


Netherlands swimming star Arno Kamminga






Olympic Games Tokyo 2020 - Spotlight on the Netherlands

aststroker transformed from 'lazy guy' to
ic silver medallist, would rather race Adam
s, and never touches the water before racing



12000 **sports facilities**
in Netherlands

**40%** are under financial loss

**10 -15 million euros** is spent unnecessarily on energy.

19,000 $m^3$ of natural **gas consumption** and 80,000 kWh of **electricity consumption**

*Nuon Report, Nederland Sportland, 2015*

Europe's 2030 Climate goals

existing stock **greenhouse gas emissions reduction**

**Deep renovations**

**Energy Efficiency** renovation projects **must** cut energy by **45-80%**

Residential

Commercial

Office

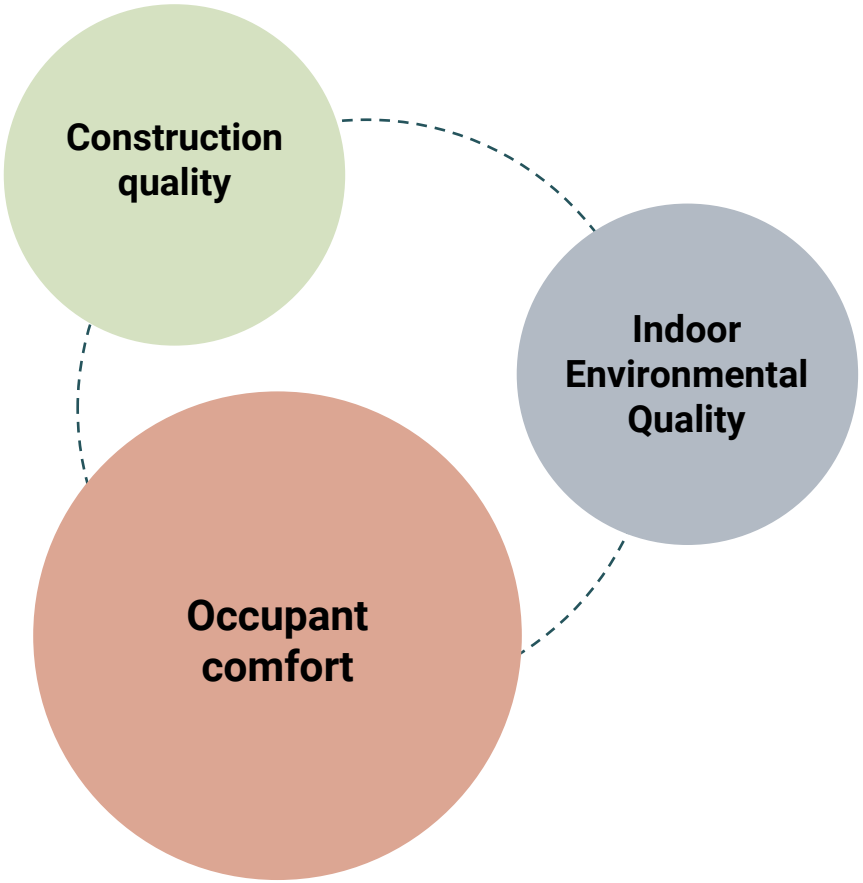
Educational

**Sports**

Huge potential in **energy transition**

*Nuon Report, Nederland Sportland, 2015*


Building energy






Health & performance of athletes

**Why energy consumption is high in existing buildings ?**

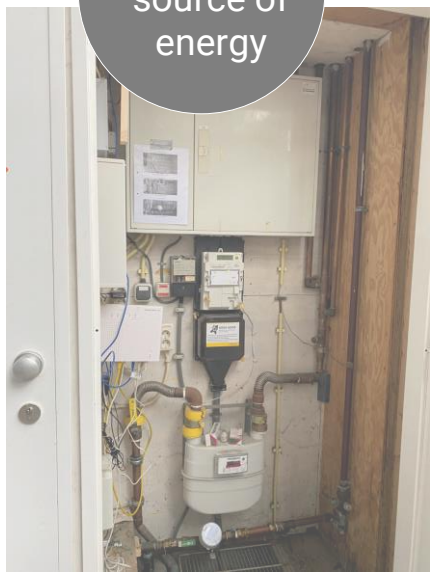
Old construction

Space shortage

Outdated building services

Varying occupancy

NO in-house source of energy

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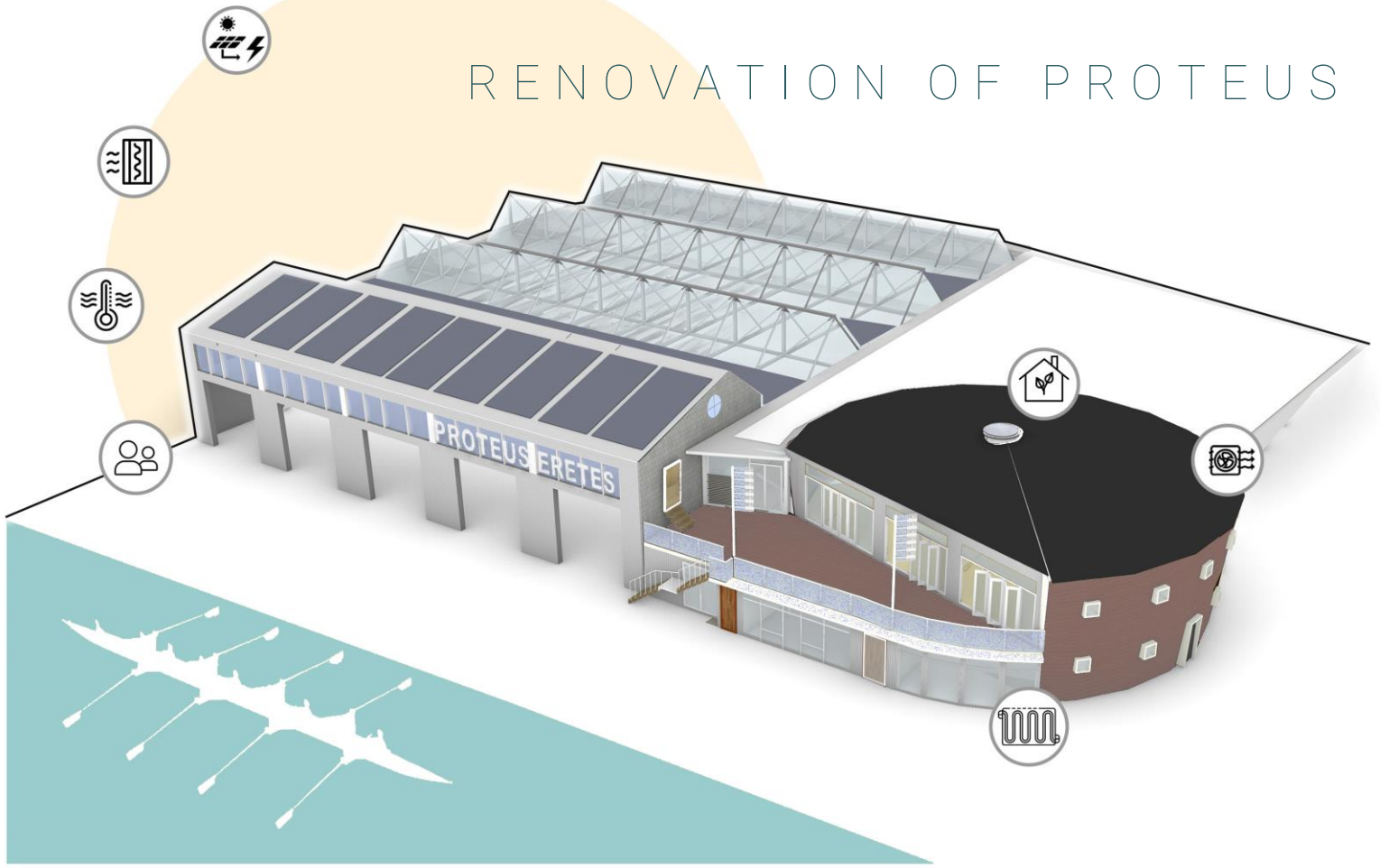
# RENOVATION OF PROTEUS ERETES




## Towards a nearly **Zero Energy Building** with **High Indoor Comfort**

**Thesis Defence**

IRUM FAISAL
29th June 2022

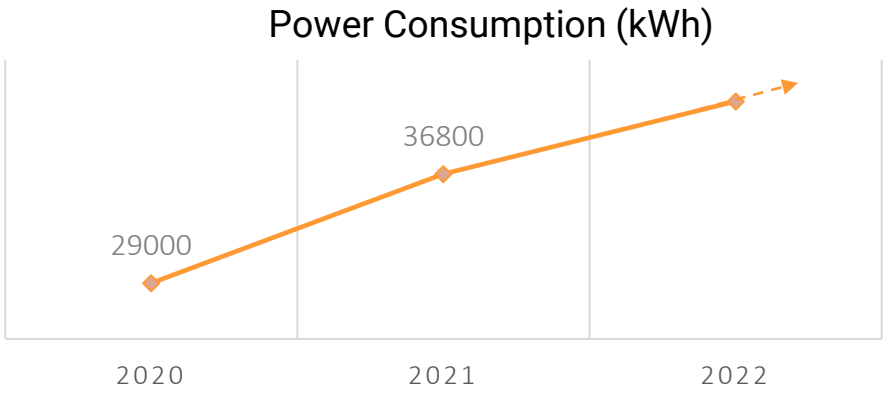
Mentor Team : Prof.dr.ir. Andy van den Dobblesteen, Prof.dr.ir. Atze Boerstra

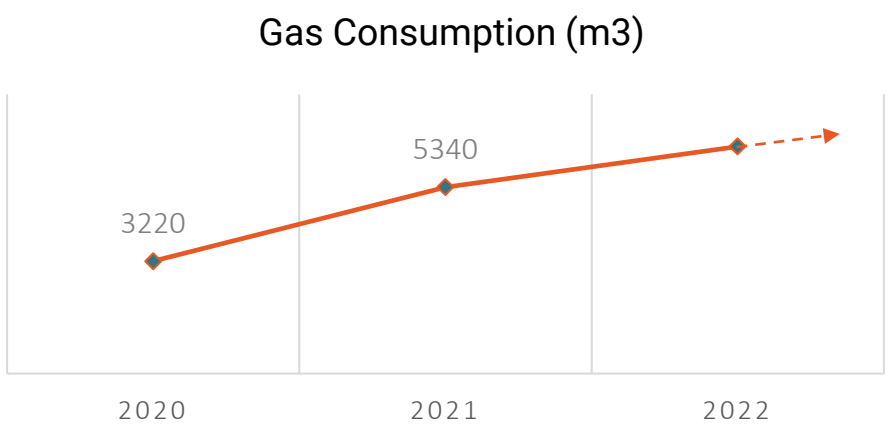
Examiner : Ir. Maarten Meijs

TU Delft

# D.S.R. Proteus Eretes

Rowing Association, Delft




…beginning point for understanding the **difficulties** about **energy consumption behaviour** with respect to **indoor climate, occupant's experience** and **construction quality**

Main Research Question

What are the **sustainable strategies** that can be used in **renovation projects** to reach **nearly zero energy (NZE)** and **high indoor environmental quality (IEQ) for user comfort ?**

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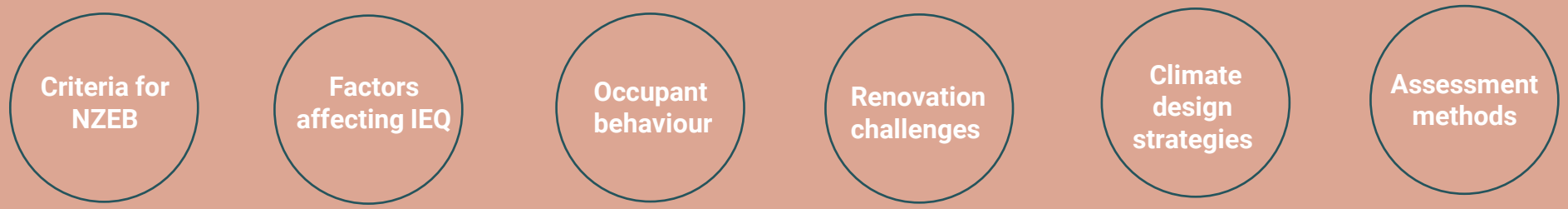


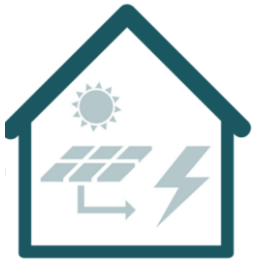
# Nearly Zero Energy Building

What is a nearly zero energy building?

**NEARLY ZERO ENERGY BUILDING**

HIGH PERFORMANCE ENVELOPE

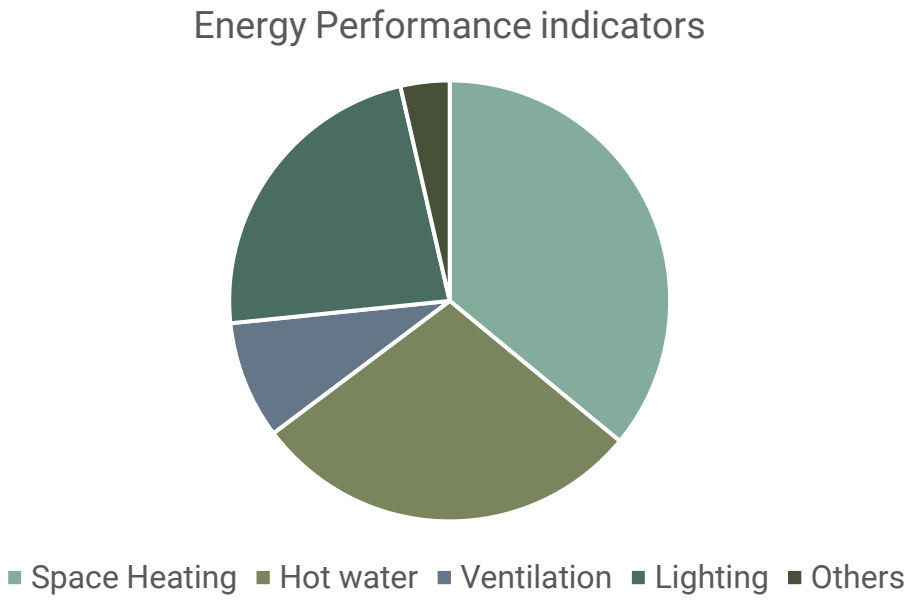
ENERGY EFFICIENT SYSTEMS

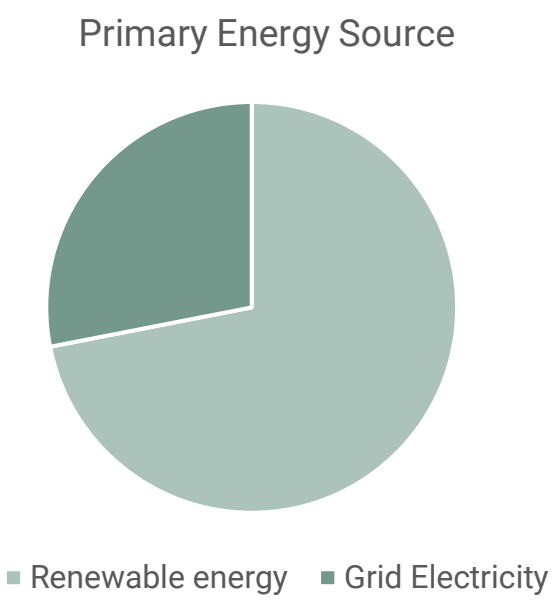


ON-SITE ENERGY PRODUCTION

# Nearly Zero Energy Building

Minimum requirements:  Energy Performance Coefficient and Energy Efficiency Standards



# Factors affecting Indoor Environmental Quality

Indoor air quality

Affected by CO2 pollutants, volatile organic compounds (VOCs), odours, particulates

Thermal Comfort

Affected by temperature, humidity, radiant heat, airflow

Analysed by the comfort experienced by used - feeling too cold, too hot, or comfortable

Lighting

Enough amount of lighting through glazing or artificial lights

Acoustics

Affected by noise quality, sound insulation factors

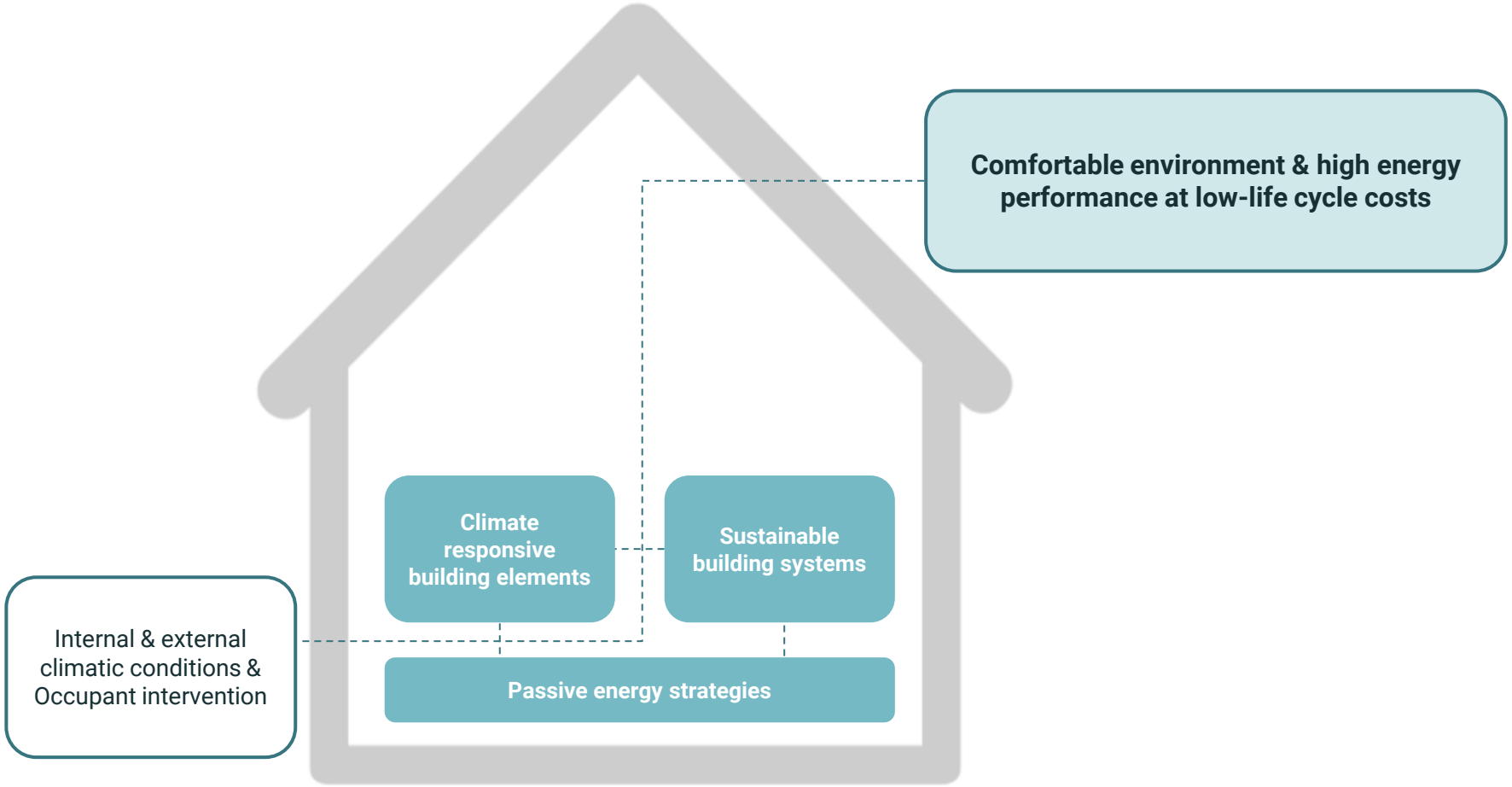
# Integrated Climate Design Strategies

…..carefully integrate climate design strategies that **minimises energy use, maximises daylight, high degree of indoor air quality and thermal comfort**, and generally **provides a high degree of occupant comfort”**

~ David Kozlowski

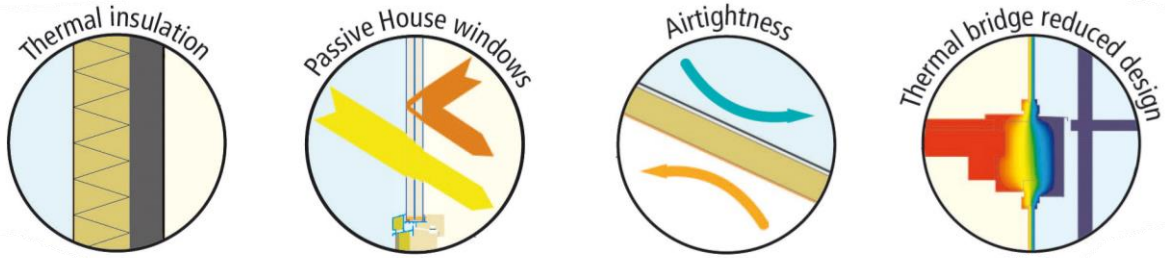
# Integrated Climate Design Strategies

SIMPLE ADAPTABLE SUSTAINABLE




*Looman, 2007*

# Integrated Climate Design Strategies




**PASSIVE STRATEGIES**

Building design & elements


**ACTIVE STRATEGIES**

Equipment & technology

# Challenges in Renovation

Societal

Technical

Financial


# RENOVATION OF PROTEUS ERETES

# Building Impression

Site visit


# Building Impression

## Survey – Indoor Environmental Quality

**Aim:** Causes of indoor discomfort / uncomfortable spaces / occupant's opinion

25 respondents

# Building Impression

## Survey – Indoor Environmental Quality

**Aim:** Causes of indoor discomfort / uncomfortable spaces / occupant's opinion

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Ergometer Room


Toilets

# Building Impression

## Survey – Indoor Environmental Quality

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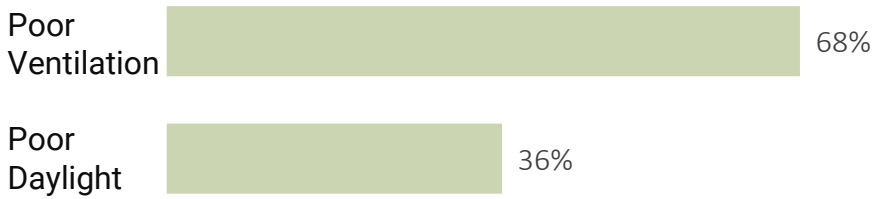





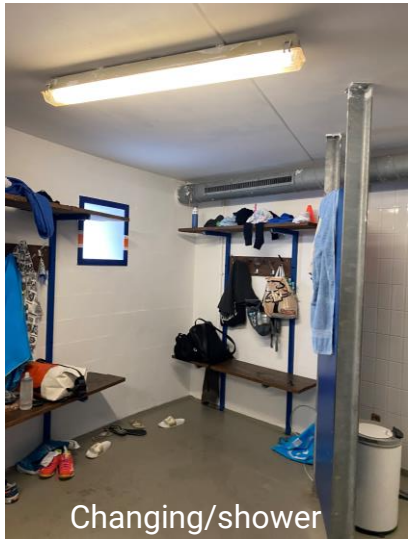


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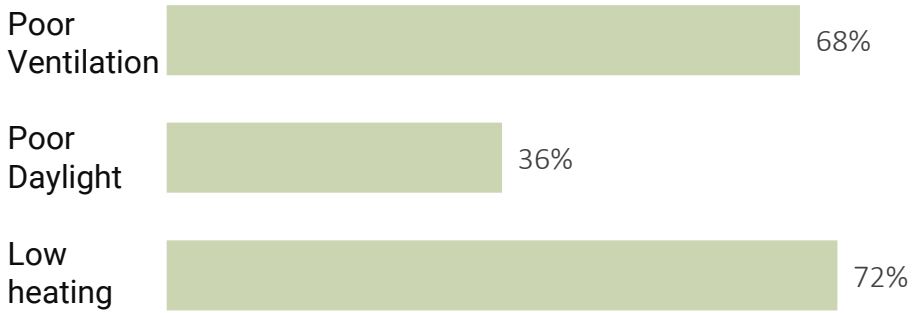



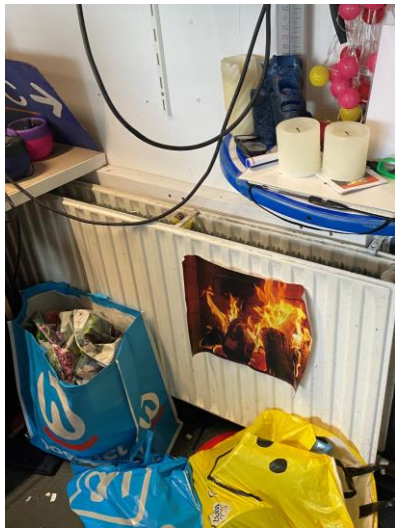

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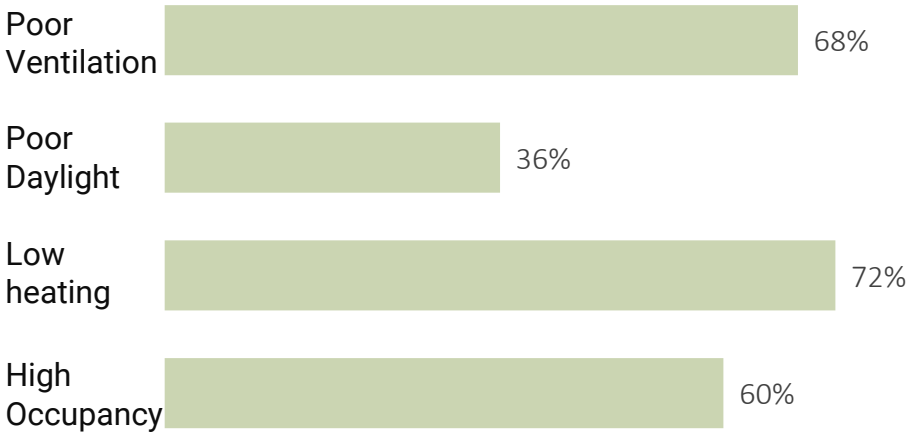
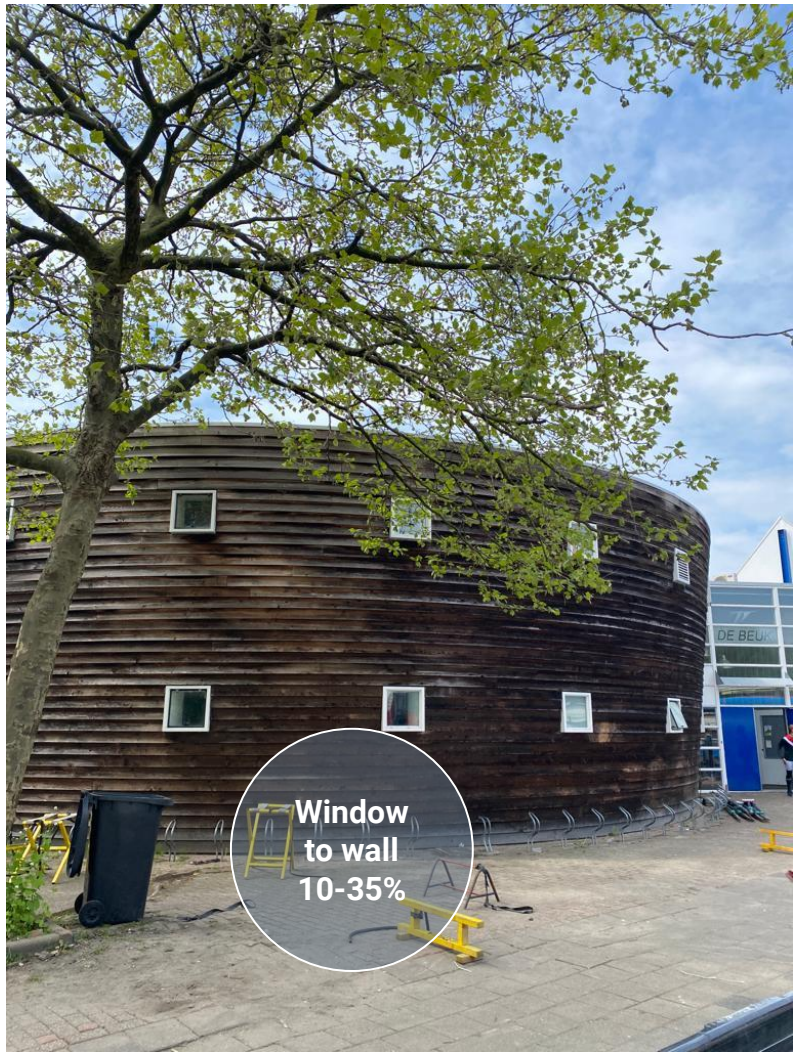




Bar Attic

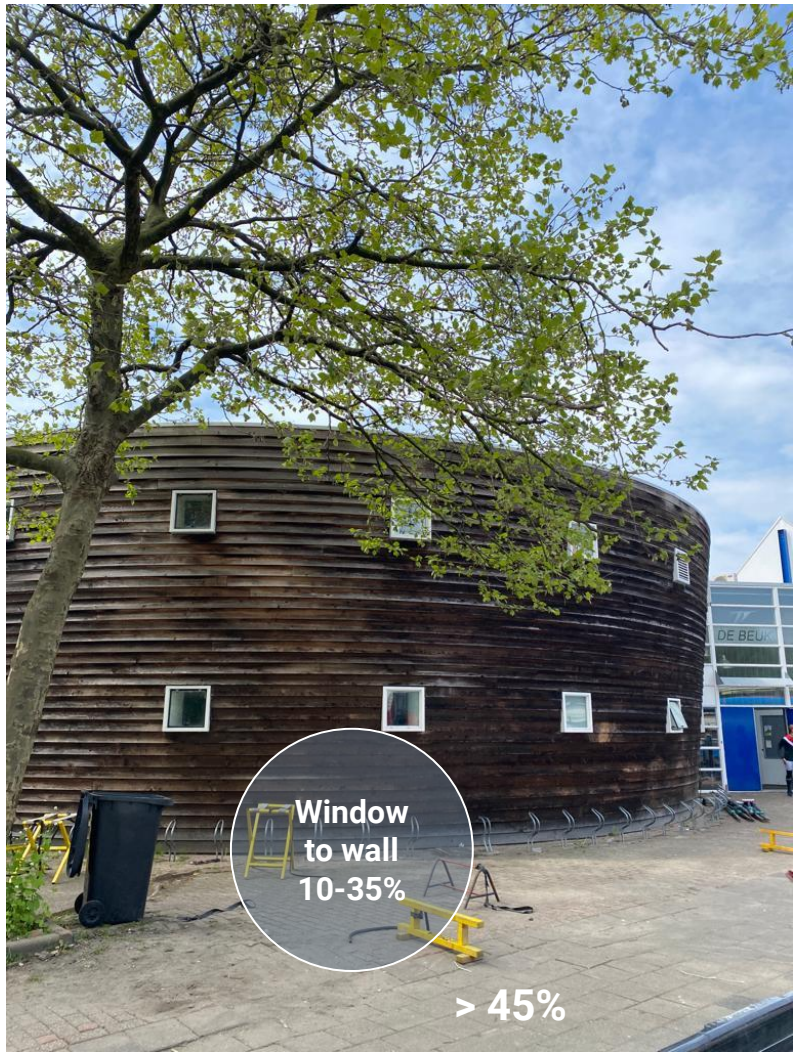
# Building Analysis

Building Envelope




# Building Analysis

Minimum requirements for thermal quality of envelope for renovation





*EPBD Standards, 2020*

# Building Analysis

Building Services


Gas boiler heating (space heating & hot water)

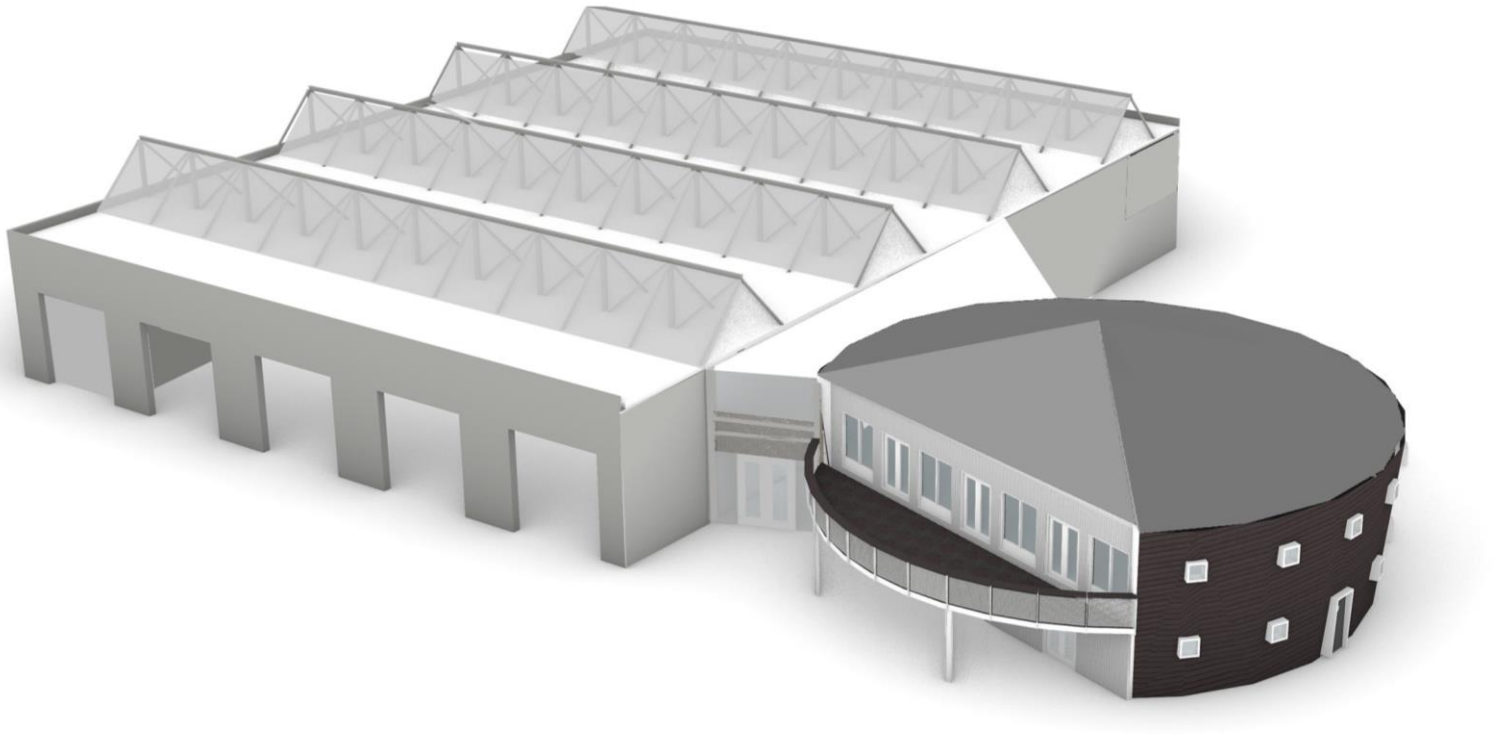
Balanced mechanical ventilation

Gas boiler heating (space heating & hot water)

Radiators

Hybrid ventilation Mechanical + Natural

# Design Process



PASSIVE

- Daylight Provision
- Natural ventilation
- Utility of spaces
- Connectivity with outdoors
- Accessibility
- User flexibility
- Robust plan

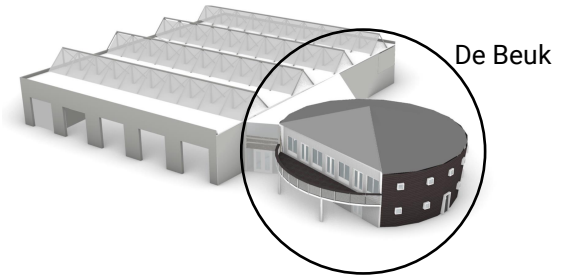
- High efficiency glazing
- Adding Insulation

ACTIVE

- Efficient heating system
- Efficient ventilation system
- Renewable Energy sources

# Design Process

Spatial layout

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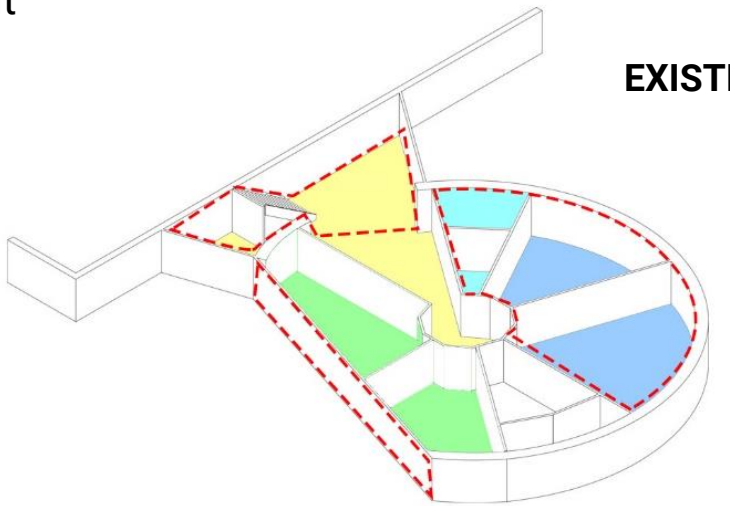
**PROPOSED**



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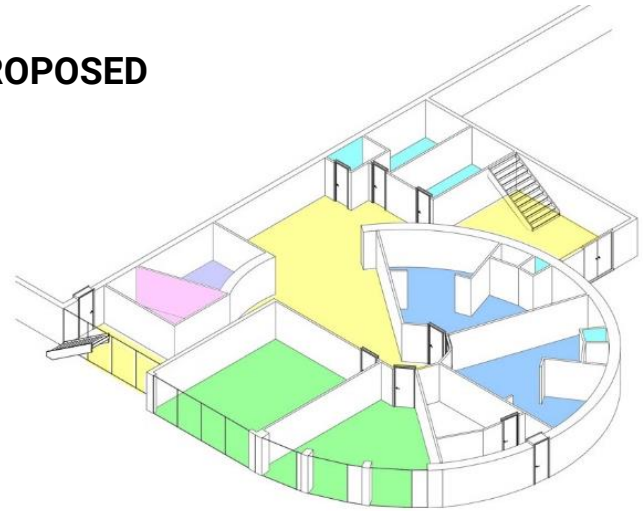

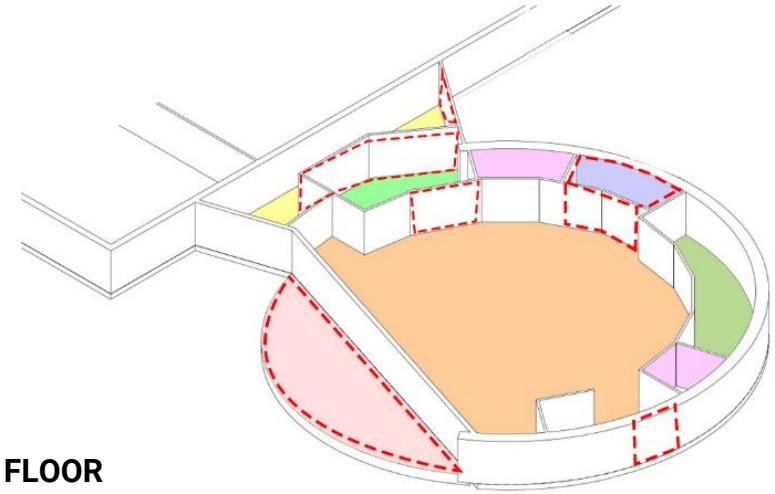

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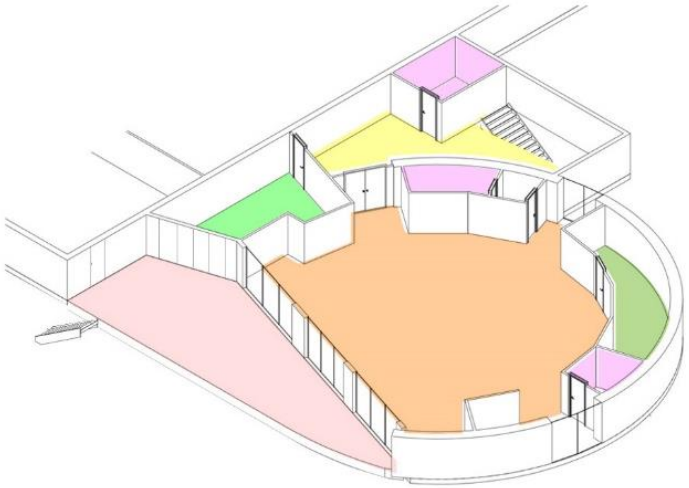
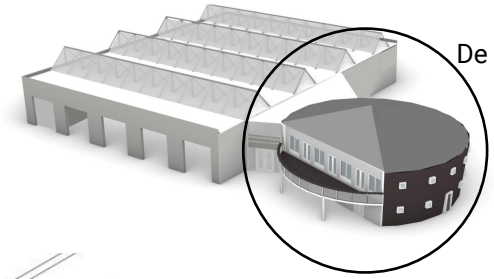


- Location of changes
- Committee room/board room
- Changing/shower
- Toilet
- Circulation
- Installation room
- Store room/Archive
- Bar Attic
- Kitchen
- Balcony

# Design Process

Spatial layout

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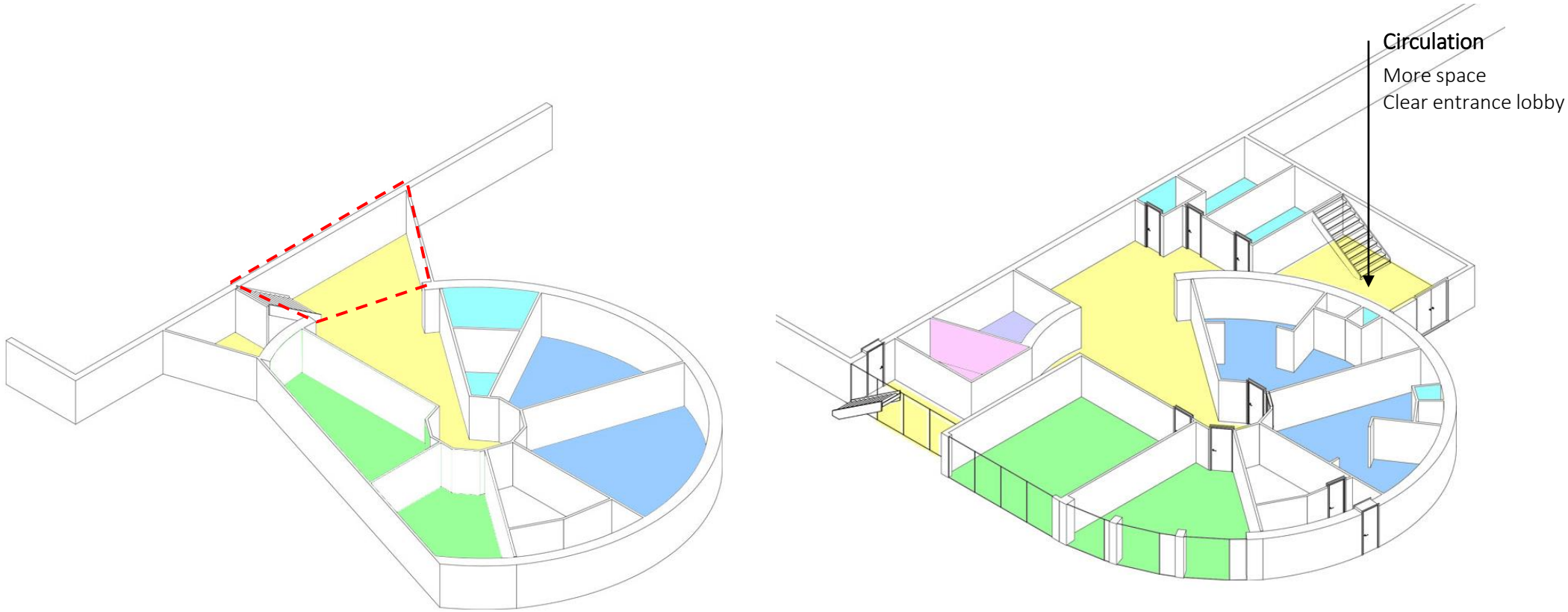


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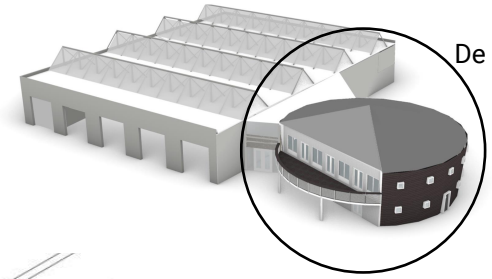
Spatial layout

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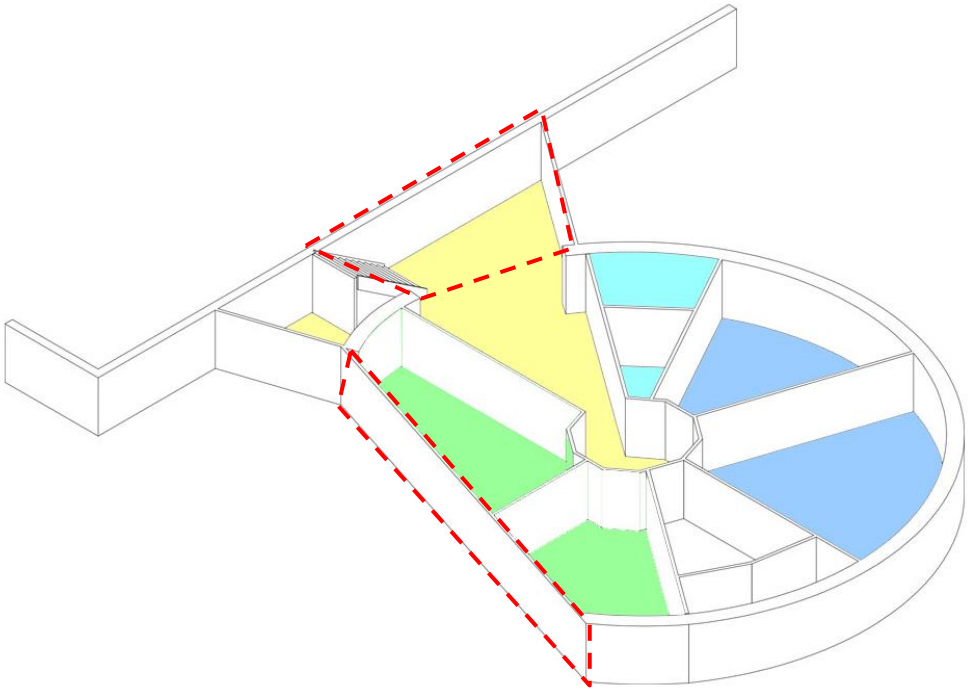

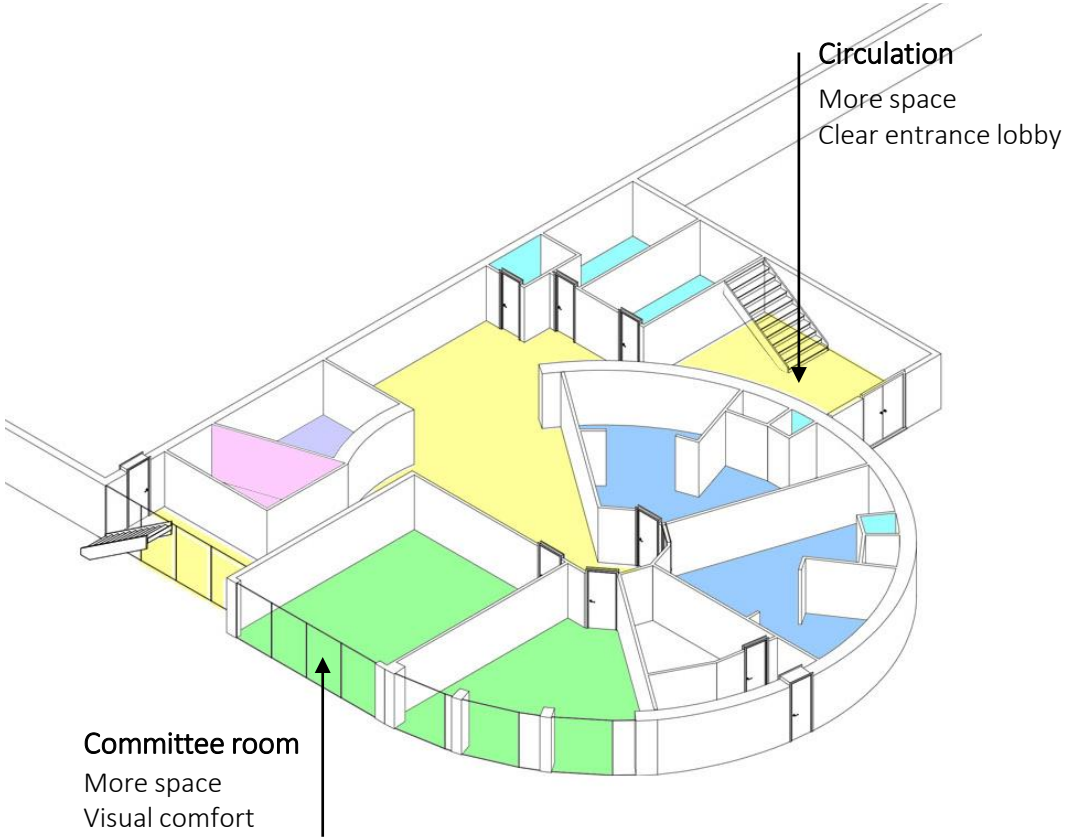


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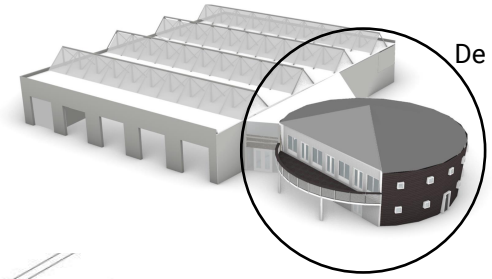
# Design Process

Spatial layout

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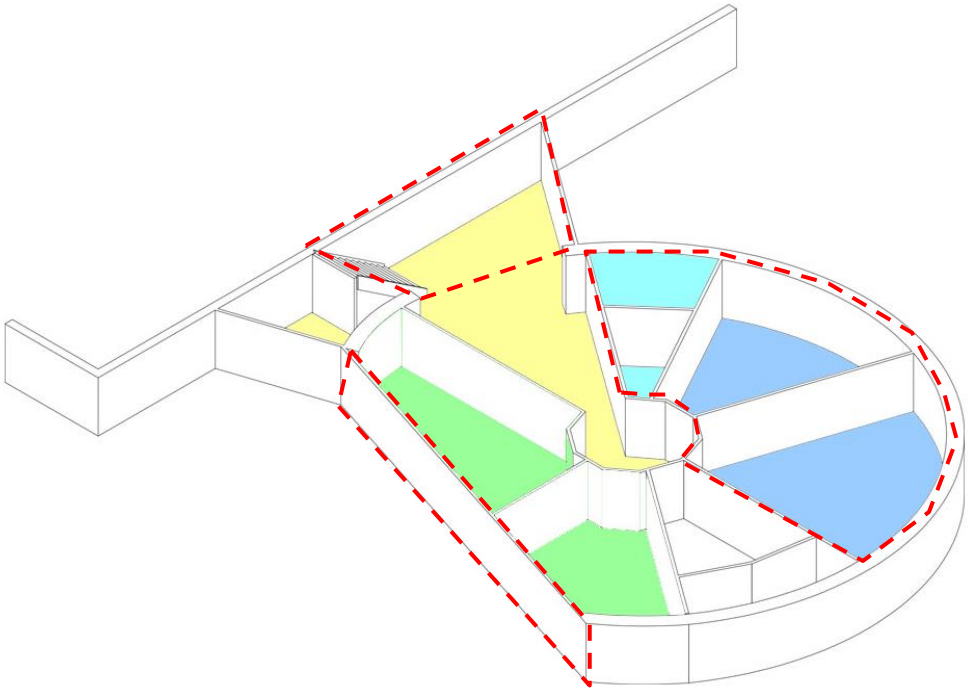

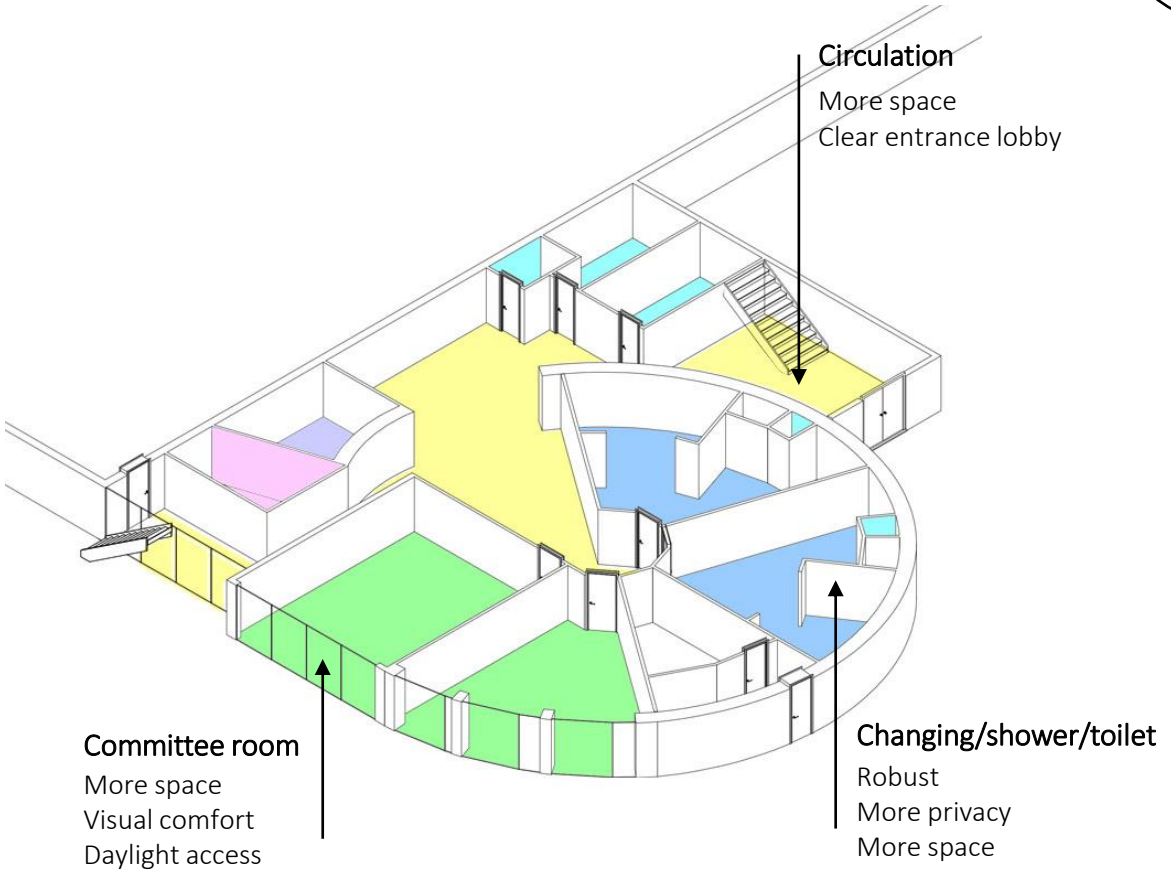


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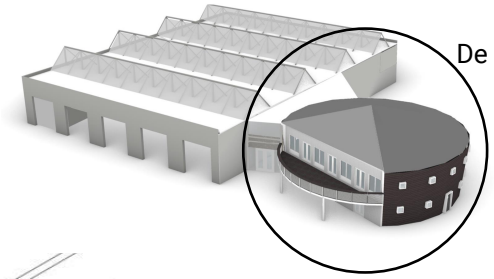


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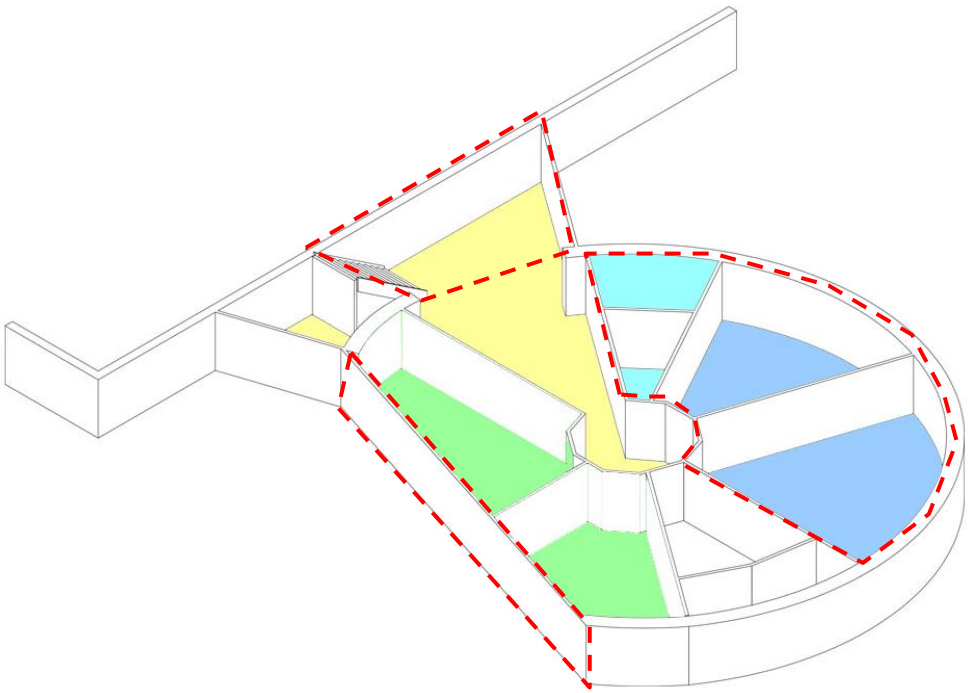

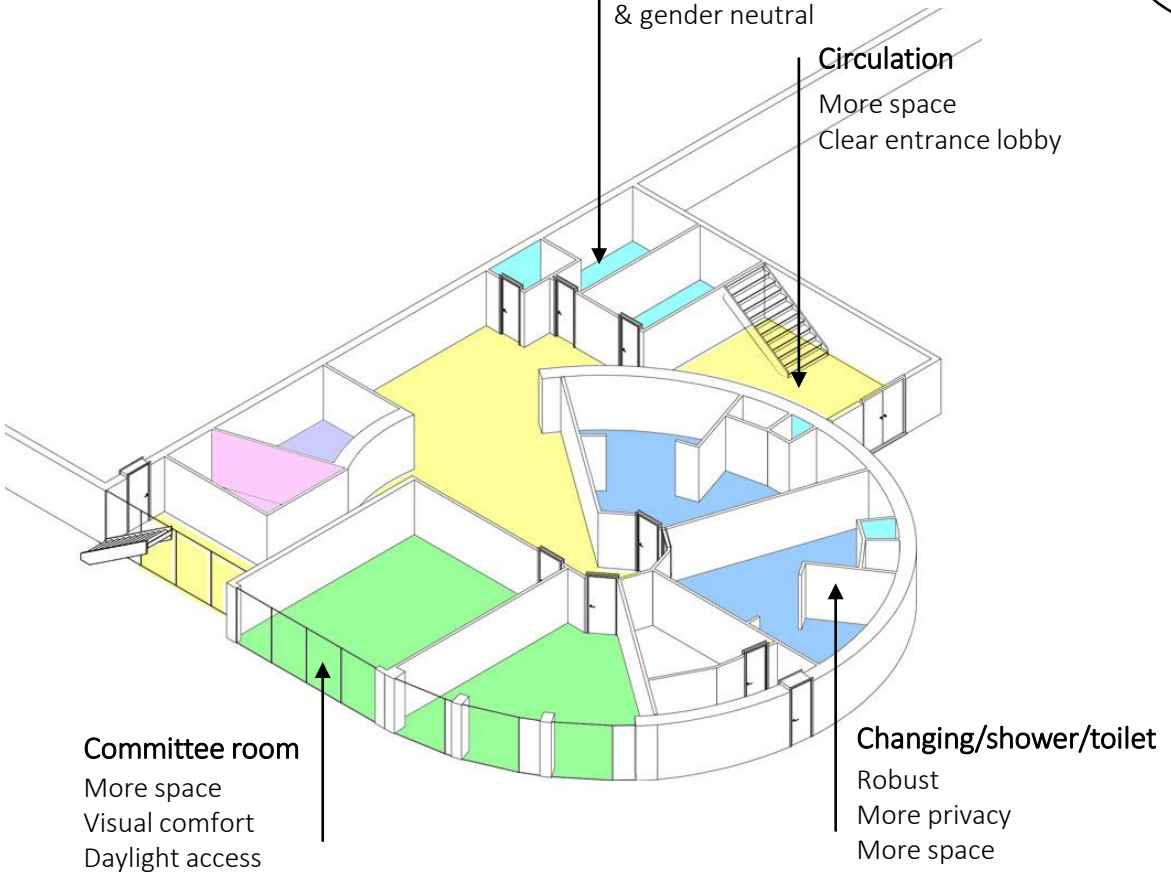


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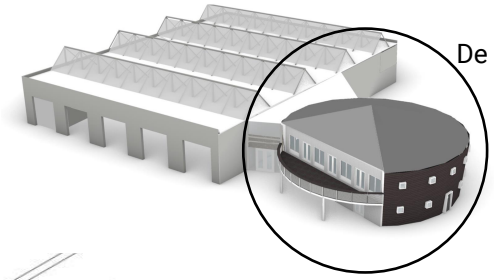


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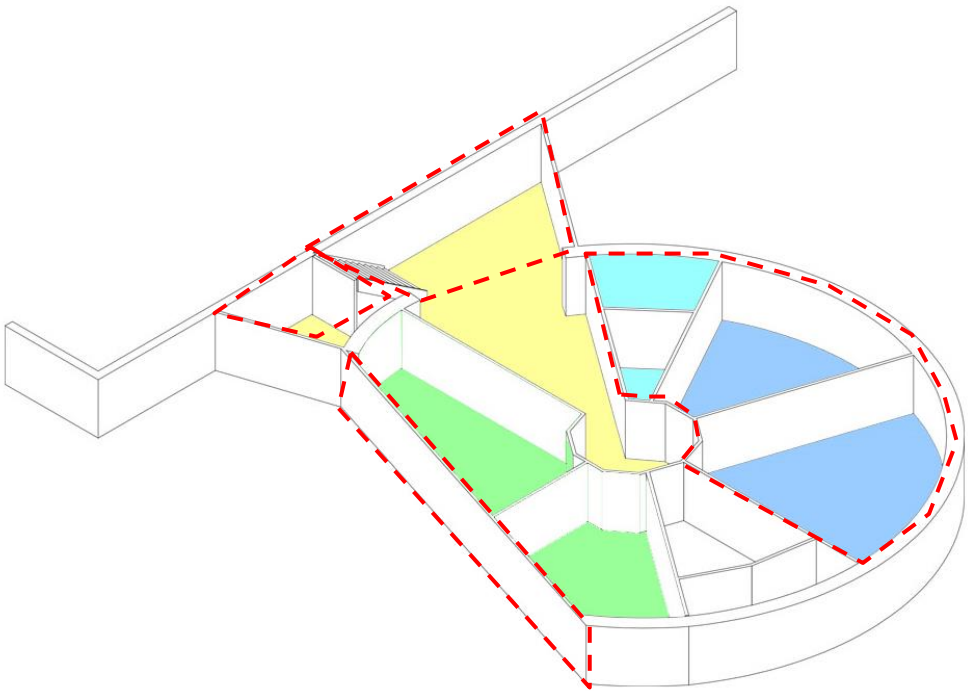
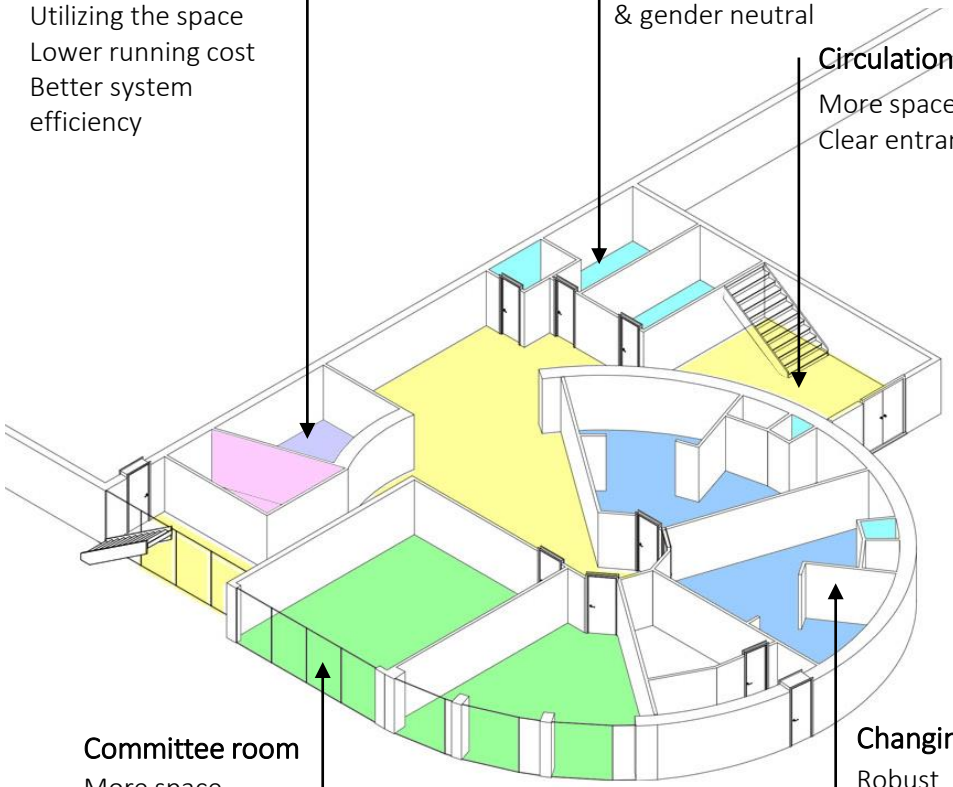


**Common installation room**
Utilizing the space
Lower running cost
Better system efficiency

**Toilets**
Less compact
Toilet for disabled & gender neutral

**Circulation**
More space
Clear entrance lobby



**Committee room**
More space
Visual comfort
Daylight access

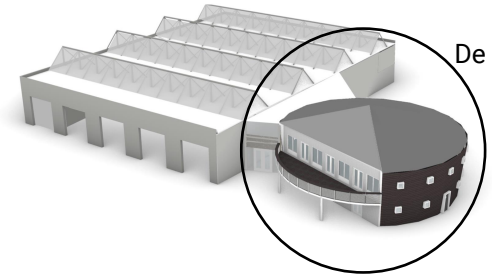
**Changing/shower/toilet**
Robust
More privacy
More space

**EXISTING**

**PROPOSED**

# Design Process

Spatial layout

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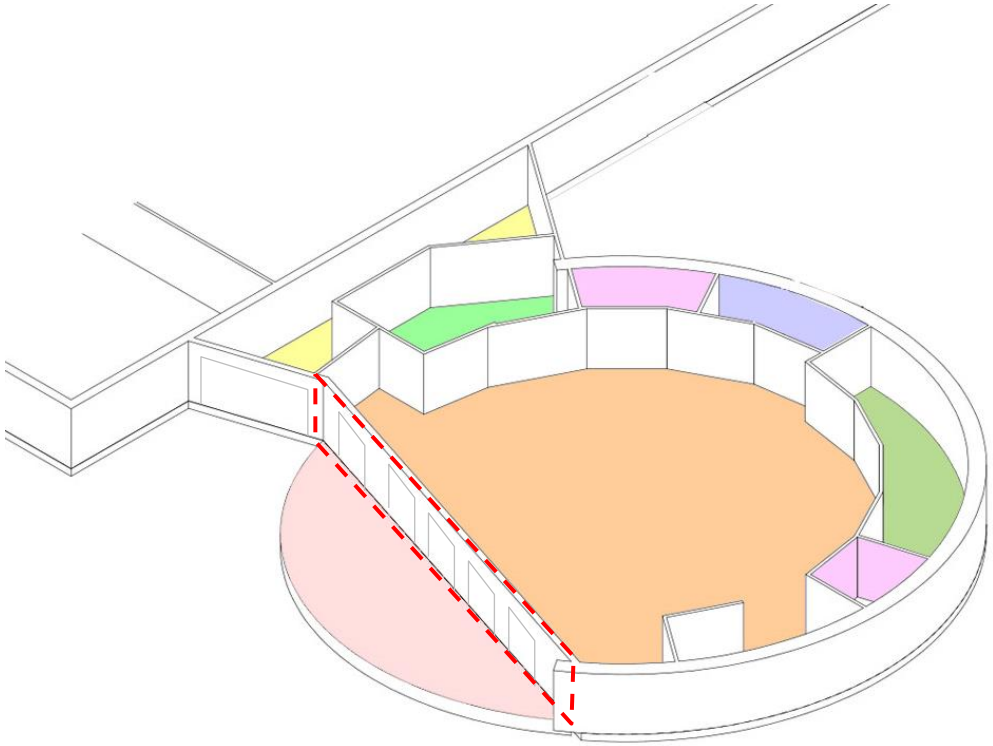

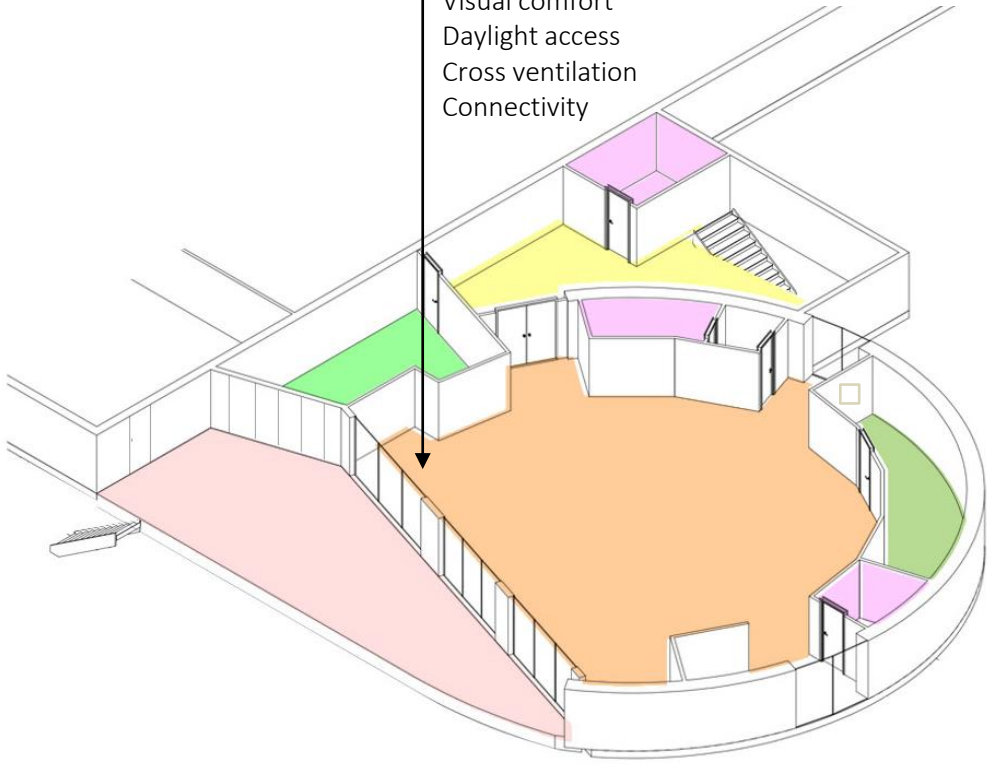


**EXISTING**

**PROPOSED**

# Design Process

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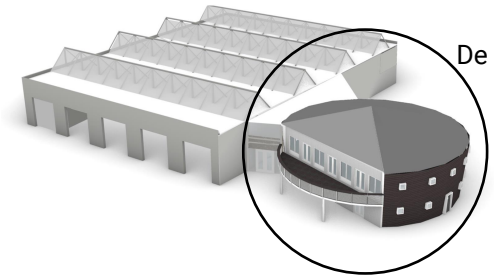


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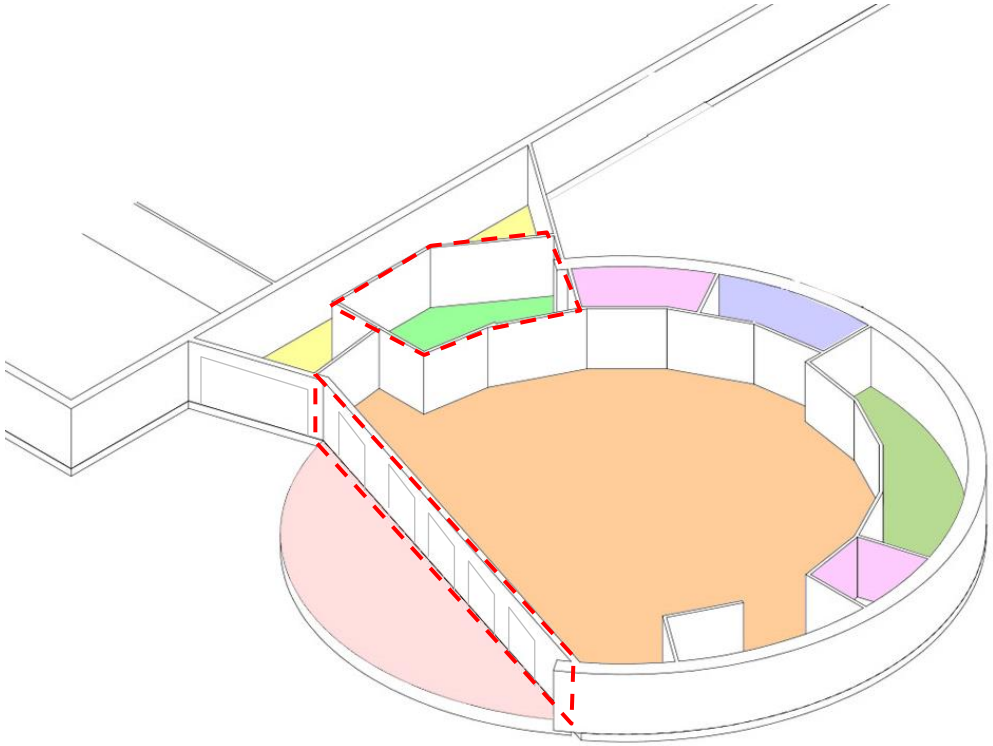
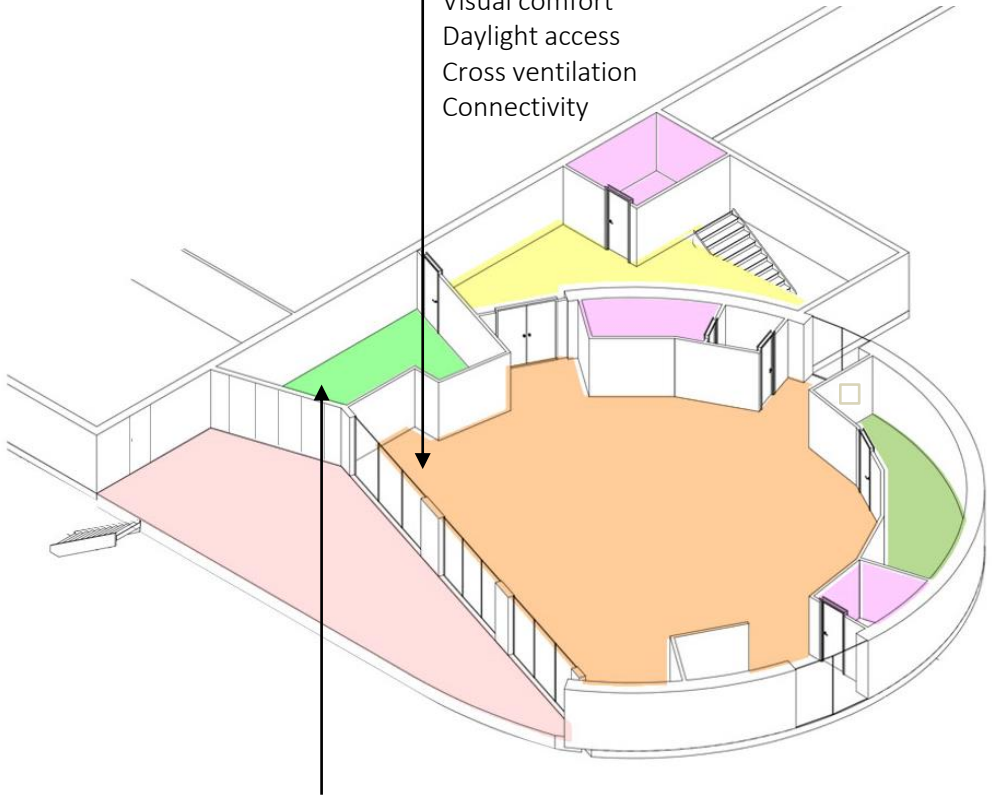


**EXISTING**

Bar Attic

High glazing %
Visual comfort
Daylight access
Cross ventilation
Connectivity



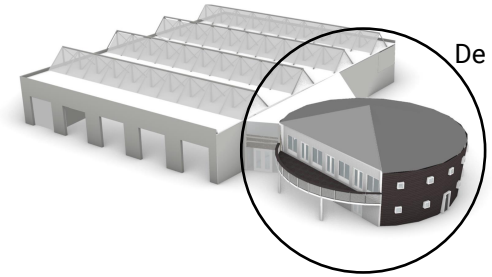
Board room

Improved visual comfort
Daylight access

**PROPOSED**

# Design Process

Spatial layout

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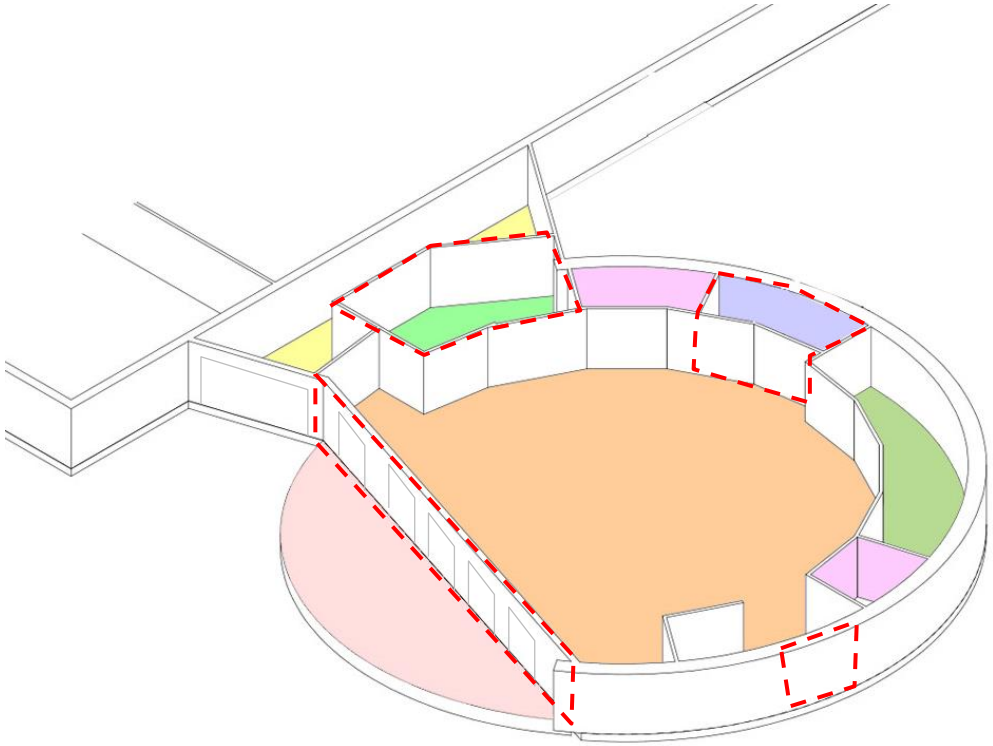

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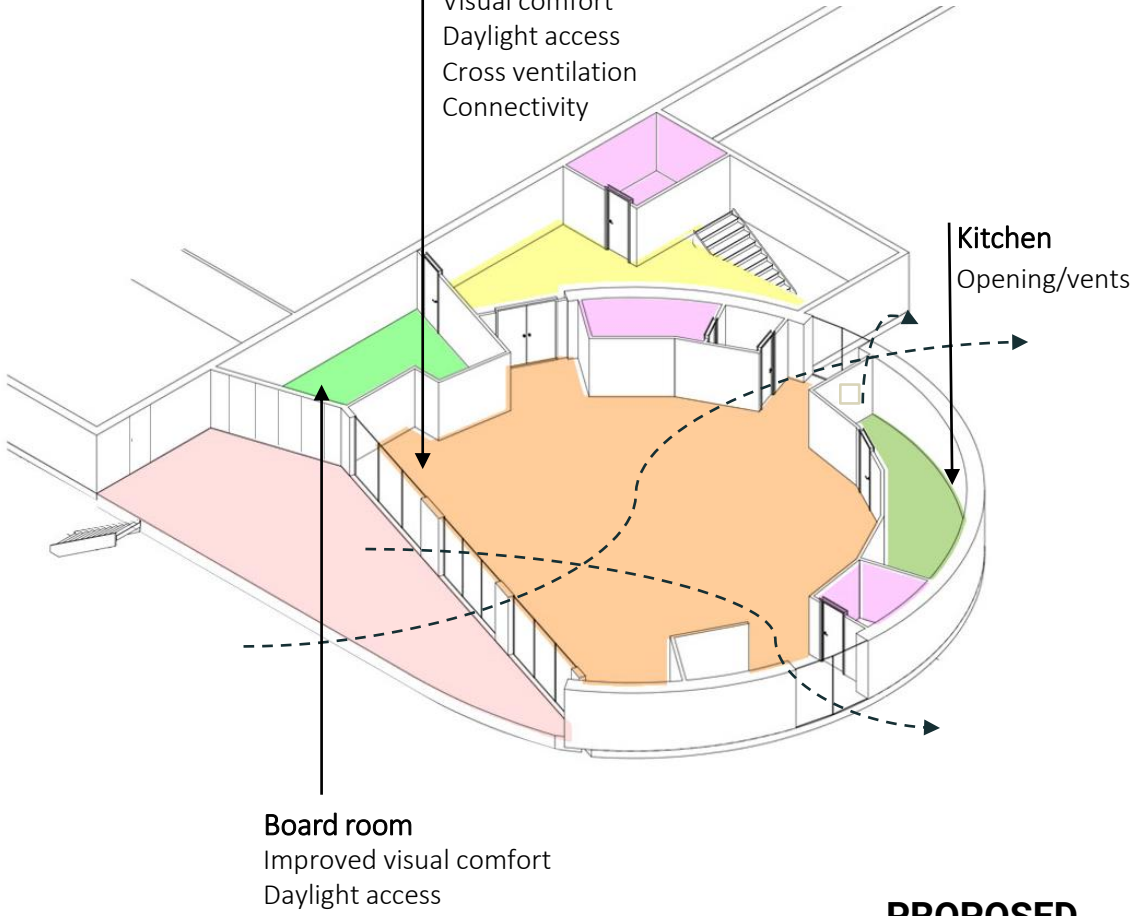
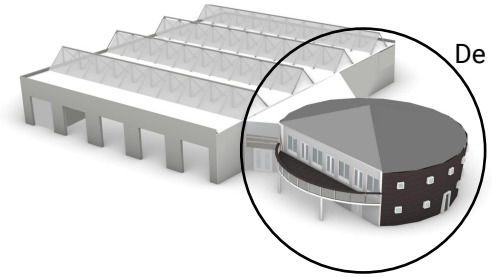



**PROPOSED**

# Design Process

Spatial layout

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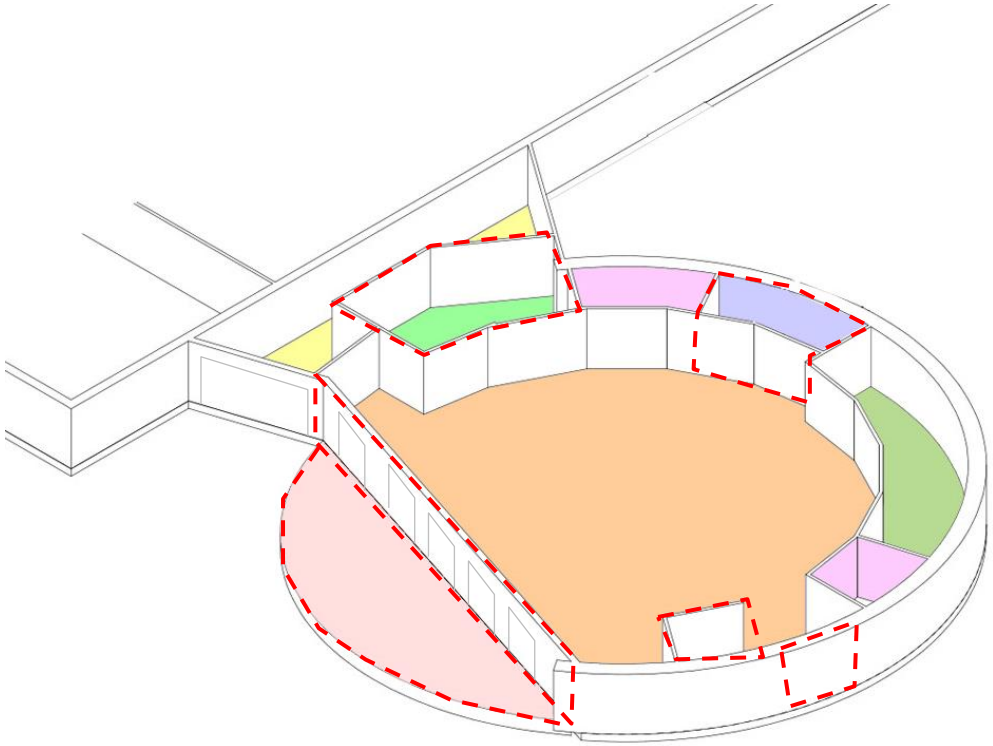

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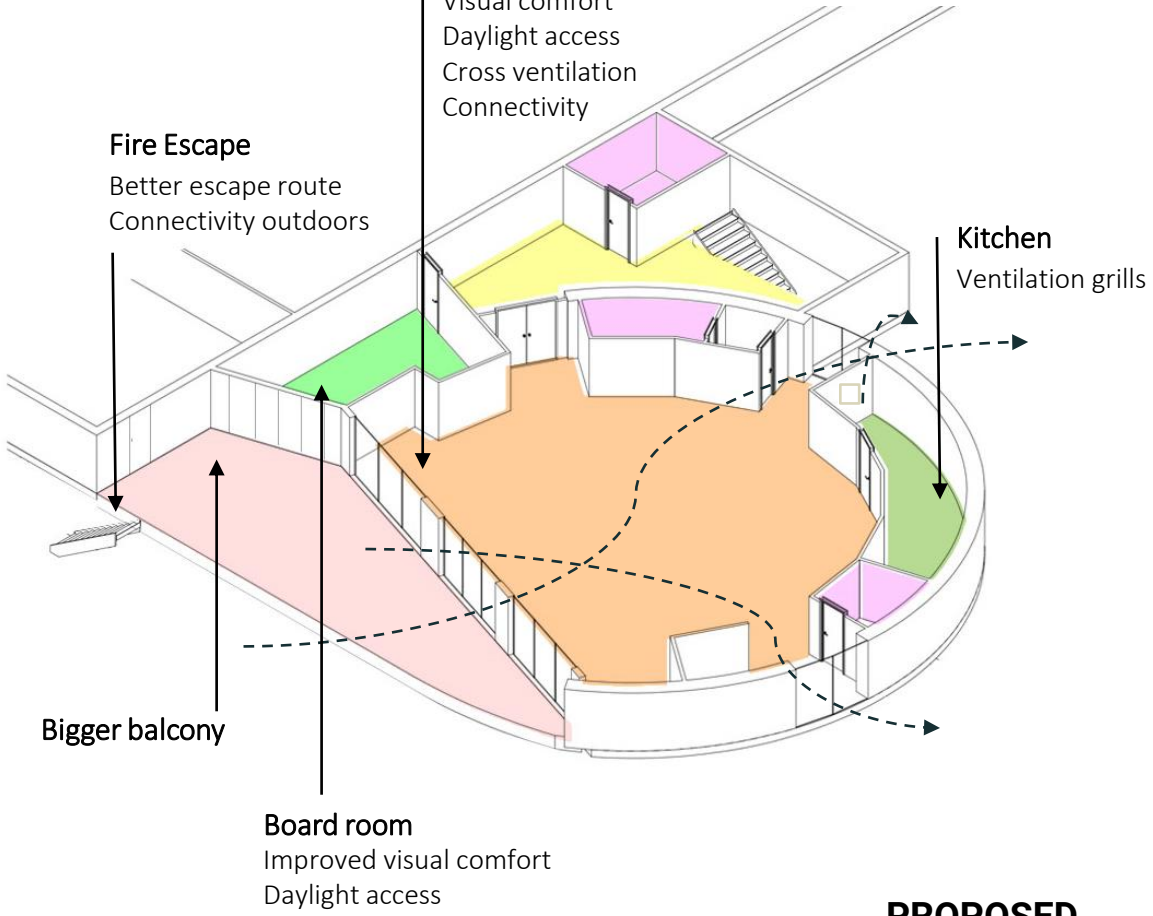
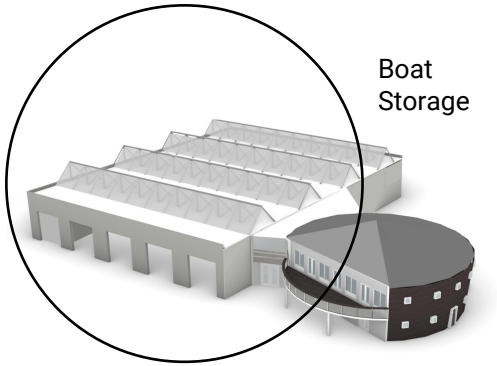



**PROPOSED**

# Design Process

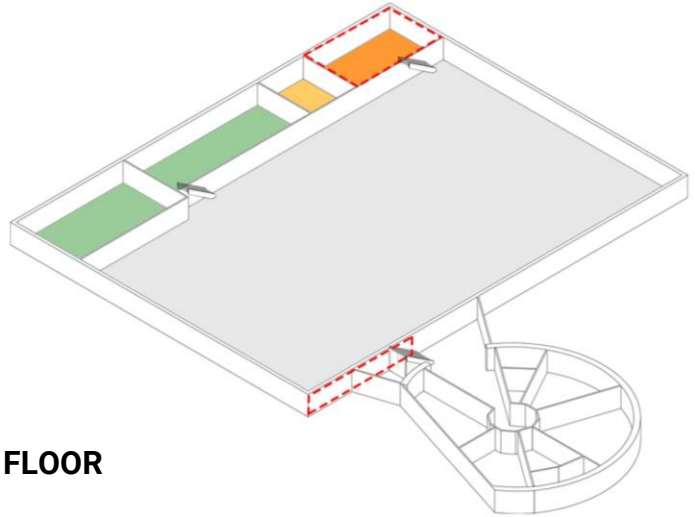
Spatial layout

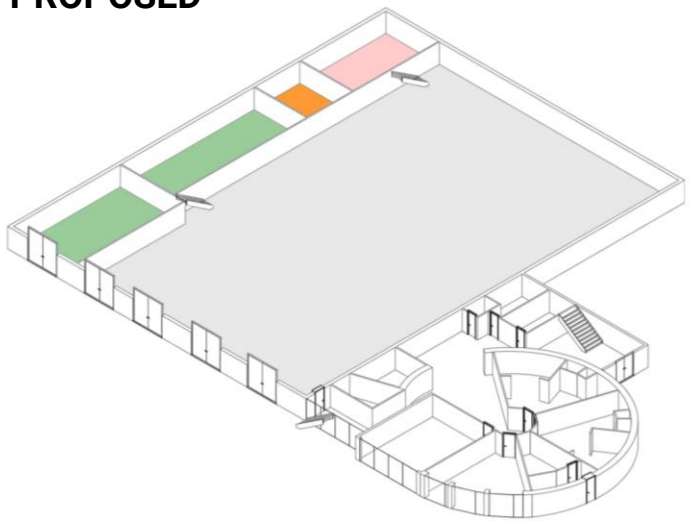



**EXISTING**

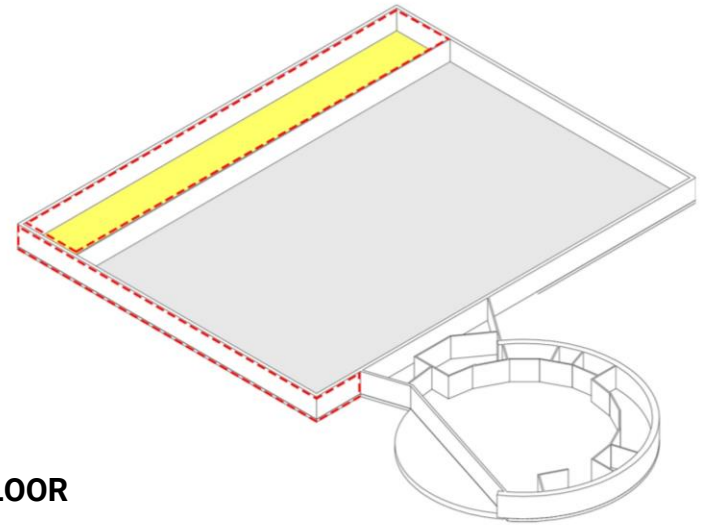
**PROPOSED**

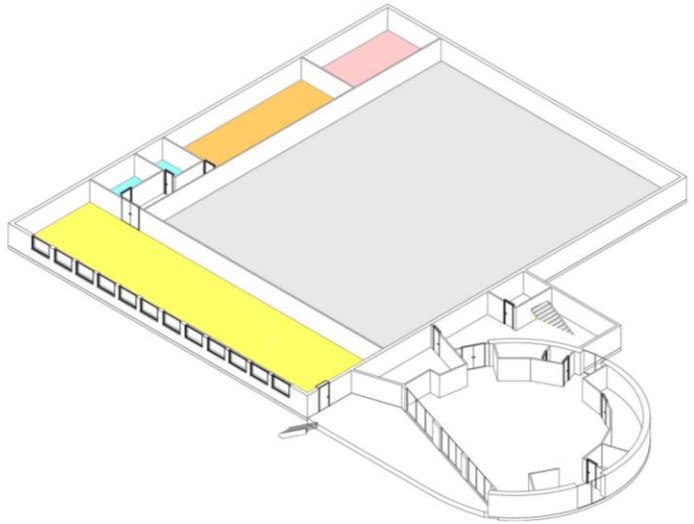
**GROUND FLOOR**





**FIRST FLOOR**

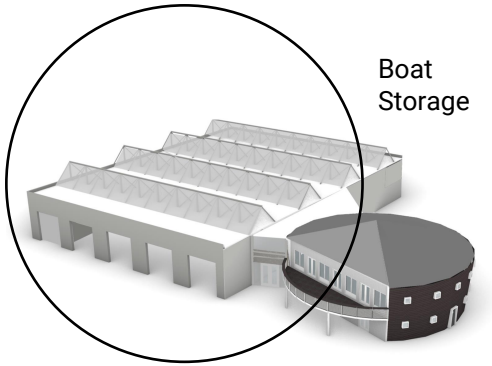


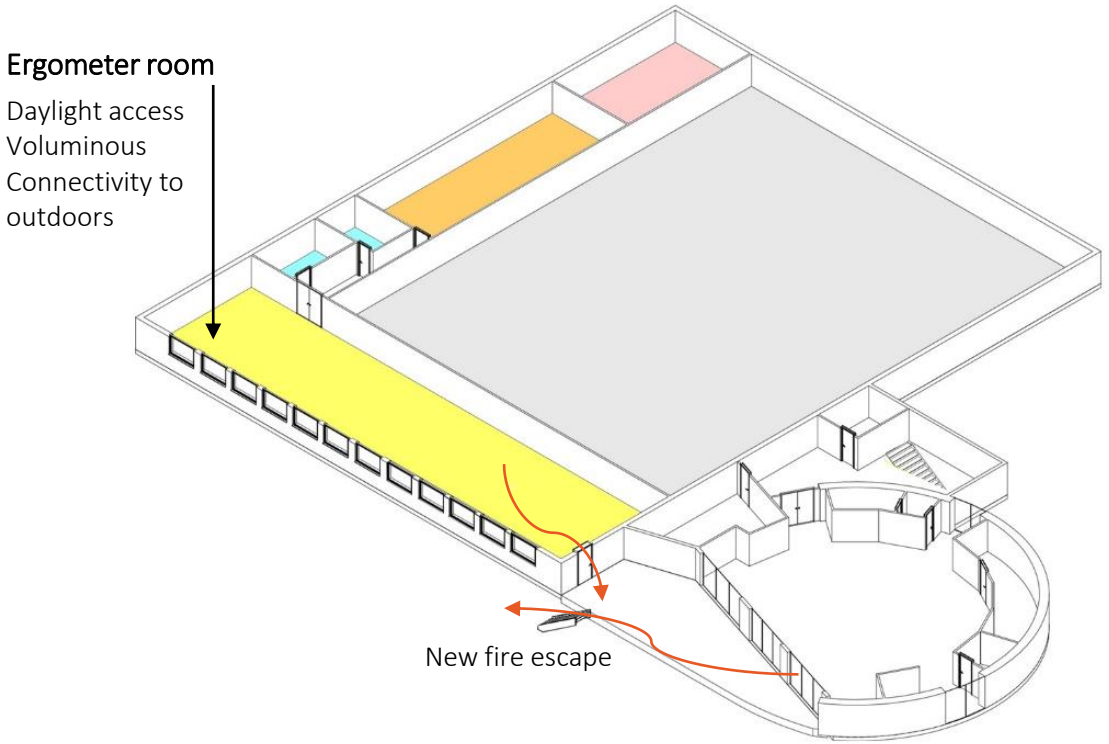


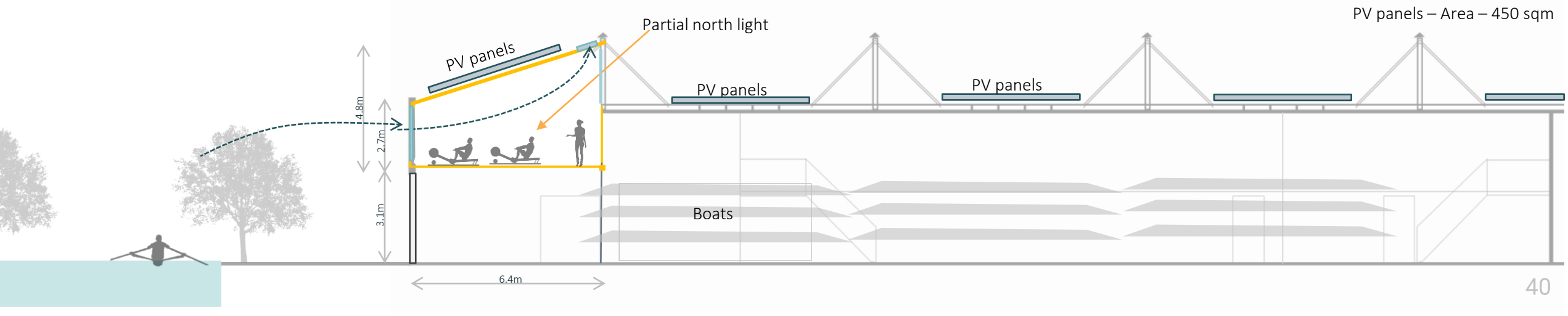
- Location of changes
- Ergometer
- Strength training room
- Meeting room/office
- Toilet
- Store room
- Workshop

# Design Process

## Spatial layout

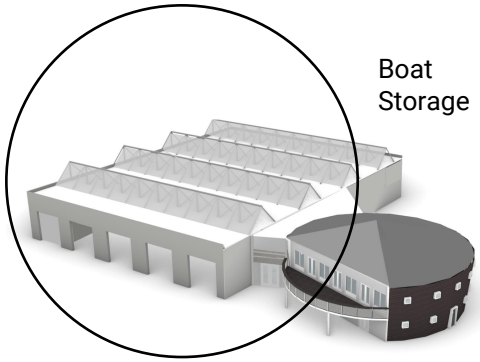


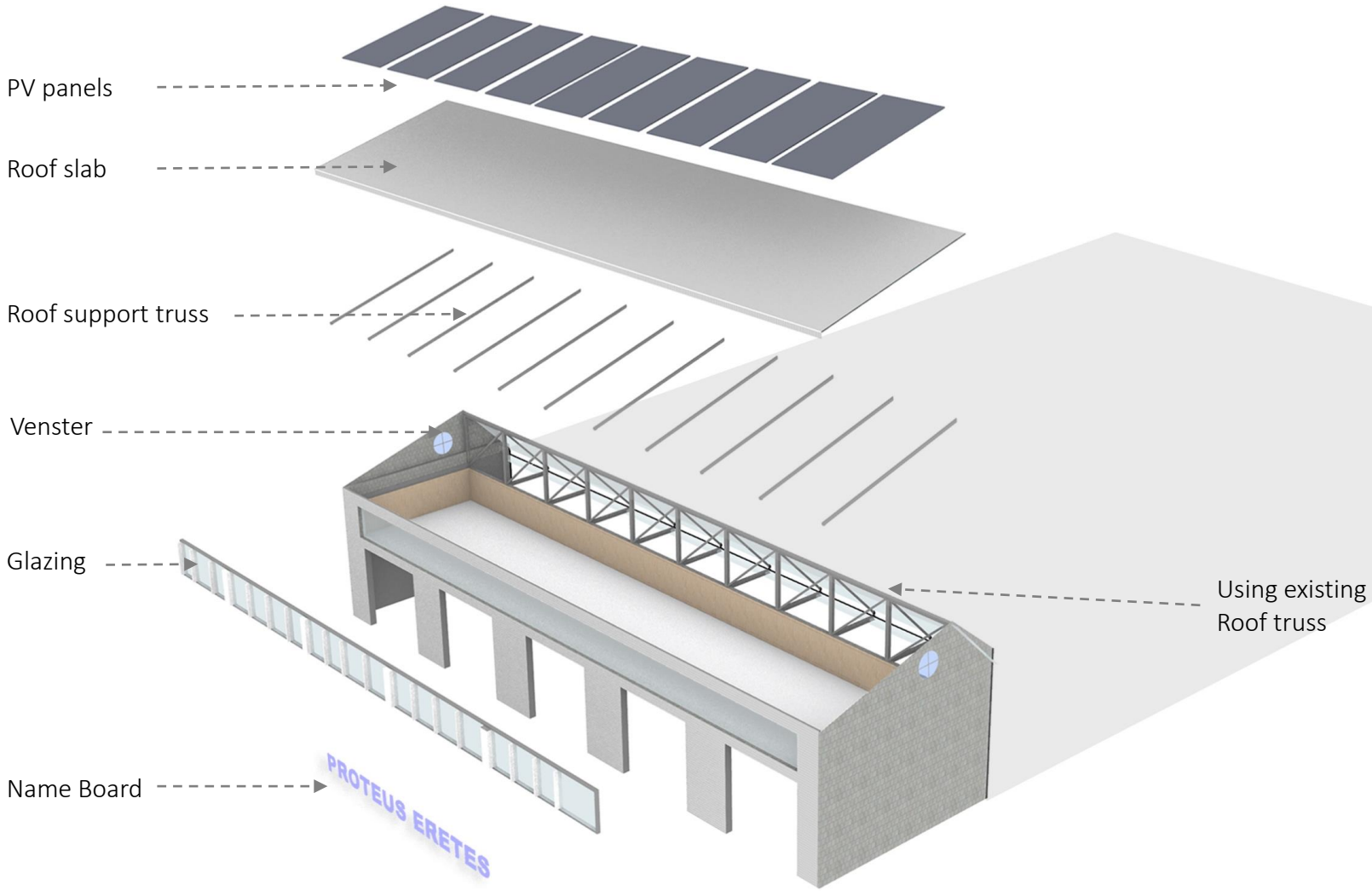



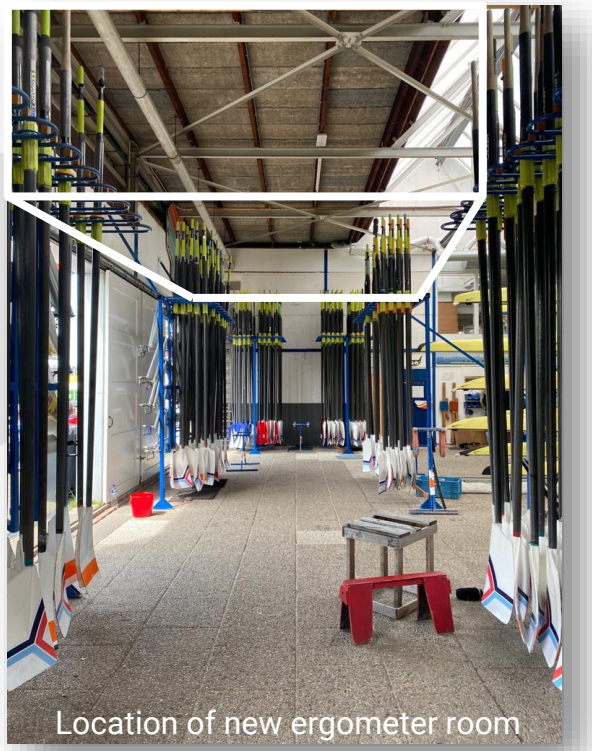
# Design Process

## Spatial layout



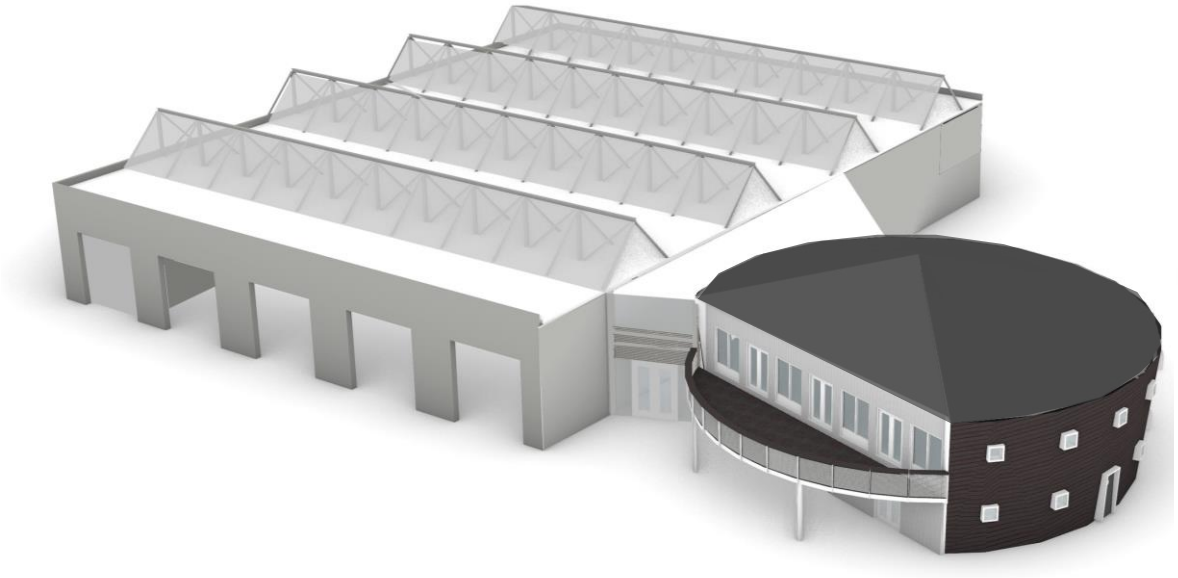

**ERGOMETER ROOM**



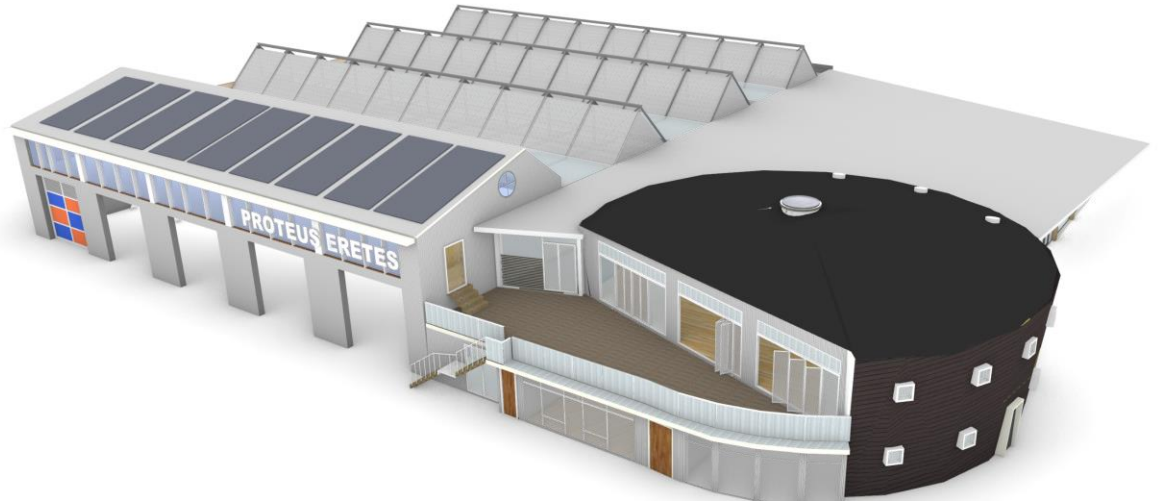



# Design Process

Building Envelope



**EXISTING**

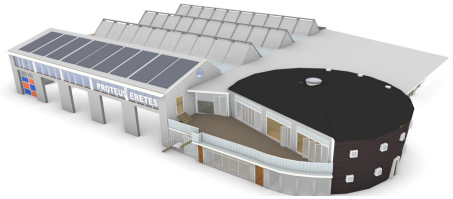



**PROPOSED**

# Design Process

## Building Envelope

**Low-e coated Double glazing**
U-value 1.0 W/m2K



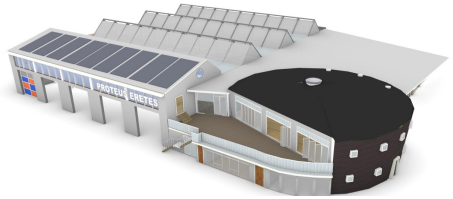
SOLAR HEAT GAIN

VISUAL LIGHT TRANSMITTANCE

HEAT LOSS

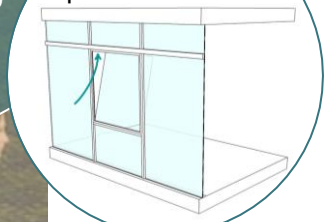
# Design Process

## Building Envelope



**Low-e coated Double glazing**
U-value 1.0
W/m2K

Openable Windows



SOLAR HEAT GAIN

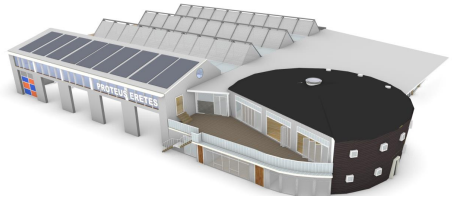
VISUAL LIGHT TRANSMITTANCE

HEAT LOSS

HEAT REJECTION

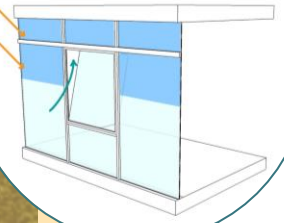
# Design Process

## Building Envelope

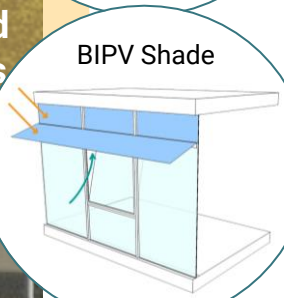


**Building Integrated PV panels**

BIPV Facade



BIPV Shade

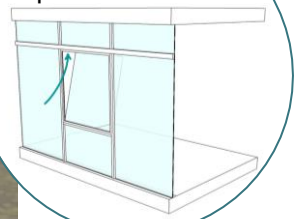


SOLAR PROTECTION

SOLAR ENERGY

**Low-e coated Double glazing**
U-value 1.0 W/m2K

Openable Windows



SOLAR HEAT GAIN

VISUAL LIGHT TRANSMITTANCE

HEAT LOSS

HEAT REJECTION

# Design Process

## Building Envelope

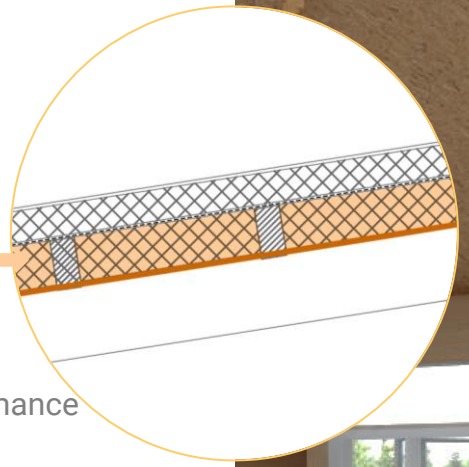
Bi-fold Doors

Seamless views
Ease of access
Better affordability
High thermal efficiency
U-0.8 W/m2K

BAR ATTIC

# Design Process

## Building Envelope



Extra internal roof Insulation

Cellulose 130mm thk
Less labour
Less expenses
Better thermal performance
Rc-value 6.5 m2K/W

Bi-fold Doors

Seamless views
Ease of access
Better affordability
High thermal efficiency
U-0.8 W/m2K

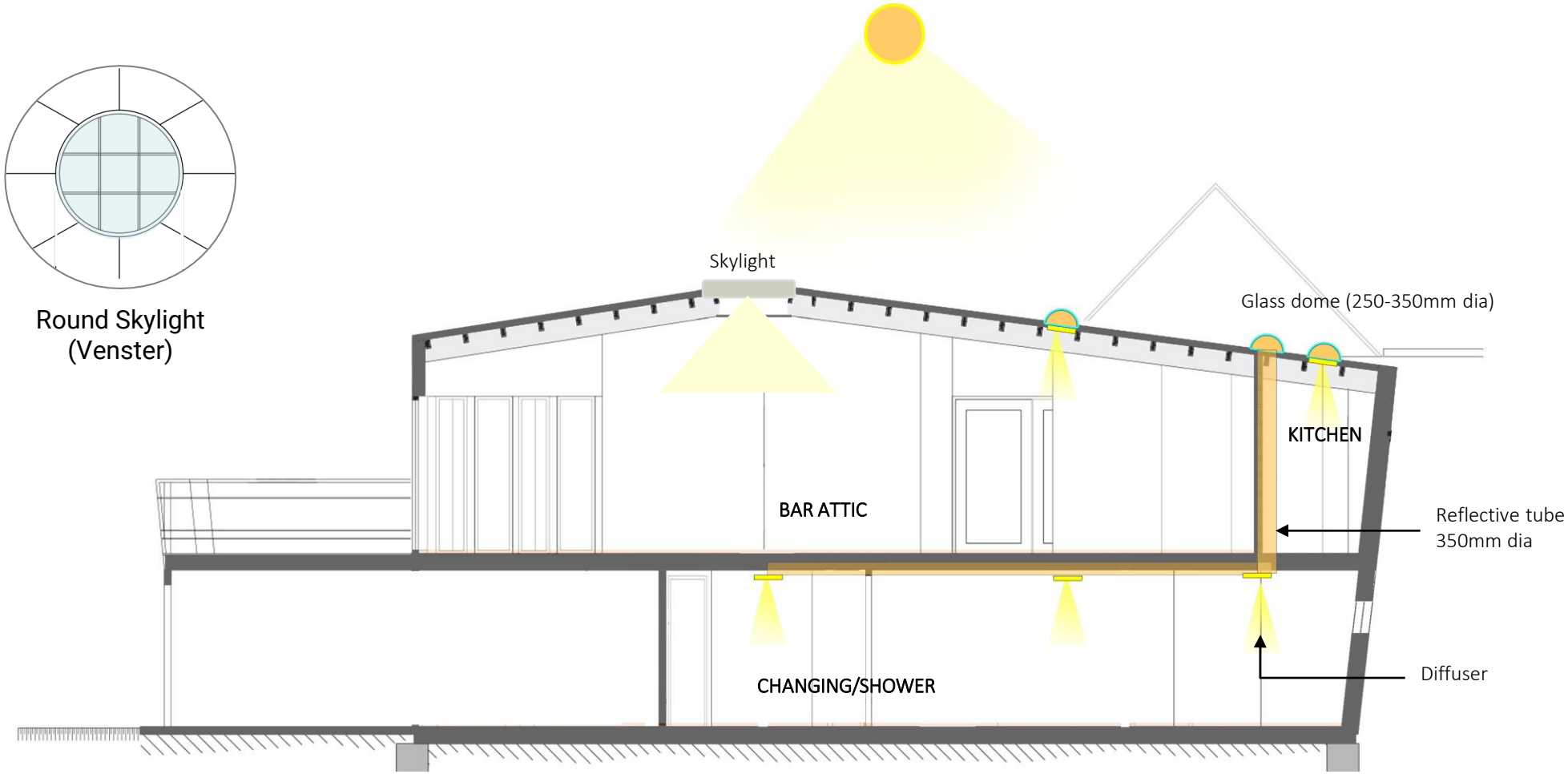
BAR ATTIC

# Design Process

## Building Envelope



Round Skylight
(Venster)




Solar Tubes

**Reduce** lighting loads

**High** visible light transmittance

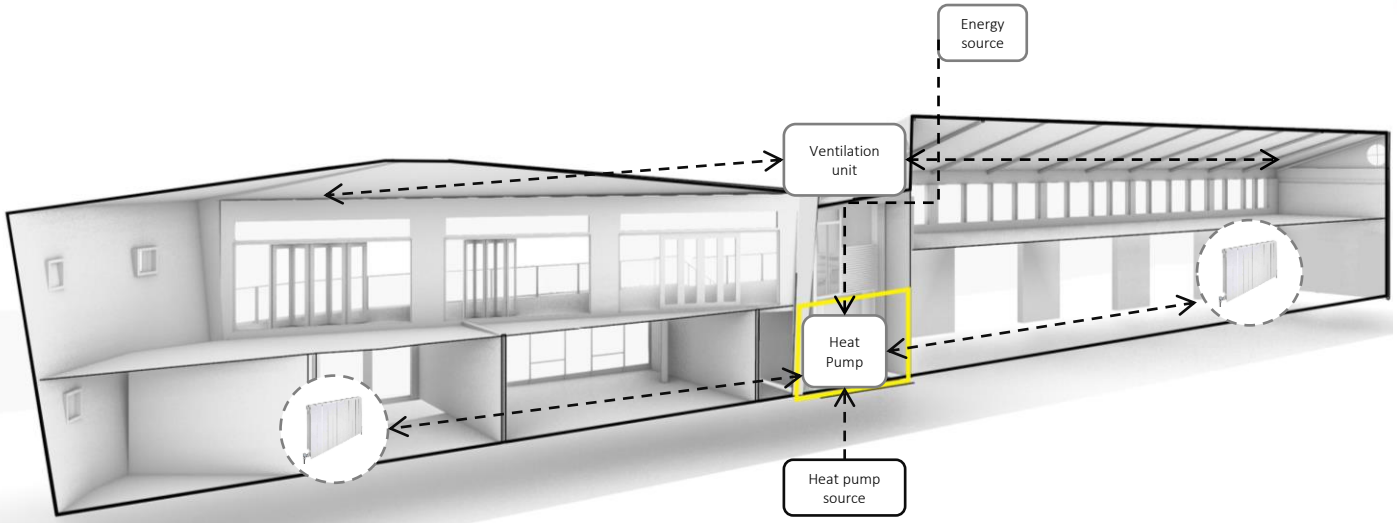
**Low** thermal impact

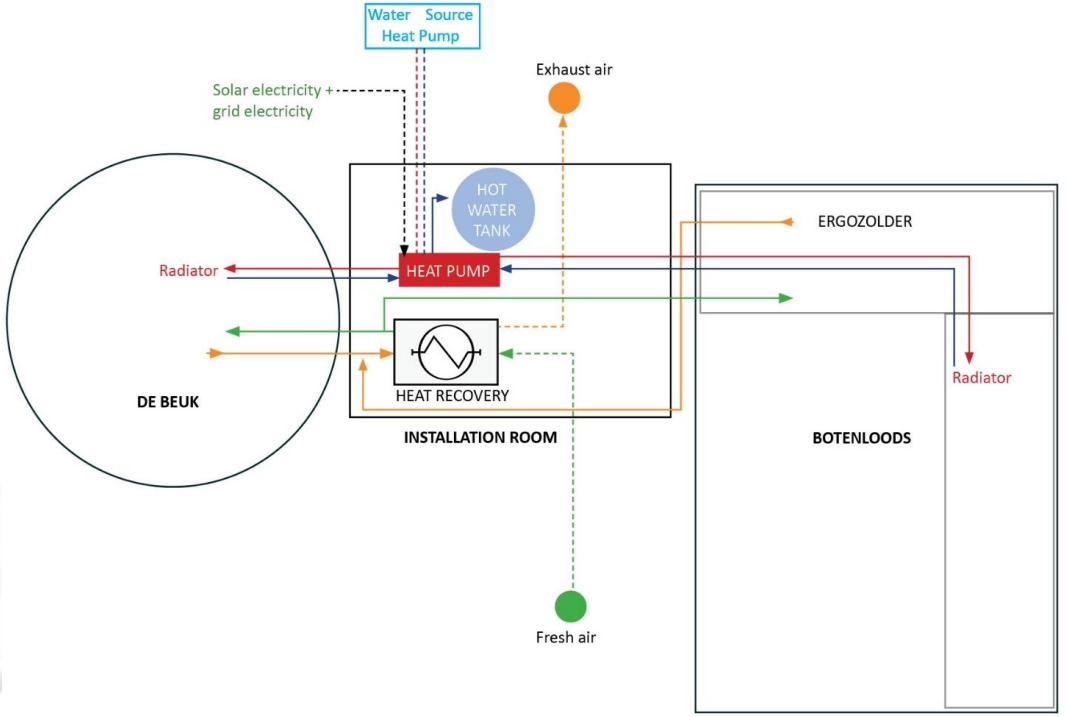
*Solatubes.uk*

# Design Process

## Building Installations

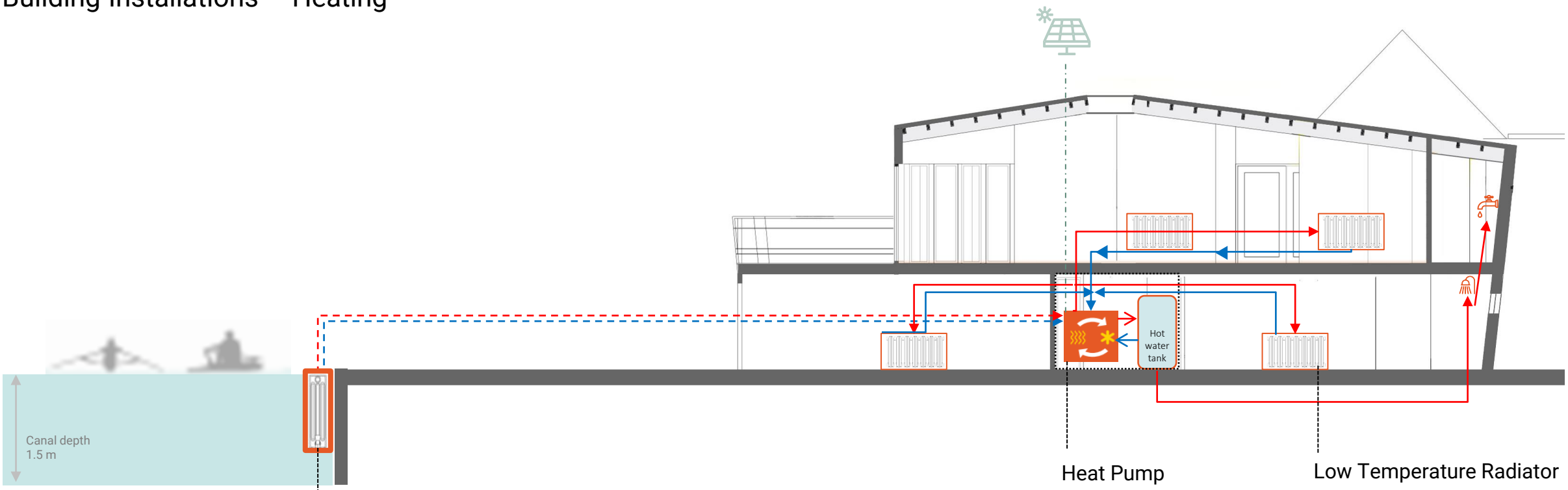
Common Installation Room

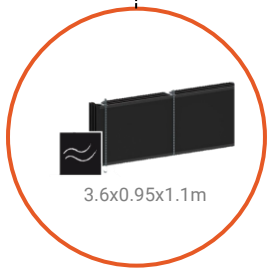


# Design Process

## Building Installations – Heating




### Water Heat Exchanger

**Use of canal** subsurface & wall
**Ideal location (specially rowing clubs)**
High extraction capacities
Lower installation cost
Longer life span
Better efficiency at low outdoor temperatures
Seasonal Performance factor – 3.5/5

### Heat Pump

Environmentally friendly
Use renewable energy source:
Ground, air, water
COP – 4

### Low Temperature Radiator

Use 30% less energy
Even heat distribution
Healthier indoor climate

*MEFA Energy systems, NL*

# Design Process

Building Installations - Ventilation

Good Indoor air quality

Reduce CO2 level

Energy efficiency

Outdoor air exchange

Minimum airflow rate required per person

Activity level of occupants

Occupancy density per sqm.

# Design Process

## Building Installations - Ventilation

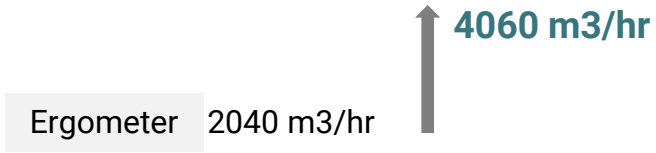
Ventilation requirement - **NORMAL OCCUPANCY**

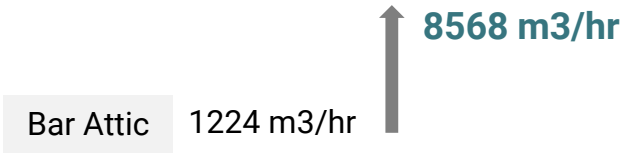
| | |
|---|---|
| Ergometer | 2040 m3/hr |
| Bar Attic | 1224 m3/hr |

# Design Process

## Building Installations - Ventilation

Ventilation requirement - **PEAK OCCUPANCY**



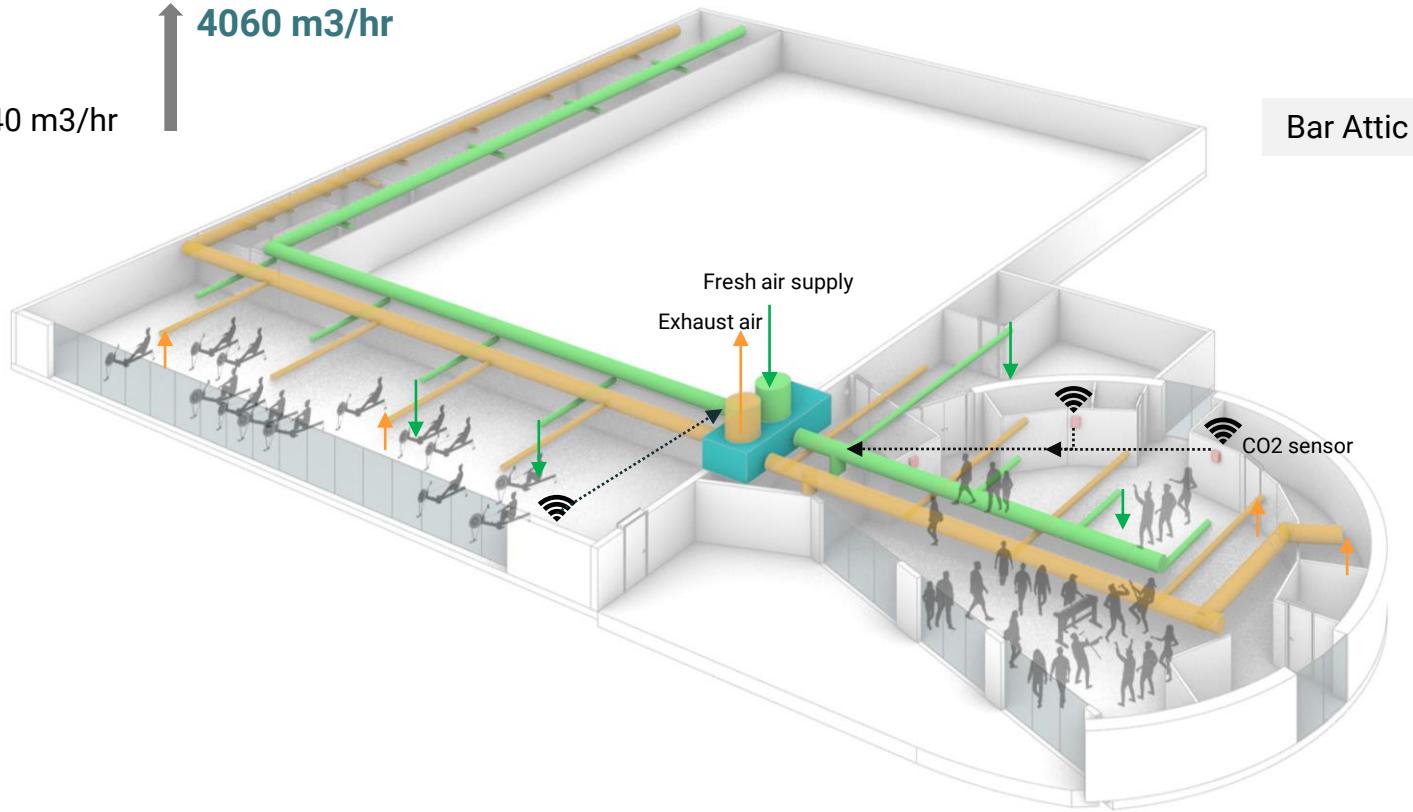
# Design Process

Building Installations - Ventilation

**Centralised heat recovery system with demand control ventilation**

Ergometer 2040 m3/hr

4060 m3/hr




Bar Attic 1224 m3/hr

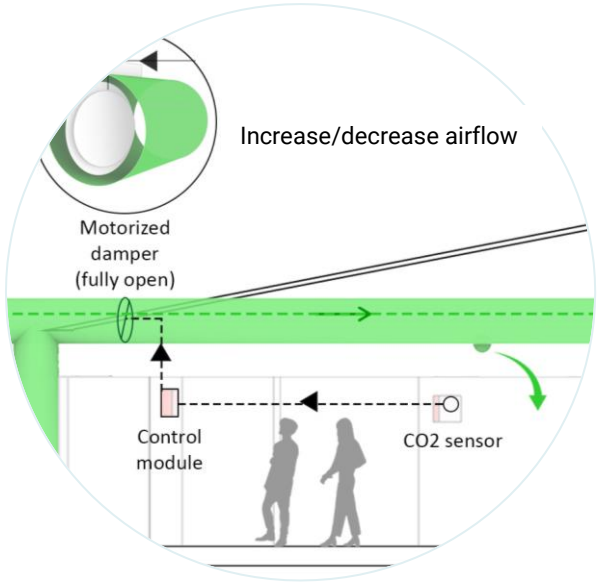
8568 m3/hr

Heat recovery unit

Supply air

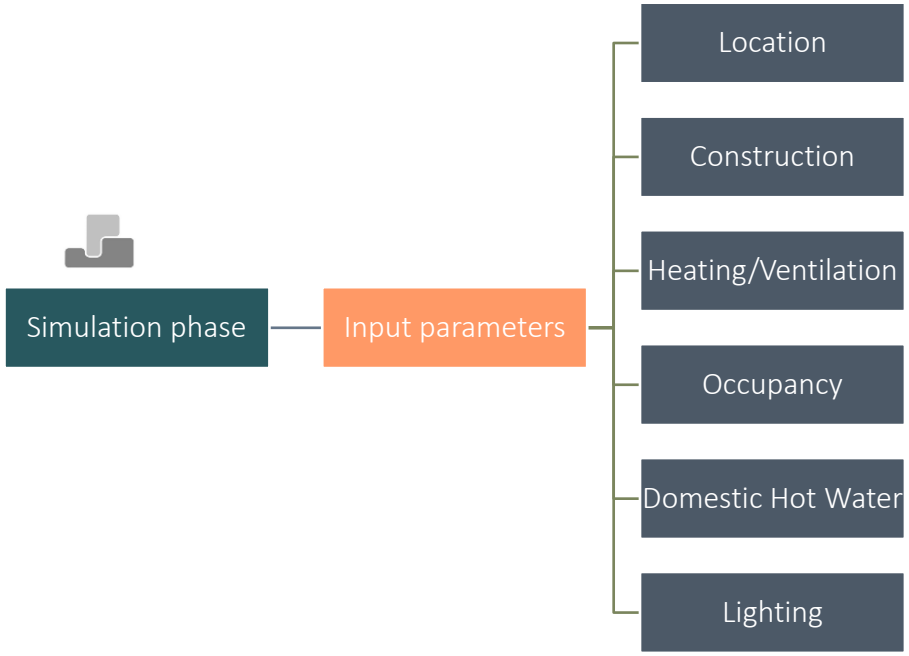
Exhaust air

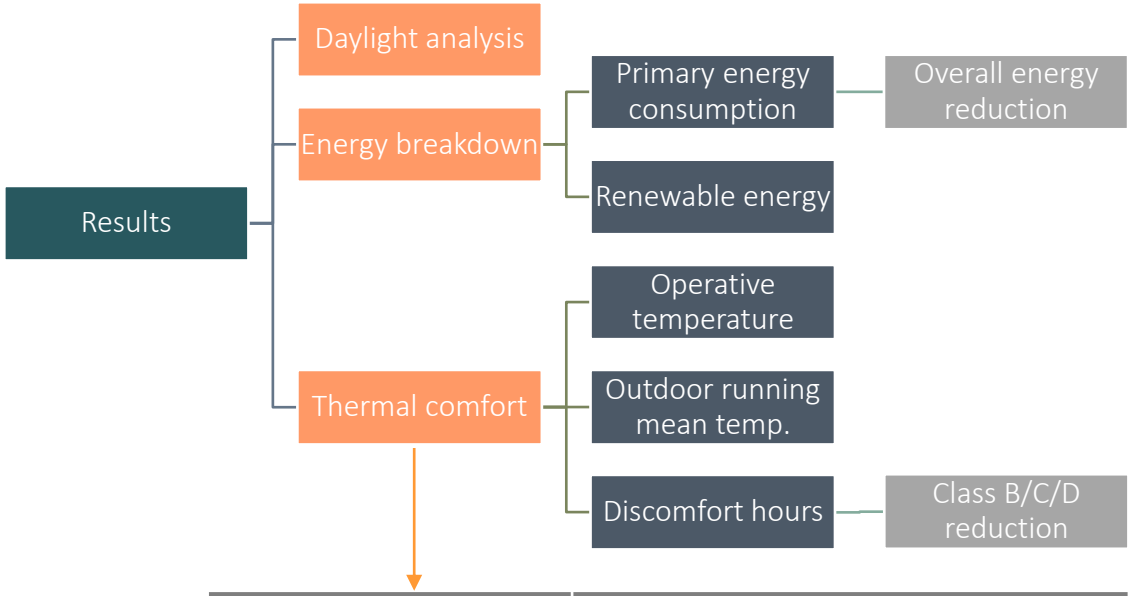
CO2 Sensors



# Design Assessment

Energy, comfort, daylight



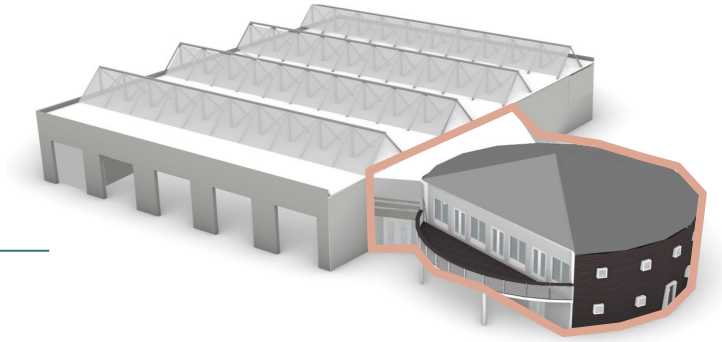

| **ATG graph - Adaptive comfort model** | Hybrid method – Mechanically ventilation or/and naturally ventilation buildings |
|---|---|

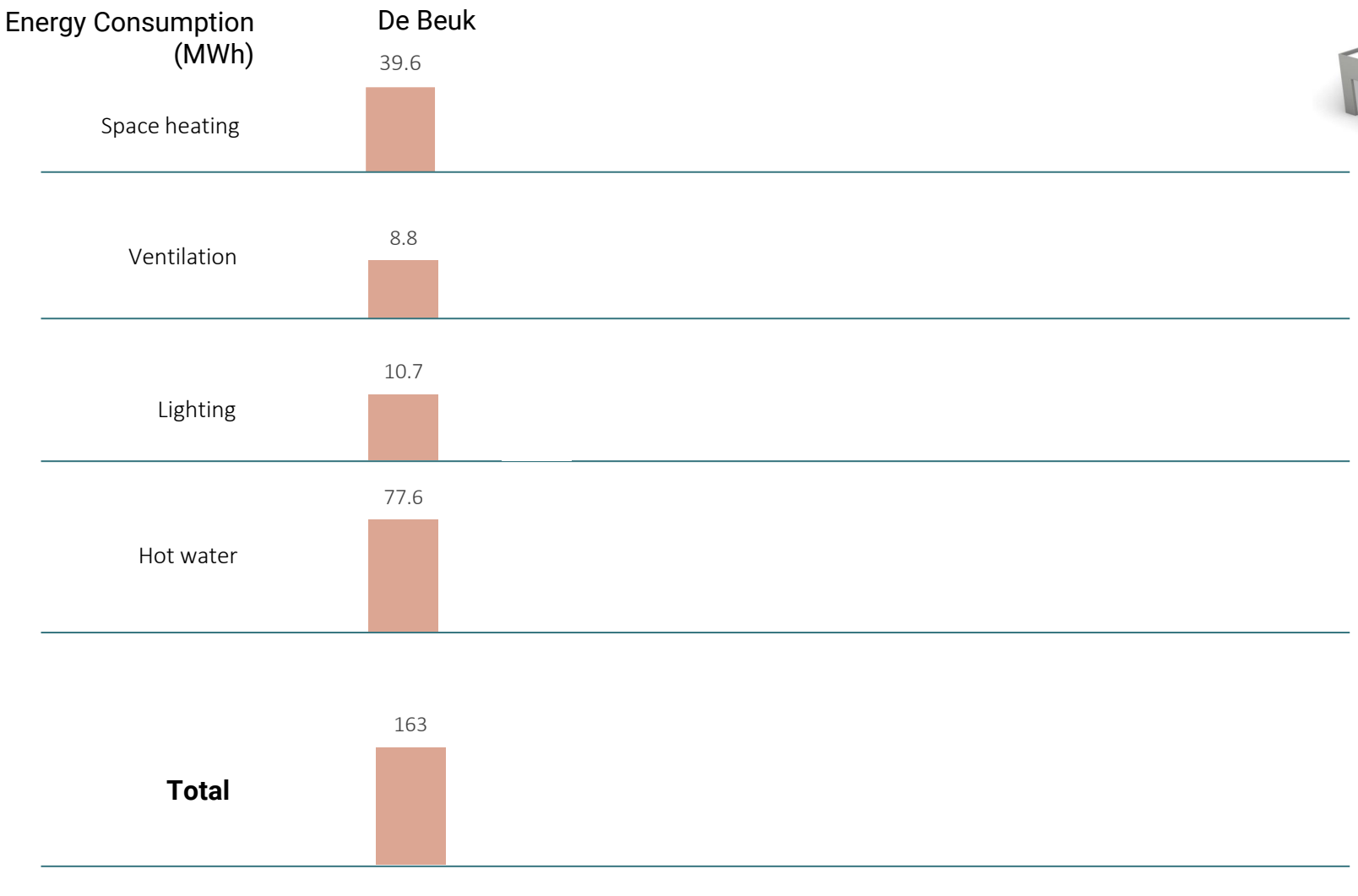
| **Bandwidth classification** | | **% people dissatisfied based on discomfort hours** |
|---|---|---|
| Class A | Sensitive buildings (hospitals) | Max 5% |
| Class B | Common expectation, new/renovation | Max 10% |
| Class C | Older buildings | Max 15% |
| Class D | Temporary buildings | Max 25% |

*ISSO 74*

# Design Assessment

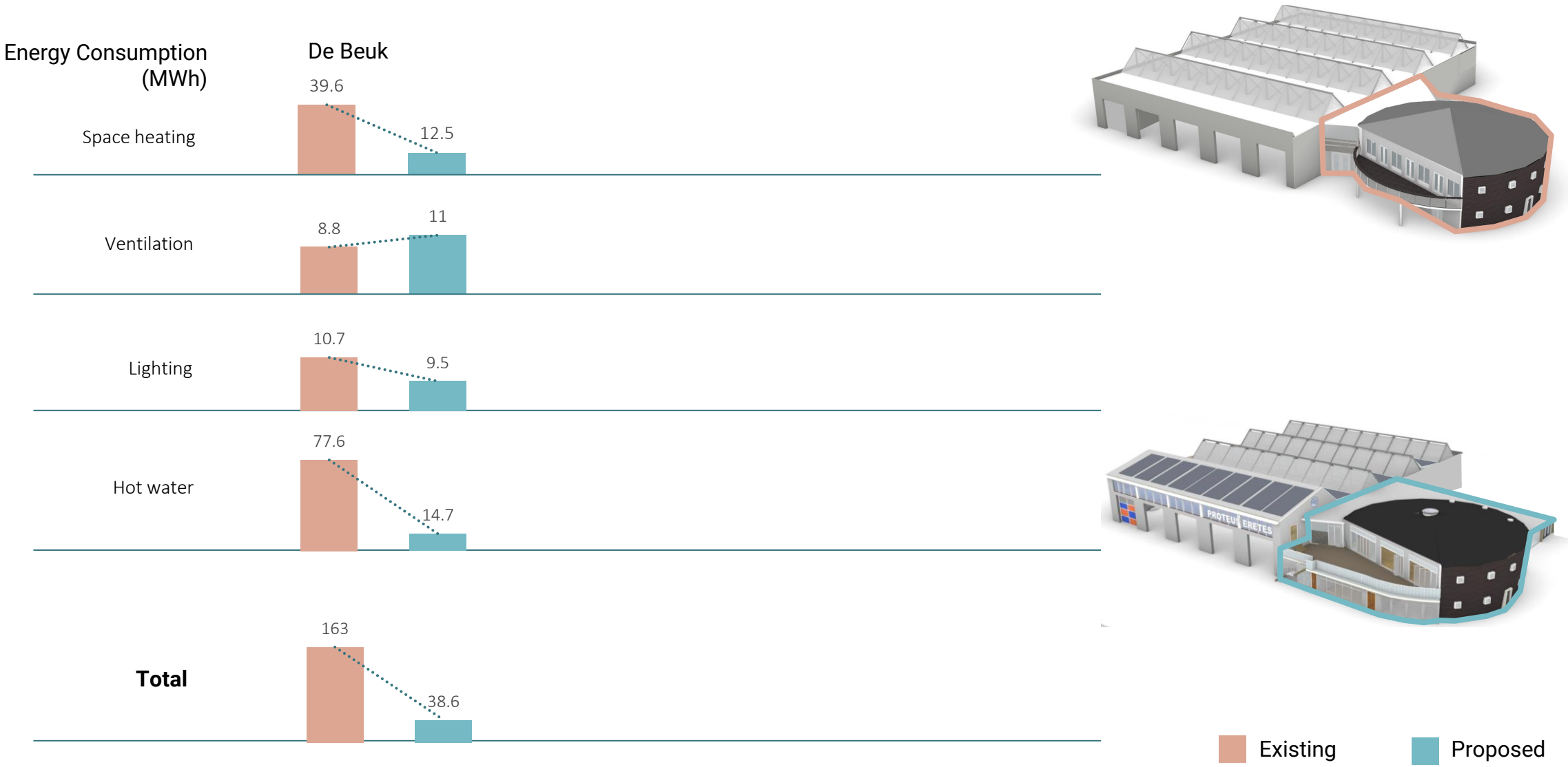
Energy, comfort, daylight





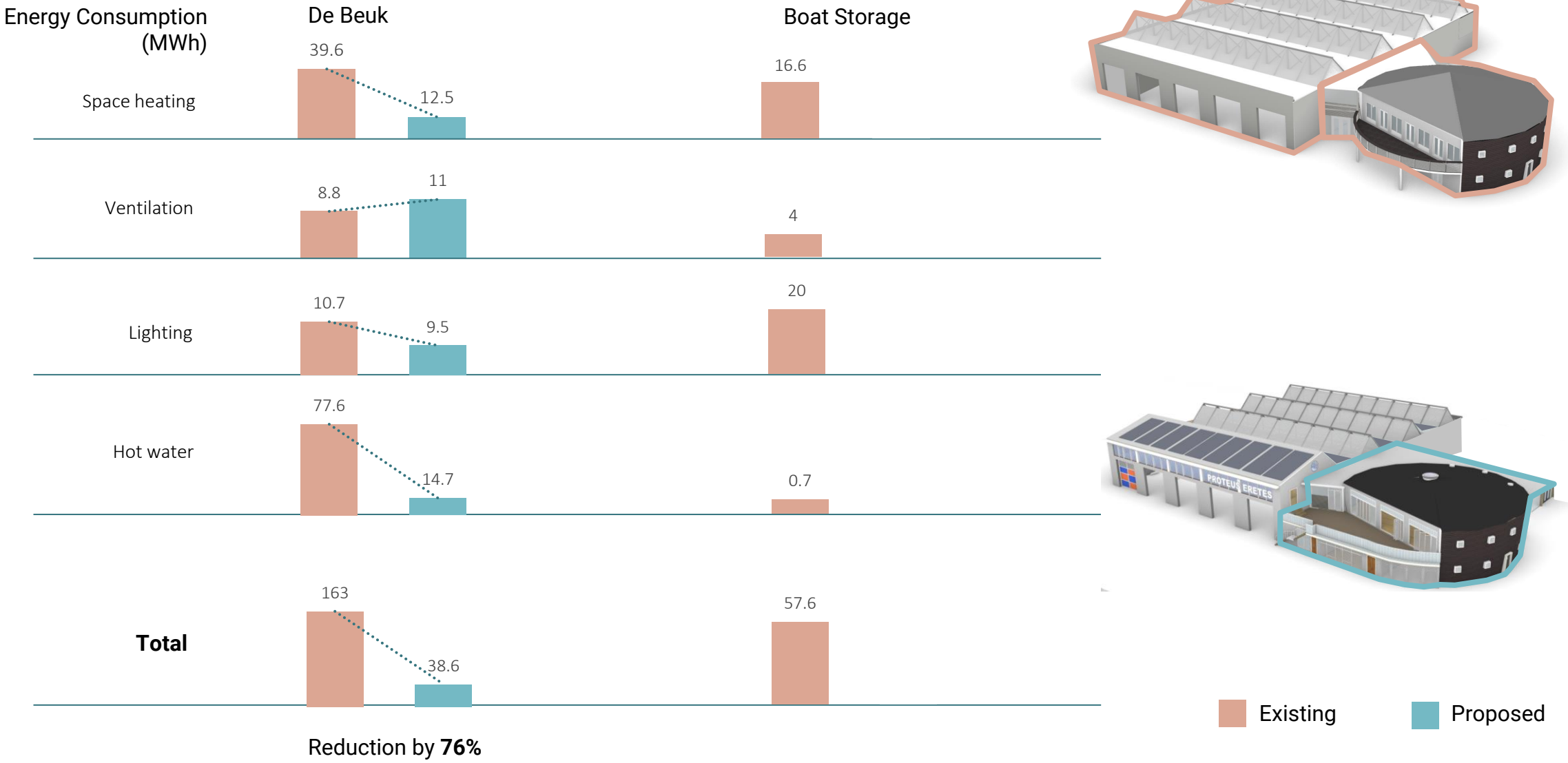
# Design Assessment

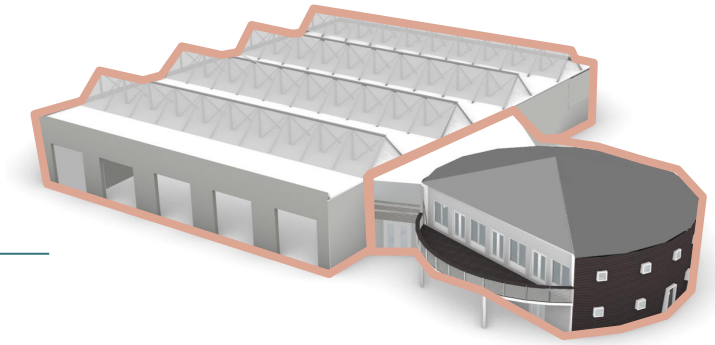
Energy, comfort, daylight



# Design Assessment

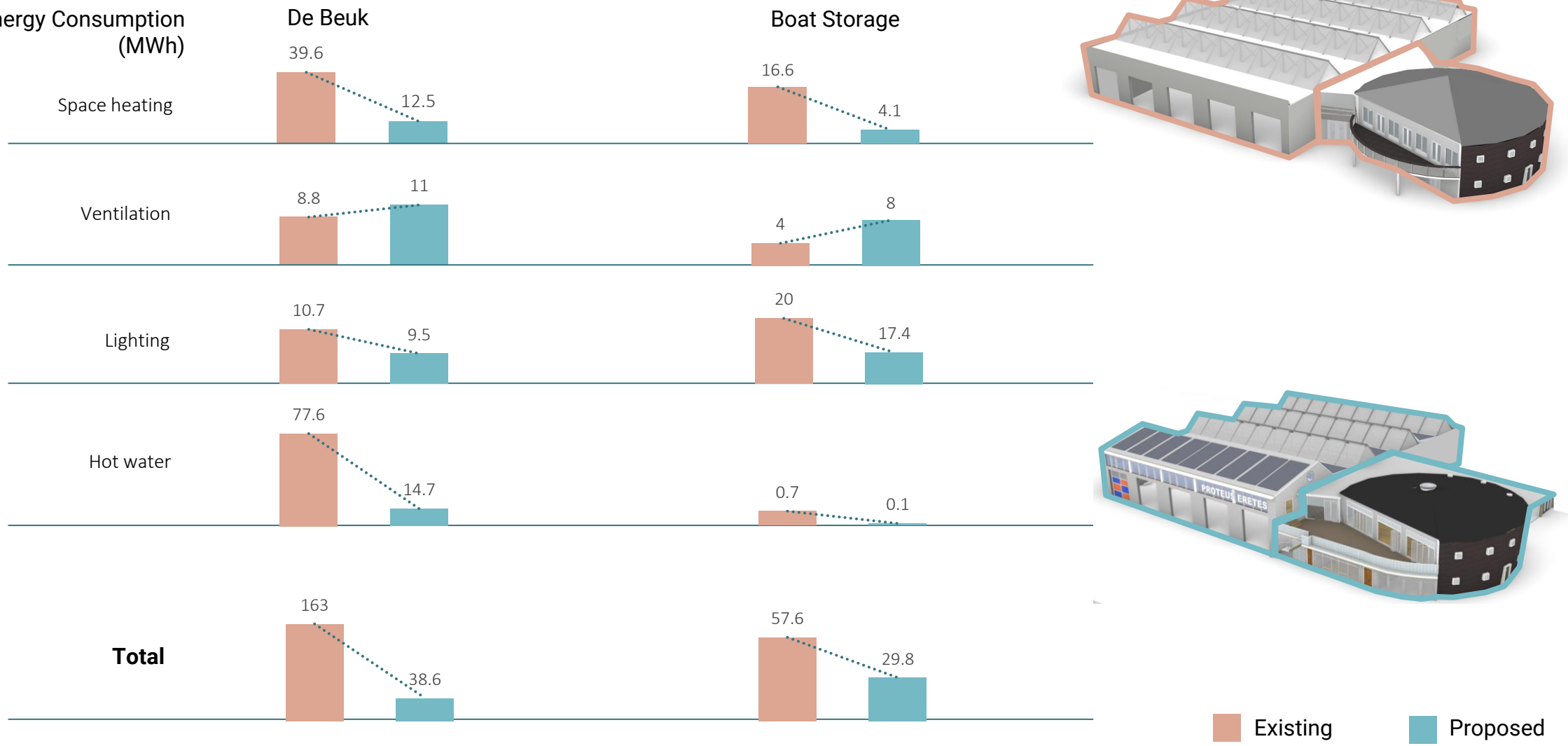
Energy, comfort, daylight

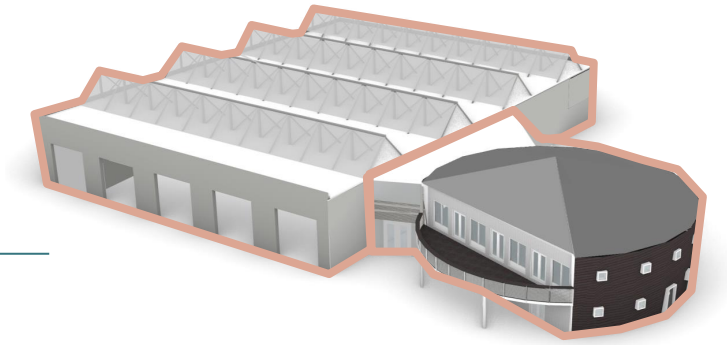


# Design Assessment

Energy, comfort, daylight

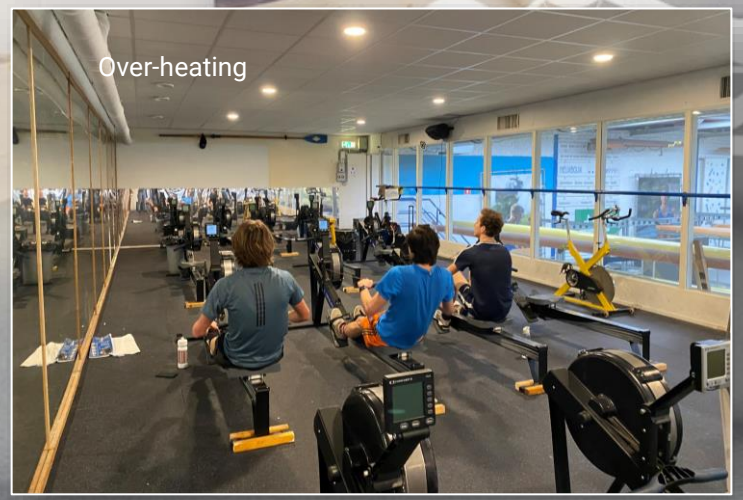


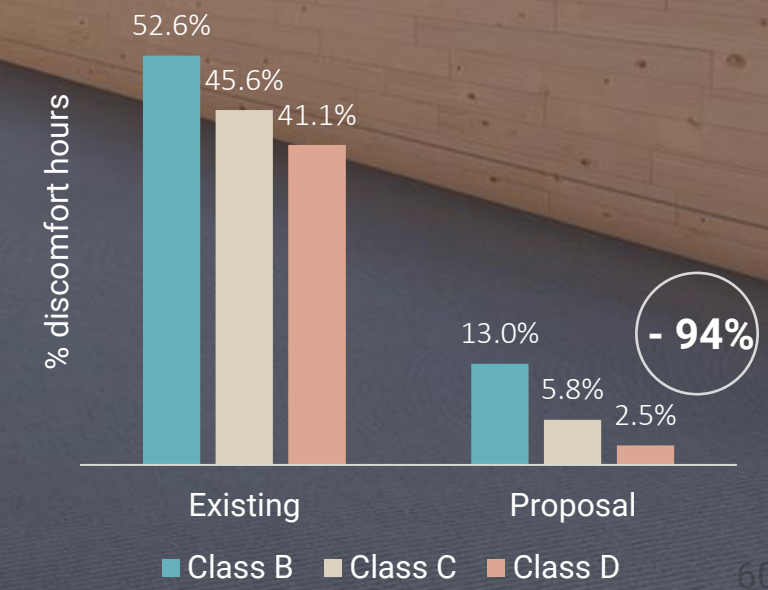



# Design Assessment

## Energy, comfort, daylight

**ERGOMETER ROOM**

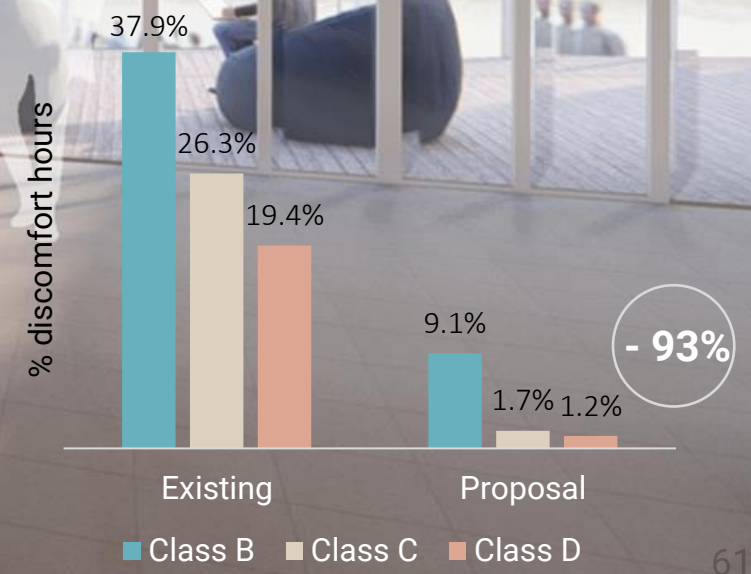


# Design Assessment

Energy, comfort, daylight

**BAR ATTIC**

# Design Assessment

Energy, comfort, daylight

**ERGOMETER ROOM**

Illuminance (lux)

750 → 1922

# Design Assessment

Energy, comfort, daylight

**OFFICE/MEETING ROOMS,
BAR ATTIC**

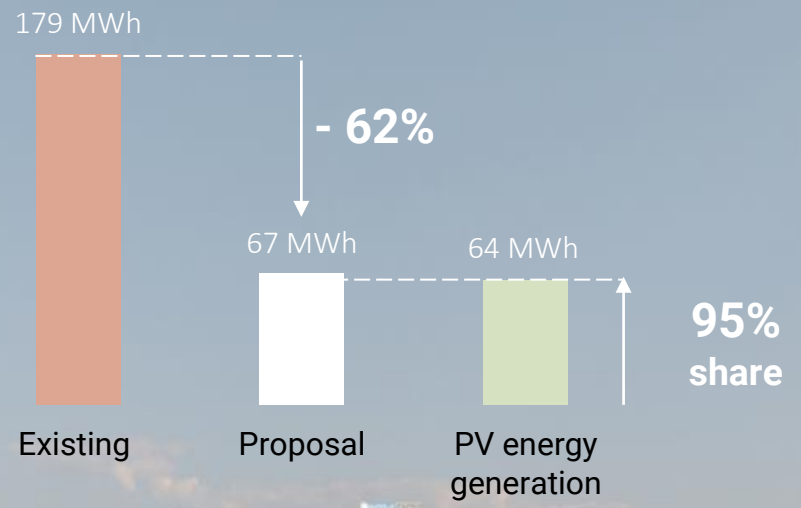
**18% reduction in lighting loads**

Illuminance (lux)

**950** → **2300**

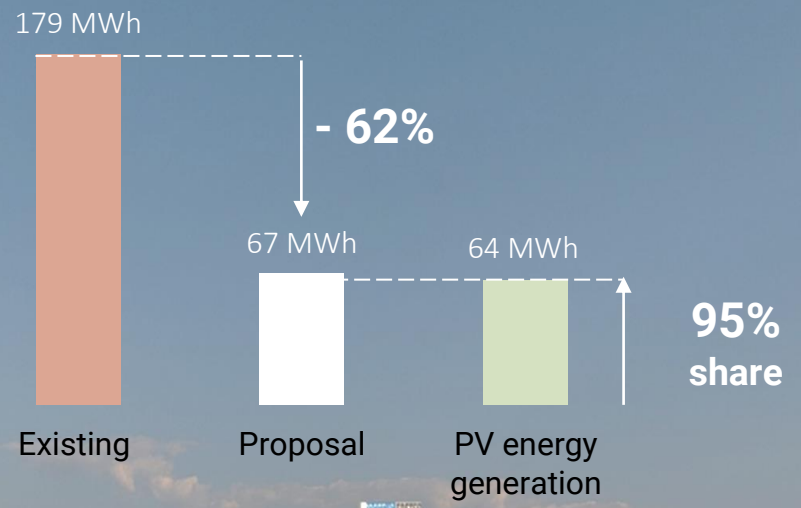
# Design Assessment

Overall energy consumption



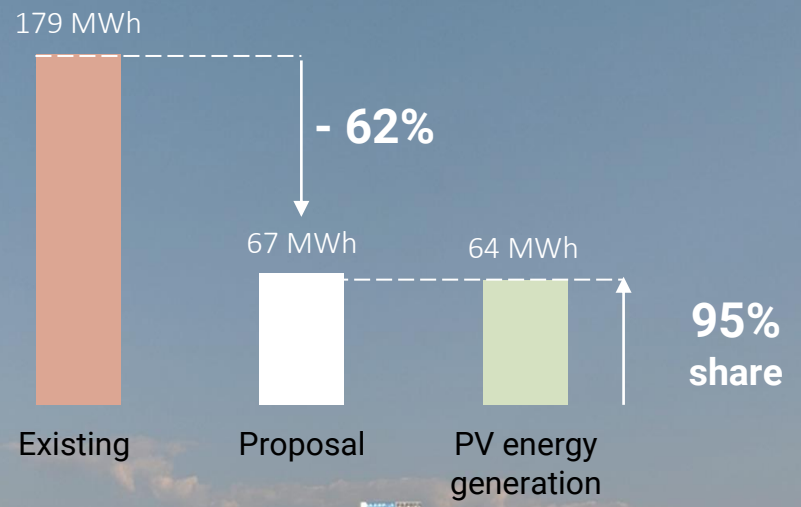
# Conclusion

**Proteus Eretes Rowing Club transitions into a nearly zero energy building with high indoor comfort**



# Conclusion

**Proteus Eretes Rowing Club transitions into a nearly zero energy building with high indoor comfort**



# Conclusion

Limitation, recommendations, learnings

**Analysis assumptions:**

- Indoor air quality

  (lack of tools - use CO2 meter on-site)
- Lighting lux levels
- Summer and winter surveys

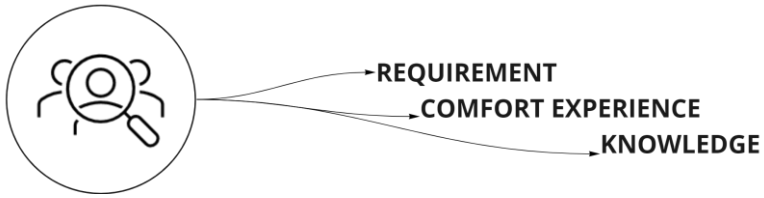
**Decision making:**

- Extent of renovation
- Choice between high–tech vs low-tech solution
- Affordability

# Conclusion

Limitation, recommendations, learnings

## Defining goals based on occupant experience




## Criteria for redesigning

Connectivity with nature

Flexibility/Accessibility of spaces

Comfortable environment at all times

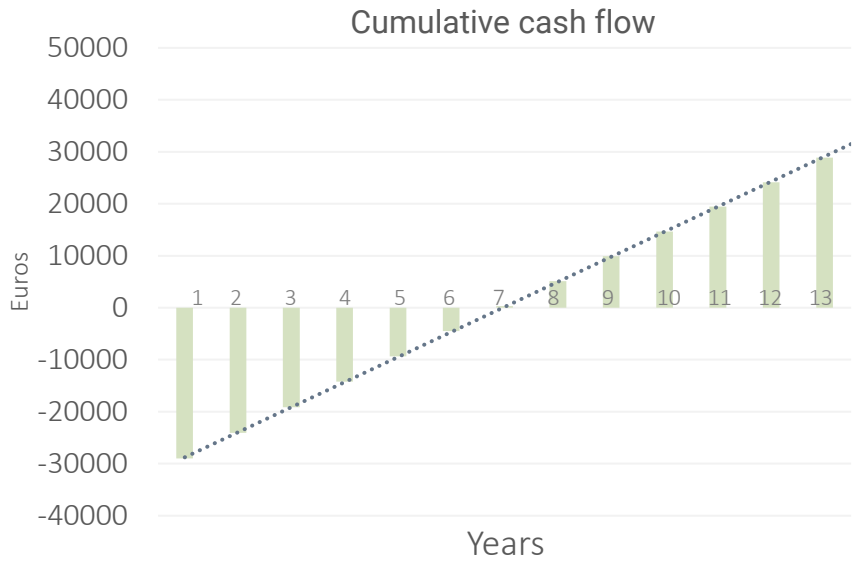
## Maximize use of renewable energy technology

**> 100% share** in renewable energy

Energy Consumer ⟶ **Energy Producer**

# Conclusion

Limitation, recommendations, learnings

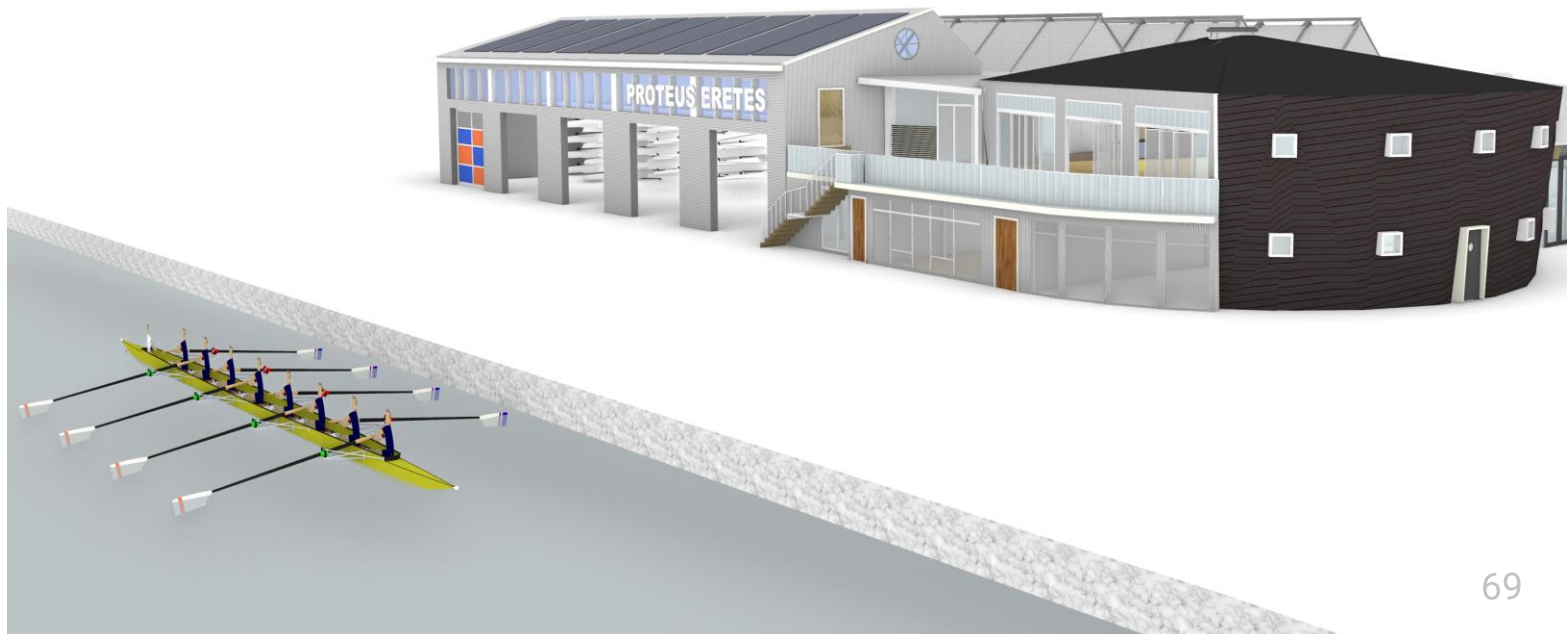



**Maximize use of renewable energy technology**

**> 100% share** in renewable energy

Energy Consumer ⟶ **Energy Producer**

**~ 7 years** payback period



# Conclusion

Limitation, recommendations, learnings

**Experience like a user**

**Design like an architect**

**Analyse like a building technologist**

**Bridge the gap** – NZEB & Indoor Environmental Quality

For a **better tomorrow**, fix **the today**



**Thank you!**