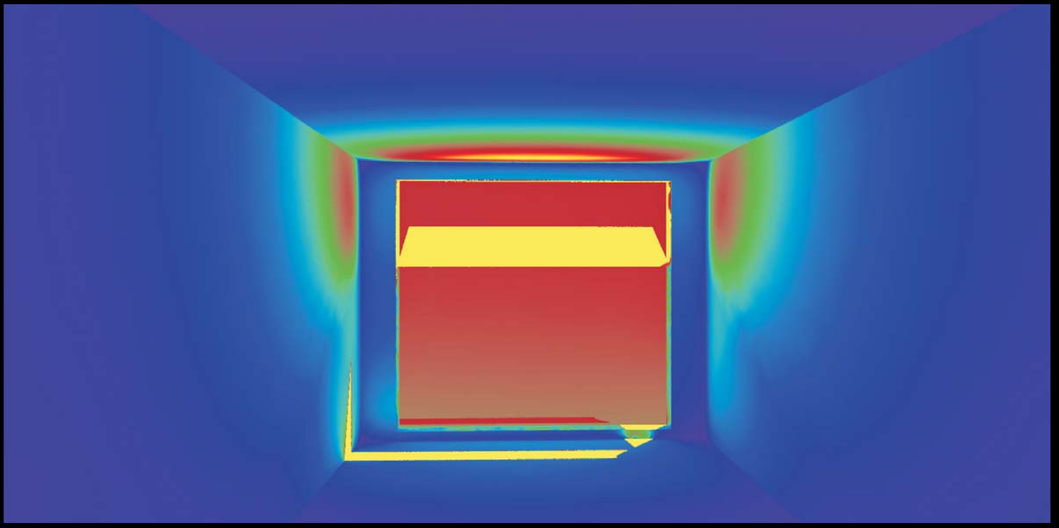
DAYLIGHT AVAILABILITY: LIGHTSHELVES VISUALIZATION



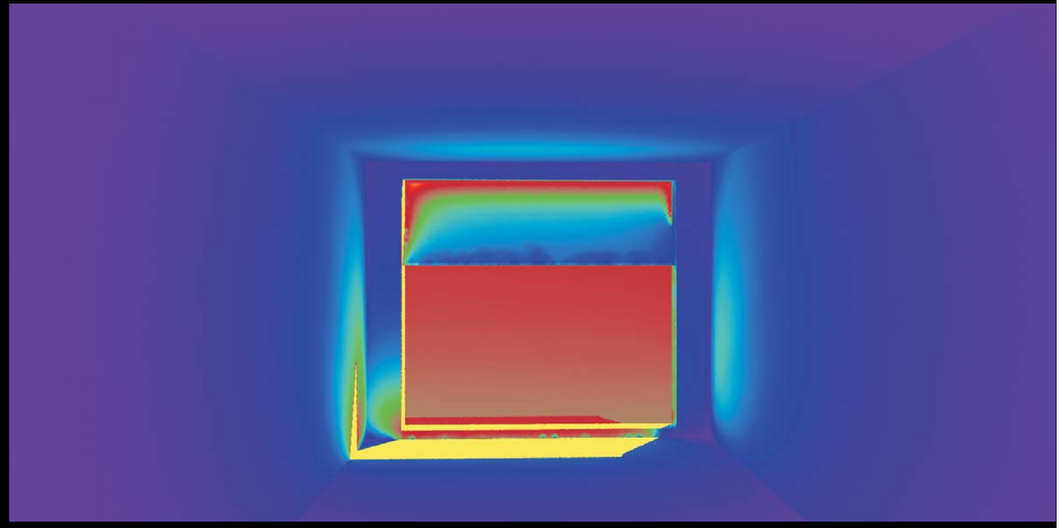
Without lightshelf



0° lightshelf



30° lightshelf



75° lightshelf

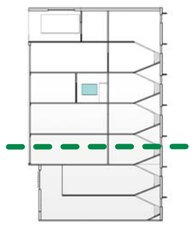
To have an idea of the **right angle and size for the lightshelf**, different variants were tested and compared based on **Spatial Daylight Autonomy** as well as the **visual effect.**

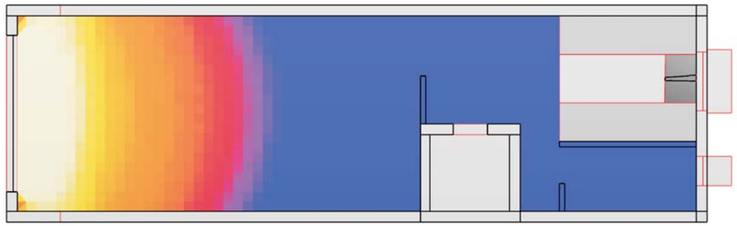
The result here shows that a **30 degree tilted lightshelf will bring the best visual effect.**

DAYLIGHT AVAILABILITY: COMPARISON

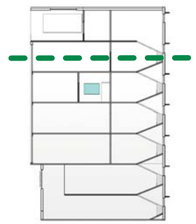
HANOI

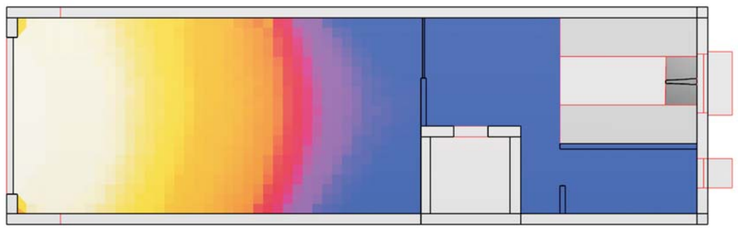
Basecase



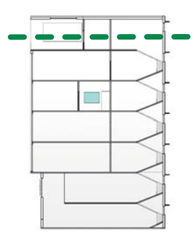


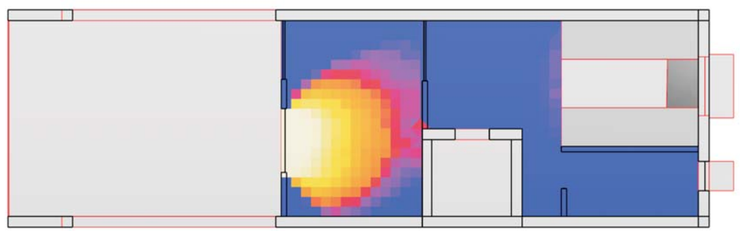
sDA$_{300,50\%}$ = 25%





sDA$_{300,50\%}$ = 43%

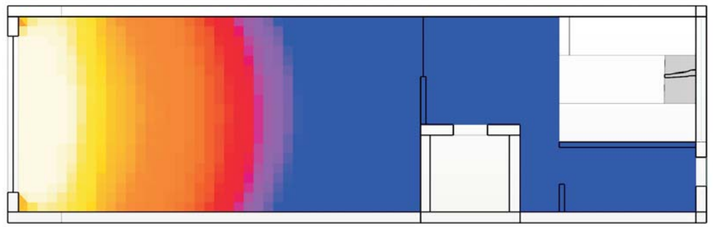




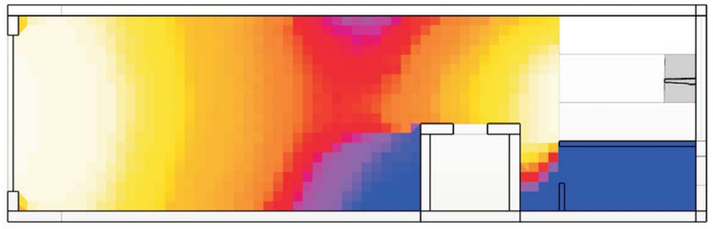
sDA$_{300,50\%}$ = 17%

Retrofitting

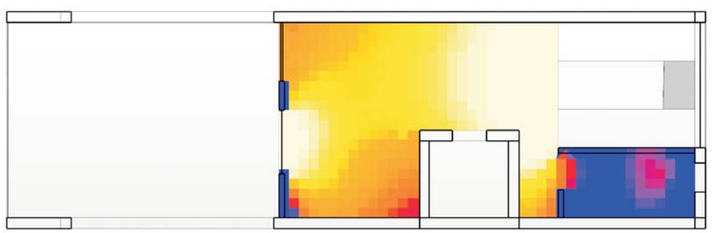
Nord



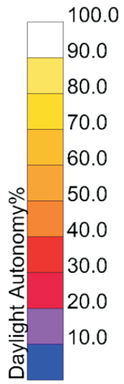
sDA$_{300,50\%}$ = 27%



sDA$_{300,50\%}$ = 63%



sDA$_{300,50\%}$ = 79%



For the climate of Hanoi with a lot of days **with overcast sky condition, the impact of lightshelf is limited since the light cannot be directed deeper into the room.** However, the visual impact of having more uniformity is there.

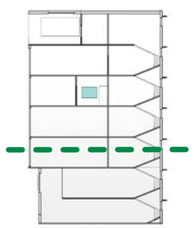
On the upper floors, by having openings, the performance is much better in comparison with basecase.

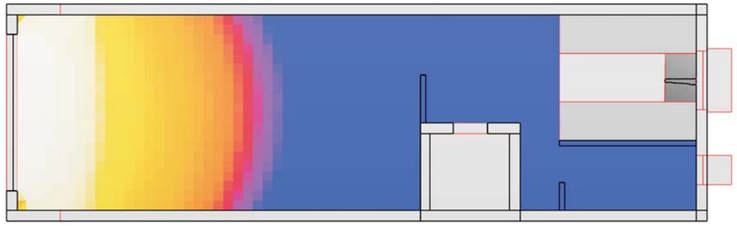
DAYLIGHT AVAILABILITY: COMPARISON

HOCHIMINH CITY

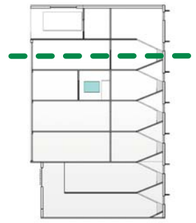
Nord

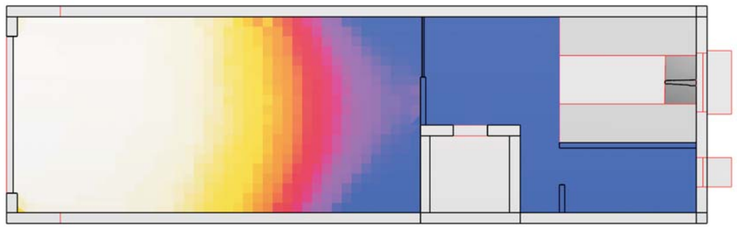
Basecase



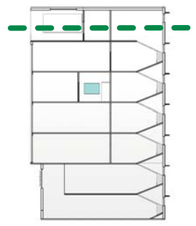


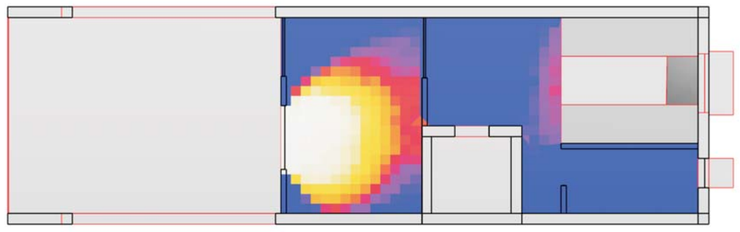
$sDA_{300,50\%}$ = 29%





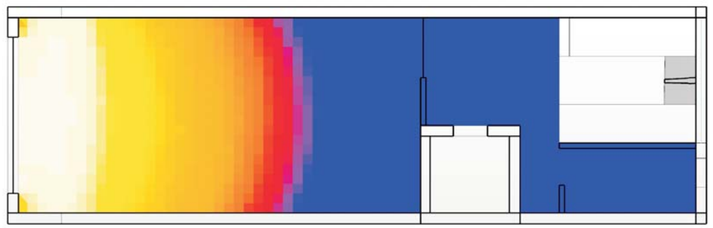
$sDA_{300,50\%}$ = 44%



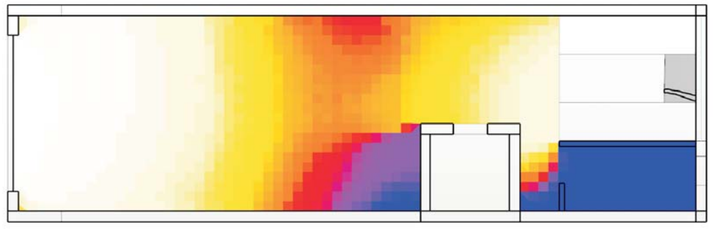


$sDA_{300,50\%}$ = 21%

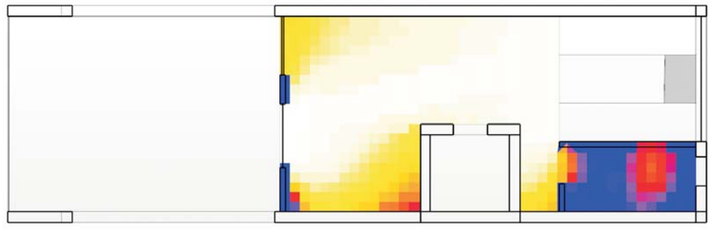
Retrofitting



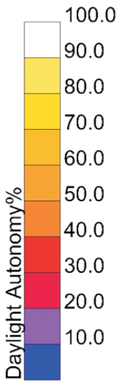
$sDA_{300,50\%}$ = 42%



$sDA_{300,50\%}$ = 77%



$sDA_{300,50\%}$ = 80%



For climate with more days in clear sky condition, the lightshelf makes a bigger impact.

The spacial daylight autonomy value for upper floors can be up to 80%.

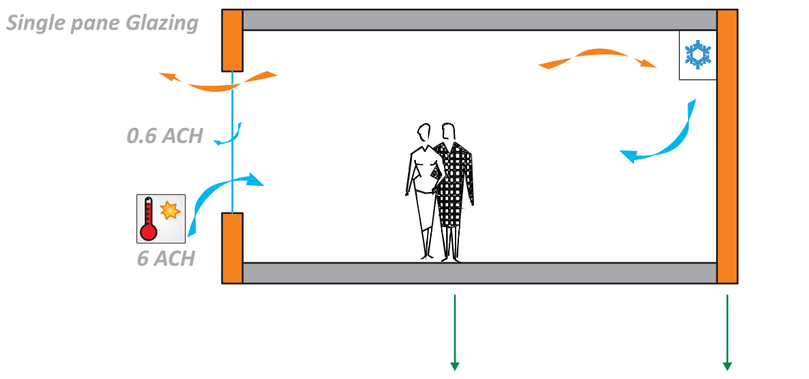
BASECASE ASSESSMENT AND RETROFITTING

Thermal Comfort and Energy Usage

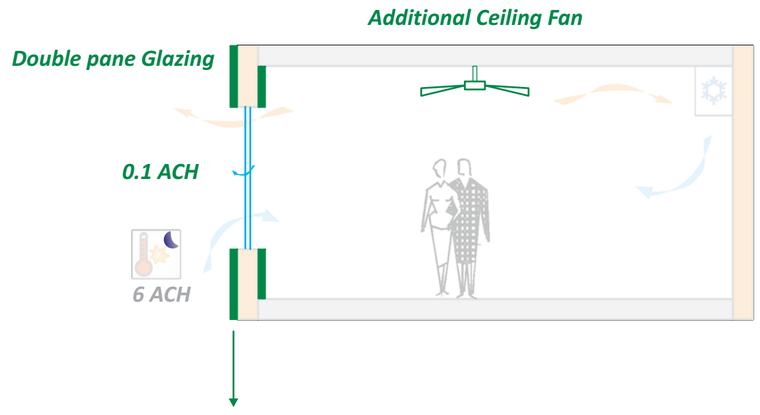
The next comparison is in term of **thermal comfort and energy consumption.**

BOUNDARY CONDITIONS

Basecase



Retrofitting



Comfort Analysis

0.61 Clo
1.1 Met
0.1 - 1.2 m/s

0.9 Clo
1.1 Met
0.1 - 1.2 m/s

In the current design, the building only has single glazing and no insulation.

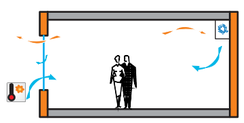
Therefore the retrofitting solutions mainly focus on **minimizing heat losses by improving the facade**, in this case with better glazing and insulation.

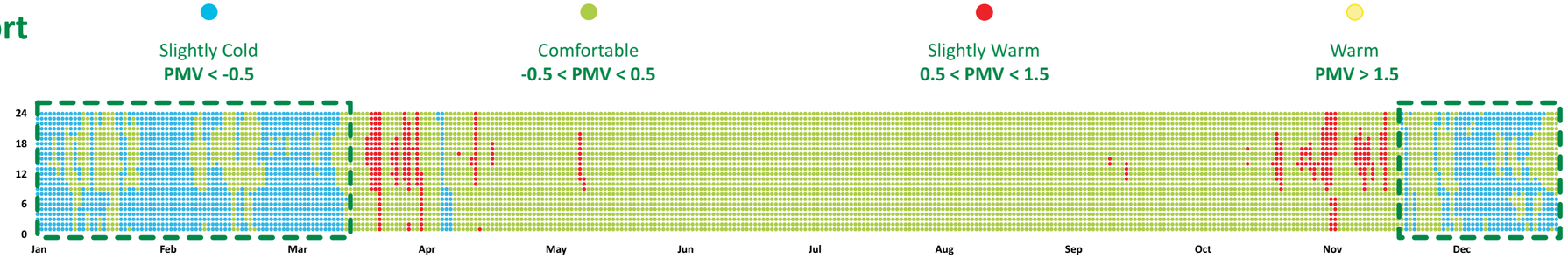
In additon, **elevated airspeed is provided** simply by using a ceiling fan.

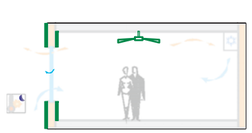
THERMAL COMFORT AND ENERGY USAGE: COMPARISON

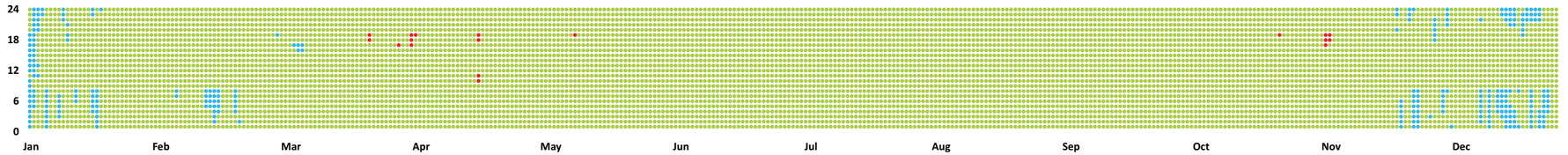
HANOI

Thermal Comfort

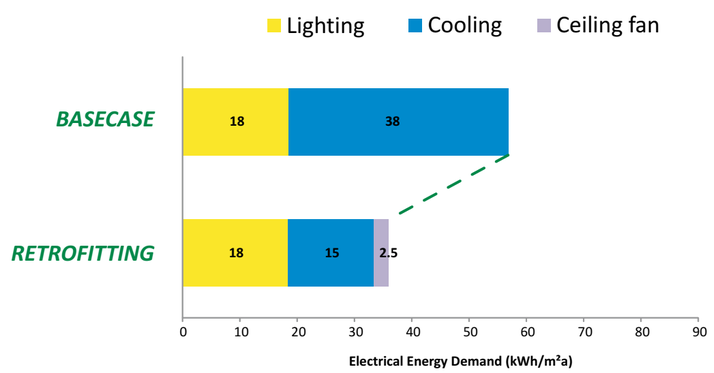








Energy Usage



25% BETTER Thermal Comfort
46% LOWER Cooling Load

The result shows that by improving the facade, **the space can perform well in winter in Hanoi without any needs for additional heating.** This dues to the fact that now all internal gains in winter are kept inside as heat sources

Overall, the retrofitting design can **improve 25% of thermal comfort while reducing 46% of electricity consumption.**

THERMAL COMFORT AND ENERGY USAGE: COMPARISON

HOCHIMINH CITY

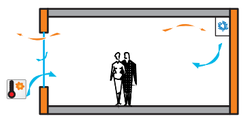
Thermal Comfort

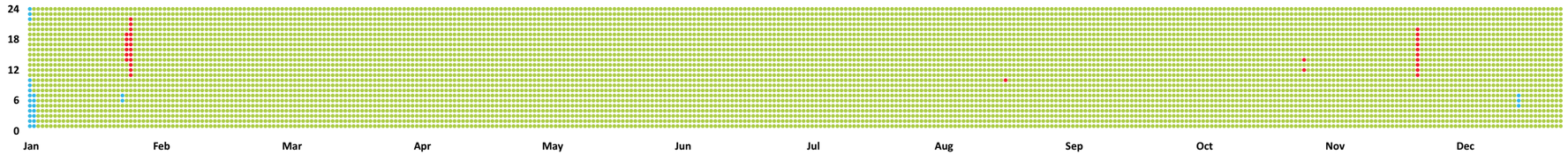
Slightly Cold
PMV < -0.5

Comfortable
-0.5 < PMV < 0.5

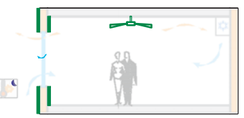
Slightly Warm
0.5 < PMV < 1.5

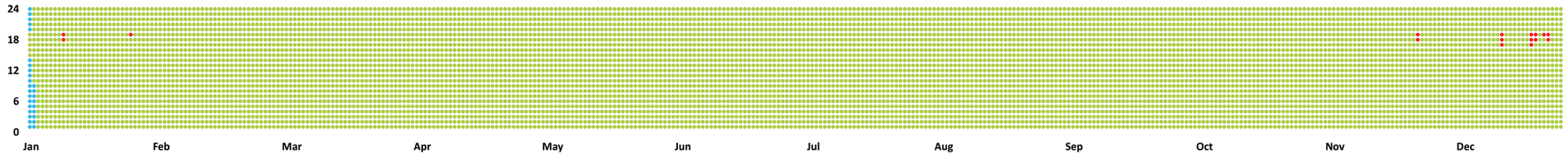
Warm
PMV > 1.5





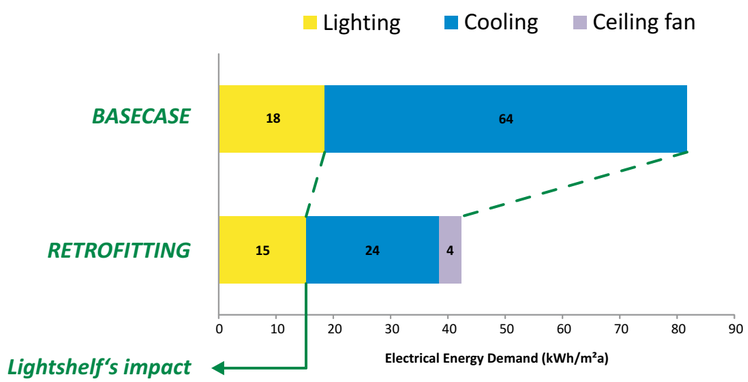
• Slightly Cold 25 Hours • Comfortable **8704** Hours • Slightly Warm 31 Hours • Warm 0 Hours





• Slightly Cold 28 Hours • Comfortable **8716** Hours • Slightly Warm 16 Hours • Warm 0 Hours

Energy Usage



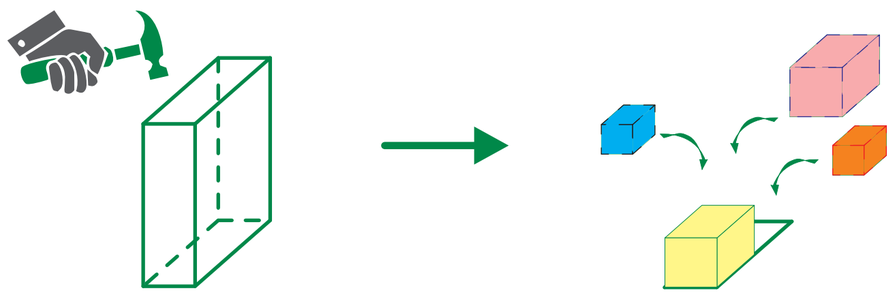
SAME Thermal Comfort
44% LOWER Cooling Load

For the climate of Hochiminh City, the retrofit design can help achieving the same comfort as a fully conditioned room while only use half of electricity.

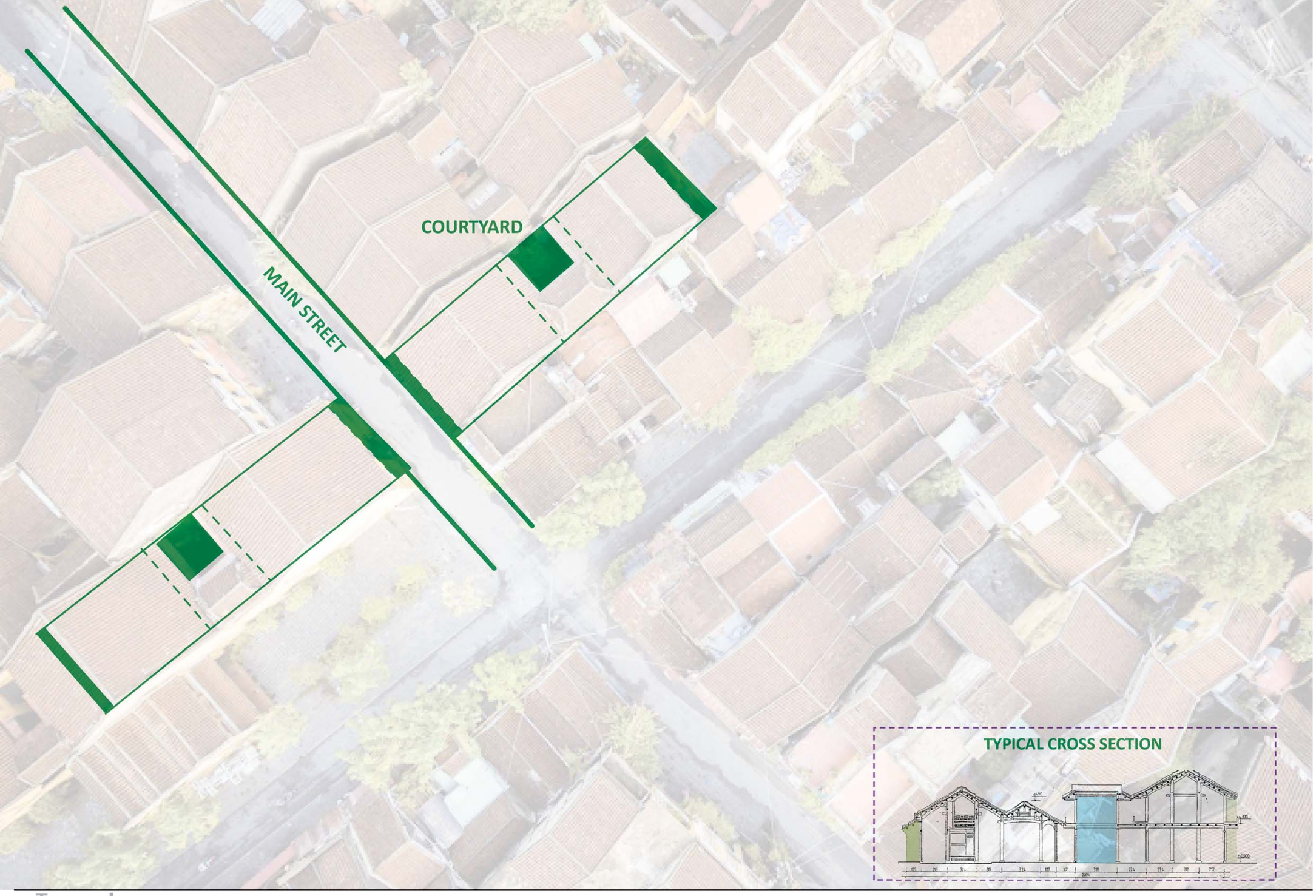
At the same time, the impact of lightshelf is shown on the reduction of lighting loads.

MODERNIZING THE „MODERN TUBE-HOUSE“

Searching for inspirations from Vietnamese Vernacular Architecture



After having understands of which solutions can bring positive impacts on the design in the climate of Vietnam, **we decided to push even further by trying to change completely the design of Vietnamese Modern Tube-House.**



TYPICAL CROSS SECTION

As mentioned in the beginning, one of the problems for modern tube-house is the lack of connections between past and present.

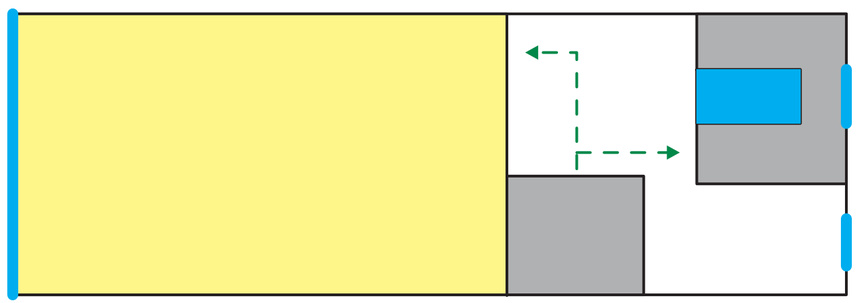
Therefore the research focuses on **looking for inspirations from** Vietnamese vernacular architecture, in this case is the uses of internal courtyard.

ZONING AND PROGRAMS

Floor Plan

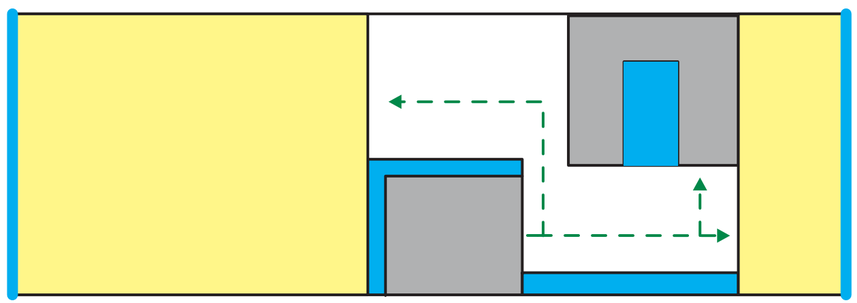
Basecase

= 33 m²



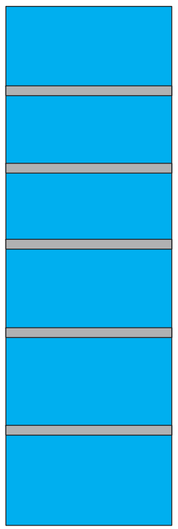
Modernized

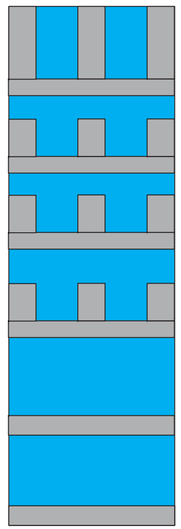
= 35 m²



Living Areas | Light Shaft | Elevator, Staircase | → Circulation

Facades

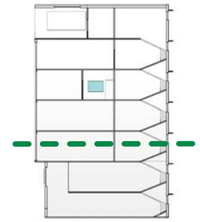




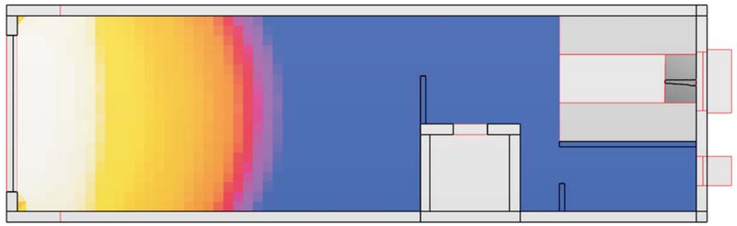
The biggest difficulty is differences in contexts between past and present, especially the density of houses in modern cities.
The living space is now broken into two instead of one in order to **fully taking advantages of both facades.** In addition, **lightshafts** are created within inside the house.

The window areas are also reduced to limit solar radiation getting into the spaces.

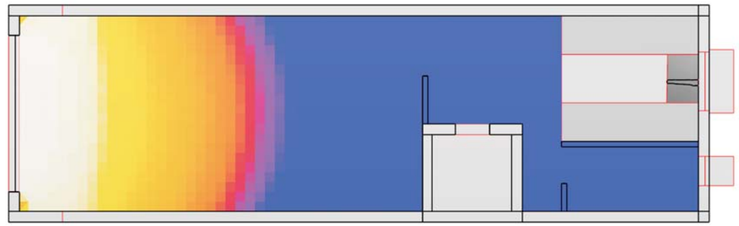
DAYLIGHT AVAILABILITY: COMPARISON



Basecase

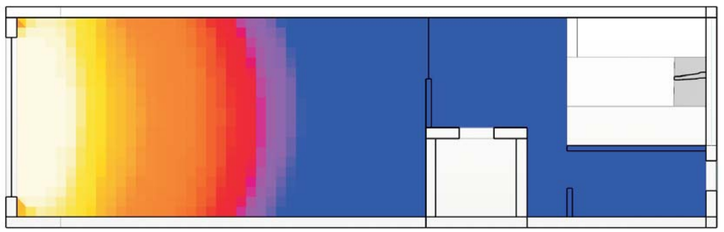


$sDA_{300,50\%}$ = 25%

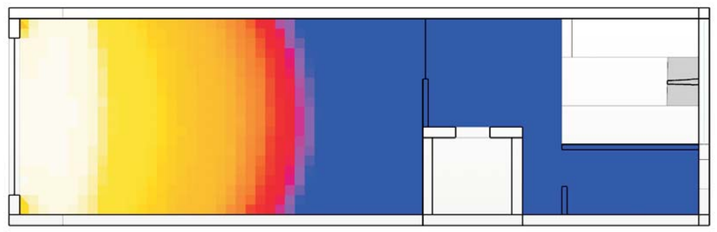


$sDA_{300,50\%}$ = 29%

Retrofitting

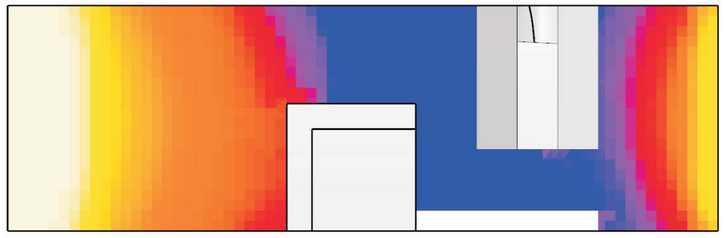


$sDA_{300,50\%}$ = 27%

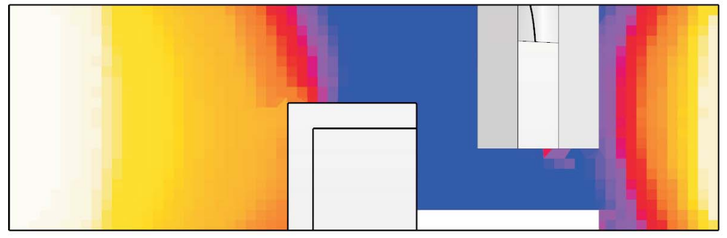


$sDA_{300,50\%}$ = 42%

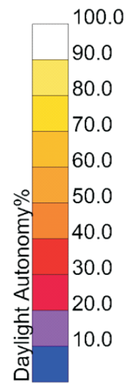
Modernizing



$sDA_{300,50\%}$ = 41%

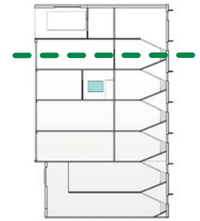


$sDA_{300,50\%}$ =61%



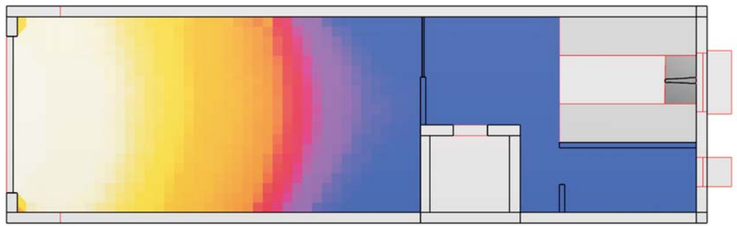
The new design has has better performance in term of daylight in both climates. By having a reasonable sizing for the spaces, there is no dark corner inside the rooms.

DAYLIGHT AVAILABILITY: COMPARISON

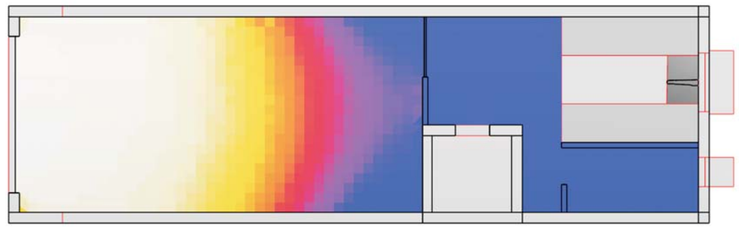


For upper levels, now we can ensure **having daylight 100% with mininum of 300lux during occupation time.**

Basecase

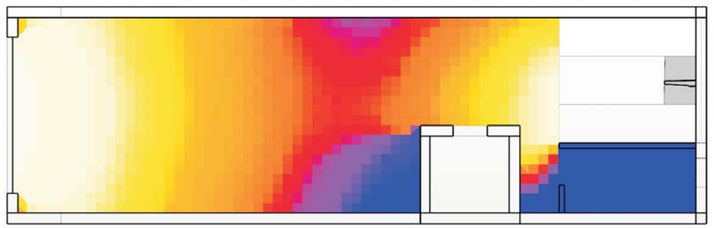


$sDA_{300,50\%}$ = 43%

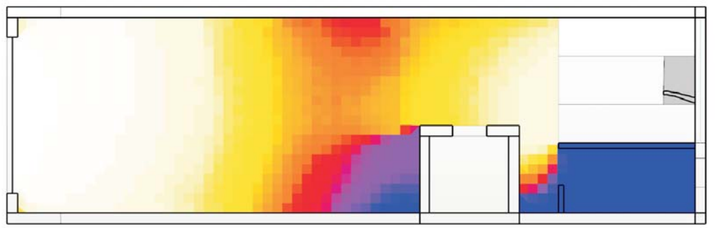


$sDA_{300,50\%}$ = 44%

Retrofitting



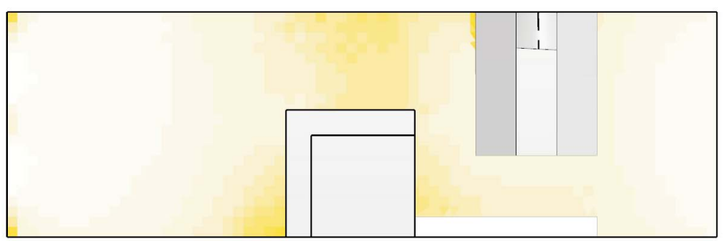
$sDA_{300,50\%}$ = 63%



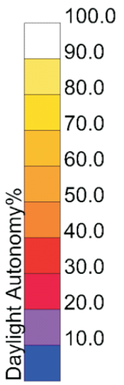
$sDA_{300,50\%}$ = 74%

Modernizing

$sDA_{300,50\%}$ = 100%

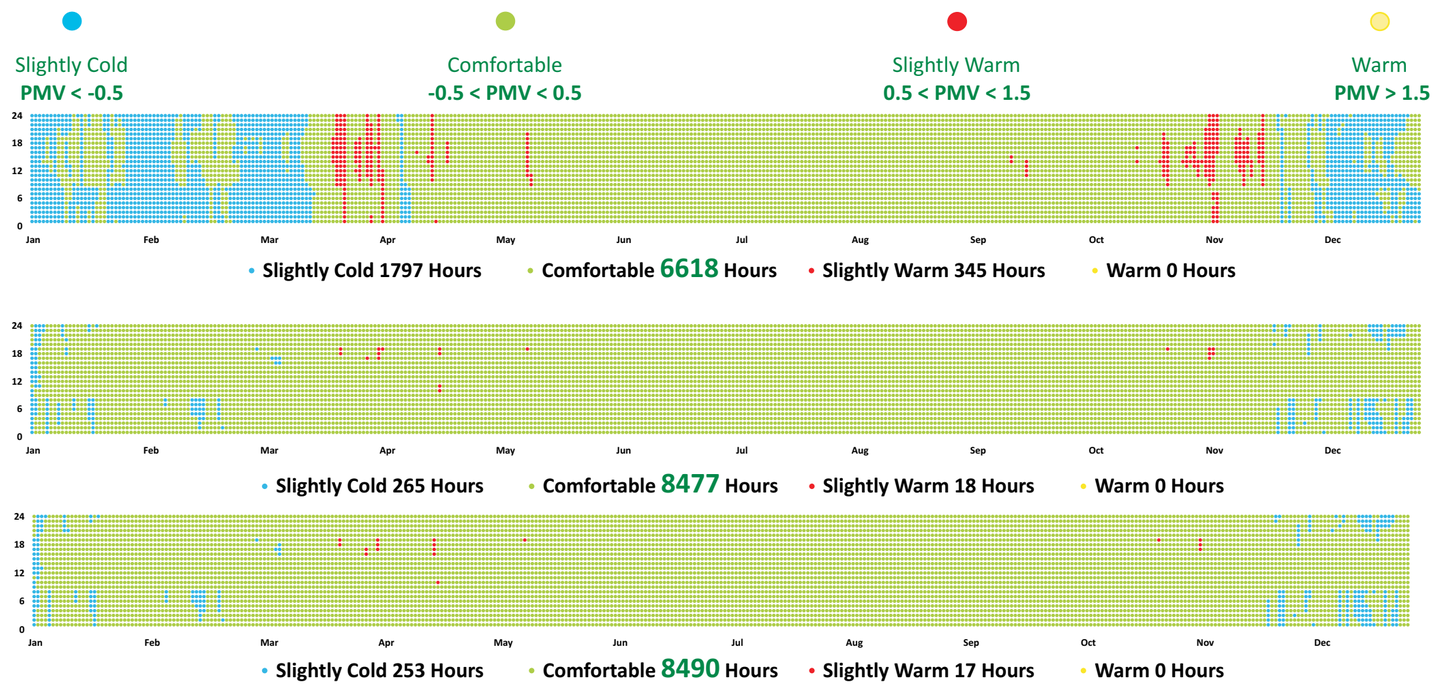


$sDA_{300,50\%}$ =100%

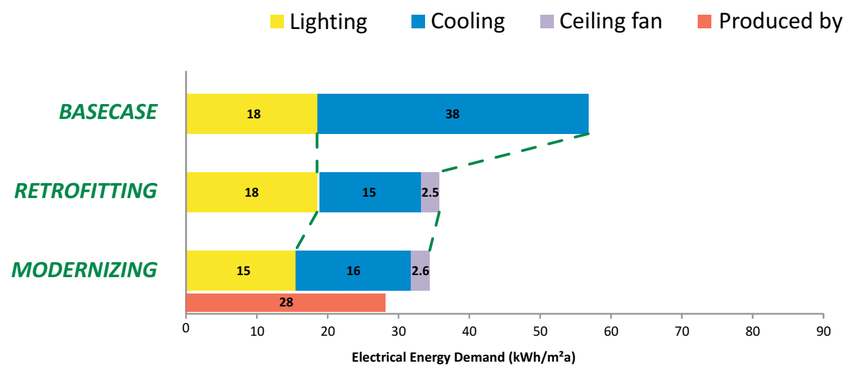


THERMAL COMFORT AND ENERGY USAGE: COMPARISON

HANOI



Energy Usage



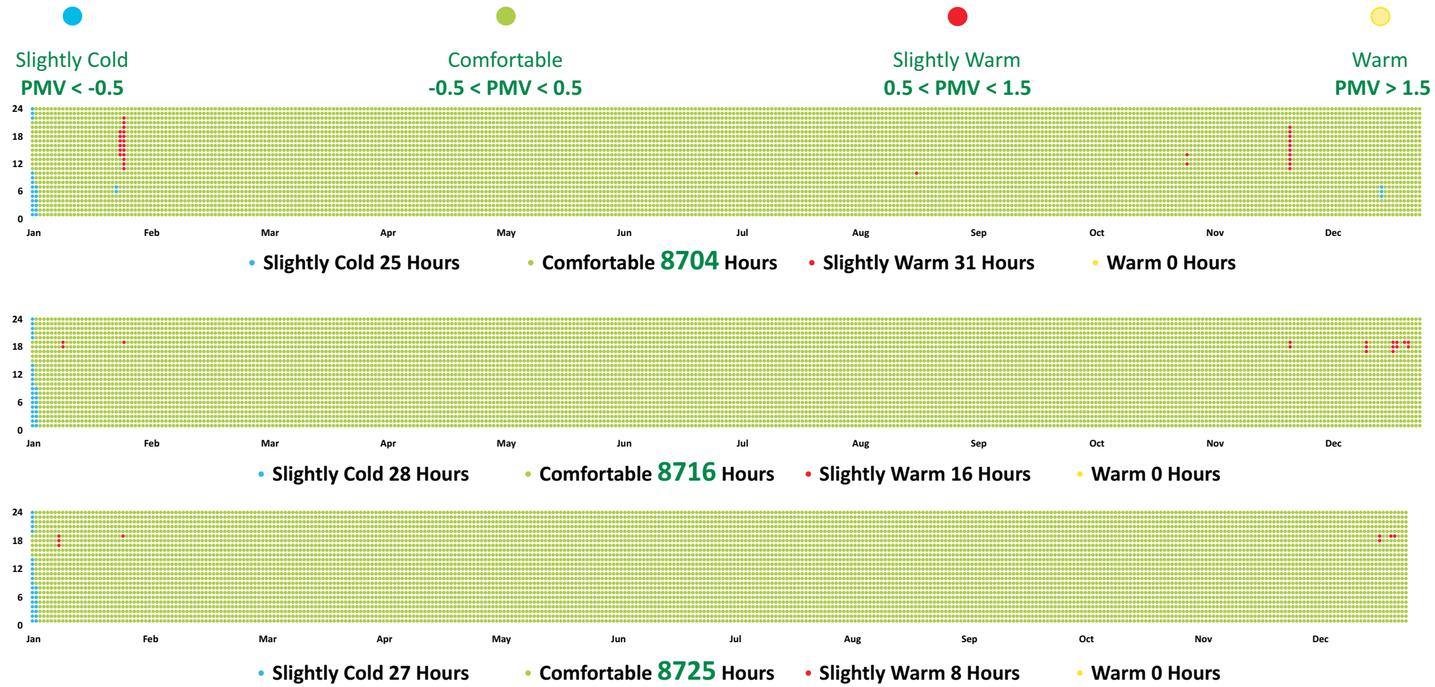
In term of thermal comfort, the new design is slightly better than the retrofitted design.

This result applies for rooms at lowest levels, what can be expected is the bigger improvement on upper levels.

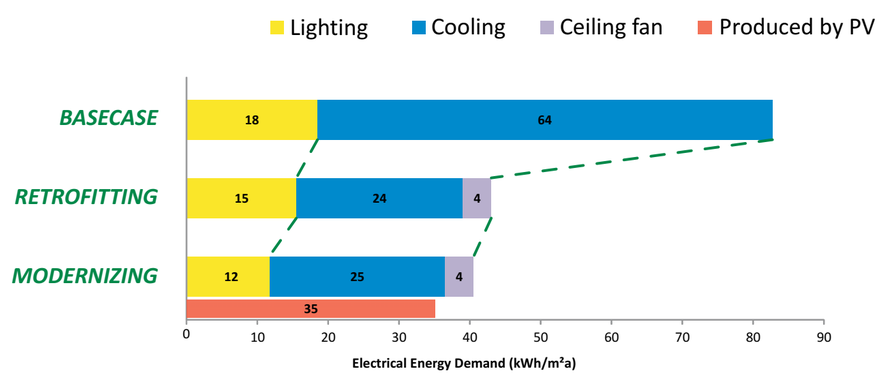
With a rough calculation, almost all the energy consumption of the house can be met by having PV panels on rooftop.

THERMAL COMFORT AND ENERGY USAGE: COMPARISON

HOCHIMINH CITY



Energy Usage



Same situation as in Hanoi case, the new design is slightly better than the retrofitted design. Also the potentials for generating energy from PV should also be taken into consideration.

THANK YOU!

Thank you,

Felix for his supports in shaping the project.

Atejandra for her inputs in daylight simulation.

Tommaso for knowledges on TRNLizard.

Moni for her spiritual supports.

Transsolar Academy for the opportunity.

And,
Transsolar for being such an amazing group.

https://upload.wikimedia.org/wikipedia/commons/d/d9/Vista_de_Ciudad_Ho_Chi_Minh_desde_Bitexco_Financial_Tower,_Vietnam,_2013-08-14,_DD_13.JPG