

A Zero Energy terminal building for Amsterdam Airport Schiphol

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first mentor

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second mentor

ROADMAP

- 0.0 MOTIVATION
- 1.0 DESIGN PREPARATION
 - 1.1 Why Zero Energy Buildings
 - 1.2 What does Zero Energy mean
 - 1.3 Selected study case
- 2.0 SITE
 - 2.1 Location
 - 2.2 Climatic aspects, influence and potential
- 3.0 ARCHITECTURE AND STRUCTURE
 - 3.1 Shape, orientation and thermal zoning
 - 3.2 Building structure
- 4.0 TECHNOLOGY
 - 4.1 Passive systems and their efficiency
 - 4.2 Active strategies overview and selection
- 5.0 PLANS AND DETAILS
- 6.0 CONCLUSION/REFLECTION

What is
your contribution to a
sustainable
world?



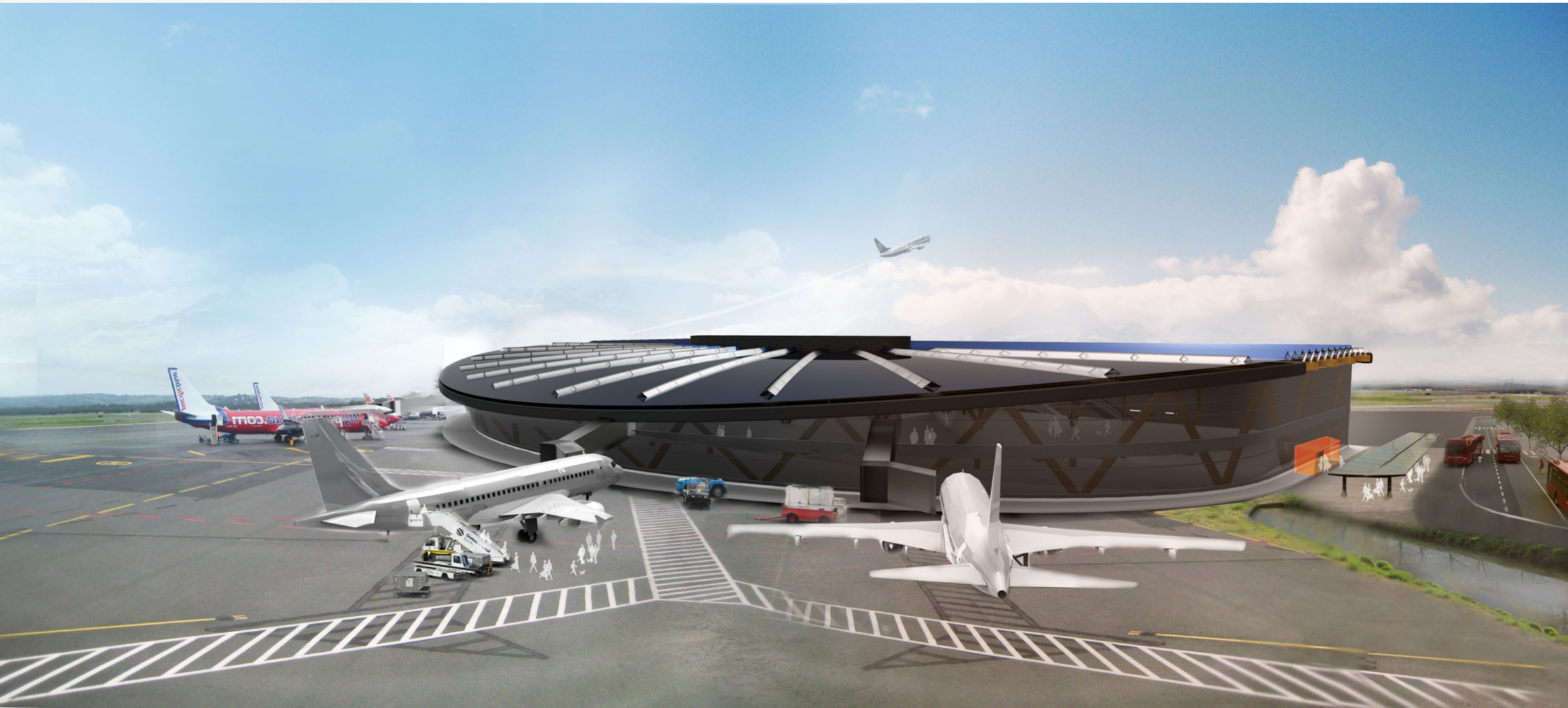
TiSD : Technology in Sustainable Development
*a graduation annotation stating
excellence in sustainability issues*



STEP BY STEP TO ZERO ENERGY AND BEYOND

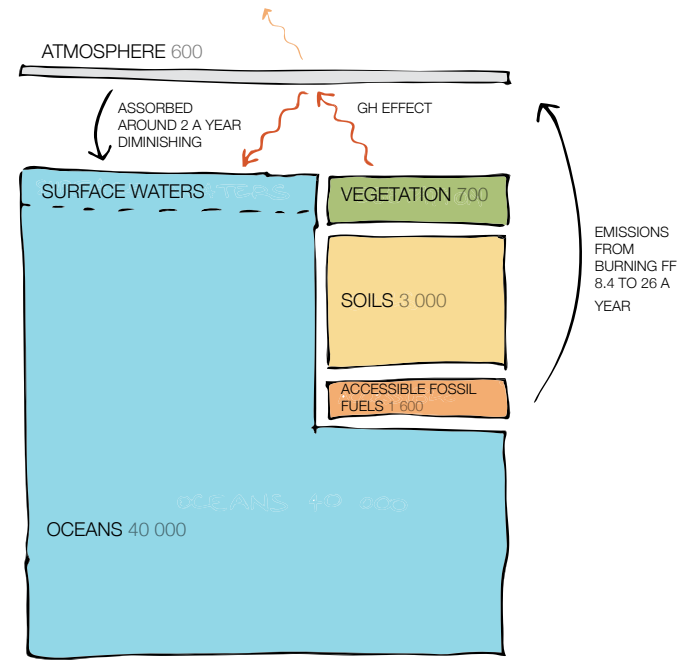
Zero Energy is the future of the built environment.

- Why do we need Zero Energy Buildings?
- When is a building energy neutral?
- How are ZEBs planned, built and evaluated?
- When are they profitable and how do we make them attractive to the market?

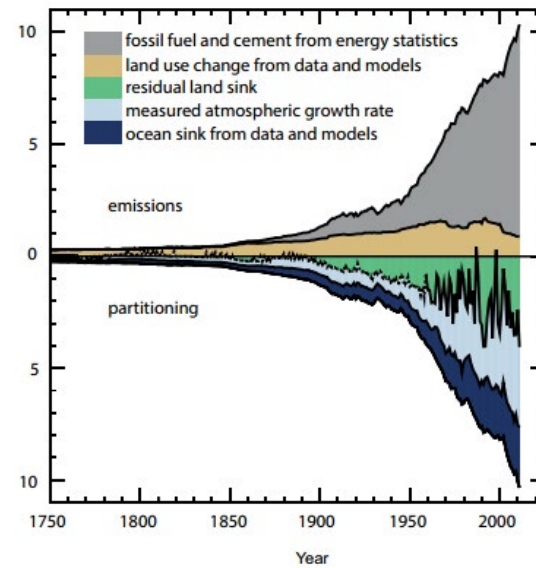


CARBON CYCLE

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Annual man-made CO₂ emissions and partitioning



RISKS OF GHG EMISSIONS-RELATED GLOBAL WARMING

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Loss of wildlife



Air pollution

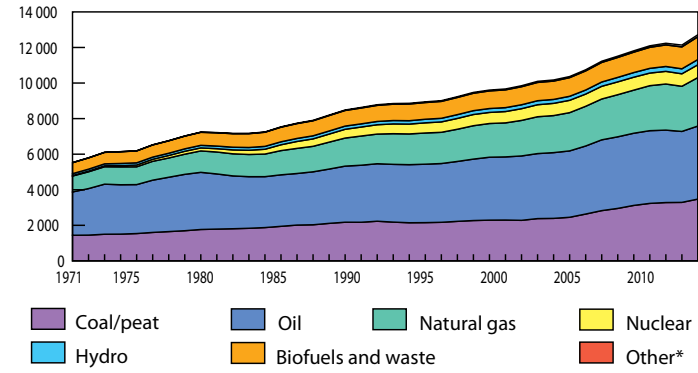


Extreme weather events and rising sea level

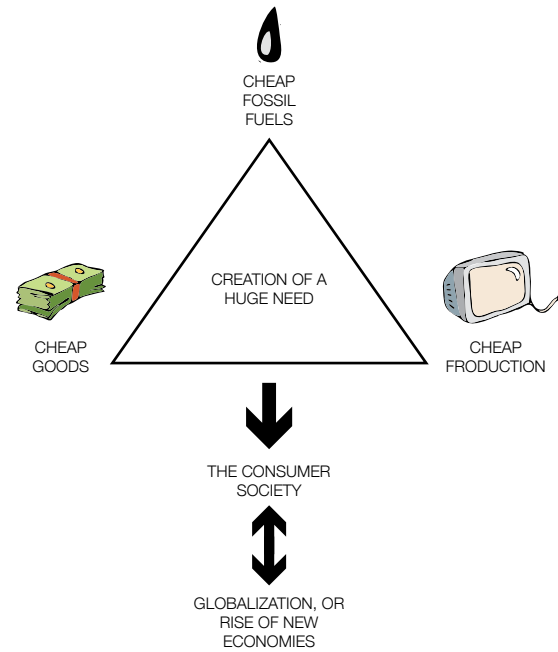
DEPLETION OF RESOURCES

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World energy supply by fuel



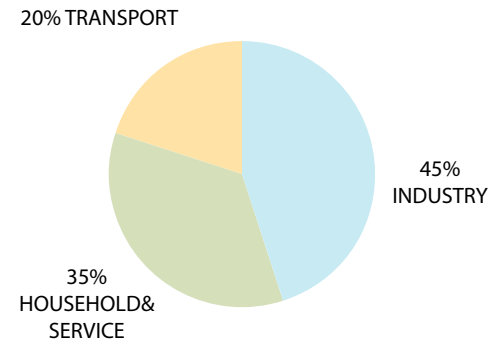
A society based on consumption



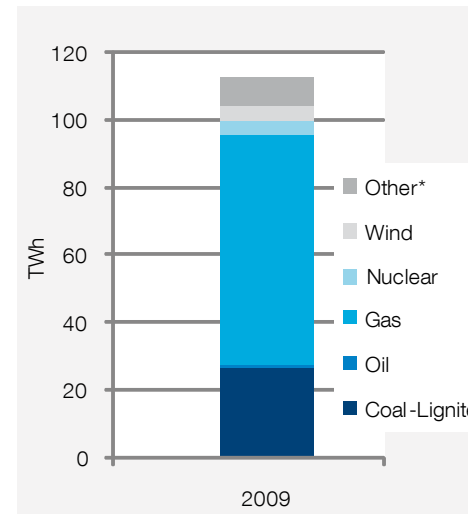
ENERGY IN THE NETHERLANDS

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Energy use by sector



Energy supply by fuel

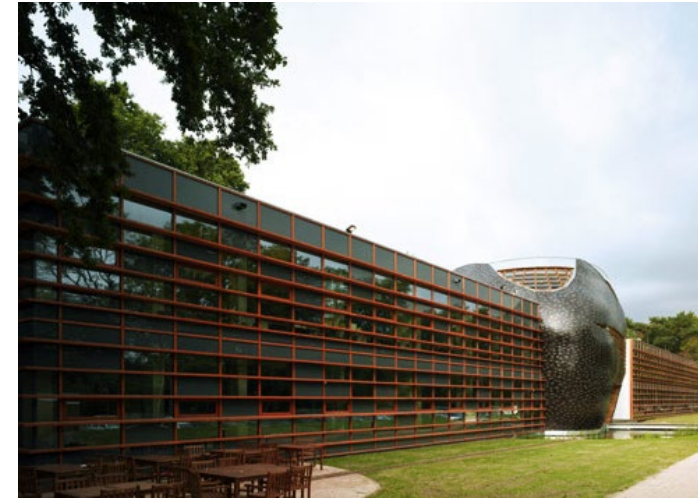


BUILT EXAMPLES

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NREL Headquarters, 2010.
Colorado



WWF Headquarters, 2006.
The Netherlands



Apartment blocks, 2003.
United Kingdom

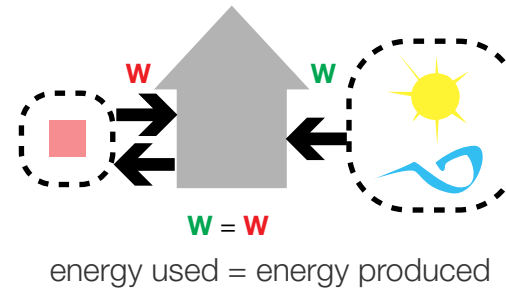
In Europe, all new buildings will have to be Energy Neutral by 2020.

All public buildings by 2018.

ESSENTIAL CONCEPTS

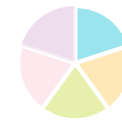
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ZEB definition



New Steps Strategy

Set peer building benchmark



1. Avoid energy demand



2. Reuse waste flows



3. Generate renewable energy



CASE-STUDY SCHIPHOL AIRPORT AMS

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Better Airport Regions reseach project

“[...] enhanced reciprocity between the airport and its surrounding metropolitan region can facilitate a transformation path towards more sustainable, better airport regions.”

“ The project starts from a joint perspective on essential flows (energy, water, materials, food and mobility), urban development and spatial quality [...]”

Also, as yet there is no existing ZEB airport terminal.



REDESIGNING THE “PIER A” EXPANSION

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📍 new satellite ZEB terminal **VS** planned expansion (2014) 📍

- less aircraft fuel
- more efficient timing
- future-proof
- even longer way to Polderbaan
- is it really the best strategy?



PROFITABILITY

An aircraft driving on the ground emits 46x more CO₂ than during take off.
The average time needed to drive to and from the Polderbaan is 40 minutes.

Considering the price of fuel and of energy, when would a new terminal that solves these issues pay back for the investment?

$$(\text{€}/\text{m}^2_{\text{Pier A}} + \text{€}/\text{kWh per year} + \text{€}/\text{liter}_{\text{kerosene}} \text{ per year} + \text{€}/\text{CO}_2 \text{ per tonne per year}) - (\text{€}/\text{m}^2_{\text{ZEB}} - \text{€}/\text{kWh per year})$$

= 13.5 projected payback years



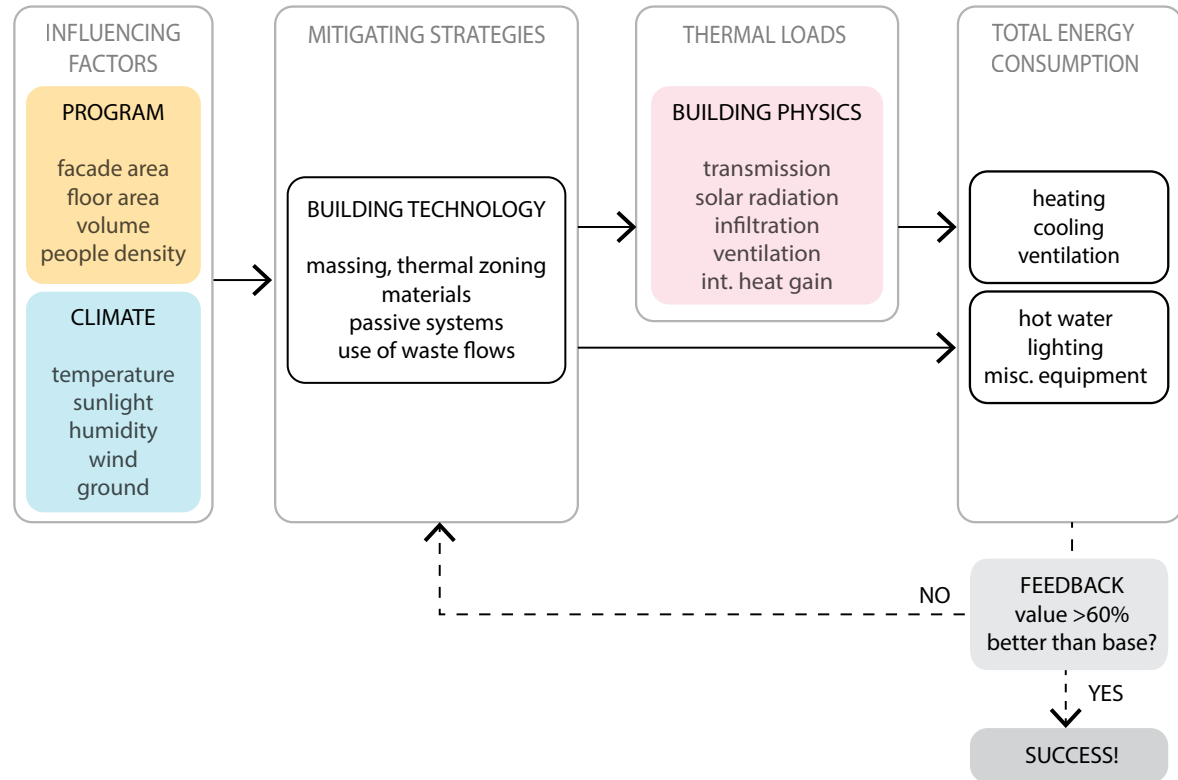
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LOCATION AND CONNECTION



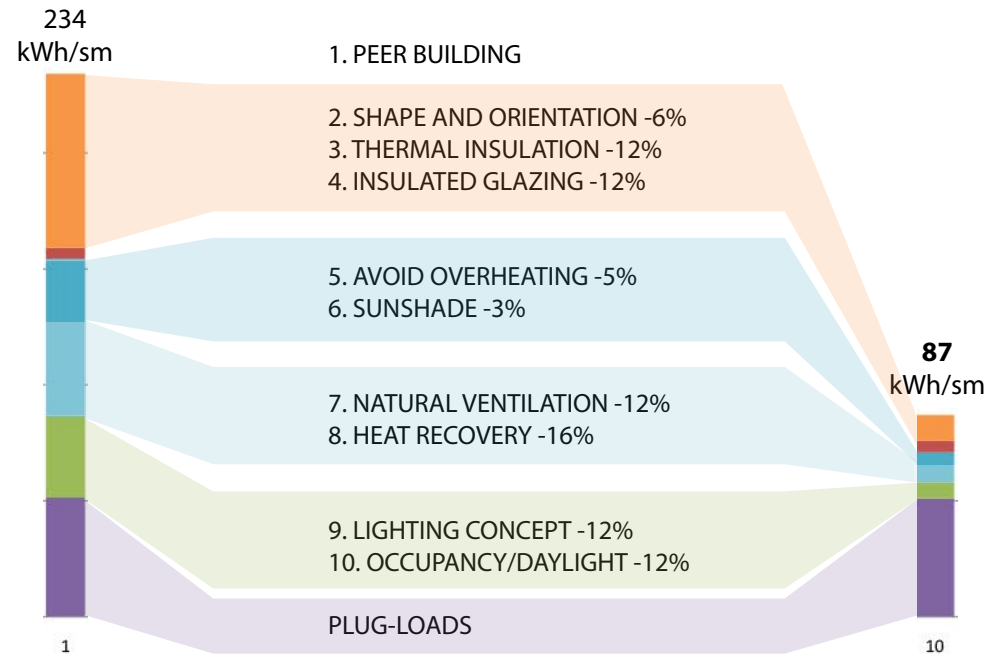
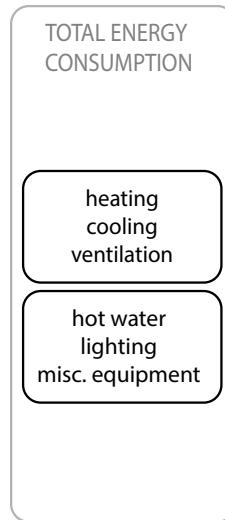
ENERGY USE

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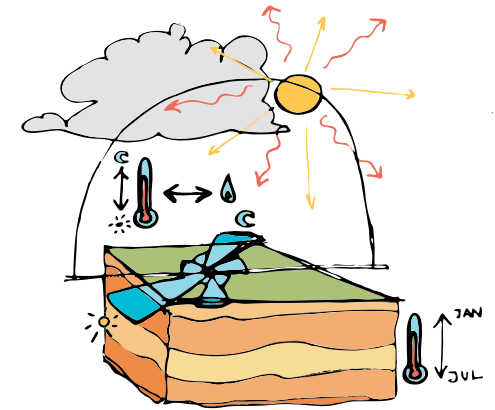
METHODOLOGY

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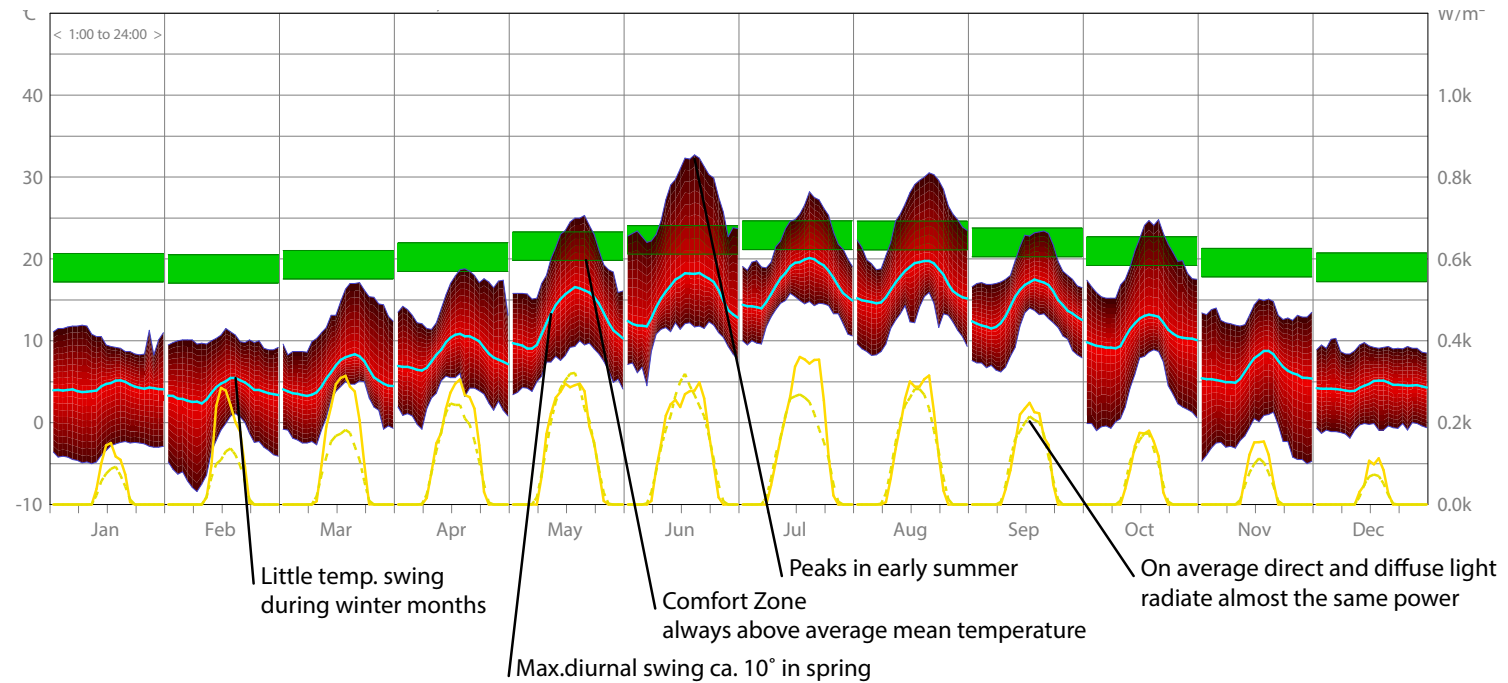


TEMPERATURES

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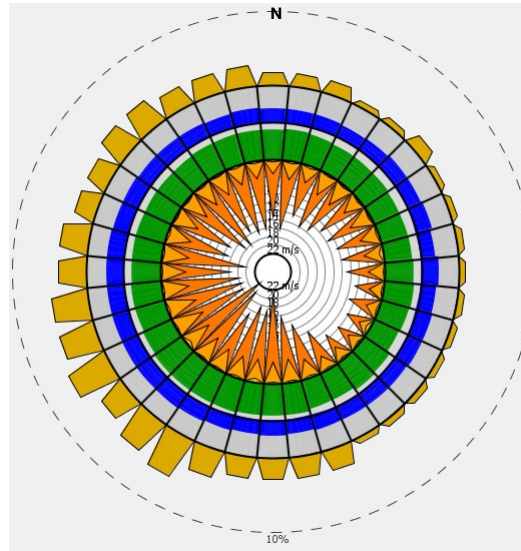
Comfort: Thermal Neutrality
 Temperature: max.-min. and av.
 Direct Solar
 Diffuse Solar



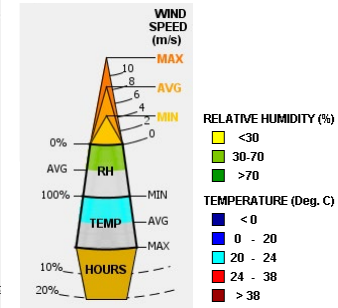
WIND PATTERNS

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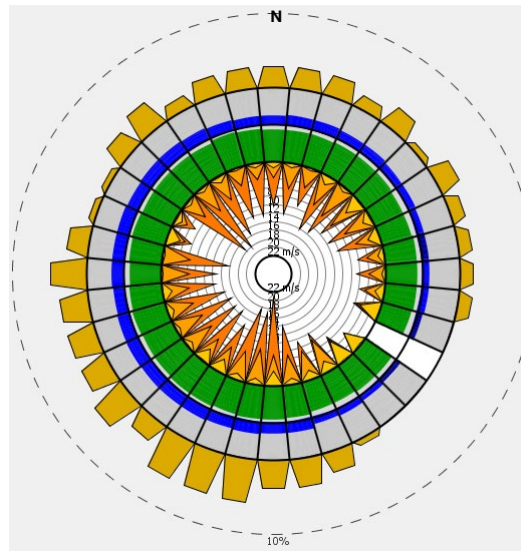
DEC-JAN



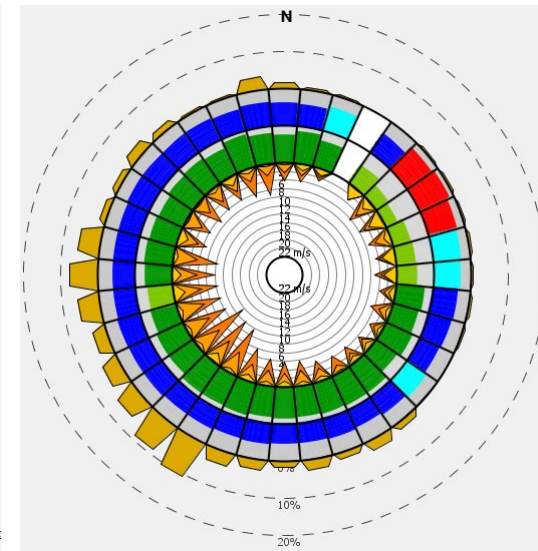
LEGEND



DECEMBER

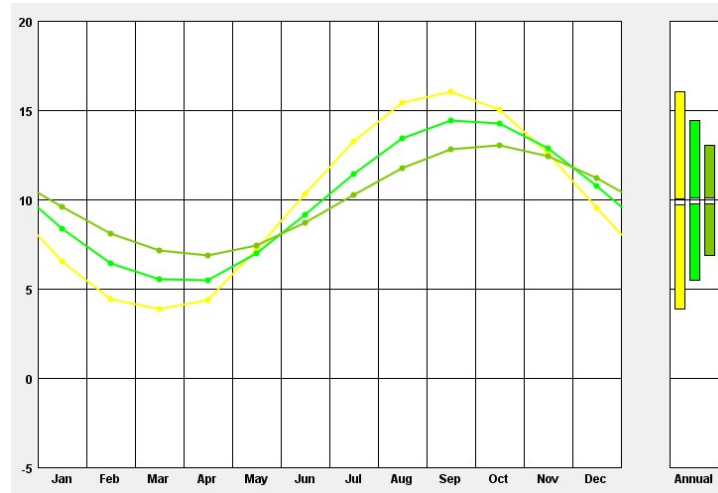


AUGUST

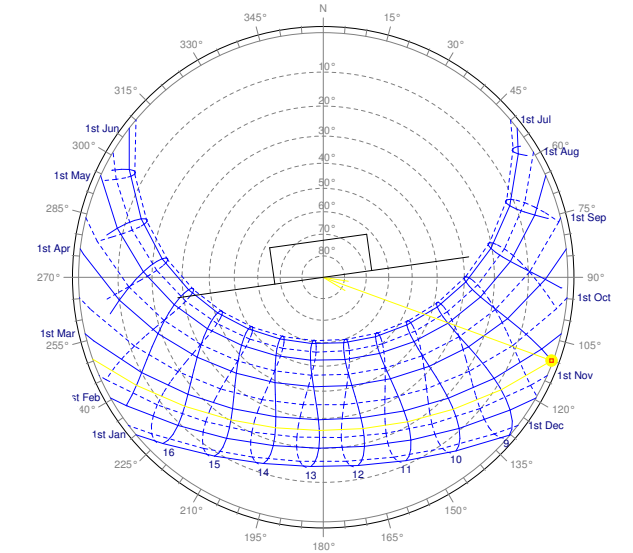


WEATHER DATA

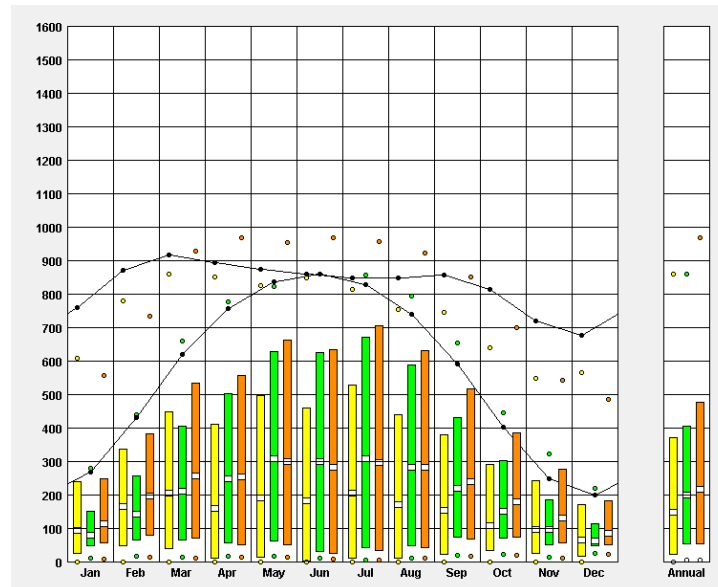
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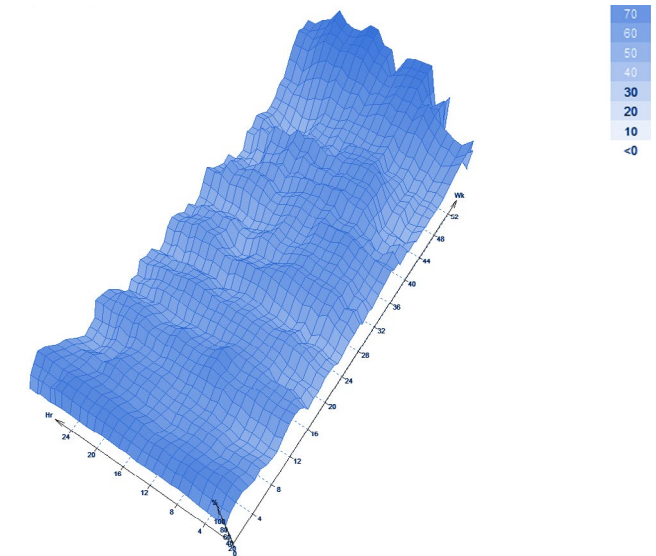
Ground temperatures



Solar geometry



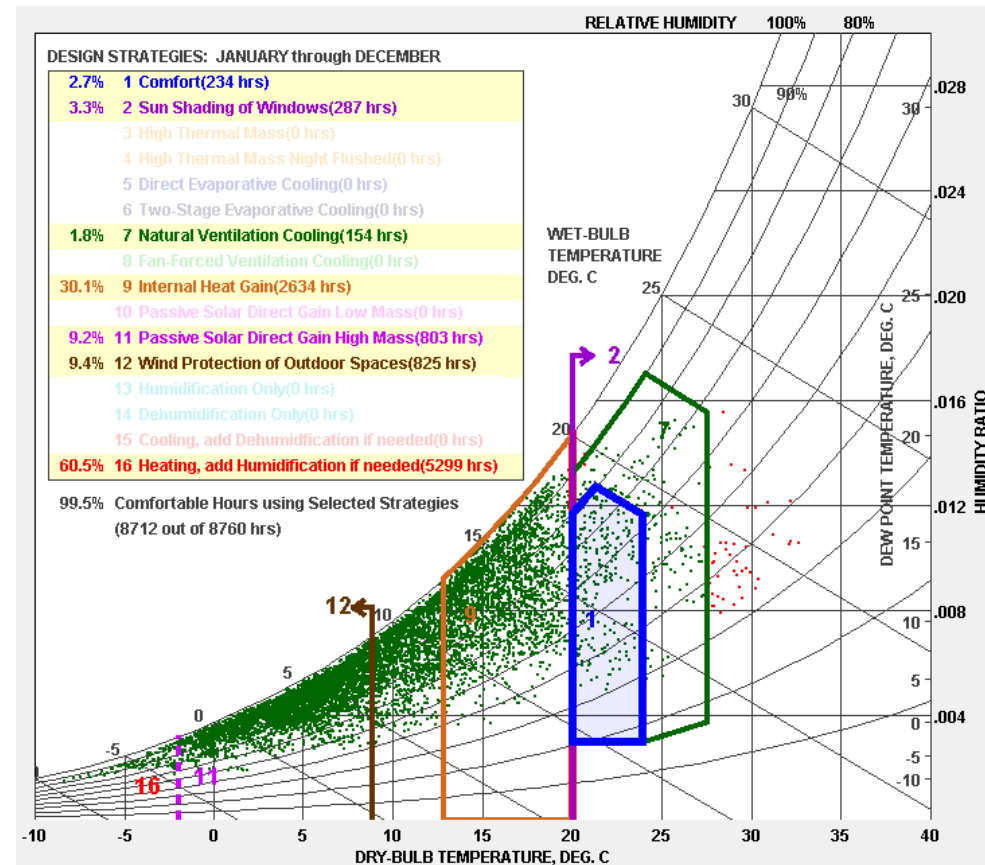
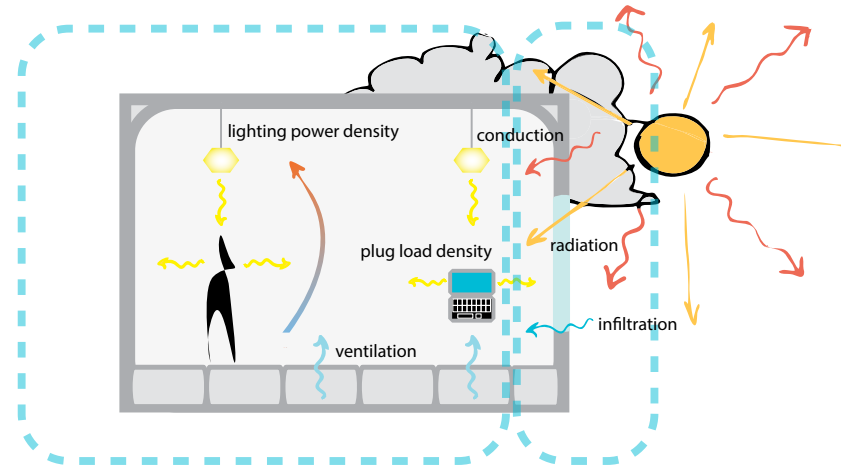
Direct, diffuse and global radiation



Sky cover

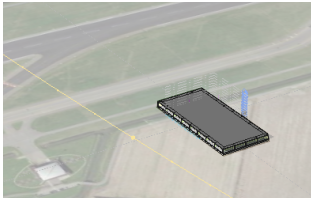
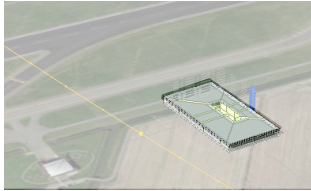
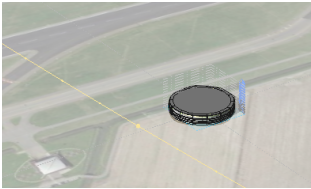
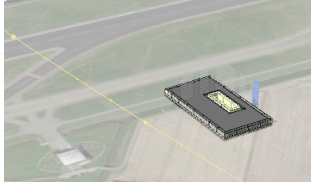
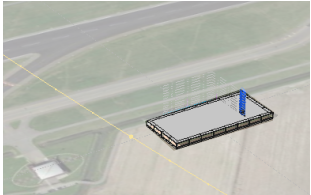
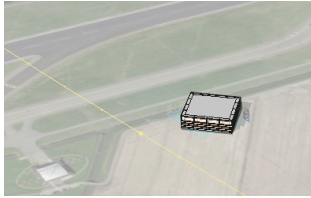
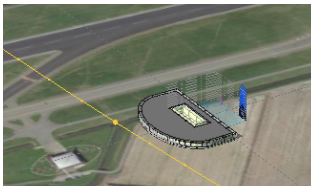
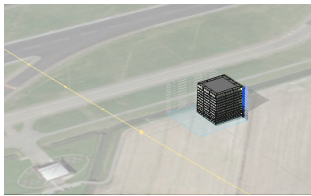

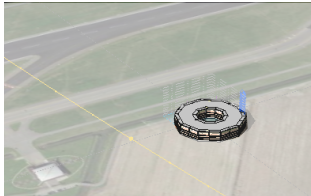
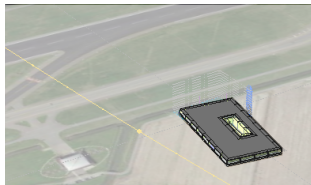
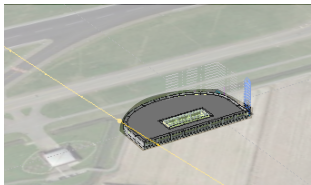
PSYCHROMETRIC CHART

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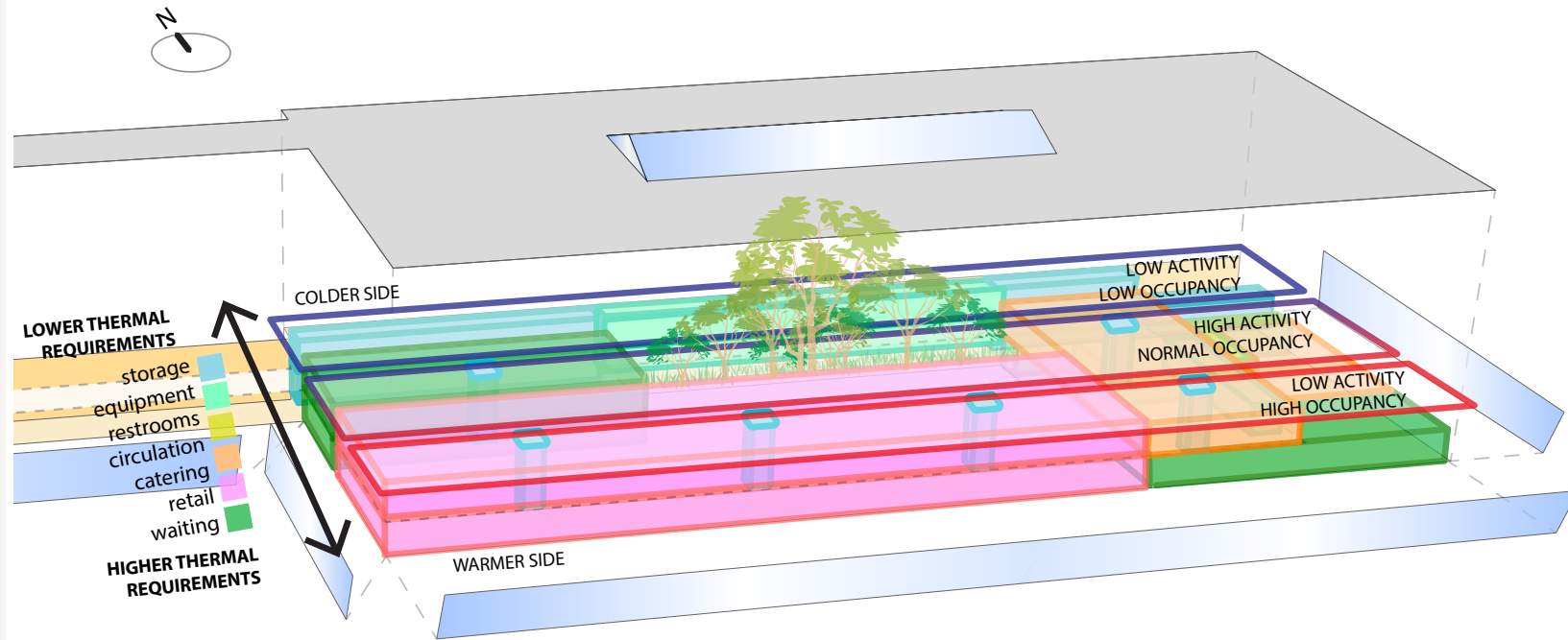
SHAPE EXPLORATION

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ranking		total MJ/sm/yr		ranking		total MJ/sm/yr
1		742	- little space for gates	7		808
2		760	- difficult to expand	8		817
3		774	- boring	9		844
4		797	- panoramic view on the whole of Schipol - enclosed atrium used as indoor garden has climatic and non-climatic advantages	10		850
5		800		11		858
6		807		12		861

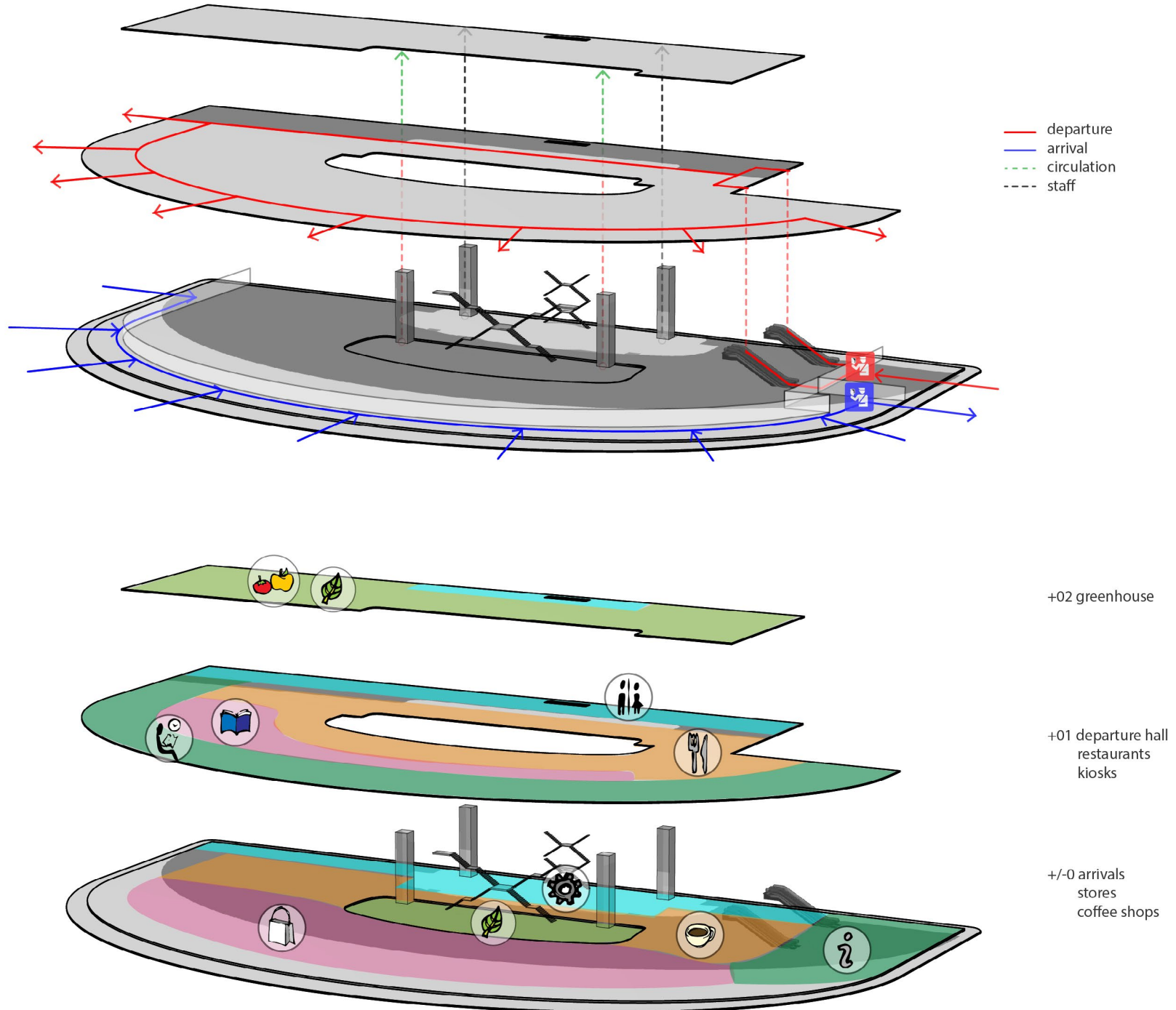
THERMAL ZONING

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BUILDING PROGRAM

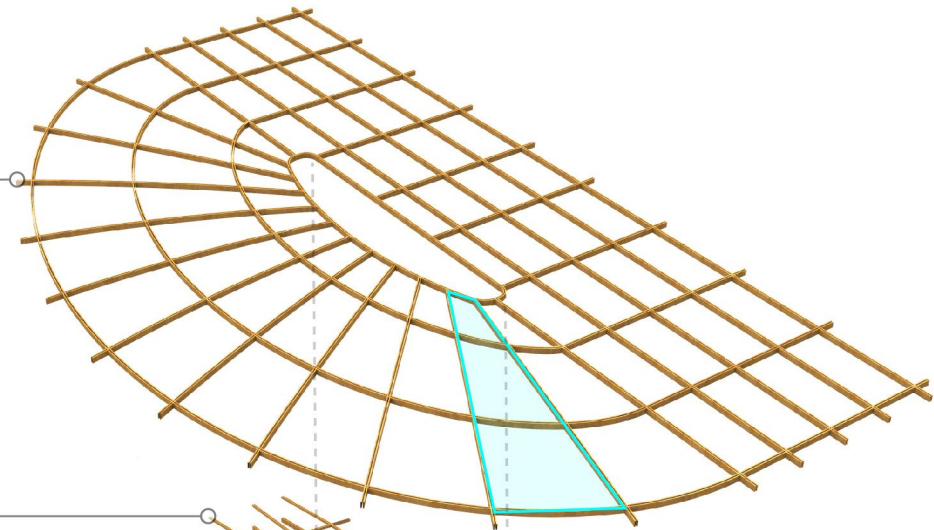
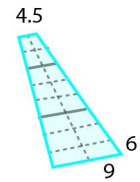
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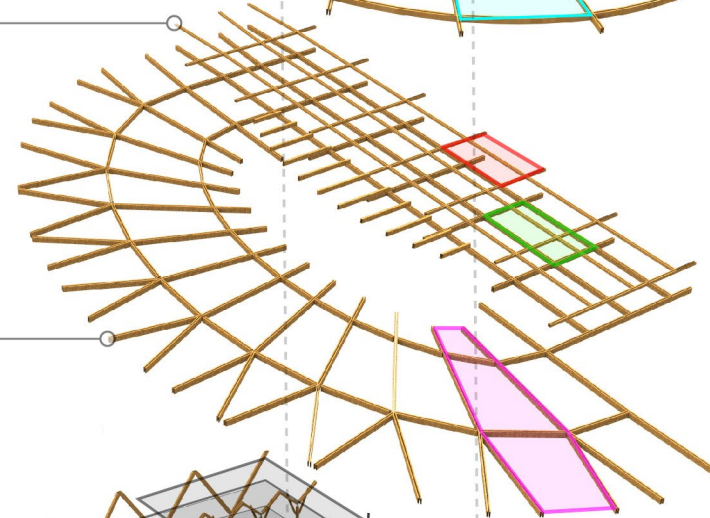
STRUCTURE

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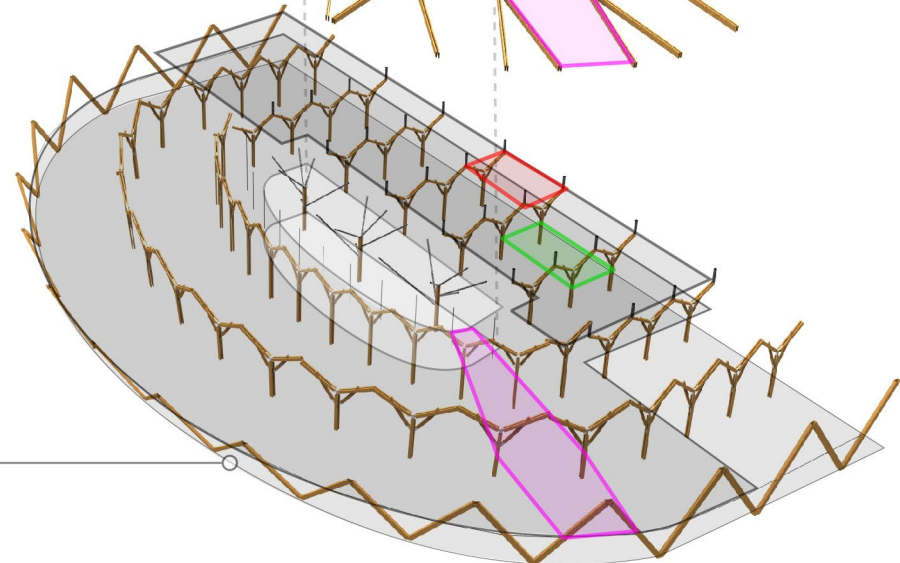
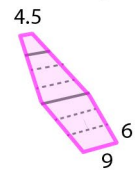
Roof
+ 12



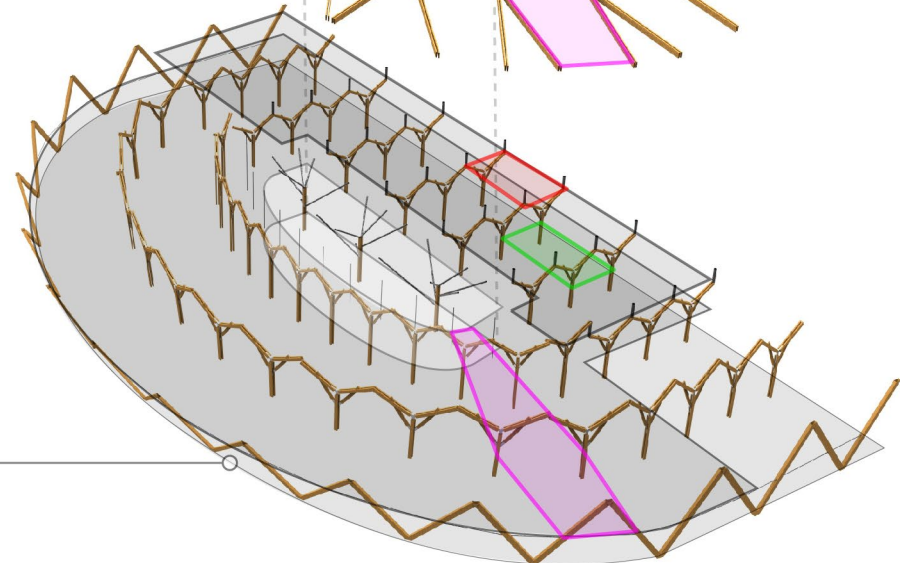
Greenhouse
+ 7



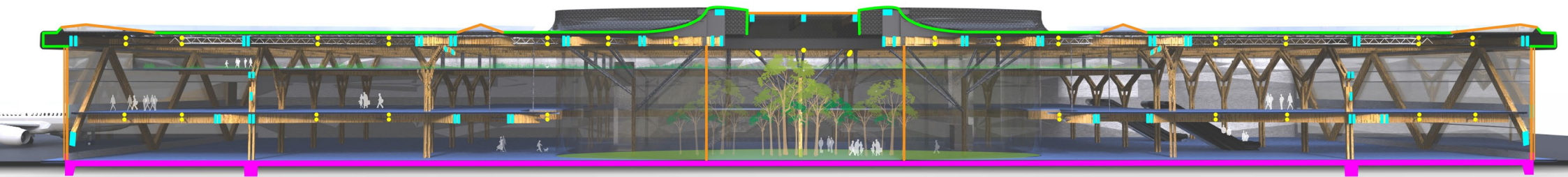
1st Floor
+ 4.5



Ground Floor
+/- 0

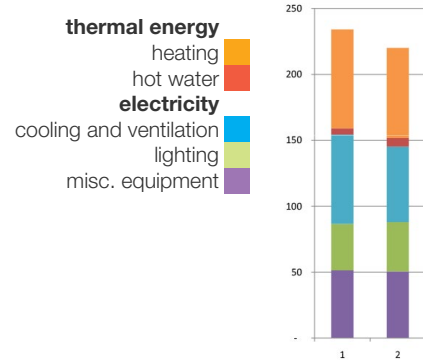


LONGITUDINAL SECTION



01. PEER BUILDING BASELINE to 02. SHAPE AND ORIENTATION

- 0.0 MOTIVATION
- 1.0 DESIGN PREPARATION
 - 1.1 Why Zero Energy Buildings
 - 1.2 What does Zero Energy mean
 - 1.3 Selected study case
- 2.0 SITE
 - 2.1 Location
 - 2.2 Climatic aspects, influence and potential
- 3.0 ARCHITECTURE AND STRUCTURE
 - 3.1 Shape, orientation and thermal zoning
 - 3.2 Building structure
- 4.0 TECHNOLOGY
 - 4.1 Passive systems and their efficiency
 - 4.2 Active strategies overview and selection
- 5.0 PLANS AND DETAILS
- 6.0 CONCLUSION/REFLECTION

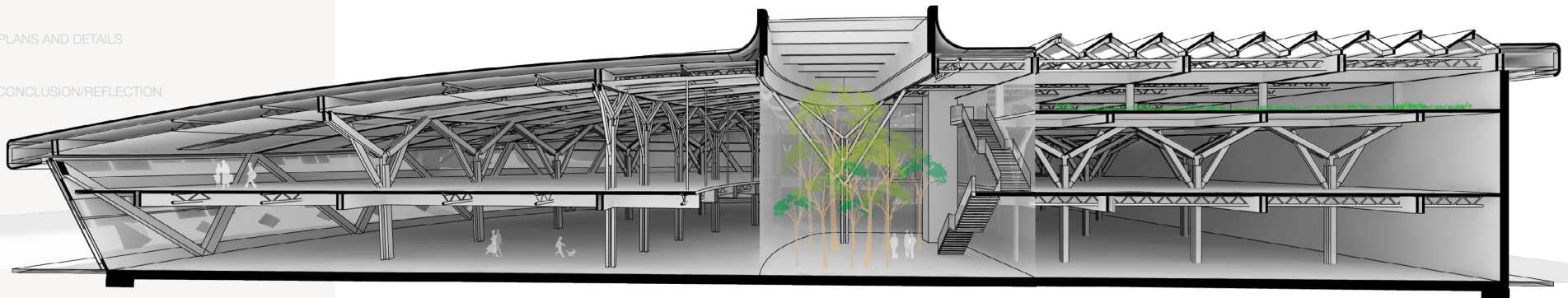


kWh/sm/yr
234 to 220

reduction from baseline
-6%

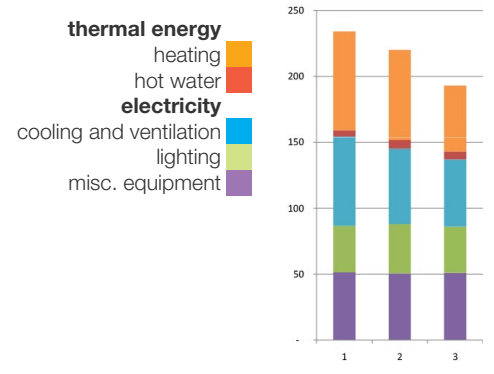
reduction from previous tot.consumption
-6%

reduction from previous heating and cooling load
-18%



03. THERMAL INSULATION

- 0.0 MOTIVATION
- 1.0 DESIGN PREPARATION
 - 1.1 Why Zero Energy Buildings
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 - 2.1 Location
 - 2.2 Climatic aspects, influence and potential
- 3.0 ARCHITECTURE AND STRUCTURE
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- 4.0 TECHNOLOGY
 - 4.1 Passive systems and their efficiency
 - 4.2 Active strategies overview and selection
- 5.0 PLANS AND DETAILS
- 6.0 CONCLUSION/REFLECTION

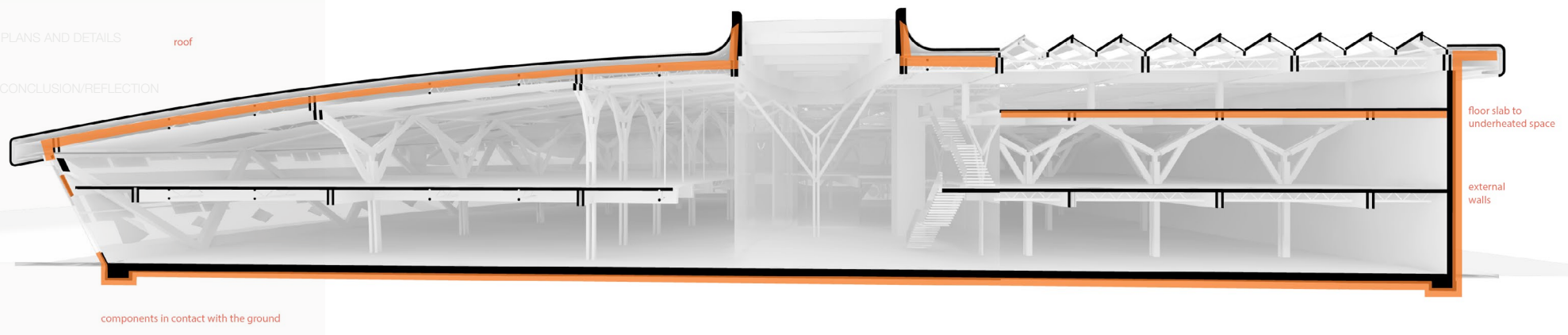
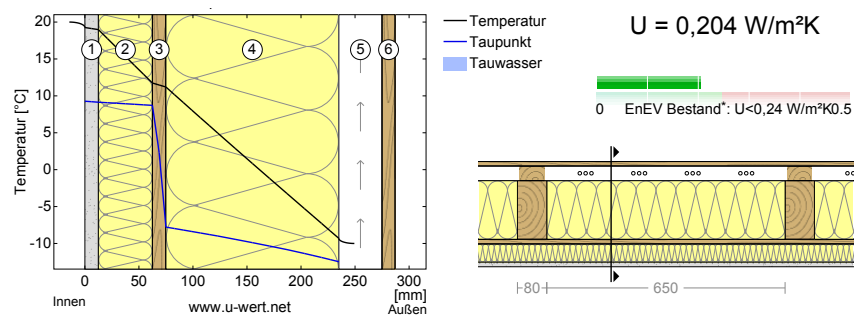


kWh/sm/yr
193

reduction from baseline
-18%

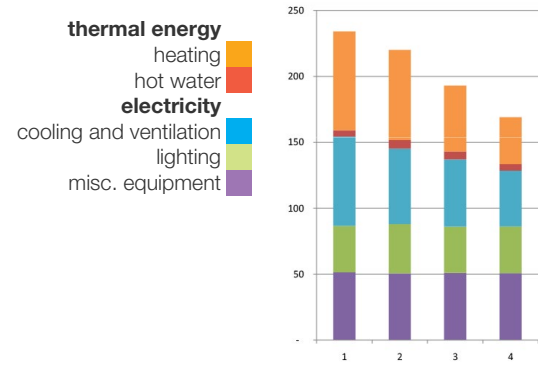
reduction from previous tot.consumption
-12%

reduction from previous heating load
-25%



04. IMPROVED GLAZING

- 0.0 MOTIVATION
- 1.0 DESIGN PREPARATION
 - 1.1 Why Zero Energy Buildings
 - 1.2 What does Zero Energy mean
 - 1.3 Selected study case
- 2.0 SITE
 - 2.1 Location
 - 2.2 Climatic aspects, influence and potential
- 3.0 ARCHITECTURE AND STRUCTURE
 - 3.1 Shape, orientation and thermal zoning
 - 3.2 Building structure
- 4.0 TECHNOLOGY
 - 4.1 Passive systems and their efficiency
 - 4.2 Active strategies overview and selection
- 5.0 PLANS AND DETAILS
- 6.0 CONCLUSION/REFLECTION

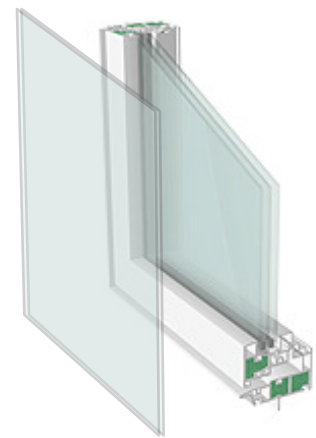


kWh/sm/yr
169

reduction from baseline
-28%

reduction from previous tot.consumption
-12%

reduction from previous heating load
-30%



double-leaf facade U-value 0.35

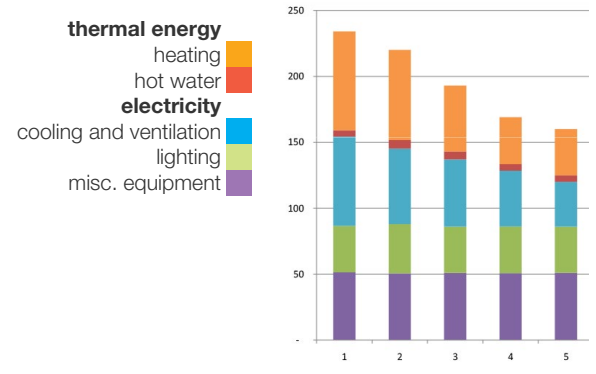
triple glazing with outer pane

non-metal insulated frame



05. AVOID OVERHEATING

- 0.0 MOTIVATION
- 1.0 DESIGN PREPARATION
 - 1.1 Why Zero Energy Buildings
 - 1.2 What does Zero Energy mean
 - 1.3 Selected study case
- 2.0 SITE
 - 2.1 Location
 - 2.2 Climatic aspects, influence and potential
- 3.0 ARCHITECTURE AND STRUCTURE
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- 4.0 TECHNOLOGY
 - 4.1 Passive systems and their efficiency
 - 4.2 Active strategies overview and selection
- 5.0 PLANS AND DETAILS
- CONCLUSION/REFLECTION

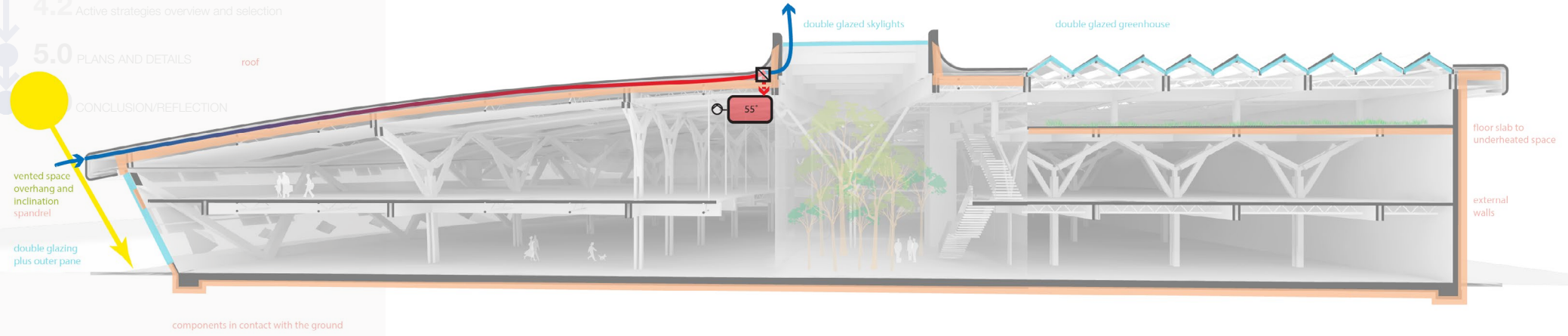
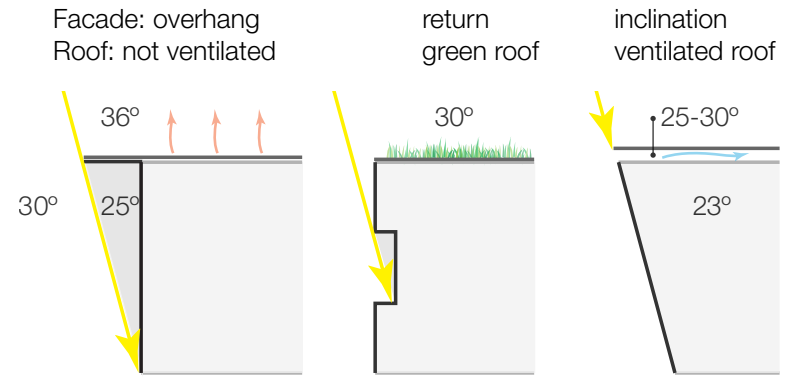


kWh/sm/yr
160

reduction from baseline
 -32%

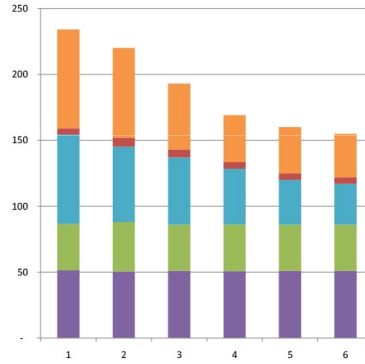
reduction from previous tot.consumption
 -5%

reduction from previous cooling load
 -60%



06. SUNSHADE

thermal energy
 heating
 hot water
electricity
 cooling and ventilation
 lighting
 misc. equipment



kWh/sm/yr

155

reduction from baseline

-34%

reduction from previous tot.consumption

-3%

reduction from previous cooling load

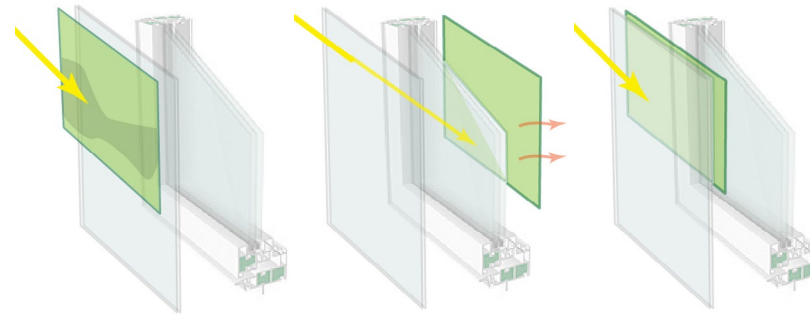
-70%

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- CONCLUSION/REFLECTION

Sunshade: external
 if none: g-value 0.8

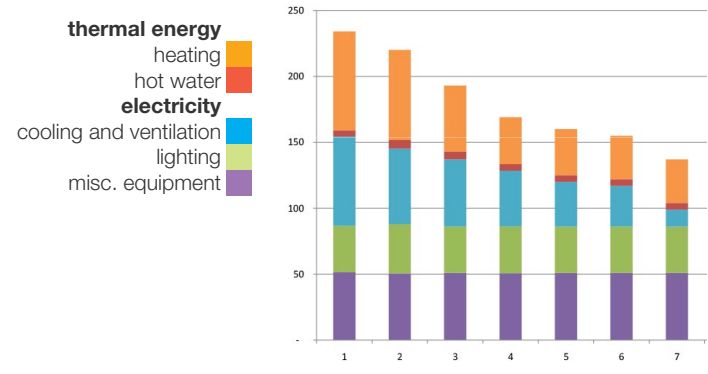
internal
 0.35

in-cavity
 0.15



07. NATURAL VENTILATION

- 0.0 MOTIVATION
- 1.0 DESIGN PREPARATION
 - 1.1 Why Zero Energy Buildings
 - 1.2 What does Zero Energy mean
 - 1.3 Selected study case
- 2.0 SITE
 - 2.1 Location
 - 2.2 Climatic aspects, influence and potential
- 3.0 ARCHITECTURE AND STRUCTURE
 - 3.1 Shape, orientation and thermal zoning
 - 3.2 Building structure
- 4.0 TECHNOLOGY
 - 4.1 Passive systems and their efficiency
 - 4.2 Active strategies overview and selection
- 5.0 PLANS AND DETAILS
- 6.0 CONCLUSION/REFLECTION



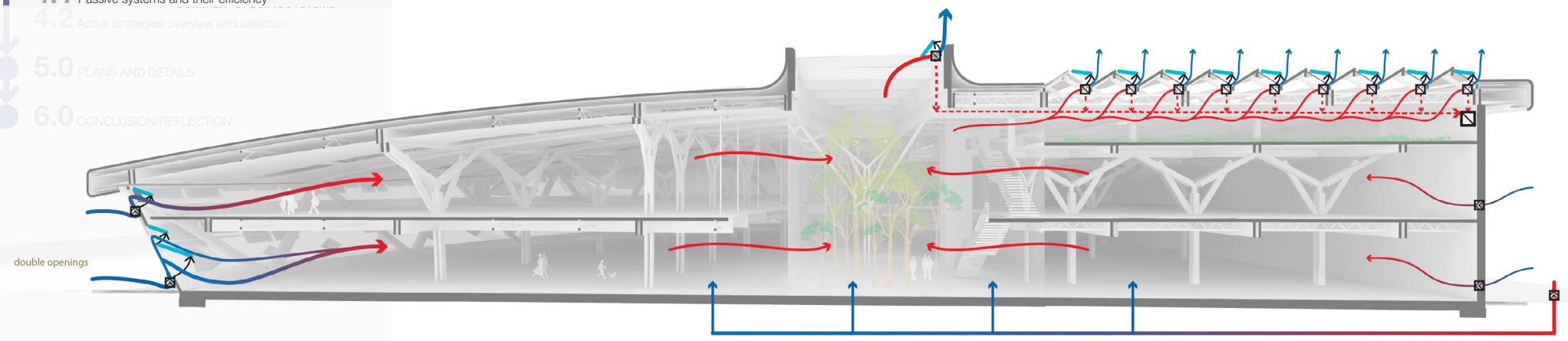
kWh/sm/yr
137

reduction from baseline
-41%

reduction from previous tot.consumption
-12%

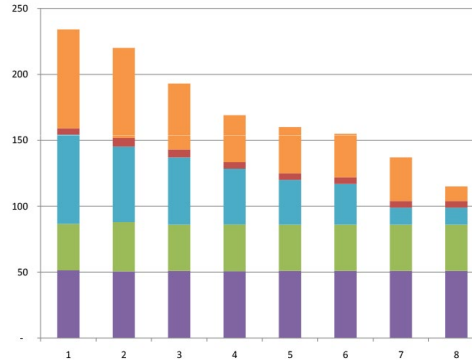
reduction from previous ventilation load
-70%

Temperate to hot days, summer nights



08. HEAT RECOVERY

thermal energy
 heating
 hot water
electricity
 cooling and ventilation
 lighting
 misc. equipment



kWh/sm/yr

115

reduction from baseline

-51%

reduction from previous tot.consumption

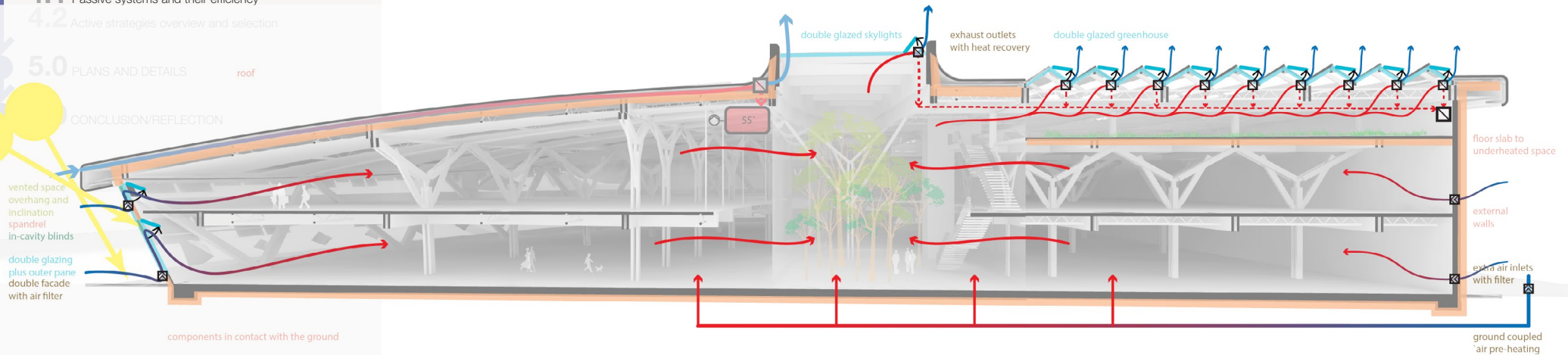
-16%

reduction from previous heating load

-65%

- 0.0 MOTIVATION
- 1.0 DESIGN PREPARATION
 - 1.1 Why Zero Energy Buildings
 - 1.2 What does Zero Energy mean
 - 1.3 Selected study case
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 - 2.1 Location
 - 2.2 Climatic aspects, influence and potential
- 3.0 ARCHITECTURE AND STRUCTURE
 - 3.1 Shape, orientation and thermal zoning
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 - 4.1 Passive systems and their efficiency
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- CONCLUSION/REFLECTION

Temperate to cold days



09. LIGHTING CONCEPT

kWh/sm/yr

101

reduction from baseline

-57%

reduction from previous tot.consumption

-12%

reduction from previous lighting load

-40%

- 0.0 MOTIVATION
- 1.0 DESIGN PREPARATION
 - 1.1 Why Zero Energy Buildings
 - 1.2 What does Zero Energy mean
 - 1.3 Selected study cases
- 2.0 LOCATION
 - 2.1 Location
- 3.0 ARCHITECTURE
 - 3.1 Shape, orientation and thermal zoning
 - 3.2 Building structure
- 4.0 TECHNOLOGY
 - 4.1 Passive systems and their efficiency
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- 6.0 CONCLUSION/REFLECTION

only diffuse light
double openings

vented space
overhang and
inclination
spandrel
in-cavity blinds
light shelf
double glazing
plus outer pane
double facade
with air filter

components in contact with the ground

stripes of translucent skylights

double glazed skylights

exhaust outlets
with heat recovery

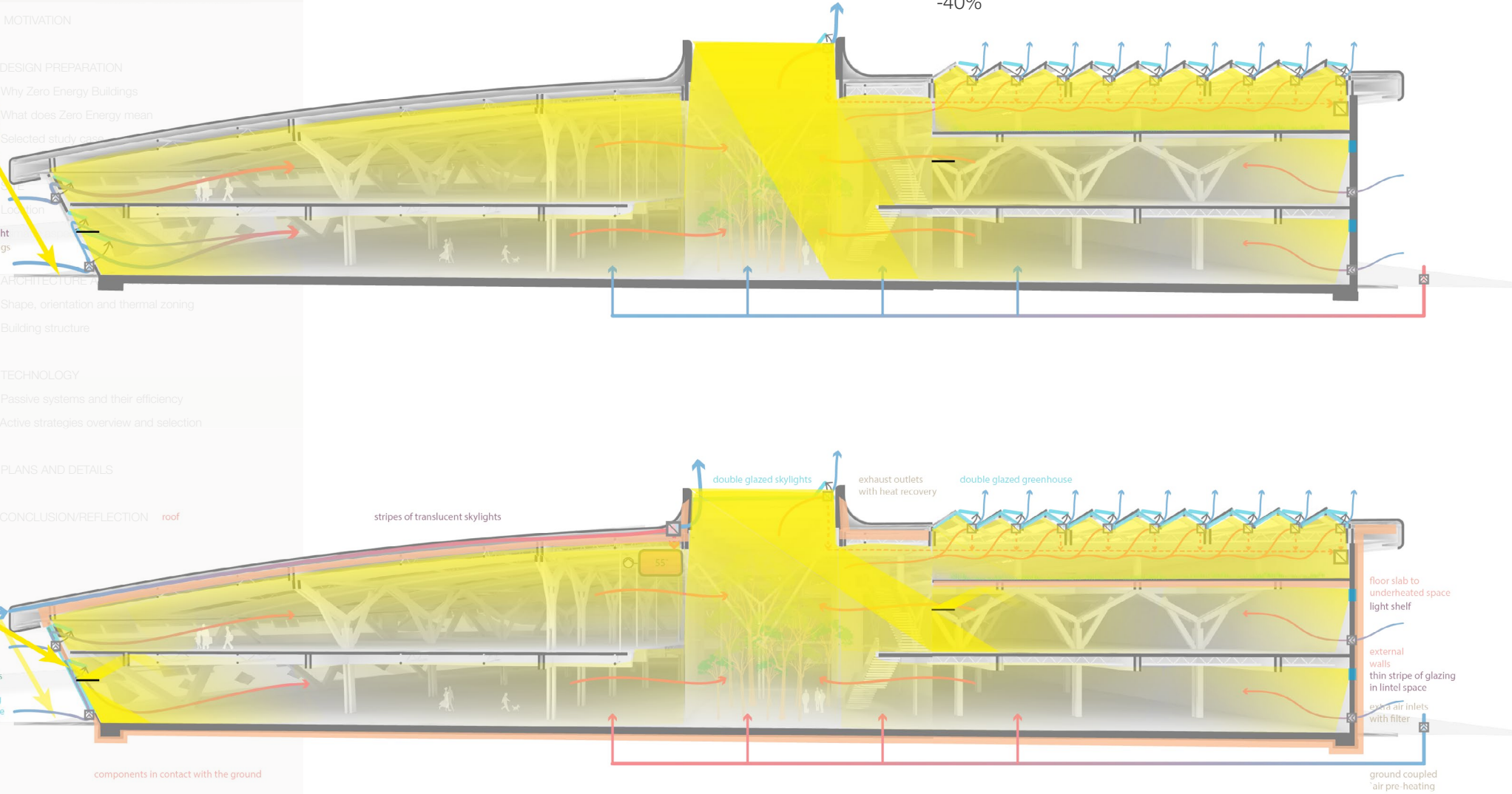
double glazed greenhouse

floor slab to
underheated space
light shelf

external walls
thin stripe of glazing
in lintel space

extra air inlets
with filter

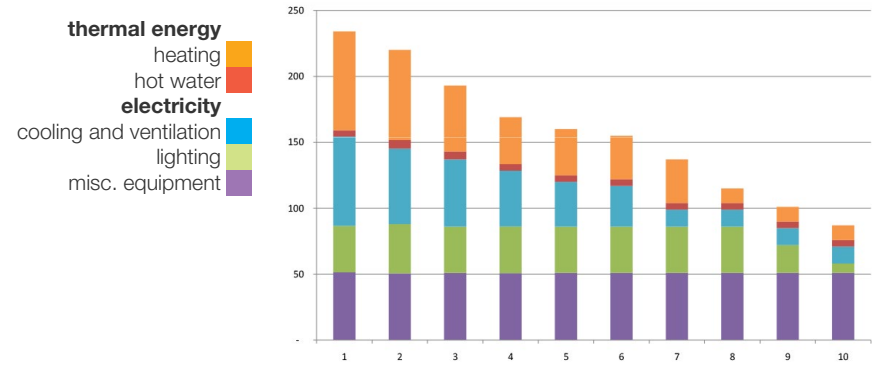
ground coupled
air pre-heating



10. OCCUPANCY AND DAYLIGHT SENSORS

- 0.0 MOTIVATION
- 1.0 DESIGN PREPARATION
 - 1.1 Why Zero Energy Buildings
 - 1.2 What does Zero Energy mean
 - 1.3 Selected study case
- 2.0 SITE
 - 2.1 Location
 - 2.2 Climatic aspects, influence and potential
- 3.0 ARCHITECTURE AND STRUCTURE
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 - 4.1 Passive systems and their efficiency
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- 5.0 PLANS AND DETAILS

- CONCLUSION/REFLECTION
- vented space overhang and inclination
- spandrel in-cavity blinds
- light shelf
- double glazing plus outer pane
- double facade with air filter



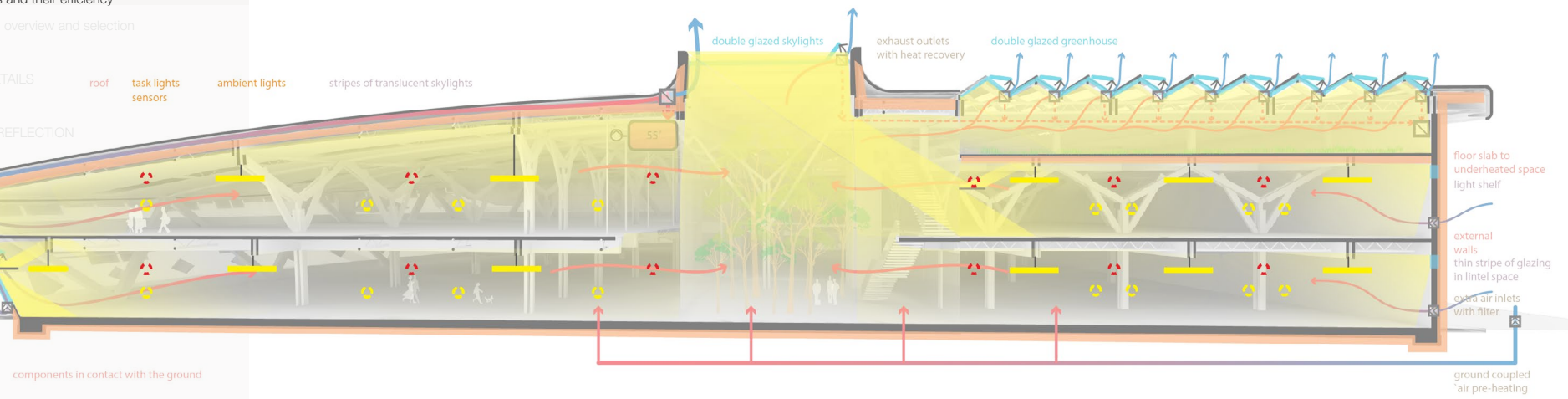
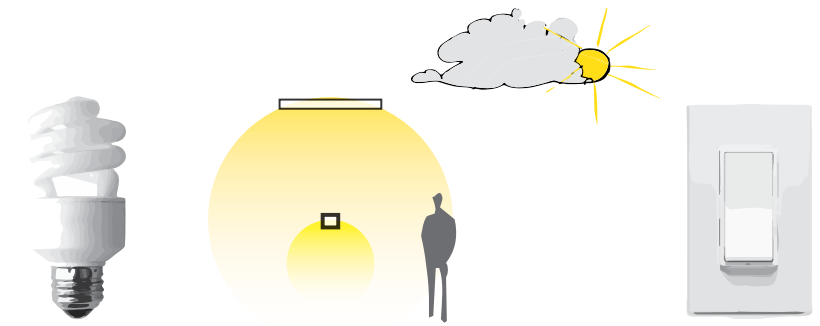
kWh/sm/yr
87

reduction from baseline
-63%

reduction from previous tot.consumption
-12%

reduction from previous lighting load
-65%

lamp efficiency ambient / task occupancy / daylight



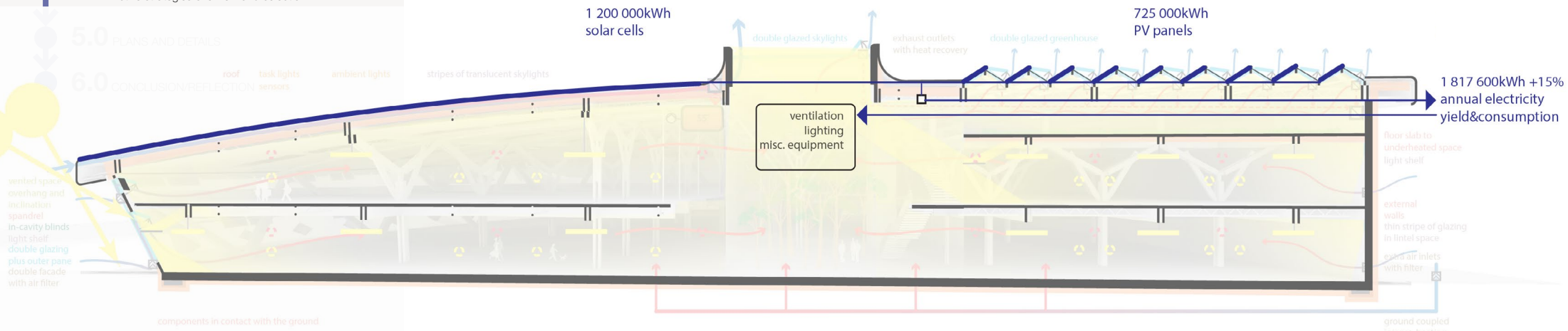
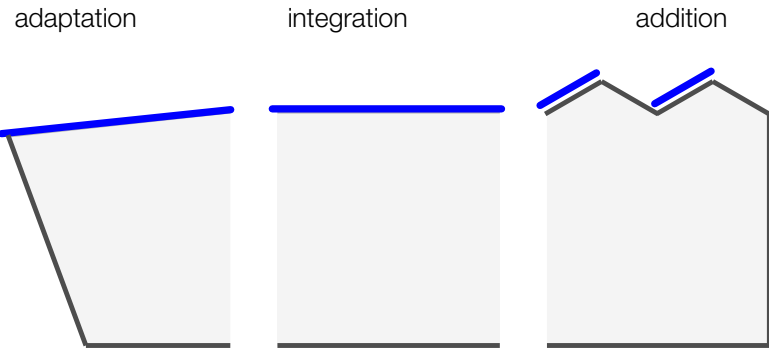
ON SITE ELECTRICITY GENERATION

thermal energy
 heating 282 000 kWh
 hot water 128 000 kWh

electricity 1 817 600 kWh
 cooling and ventilation
 lighting
 misc. equipment



- 0.0 MOTIVATION
- 1.0 DESIGN PREPARATION
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- 4.0 TECHNOLOGY
 - 4.1 Passive systems and their efficiency
 - 4.2 Active strategies overview and selection



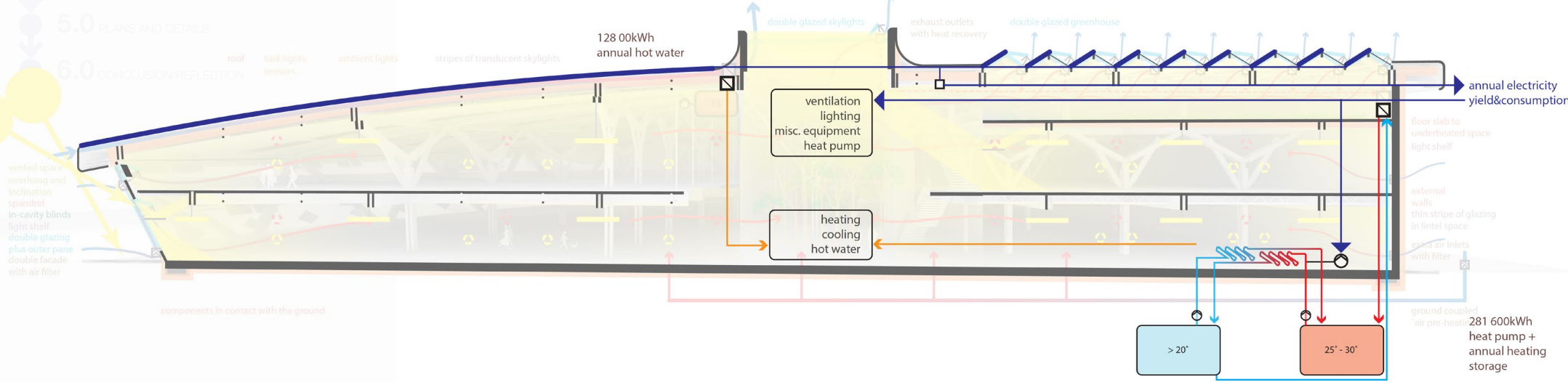
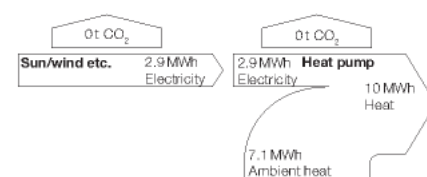
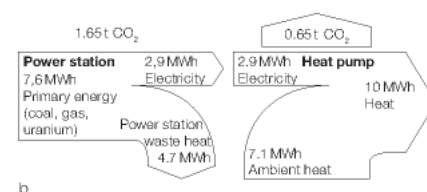
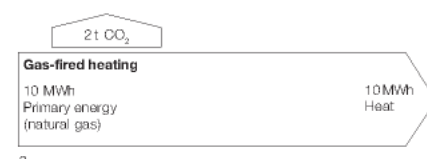
THERMAL ENERGY GENERATION AND STORAGE

thermal energy
 heating 282 000 kWh
 hot water 128 000 kWh

electricity 1 817 600 kWh
 cooling and ventilation
 lighting
 misc. equipment



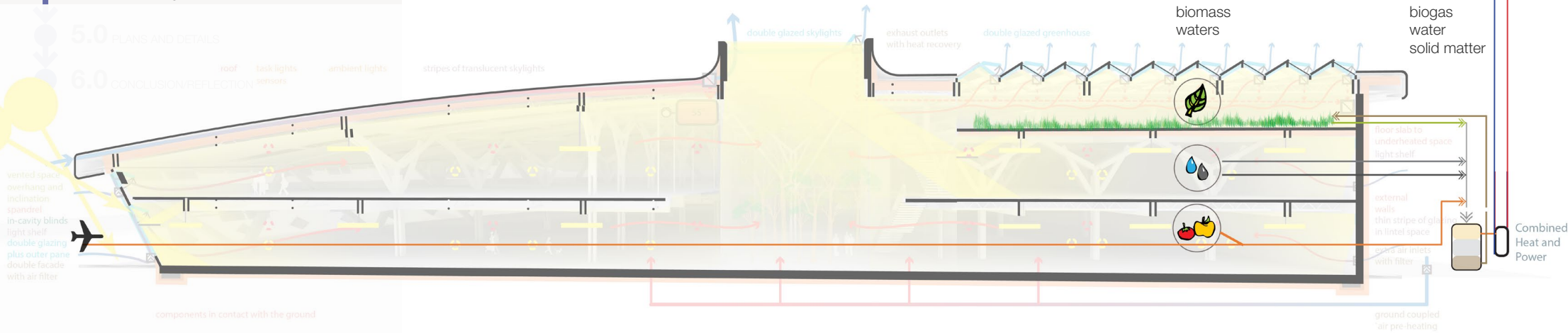
- 0.0 MOTIVATION
- 1.0 DESIGN PREPARATION
 - 1.1 Why Zero Energy Buildings
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OFF SITE COMBINED HEAT AND POWER

efficiency 90%
 thermal energy 62%
 electricity 28%

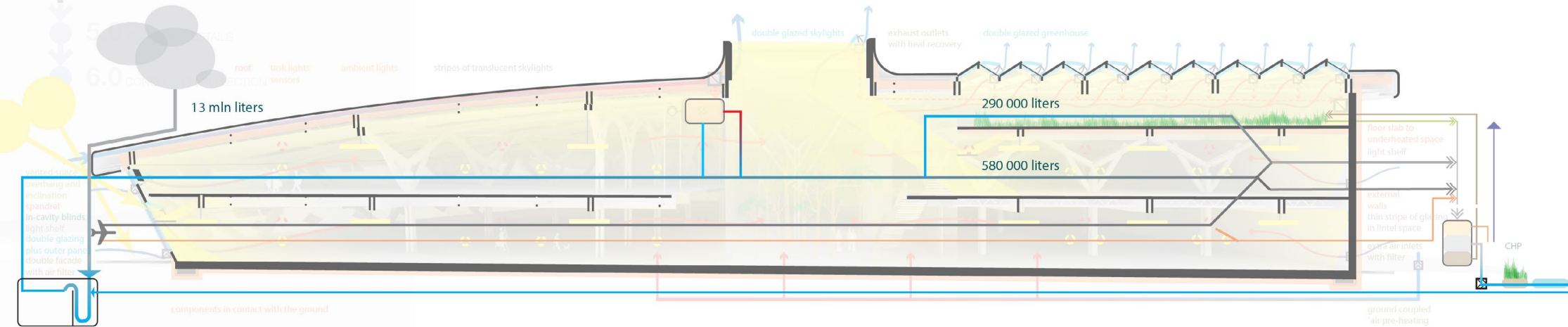
- 0.0 MOTIVATION
- 1.0 DESIGN PREPARATION
 - 1.1 Why Zero Energy Buildings
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- 2.0 SITE
 - 2.1 Location
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Combined Heat and Power

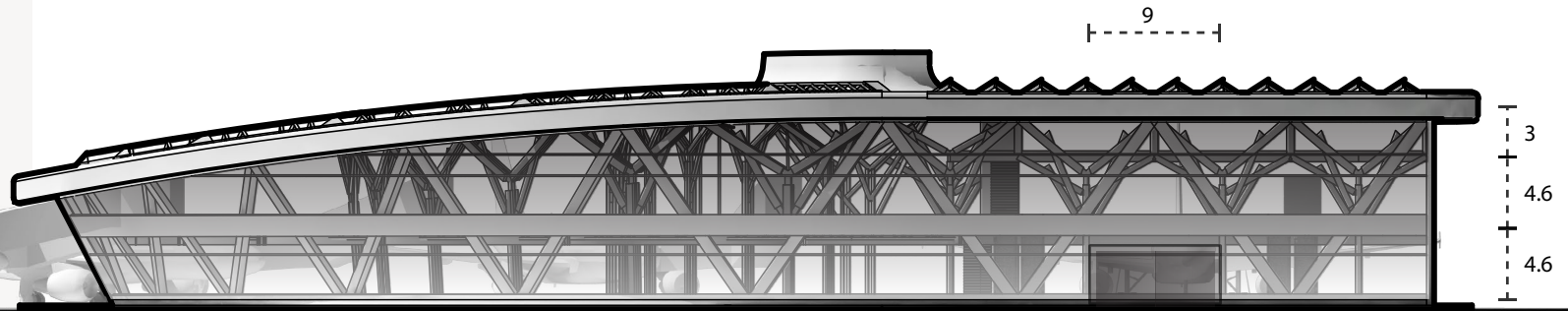
WATER CYCLE

- 0.0 MOTIVATION
- 1.0 DESIGN PREPARATION
 - 1.1 Why Zero Energy Buildings
 - 1.2 What does Zero Energy mean
 - 1.3 Selected study case
- 2.0 SITE
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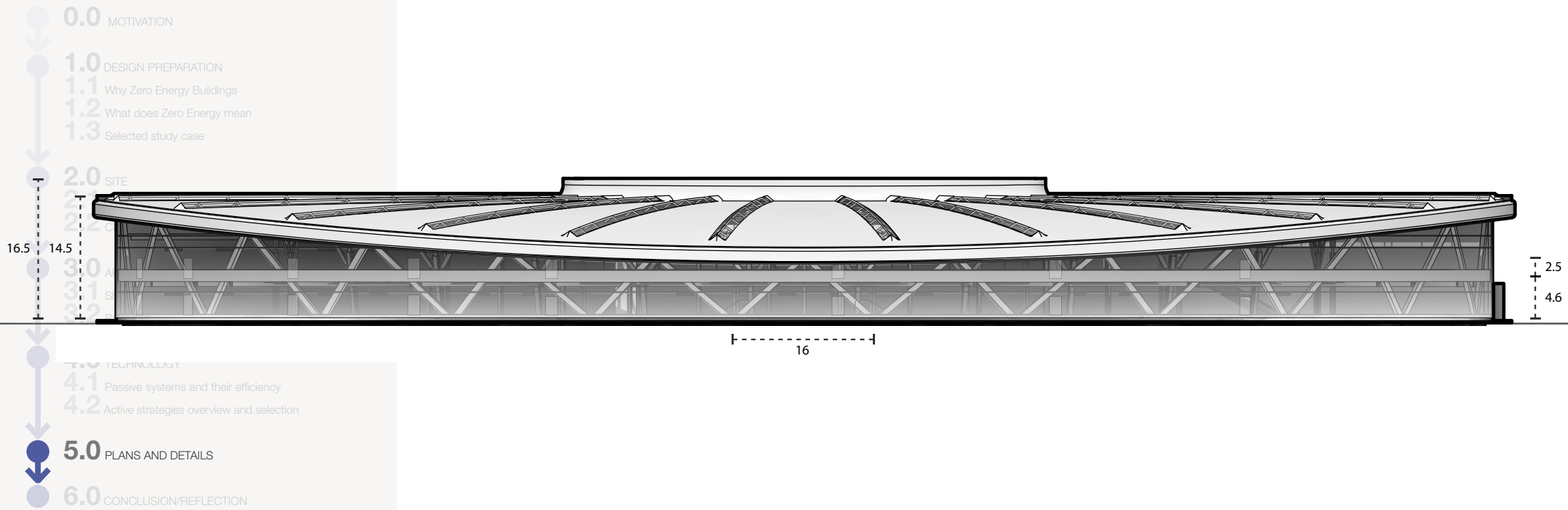


EAST ELEVATION

- 0.0 MOTIVATION
- 1.0 DESIGN PREPARATION
 - 1.1 Why Zero Energy Buildings
 - 1.2 What does Zero Energy mean
 - 1.3 Selected study case
- 2.0 SITE
 - 2.1 Location
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 - 4.2 Active strategies overview and selection
- 5.0 PLANS AND DETAILS**
- 6.0 CONCLUSION/REFLECTION

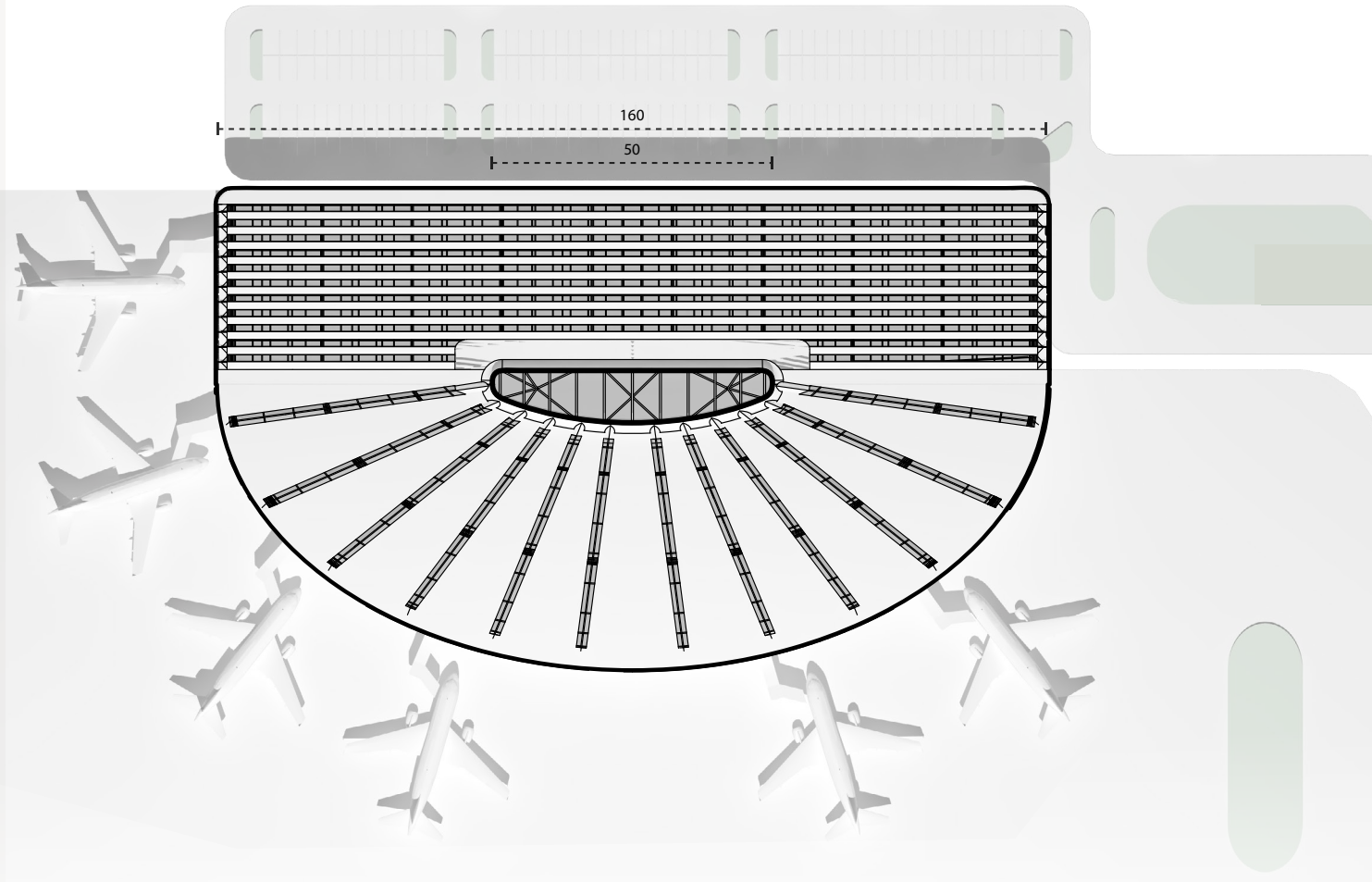


SOUTH ELEVATION

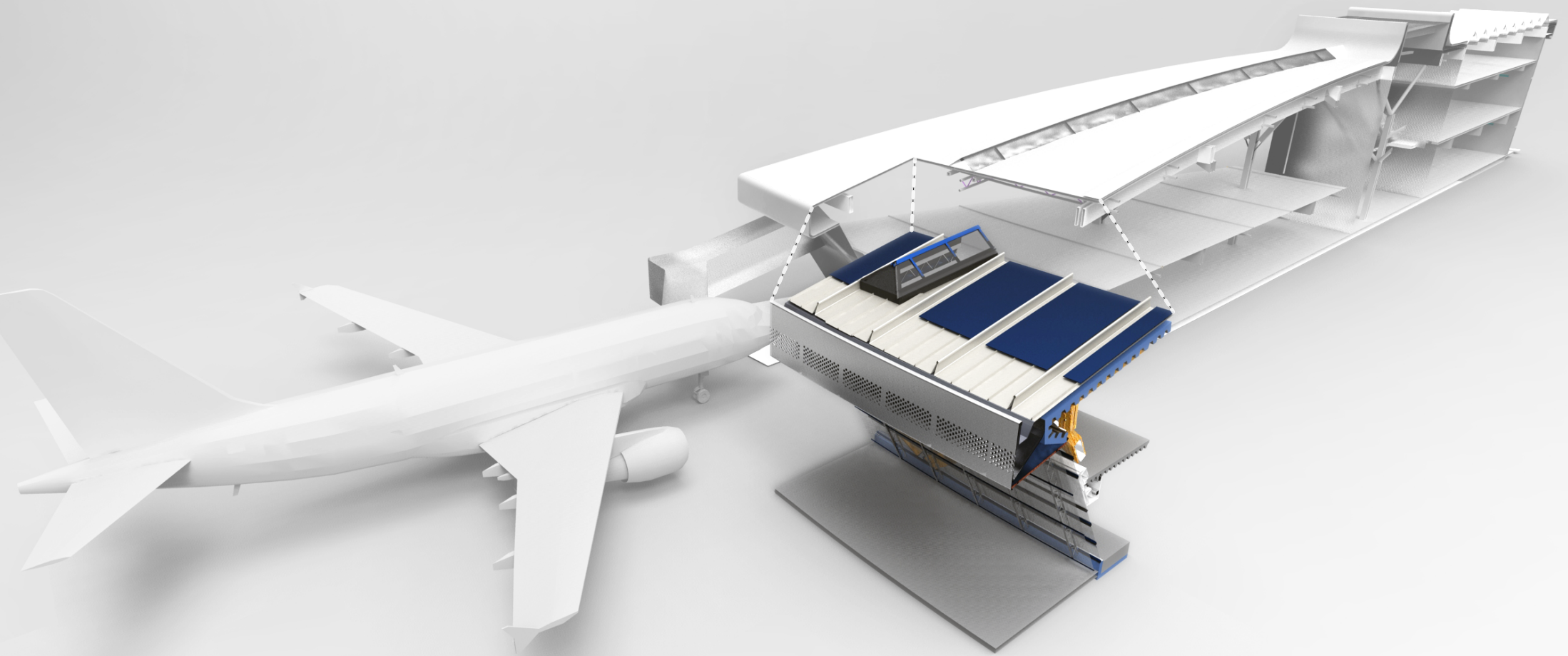


TOP VIEW

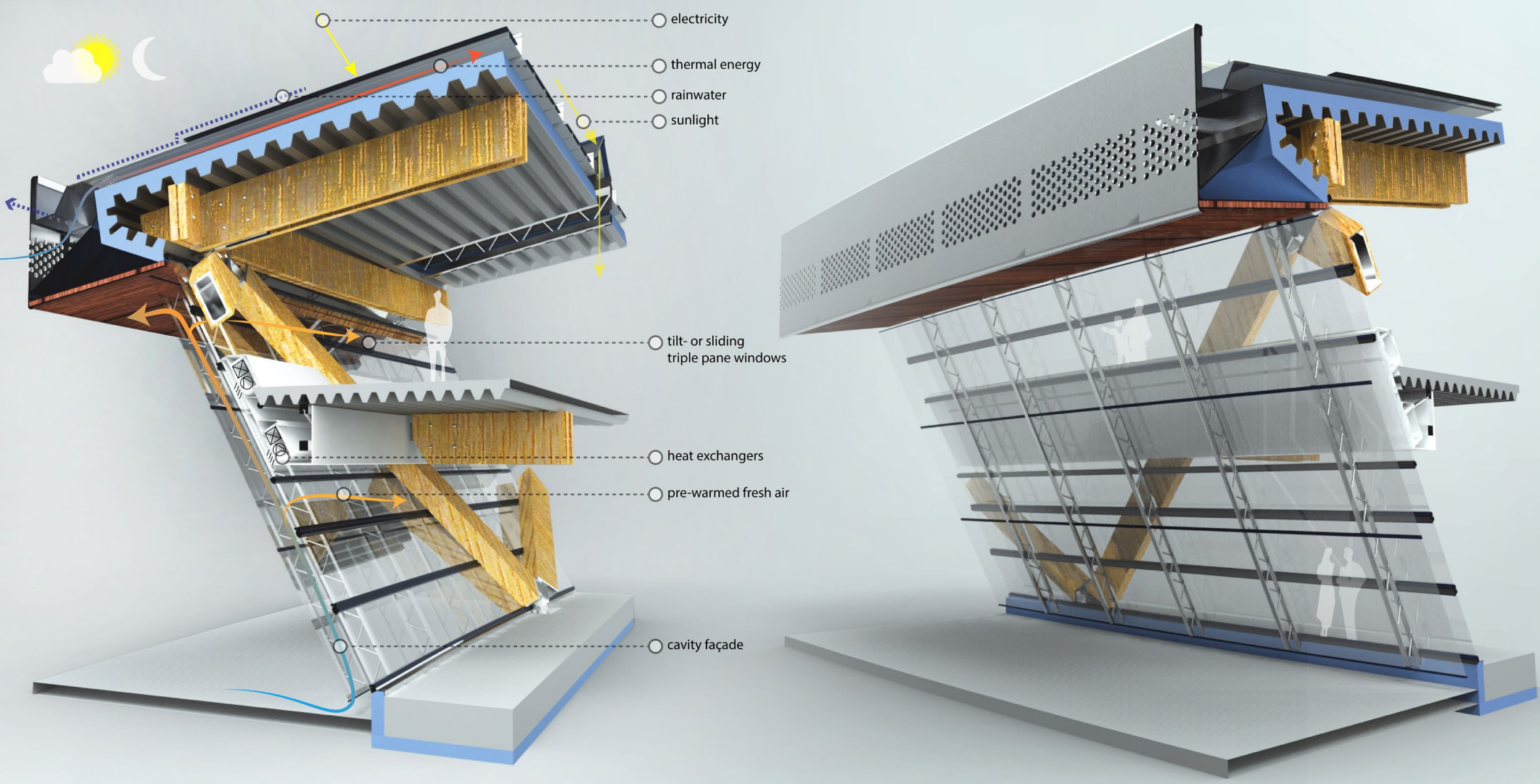
- 0.0 MOTIVATION
- 1.0 DESIGN PREPARATION
 - 1.1 Why Zero Energy Buildings
 - 1.2 What does Zero Energy mean
 - 1.3 Selected study case
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- 4.0 TECHNOLOGY
 - 4.1 Passive systems and their efficiency
 - 4.2 Active strategies overview and selection
- 5.0 PLANS AND DETAILS**
- 6.0 CONCLUSION/REFLECTION



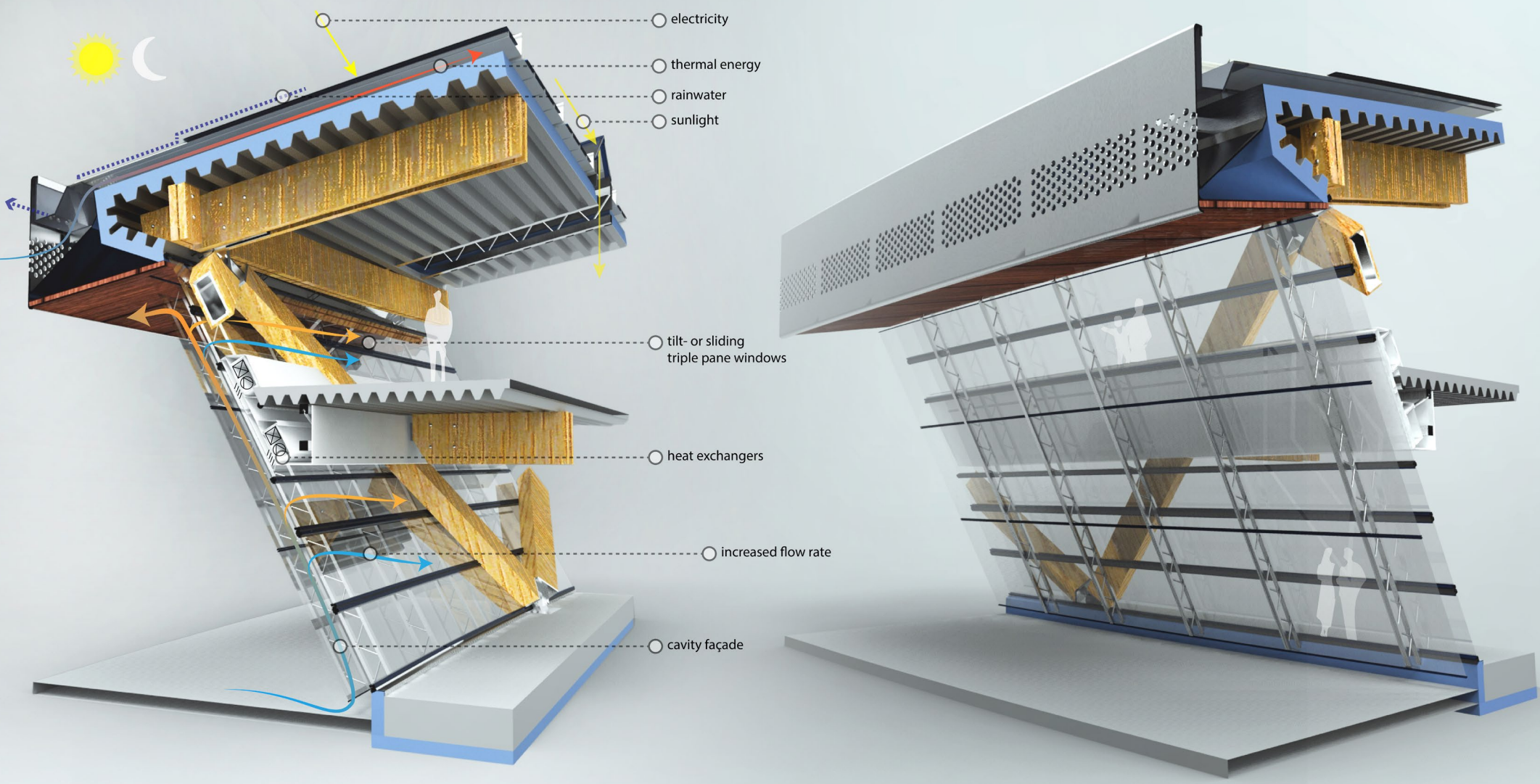
CORNER DETAIL



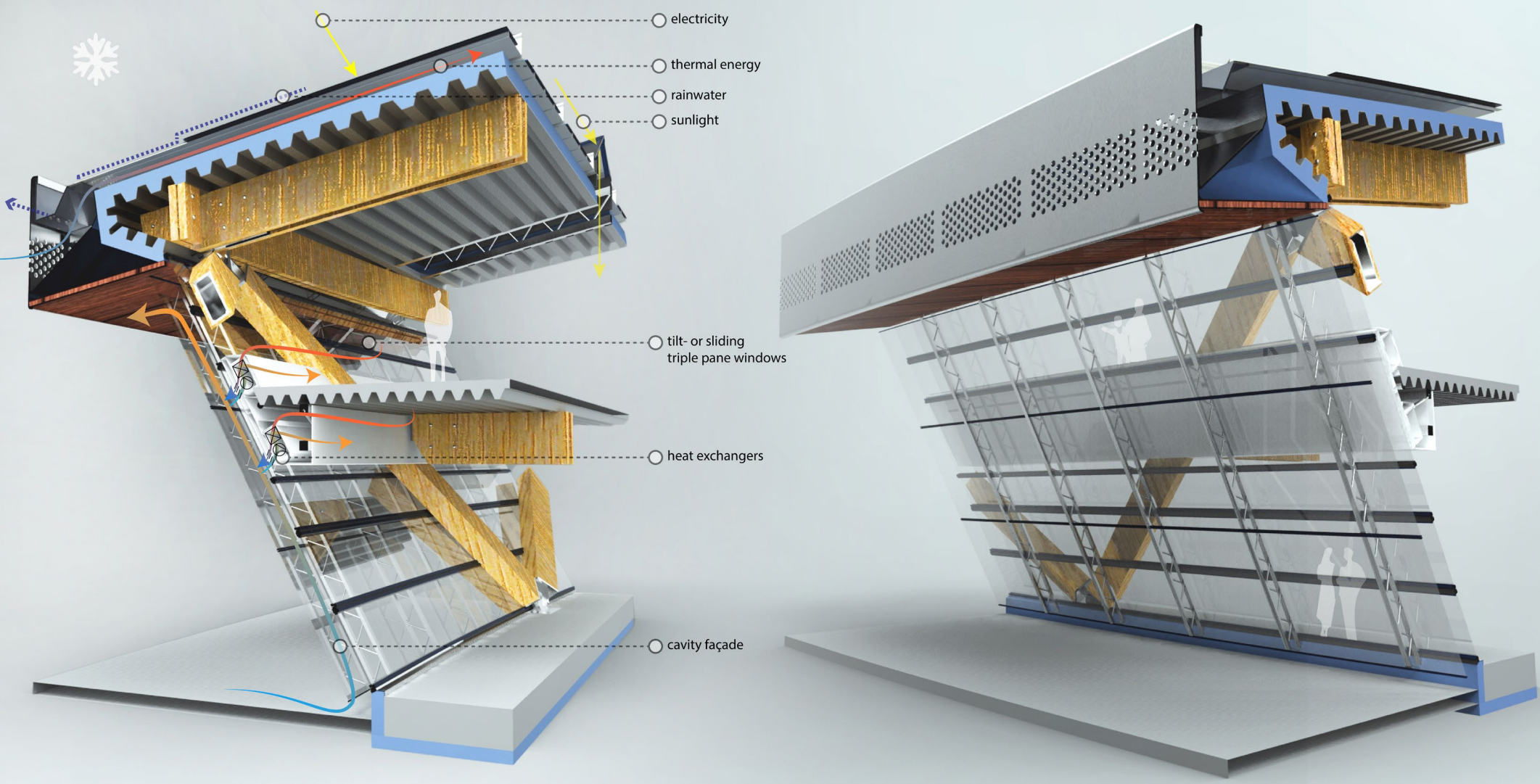
SKIN CLIMATE CONCEPT INTERSEASON



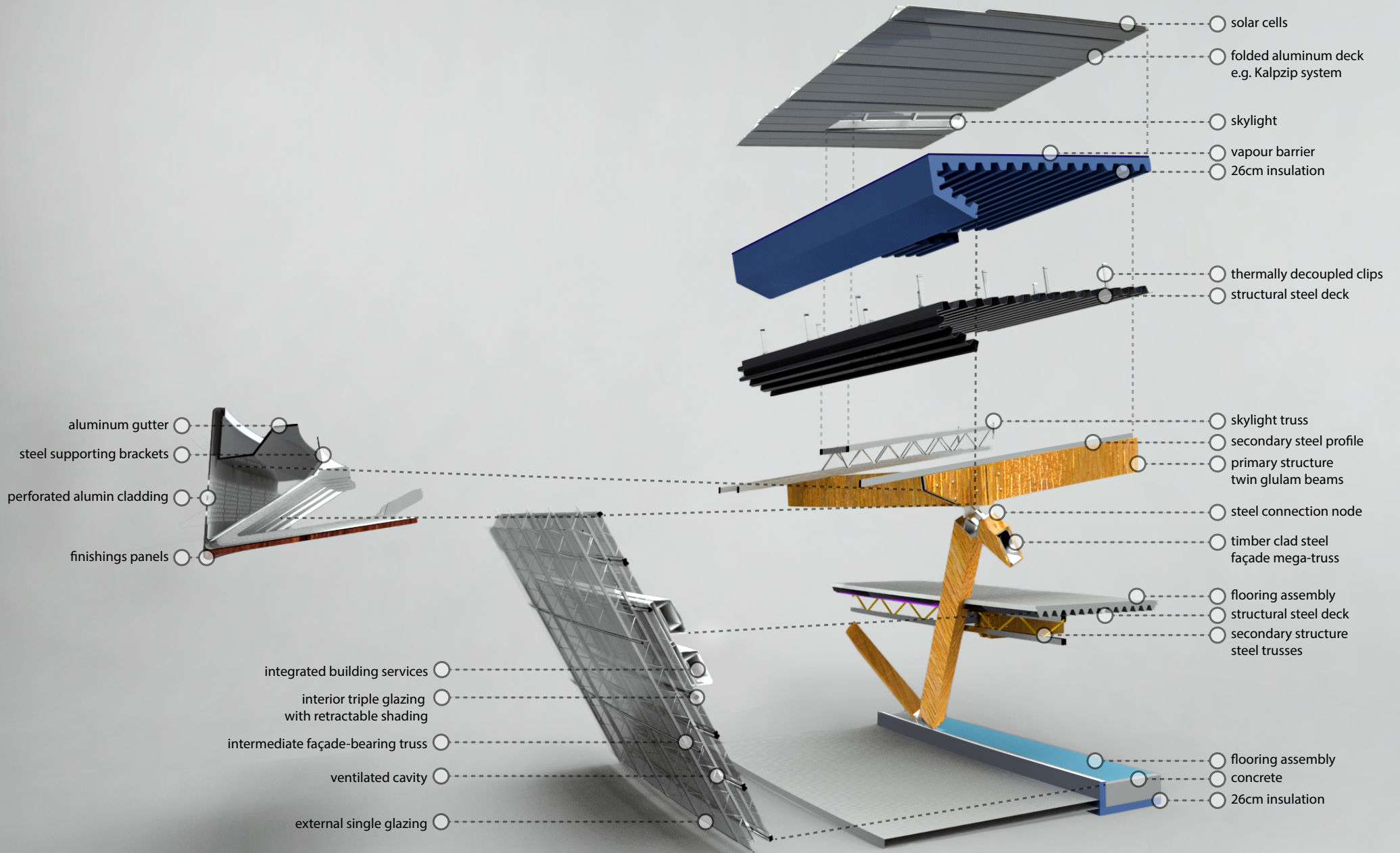
SKIN CLIMATE CONCEPT HOT SEASON



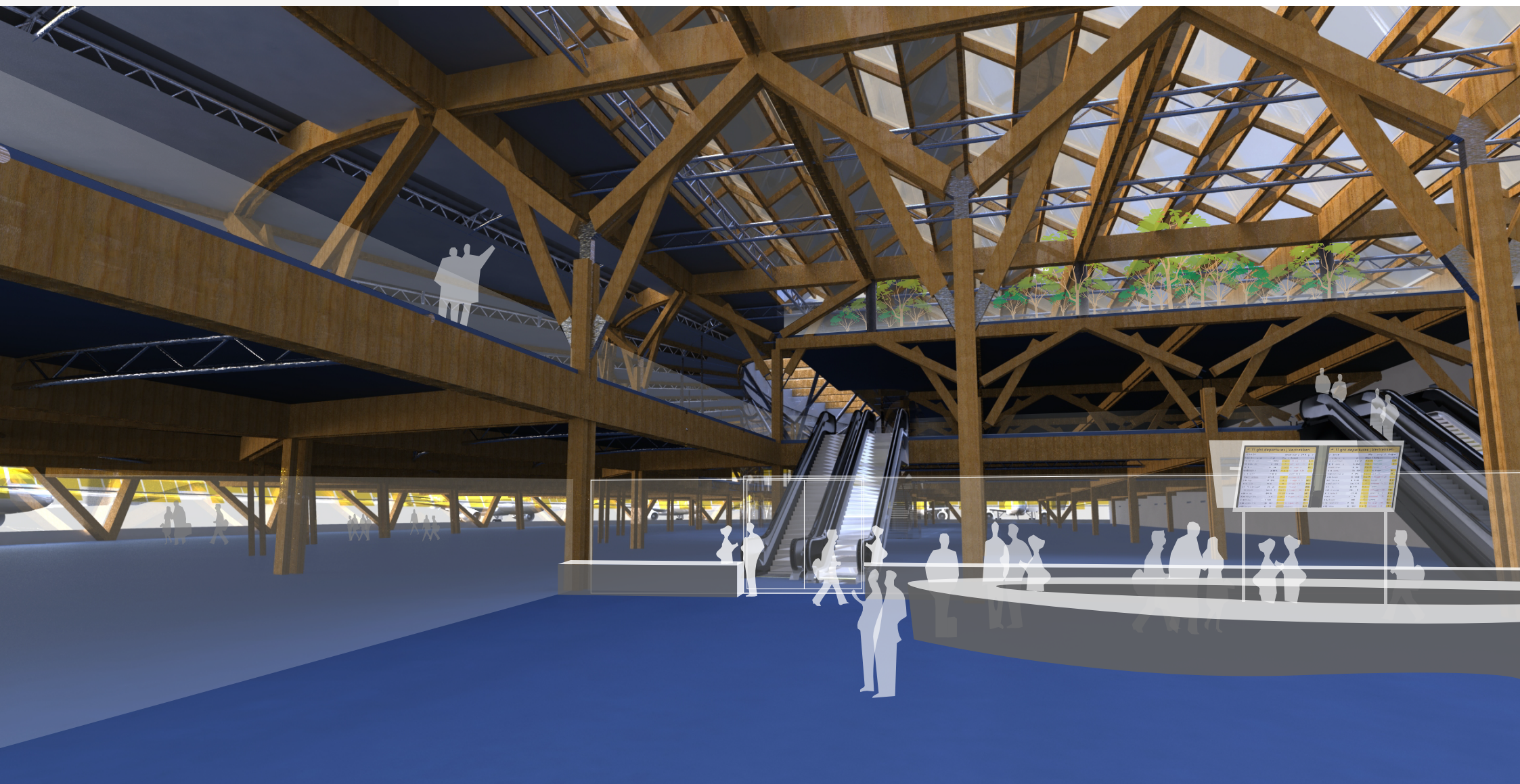
SKIN CLIMATE CONCEPT COLD SEASON



ASSEMBLY

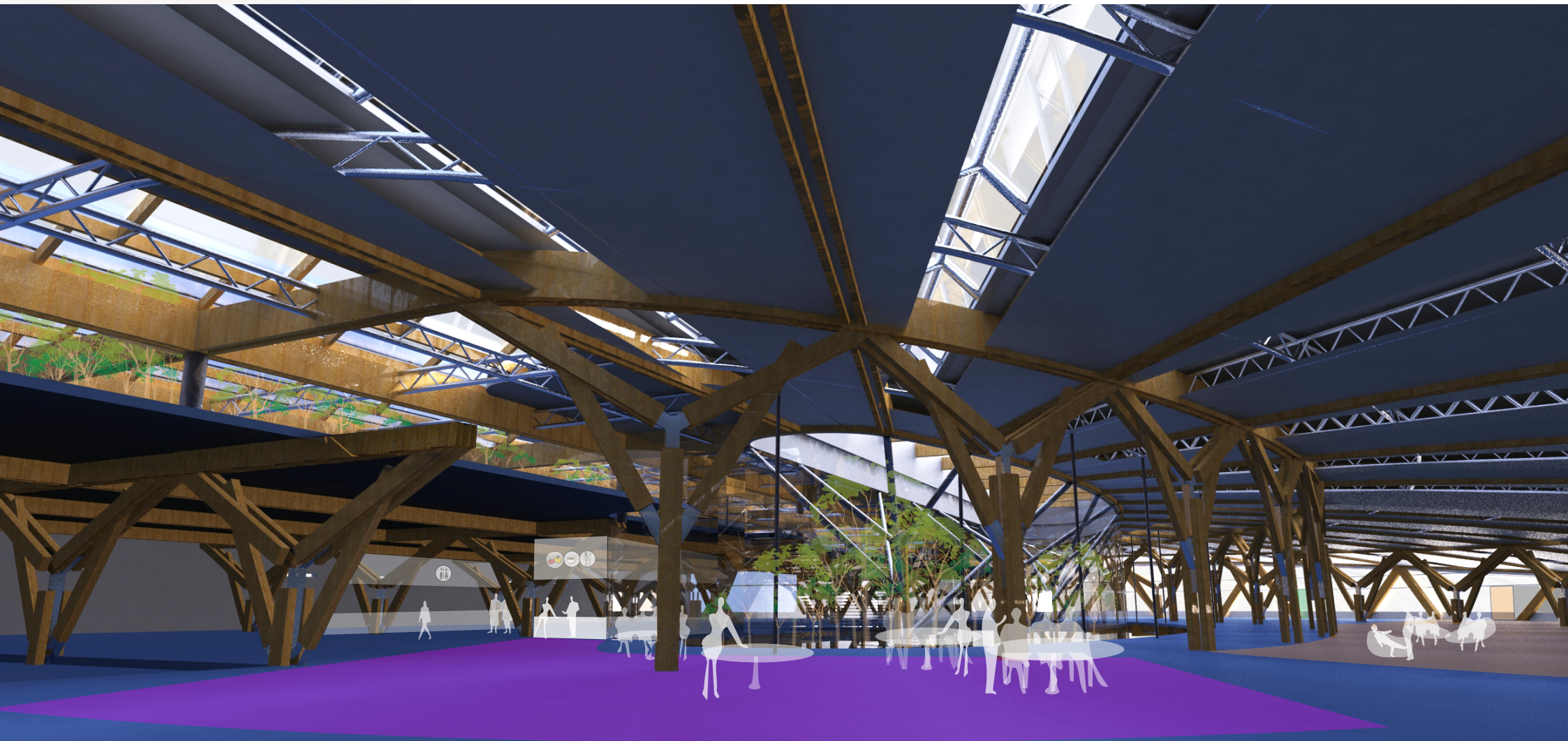


ENTRANCE HALL



6.0 CONCLUSION AND REFLECTION

- Energy efficiency is not a matter of technology but of planning.
- Stakeholders are not motivated enough to put energy efficiency as a priority, and knowledge of the topic is still fragmentary.
- Choices related to architecture and to energy efficiency can integrate each other perfectly, the level of creativity and originality that this methodology creates is outstanding.



6.0 CONCLUSION AND REFLECTION

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- Stakeholders are not motivated enough to put energy efficiency as a priority, and knowledge of the topic is still fragmentary.
- Choices related to architecture and to energy efficiency can integrate each other perfectly, the level of creativity and originality that this methodology creates is outstanding.

