# desi | grated

**D**esiccant **I**ntegrated
**F**acade System

**P5 Presentation**

Natchai Suwannapruk
4738128

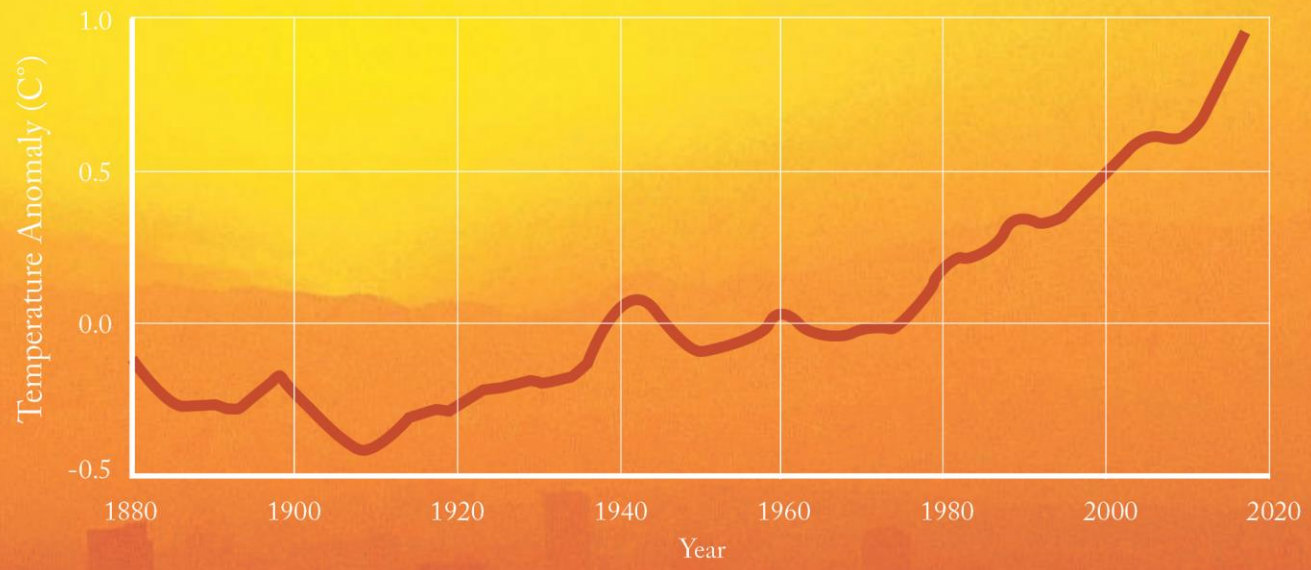
**9 July 2019**

*“ If our house is falling apart you wouldn't say that you have the situation under control...*

*And place the living conditions of all species in the hand of inventions that are yet to be invented.* *”*

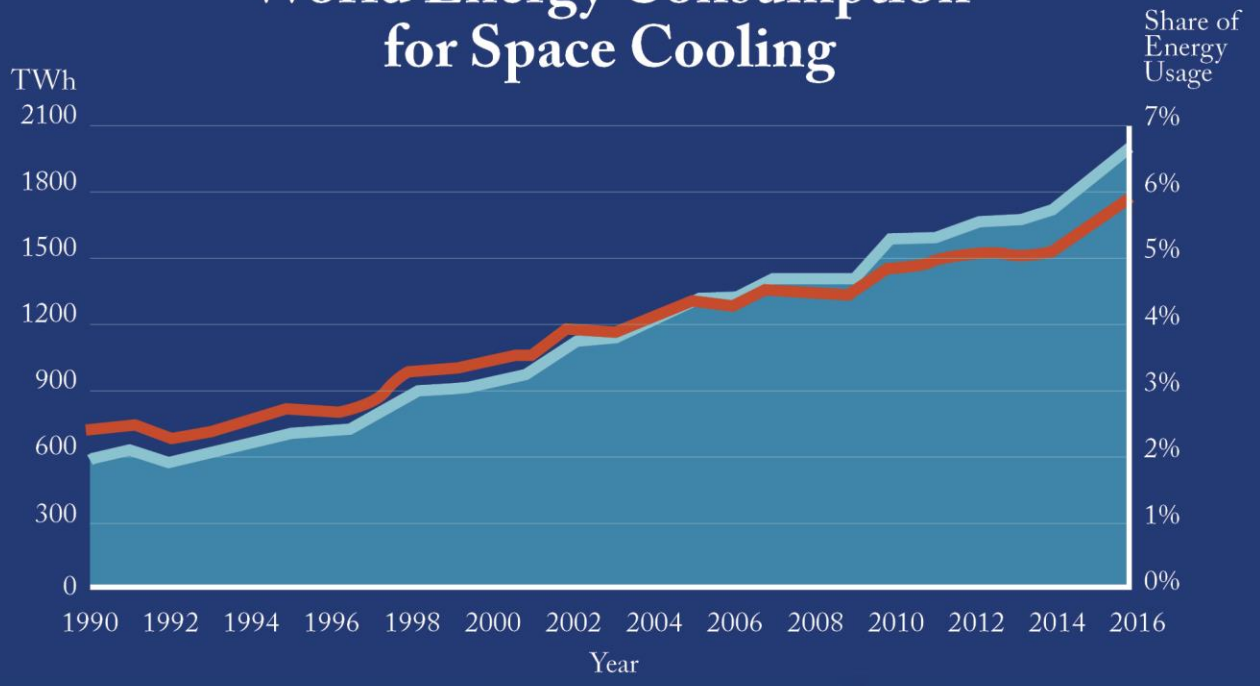
Greta Thunberg, 2019

# Global Land-Ocean Temperature Index




Source : https://climate.nasa.gov/vital-signs/global-temperature/

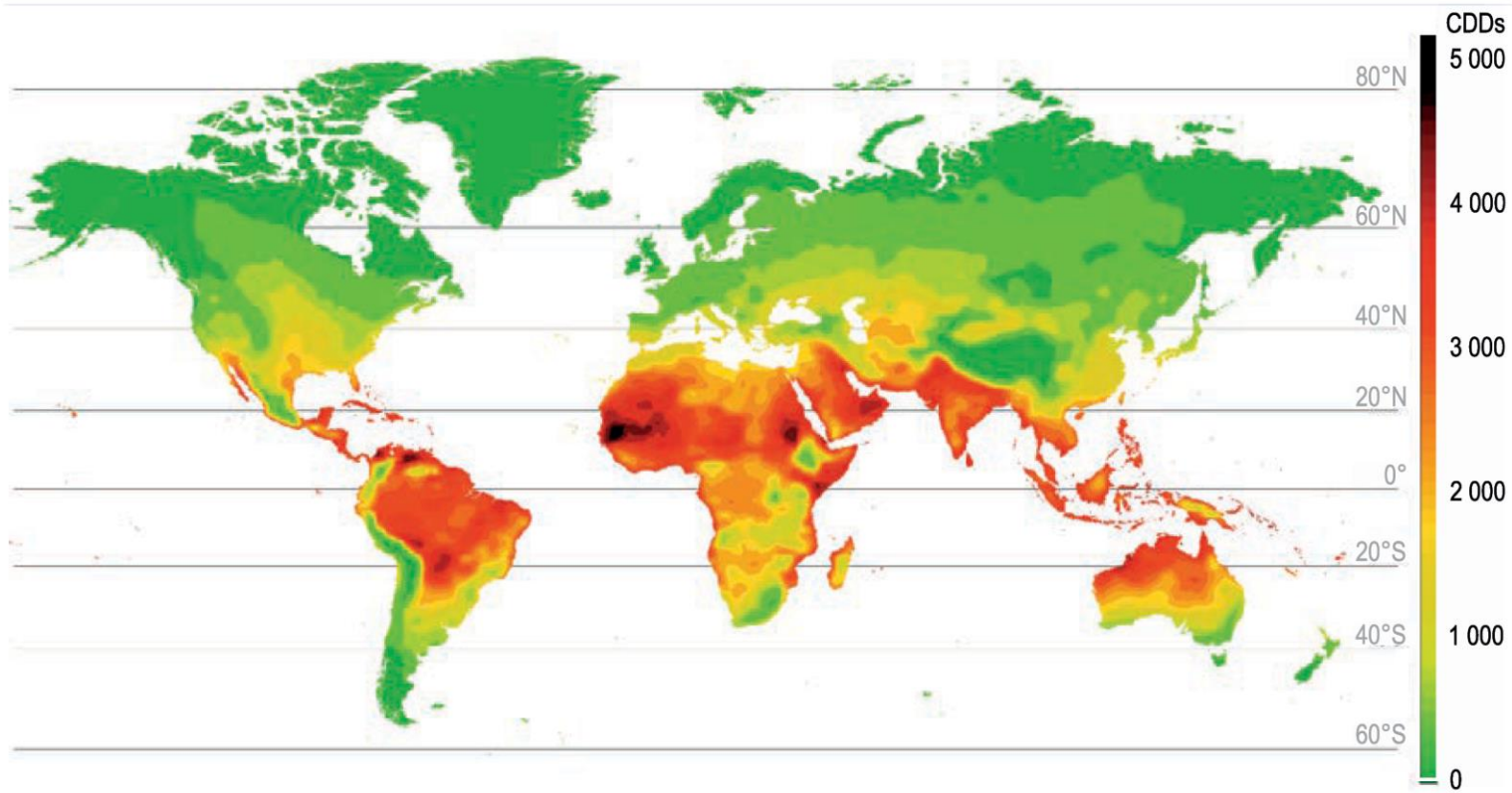
# World Energy Consumption for Space Cooling




OECD, and IEA. "The Future of Cooling." The Future of Cooling Opportunities for Energy-Efficient Air Conditioning, 2018, doi:10.1787/9789264301993-en.

# Drivers for Cooling Demand

v




## Drivers of energy use for cooling

High levels of humidity tend to increase the need for cooling to achieve a given level of thermal comfort

OECD, and IEA. "The Future of Cooling." The Future of Cooling Opportunities for Energy-Efficient Air Conditioning, 2018, doi:10.1787/9789264301993-en.

# Driver for Cooling Demand

## Population and Economic Growth

*"In hot countries, rising incomes and population are pushing up demand for cooling."*


OECD and IEA, "Policies for Cooling." The Future of Cooling: Opportunities for Energy-Efficient Air Conditioning. https://doi.org/10.1787/9789264301993-en

Image From: https://www.architectureelo.net/super-simple-warning-signs-normal-functioning-hvac-unit/

## Population Growth Rate


## Office Area Growth Rate


**662,676**
sq.m
Will be completed in 2019-2021


Solar Radiation

Humidity

High Temperature

*"without new cooling technologies or strategies,* ***air conditioning*** *alone would be accounted for* ***40% of South East Asia's electricity demand***"



Eco-Business Research, "Freezing in the tropics: Asean's air-con conundrum"
Eco-Business Pte Ltd, 2018, http://k-cep.org/wp-content/uploads/2018/01/freezing_in_the_tropics.pdf

# Research Objective

**Elaborate** the challenges imposed
by the hot and humid climate context

**Explore** the potential of existing dehumidification technologies, cooling technologies, and heat prevention strategies

**Develop** a facade scheme by
assembling the applicable system

**Develop and evaluate** an integration strategy of
the facade scheme

"How can the **desiccant cooling facade system** be integrated into the built environment to reduce cooling load of **office buildings** in a **hot and humid climate**?"

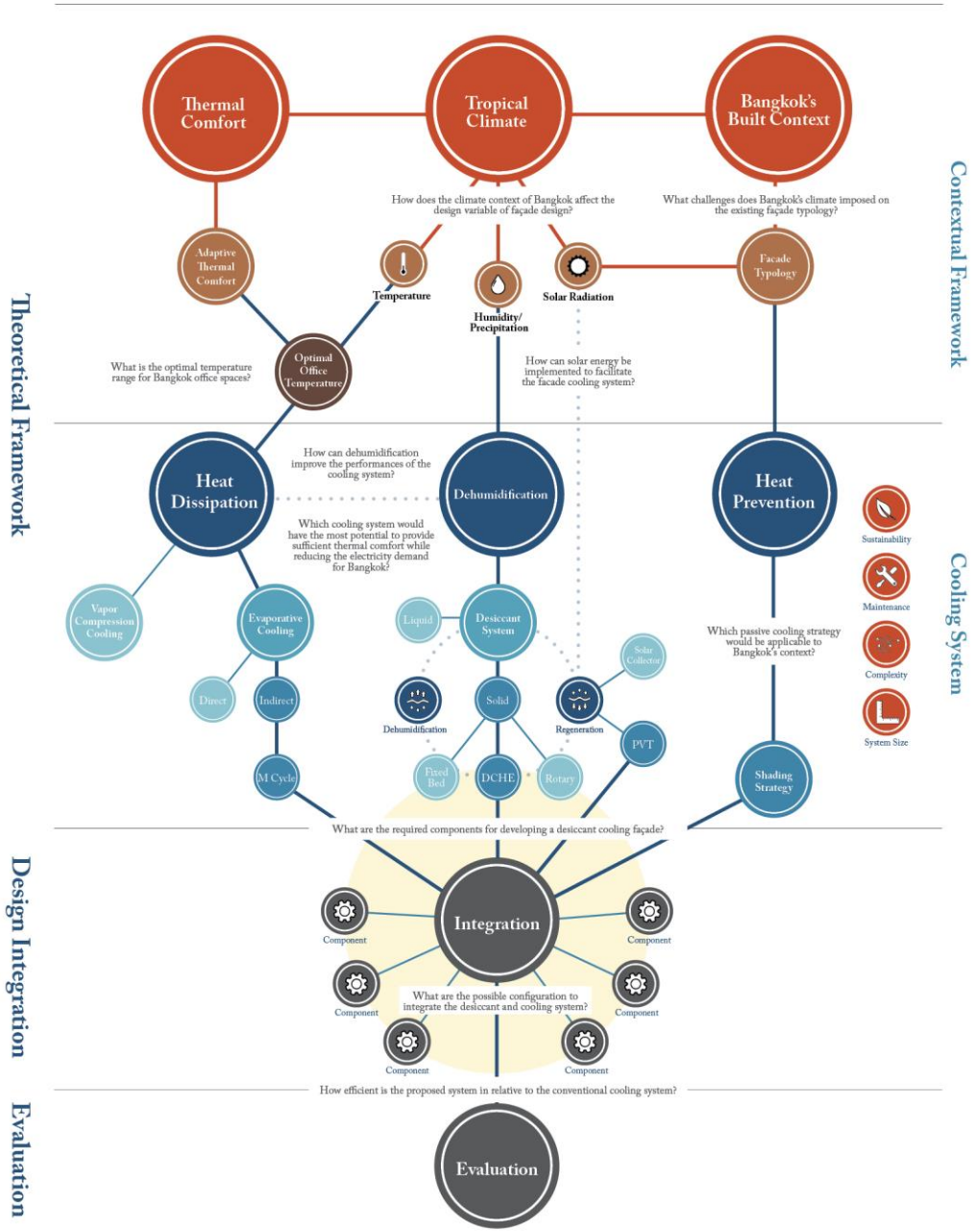
# Design Strategy

Disassembly

Redesign

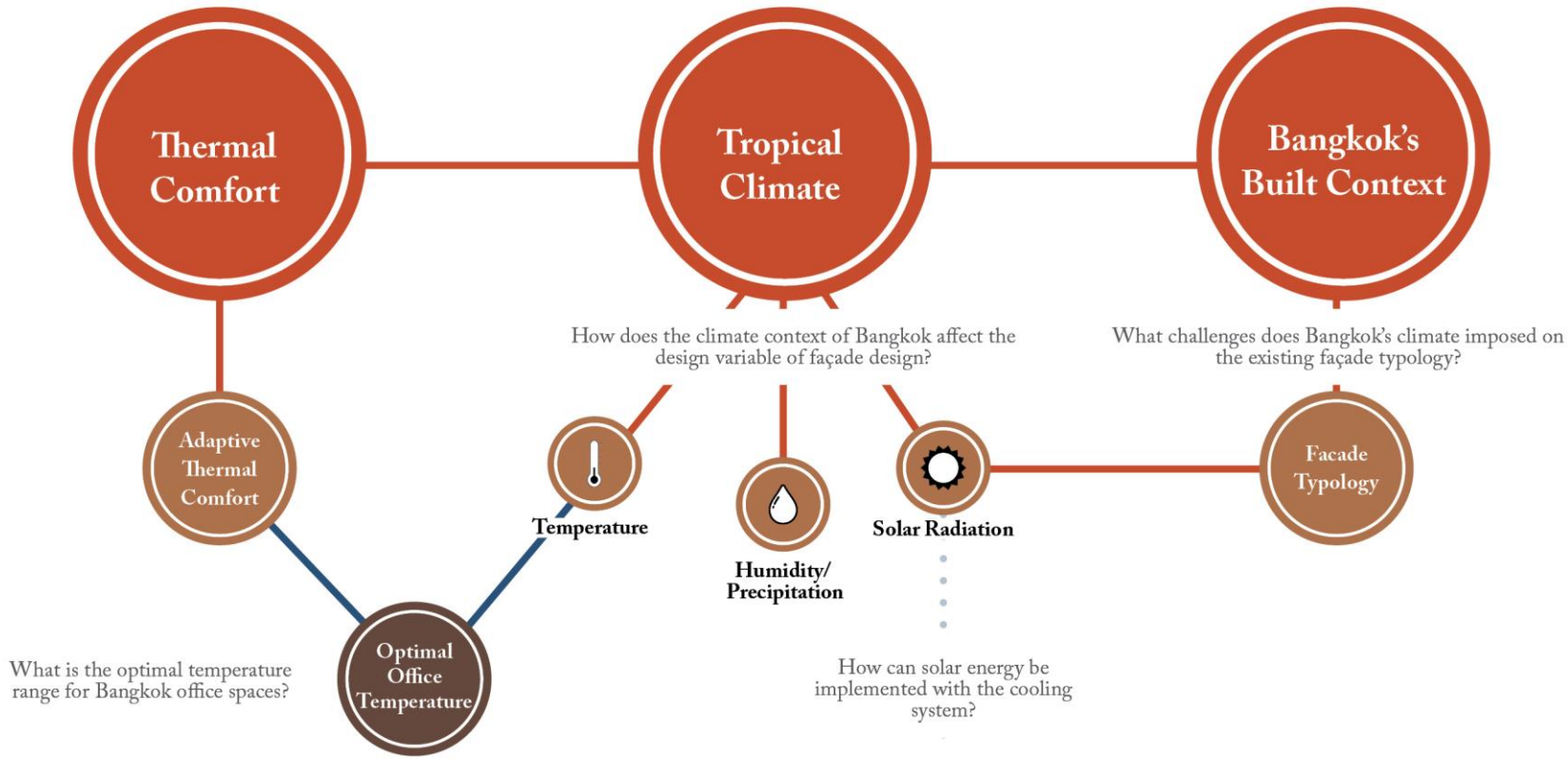
Integration

# Research Structure



# Research Structure

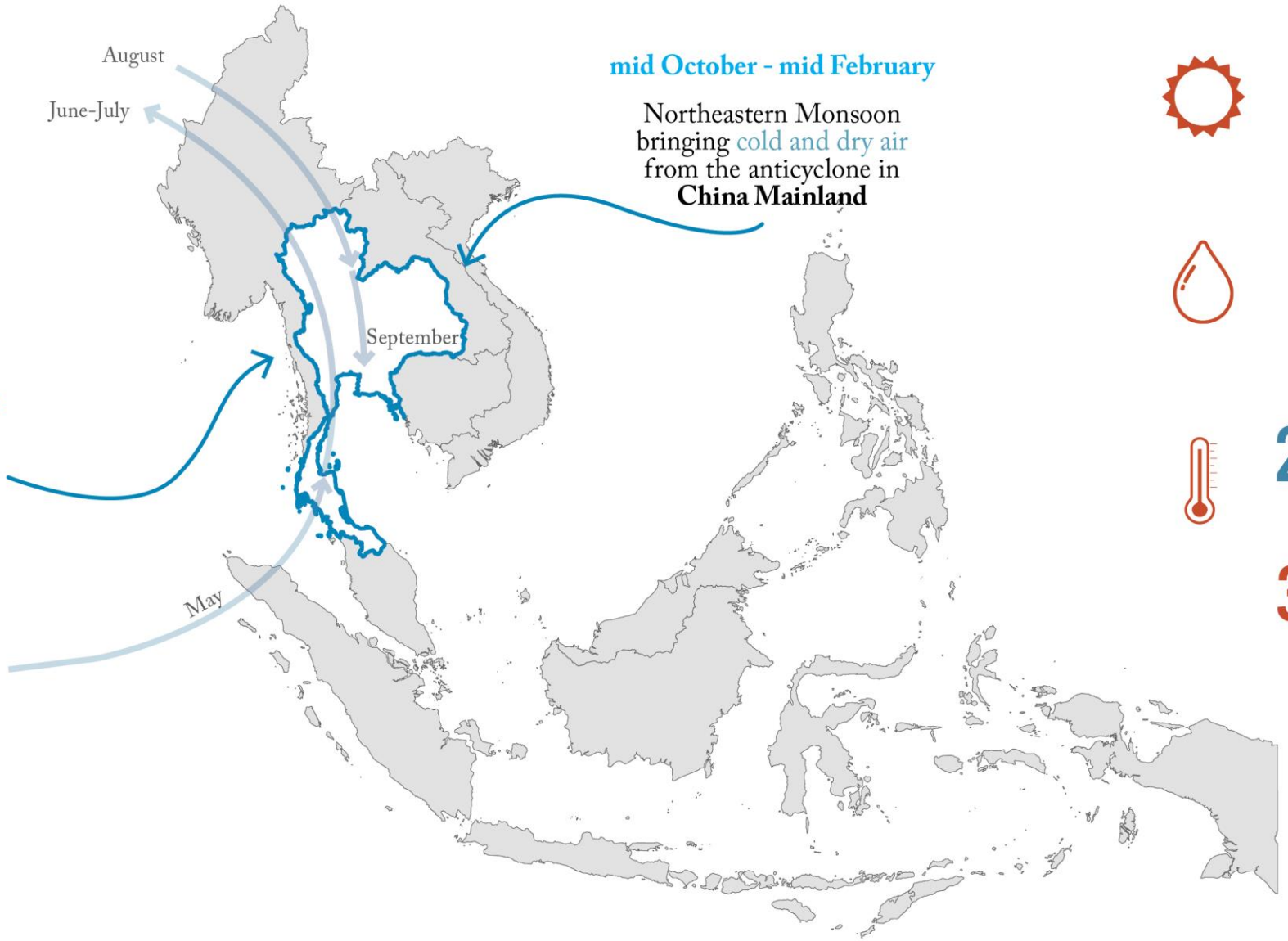
## Contextual Framework



Tropical Climate

# A. Tropical

High and constant net solar radiation throughout the year.
Temperature difference between day and night is greater than that between the warmest and the coolest month.




**mid October - mid February**

Northeastern Monsoon bringing cold and dry air from the anticyclone in **China Mainland**

**mid May - mid October**

South west Monsoon brings a stream of warm moist air from **Indian Ocean**

**Tropical Convergence Zone (ITCZ)**

and tropical cyclones which produce a large amount of rainfall.

**1175**
kWh/m²
Direct Radiation

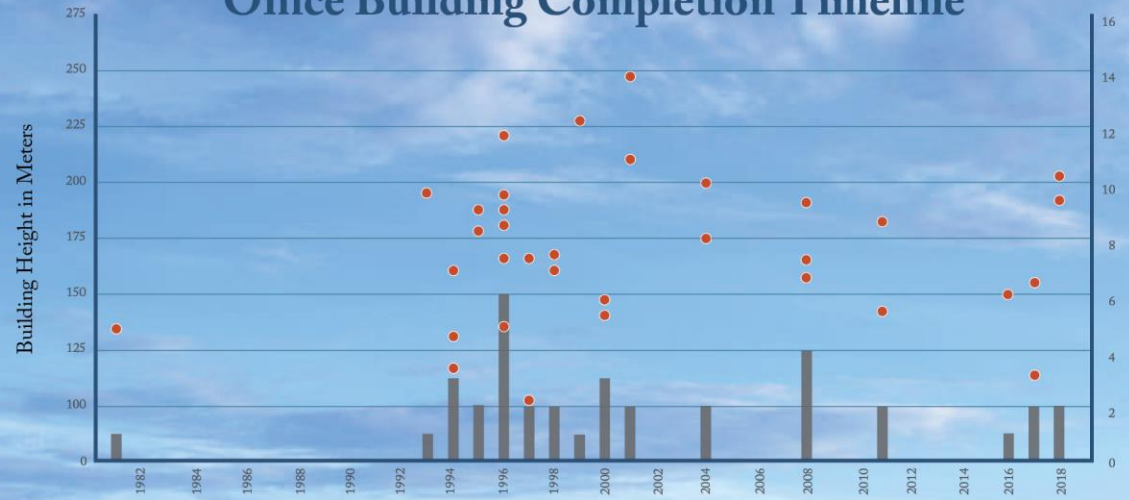
**71%**
Average Humidity

**28.8°C**
Average Temperature

**38.7°C**
Maximum Temperature

# Bangkok's Built Context

## Office Building Completion Timeline




## Office Area Growth Rate

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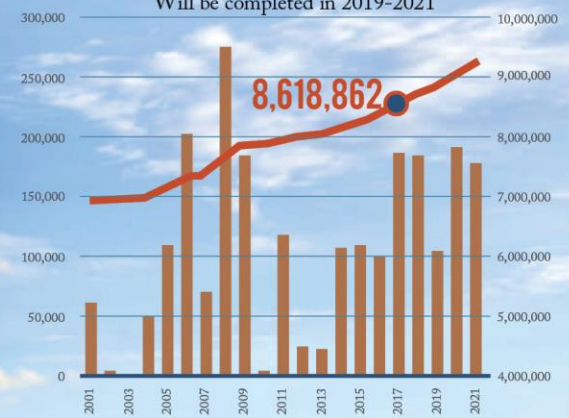
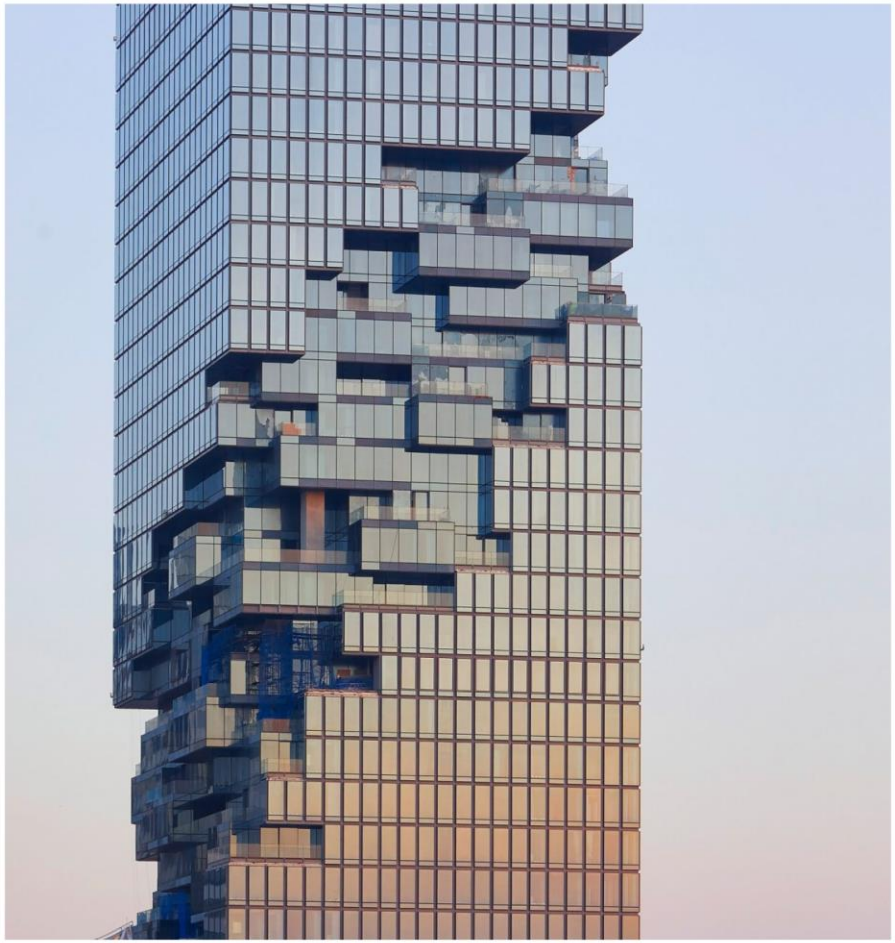


# Facade Classification

## Facade Typologies

Bangkok's Built Context



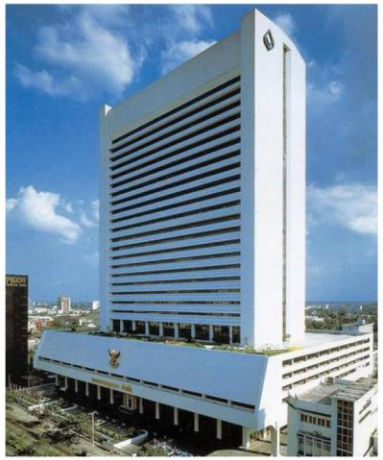
Thin Skins

Thick Skins

# Office Building Typology

Office Building over 100m

## 1982



Bangkok Bank Tower

## 1993

Sinn Sathorn Tower

## 1994

TMB Bank Tower

Sathorn City Tower

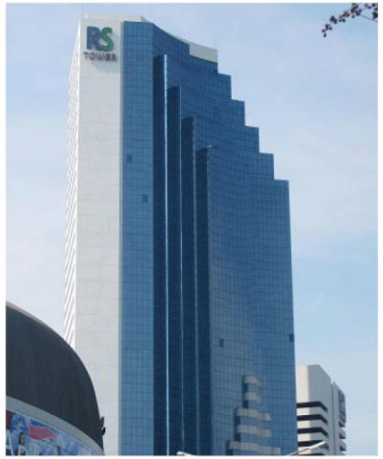
Vanity Tower

## 1995

K-Bank Tower

United Center Tower

## 1996




RS Tower

SiamBank Tower

Tipco Tower

**Bangkok's Built Context**

## 1996

Abdulrahim Place

Thai Wah Tower

## 1997

Jewelry Trade Tower

Ital Thai Tower

Elephant Tower

## 1998

U Chu Liang Tower

Emporium Suites Tower

## 1997

Sathorn House Tower

## 2000

Capitol Tower


Shinawatra IIITower

## 2001

CRC Tower

## 2004

State Tower

Office at Central World

## 2008

ExchangeTower

Chamchuri Square Tower

## 2011

Park Venture Tower

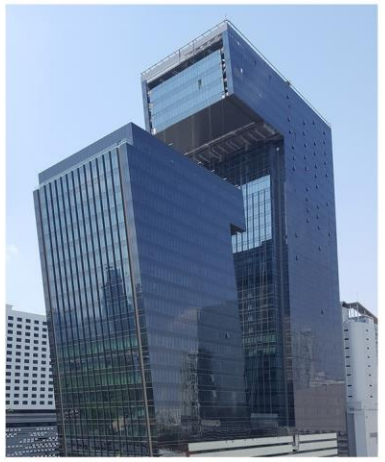
## 2016

Sathorn Square Tower

Pearl Tower

## 2017

Gaysorn Tower



Square Tower

# Office Building Typology

## Future Trend

**2018**

Krungsri Ploenchit Tower

**2019**

Samyan Mitrtown

Ari Hill Tower

T1 Tower

MS Siam Tower

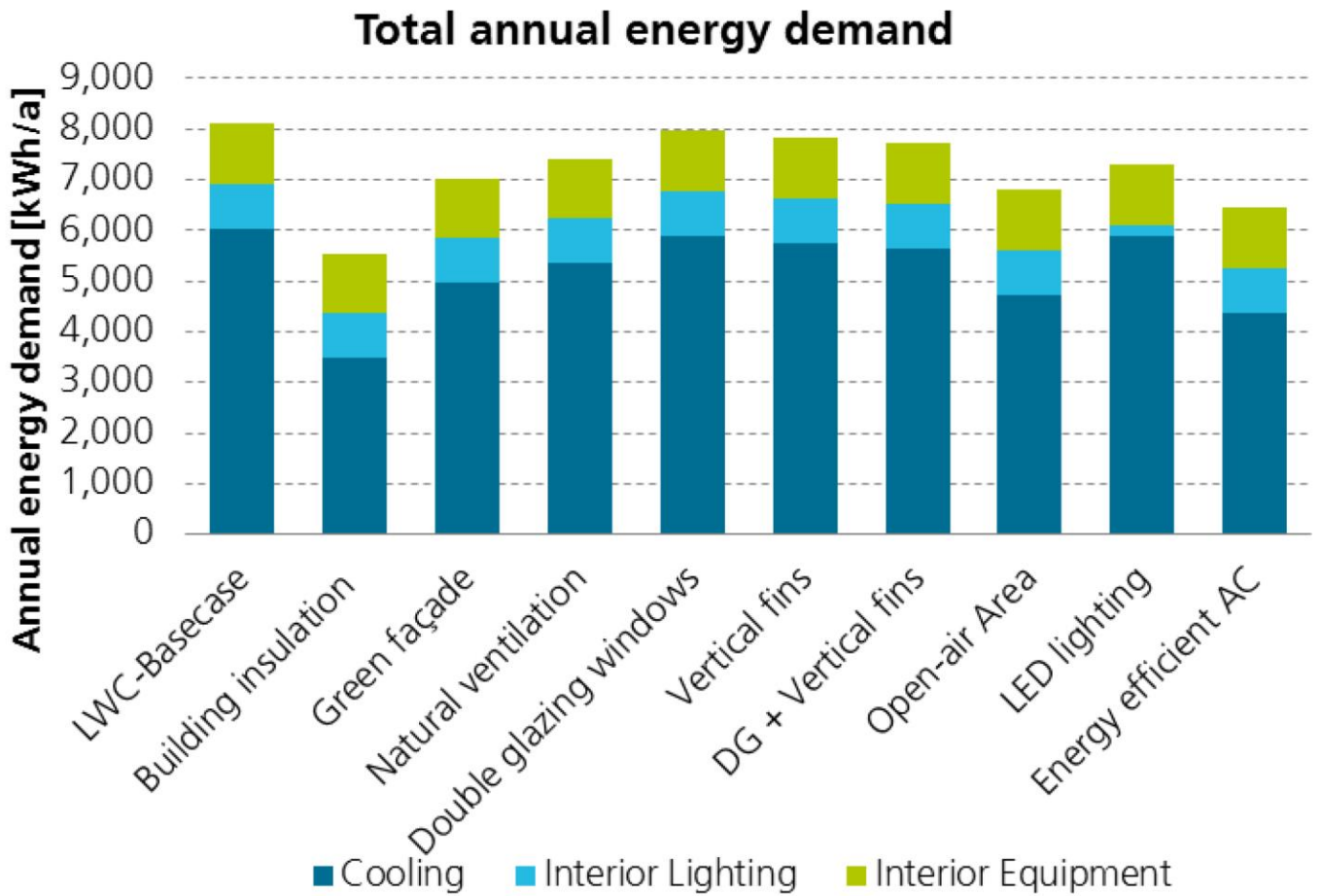
**The result of improvements in the window U-value**

**Shift of architectural trend from conventional to modern ones**

**Building's technological advancement**

Singha Complex

# Challenges
## Efficiency of Energy Saving Strategy



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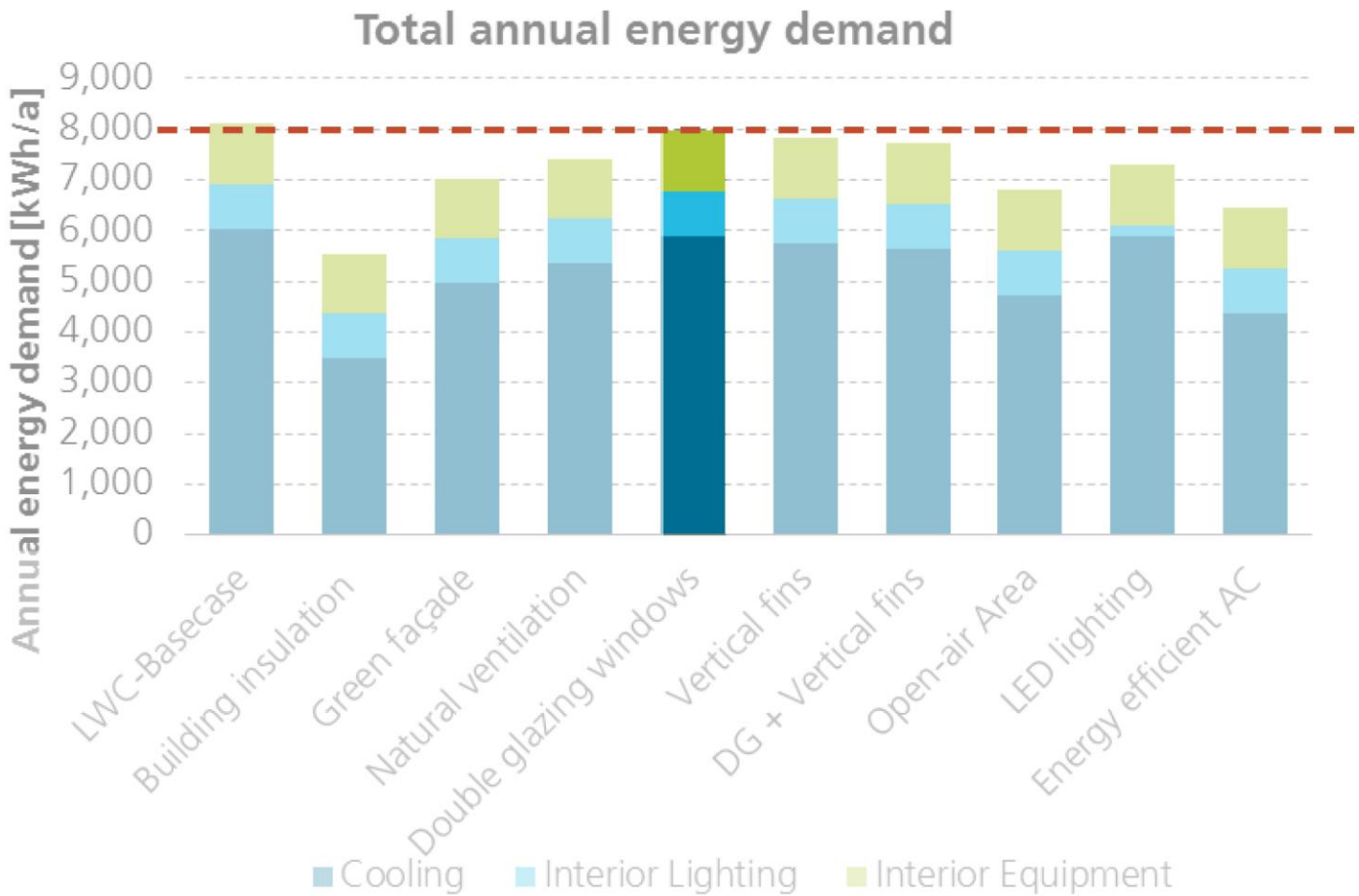

# Thermal Comfort

## Acceptable Thermal Condition

| Case Study I : John F. Busch | | | Case Study II : Yamtraipat et.al |
|---|---|---|---|
| 770 Office Workers | | No. of Surveys | 1520 Office Worker |
| 1.1 MET | 0.56 clo | Metabolic \| Clothing | 1.2 MET |
| 24.7°C ET Mean Temperature | 24.3°C SET Mean Temperature | | 25.6°C Mean Temperature |
| 22C°–28C° Acceptable Range | | Temperature | 24.5C°–27.4C° Acceptable Range |
| | | Humidity | 50%–60% Humidity |
| | | Air Speed | 0.2 m/s Wind Speed |

**Average Value**

- 24.9°C Mean Temperature
- 25.5°C Acceptable Range
- 55% Humidity
- 0.2 m/s Wind Speed

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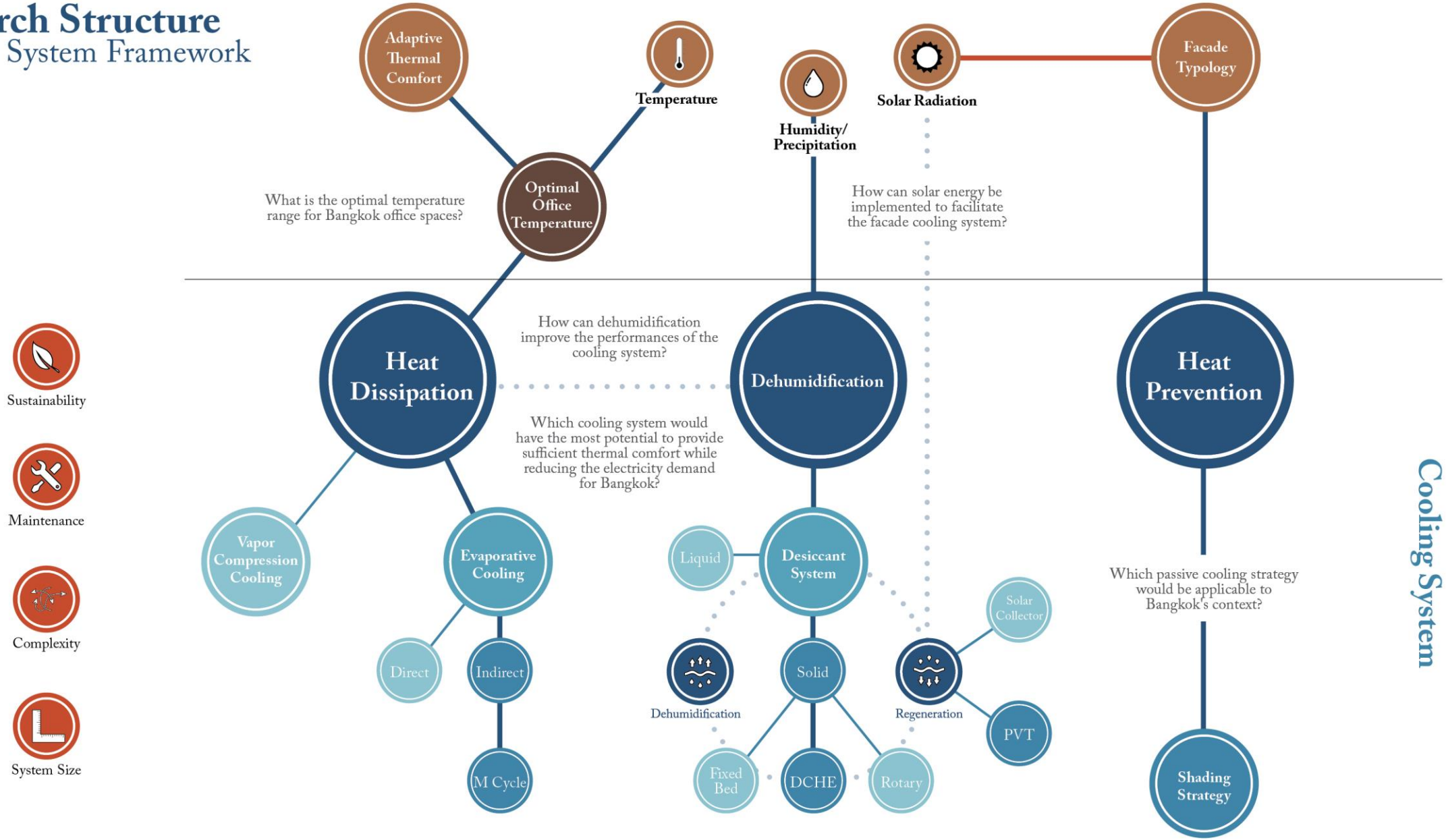
# Research Structure
## Cooling System Framework



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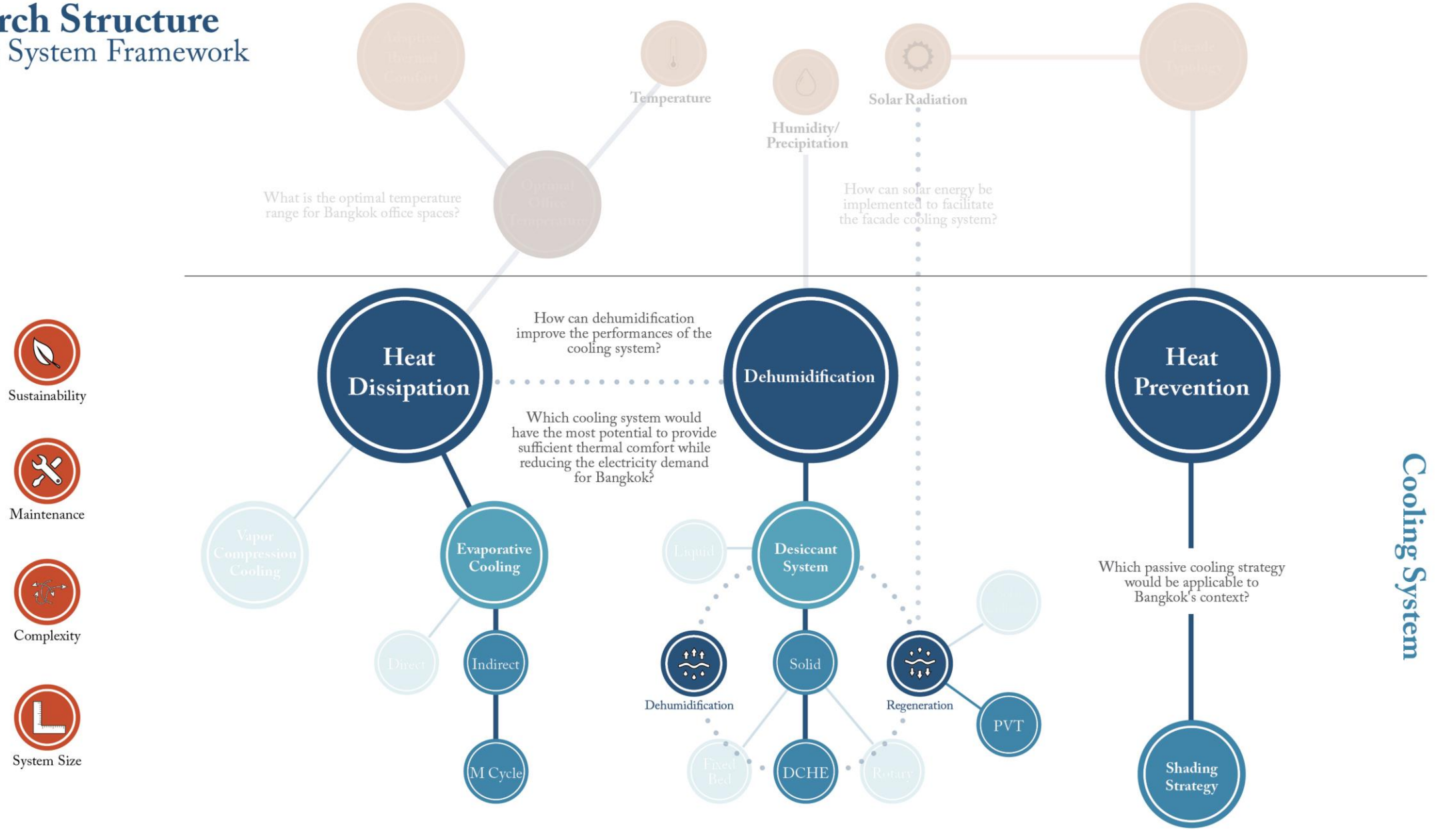
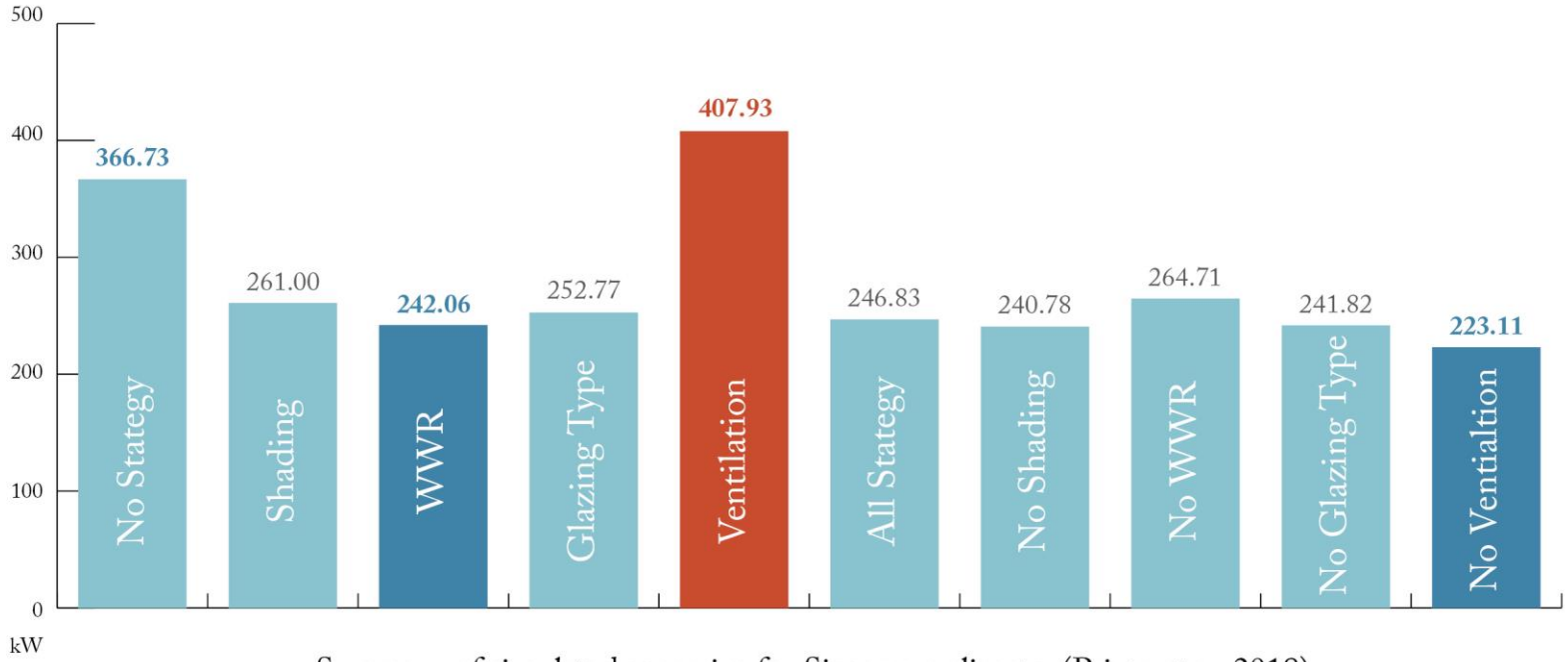
## Cooling System Framework



# Cooling Strategies

## Passive Cooling Strategies

Heat Prevention

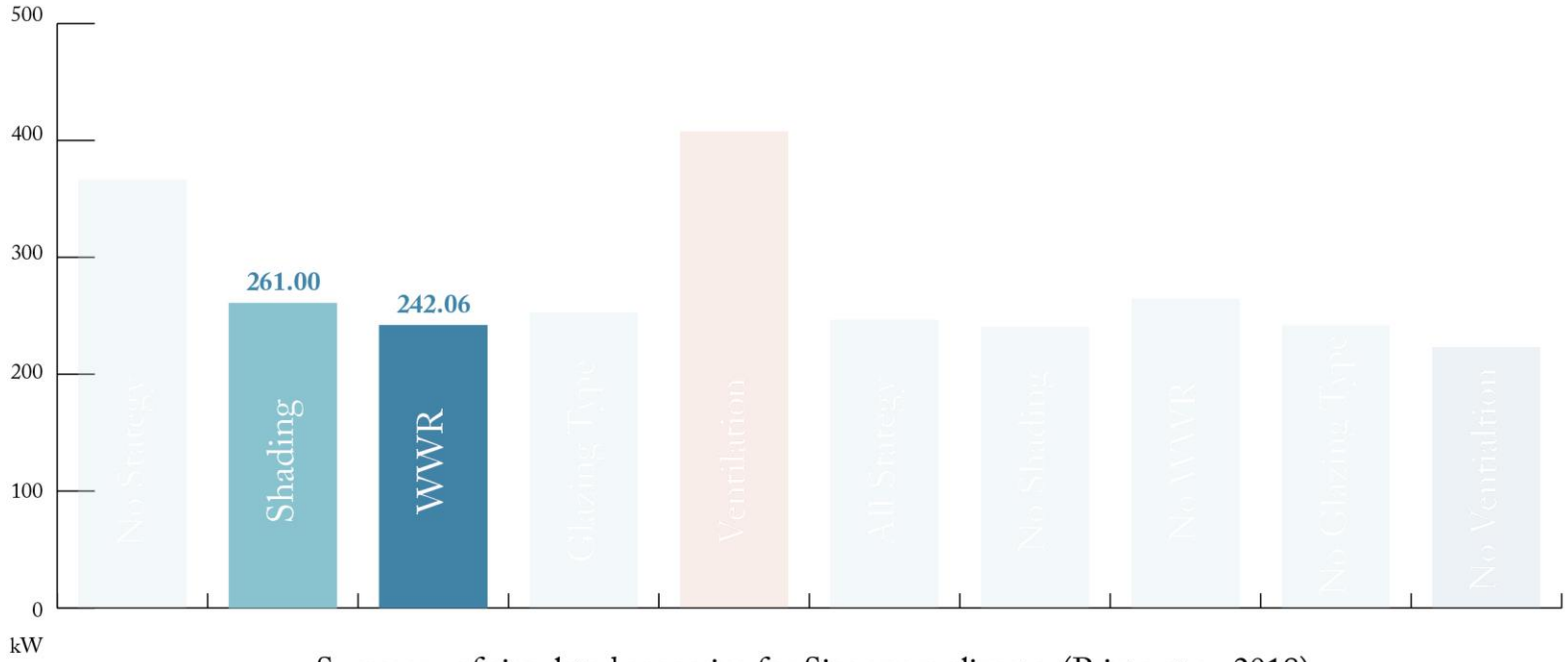



Summary of simulated scenarios for Singapore climate (Prieto et a., 2018)

**Ventilation strategy is not suitable for a warm-humid climate**

# Cooling Strategies
## Passive Cooling Strategies

Heat Prevention




Summary of simulated scenarios for Singapore climate (Prieto et a., 2018)

**Smaller glazed area is highly recommended in a warm-humid climate**

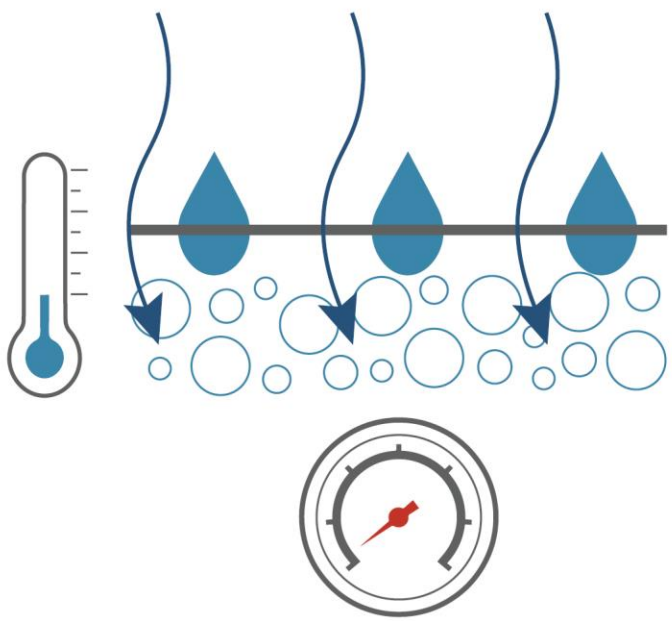
**Shading and glazing type should be considered according to the façade requirements**

# Dehumidification Strategy

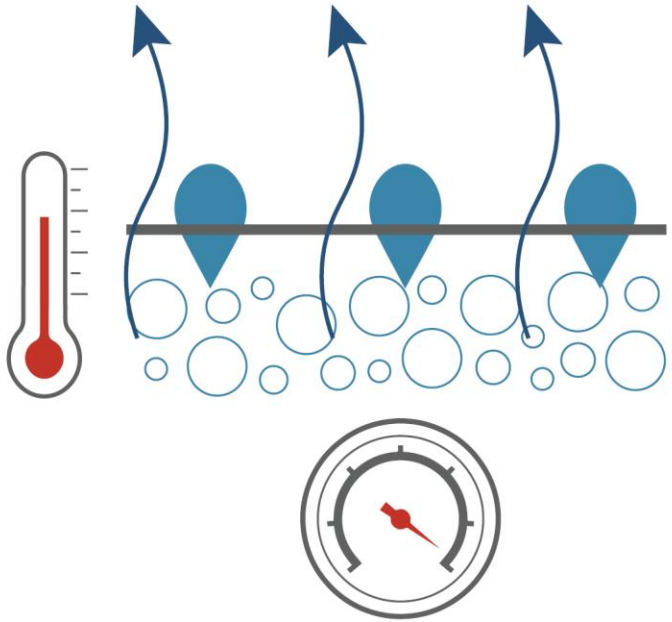
## Desiccant System

Dehumidification

**Desiccants work based on the principle of moisture transfer due to the difference of vapor pressure between the air and the desiccant**



**Dehumidification**

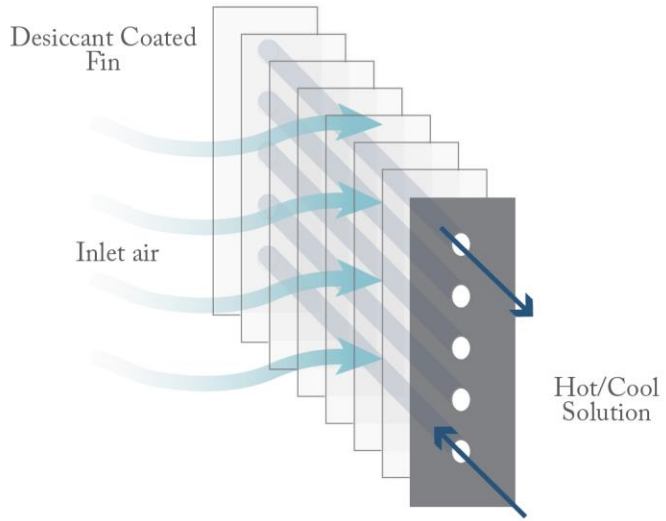


**Regeneration**

# Solid Desiccant System

## Desiccant Coated Heat Exchanger (DCHE)

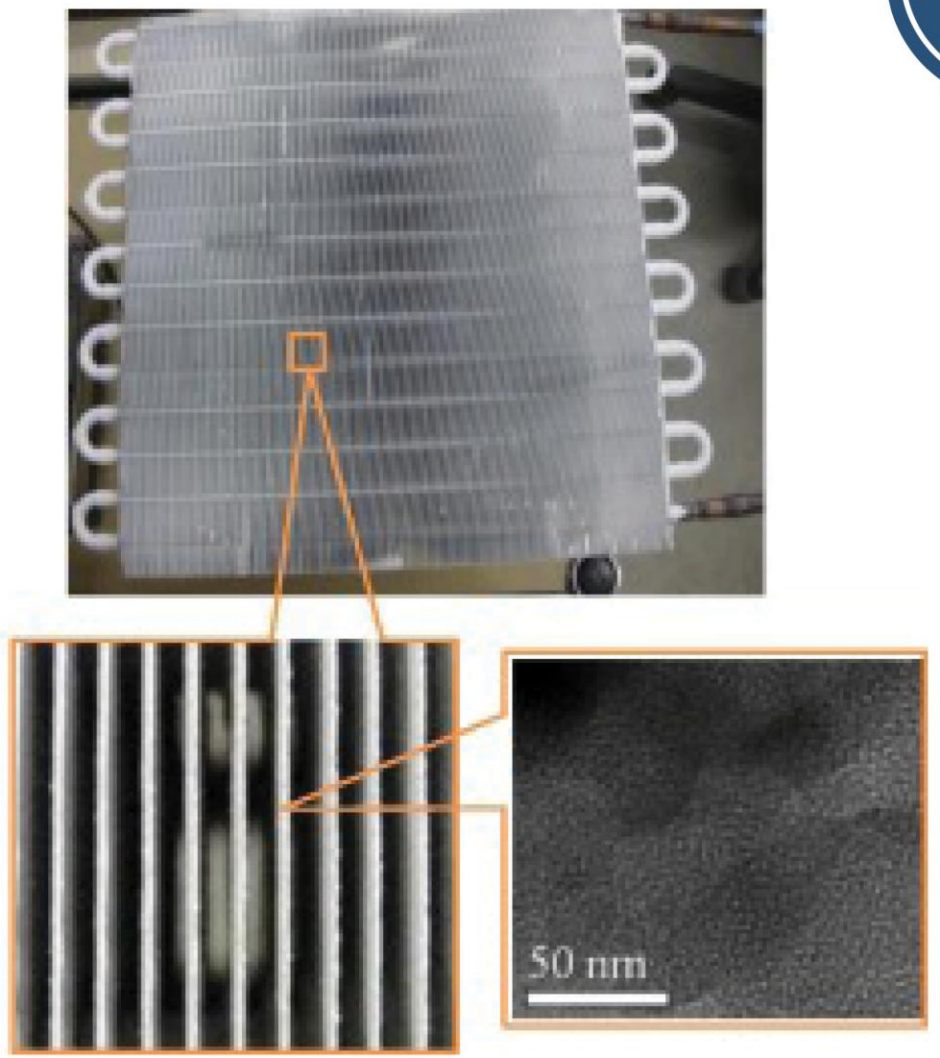
Dehumidification




### Desiccant Coated Heat Exchanger (DCHE)

DCHE is fabricated by coating the desiccant material directly onto the fin side of a conventional fin tube heat exchanger.

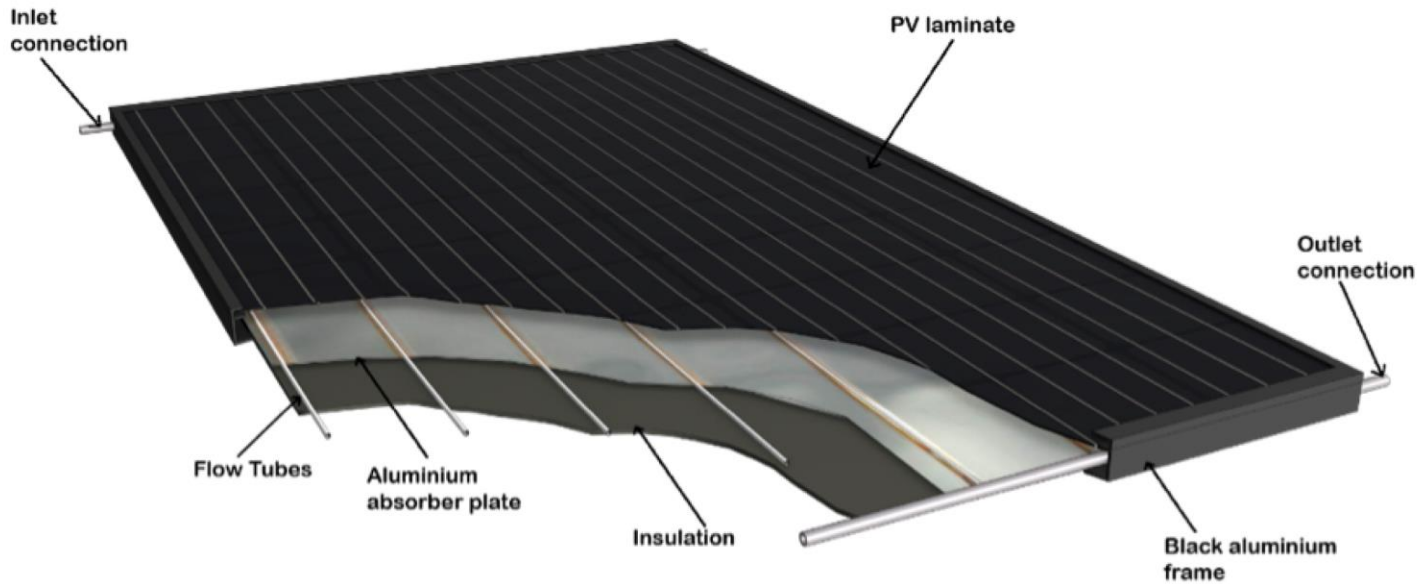
- Developed to deal with the limitations of the conventional desiccant packages
- Regeneration could be done with relatively higher efficiency



# Regneration System

## Photovotaic-Thermal System

Regeneration




## Liquid PVT Collector

**7.54%**
Electrical Efficiency

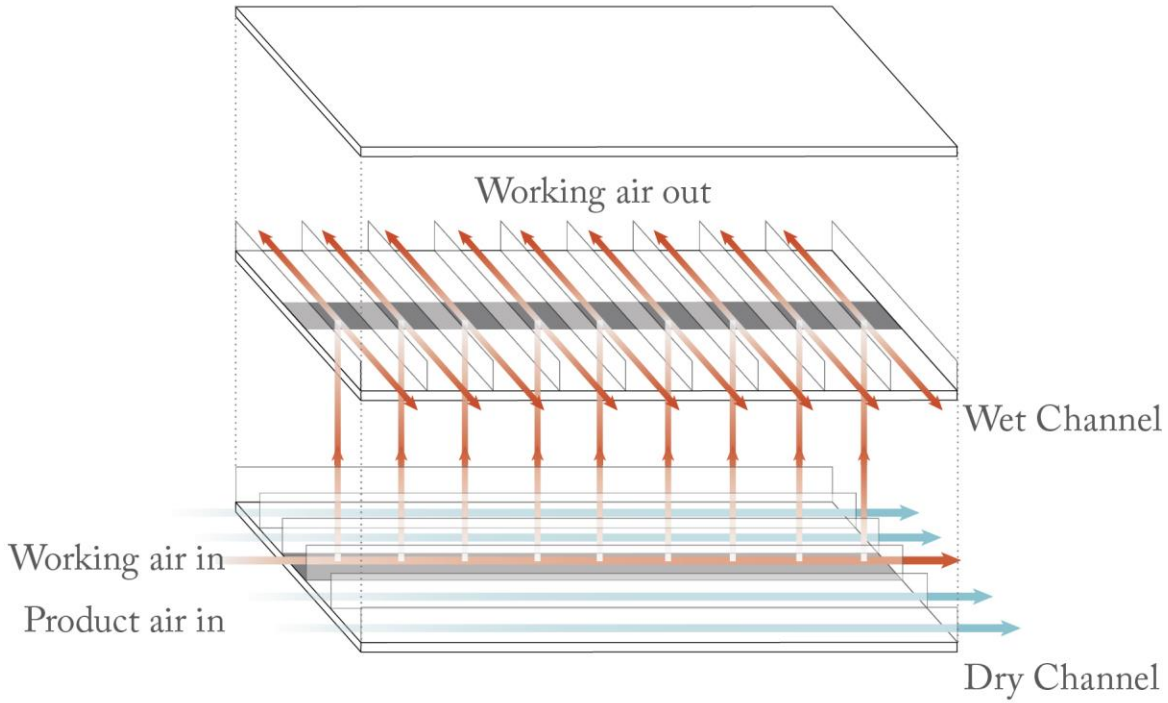
**70%**
Thermal Efficiency

# Evaporative Cooling Strategy

## Maisotsenko-cycle

Riangvilaikul and Kumar

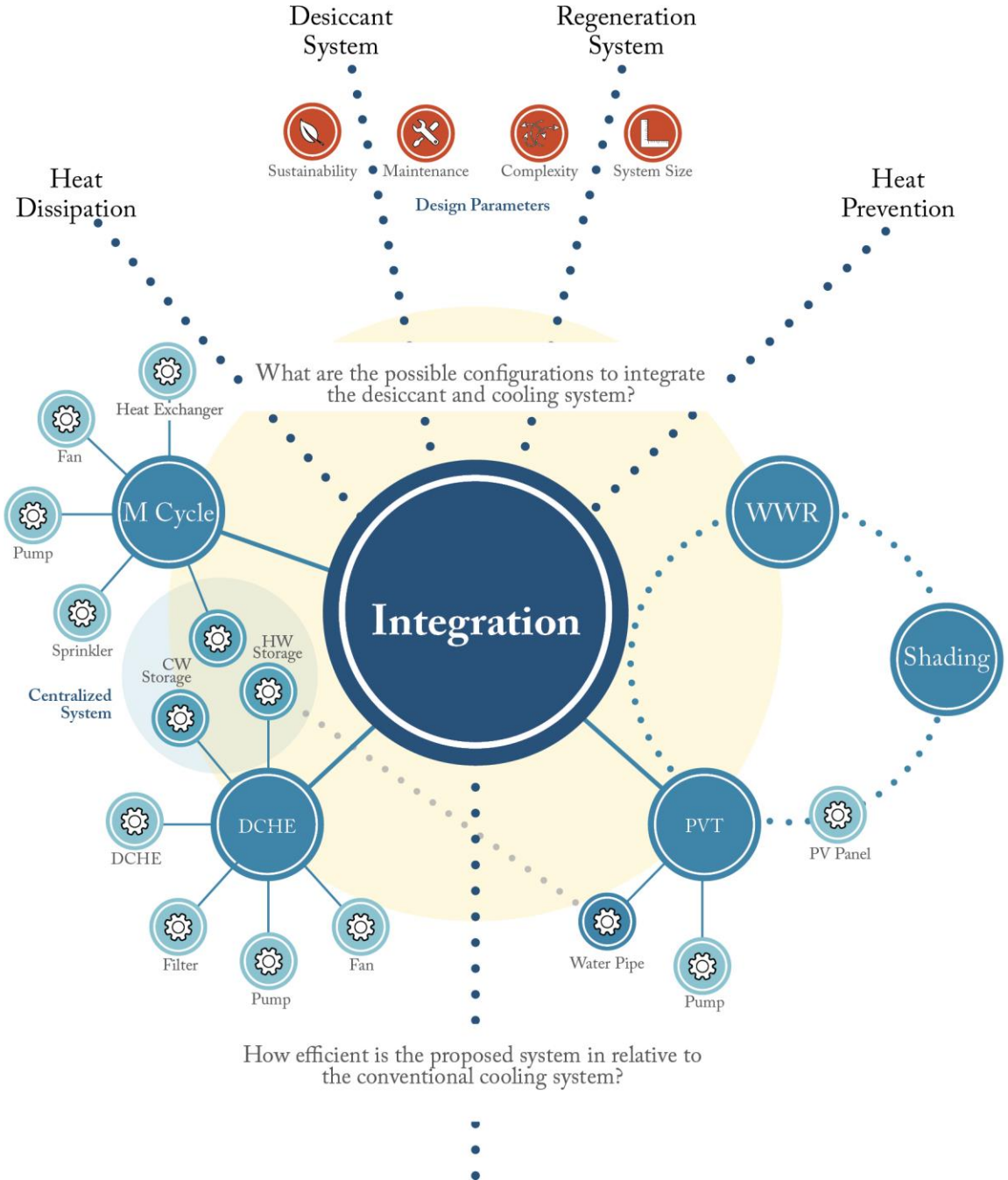
Heat Dissipation



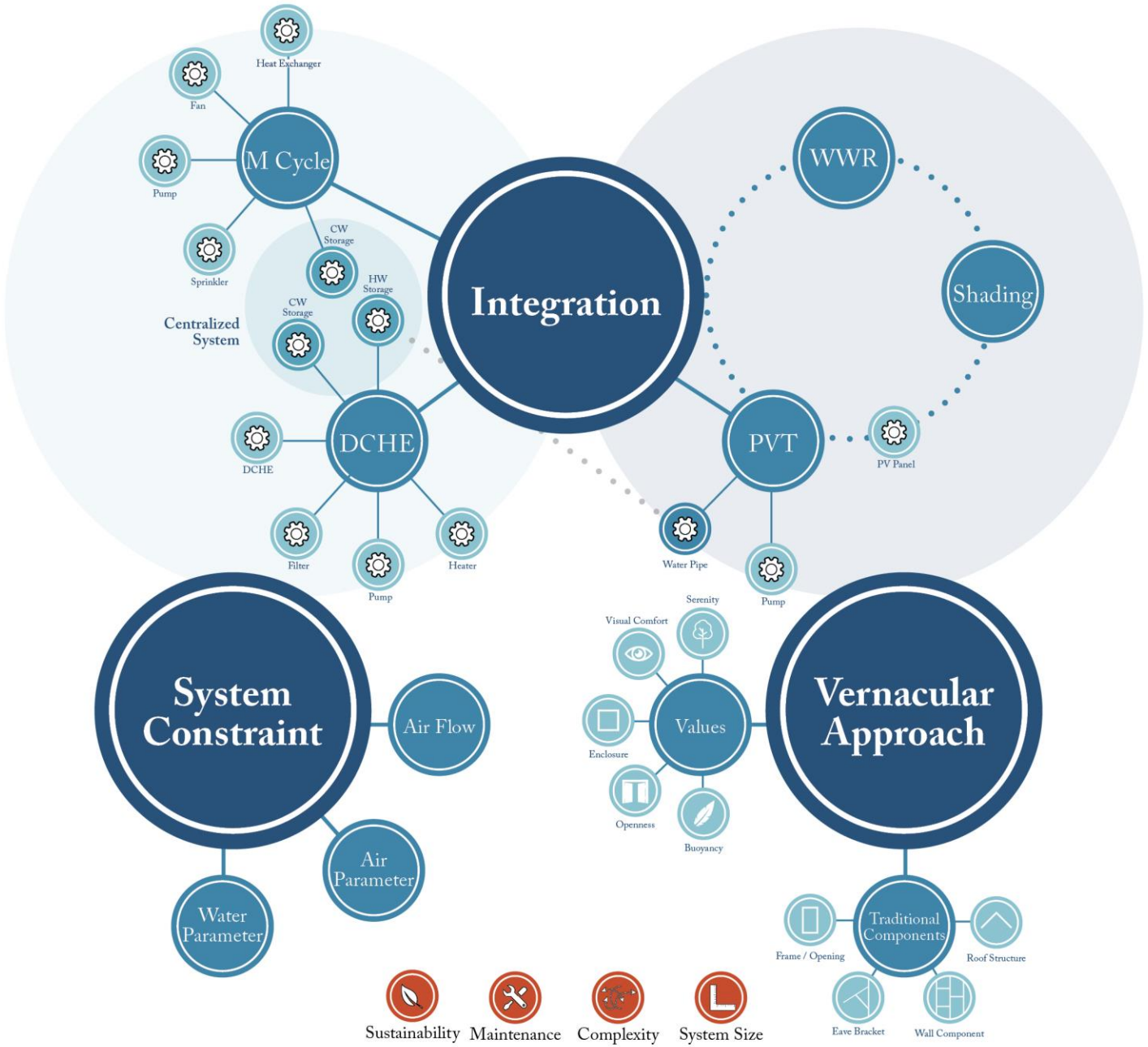

**Maisotsenko Cycle (M-Cycle)**

**63-85%**
Dew-point
Effectiveness

**100-115%**
Wet Bulb
Effectiveness


Desiccant System
Regeneration System
Sustainability
Maintenance
Complexity
System Size
Design Parameters
Heat Dissipation
Heat Prevention
What are the possible configurations to integrate the desiccant and cooling system?
Heat Exchanger
Fan
M Cycle
Pump
Sprinkler
CW Storage
HW Storage
Centralized System
Integration
WWR
Shading
DCHE
DCHE
Filter
Pump
Fan
PVT
PV Panel
Water Pipe
Pump
How efficient is the proposed system in relative to the conventional cooling system?

# Design Concept




Serenity
Visual Comfort
Values
Enclosure
Openness
Buoyancy


Traditional Components
Frame / Opening
Roof Structure
Eave Bracket
Wall Component

"How can the **desiccant cooling facade system** be integrated into the built environment to reduce cooling load of **office buildings** in a **hot and humid climate**?"

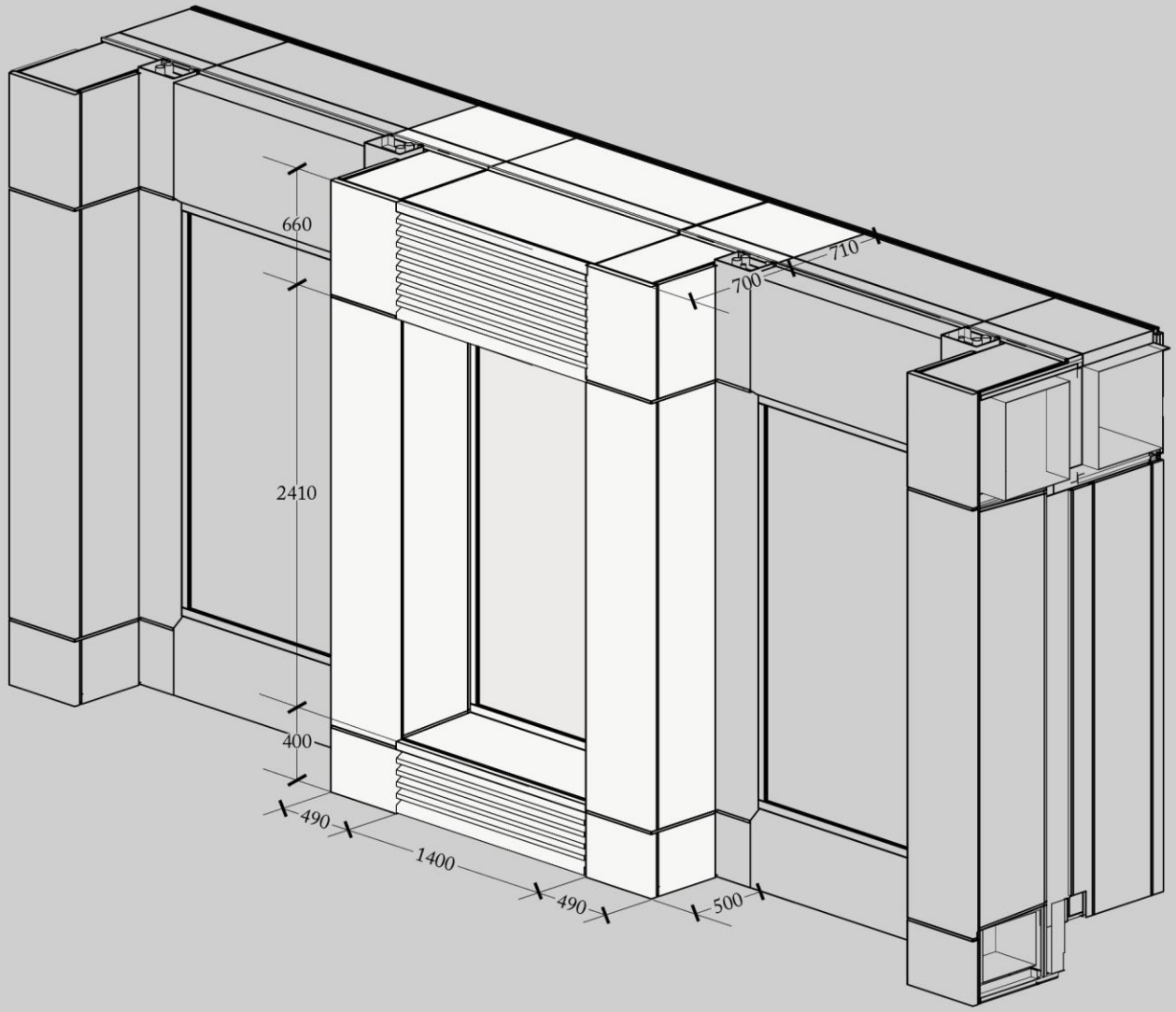
# ‘Desi-grated’

Desiccant Integrated Facade System

# ‘Desi-grated’

## Part I : Dehumidification Component

Frame / Opening



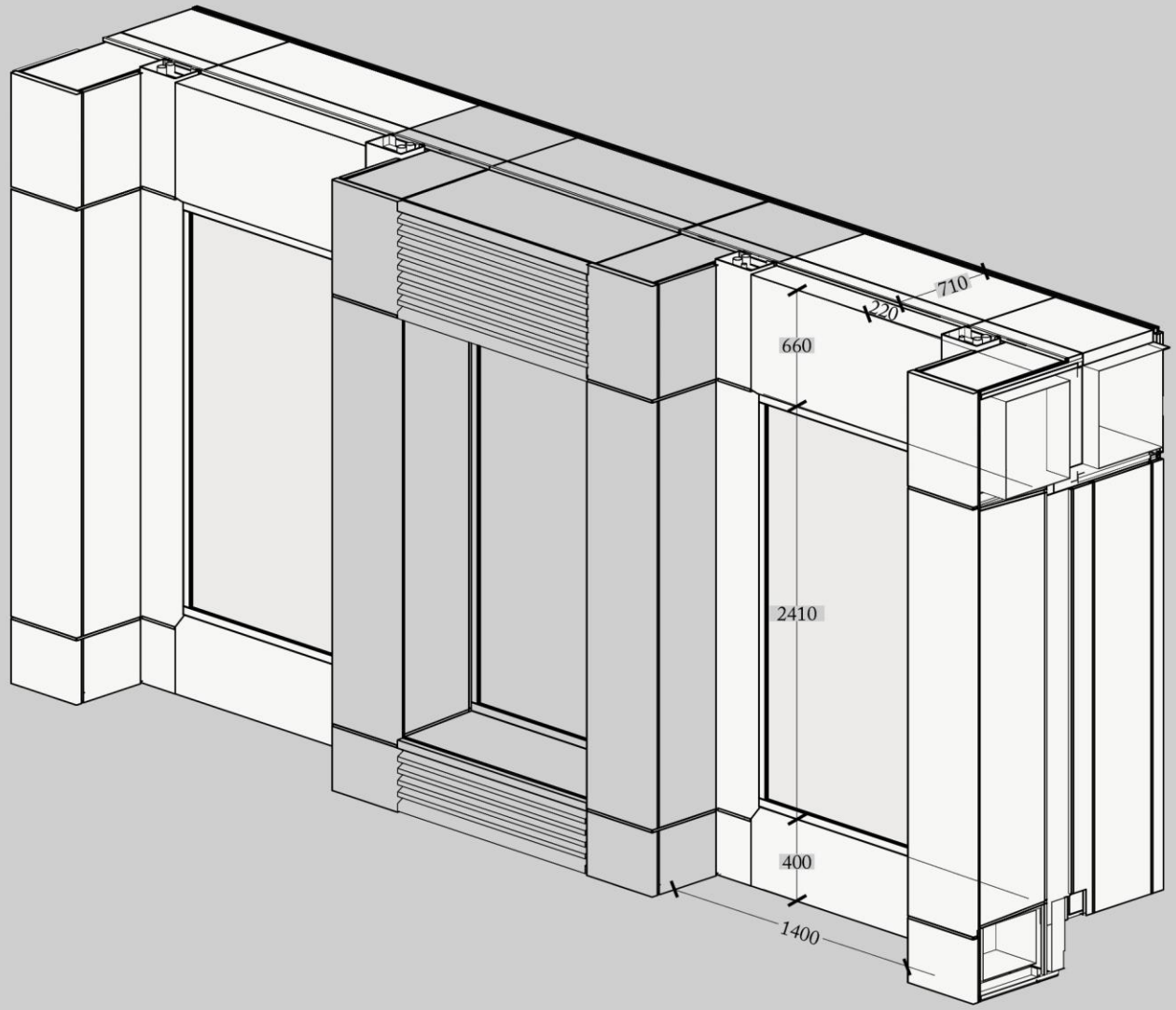
# ‘Desi-grated’

## Part II : Air Supply Component

Frame / Opening

**Modularity**

**Wall Component**



# ‘Desi-grated’

## Part III : Shading Component

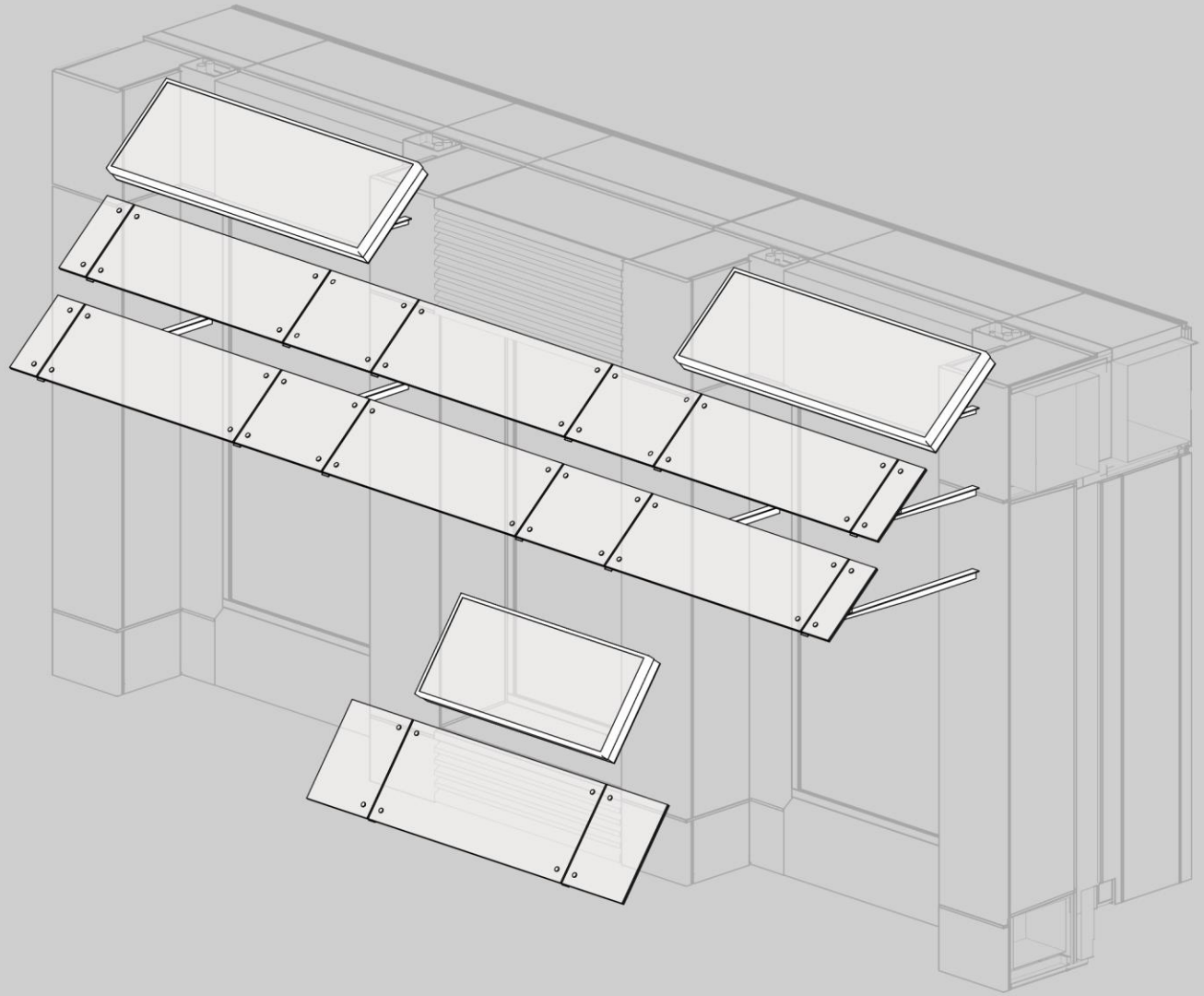
Frame / Opening

Modularity

Wall Component

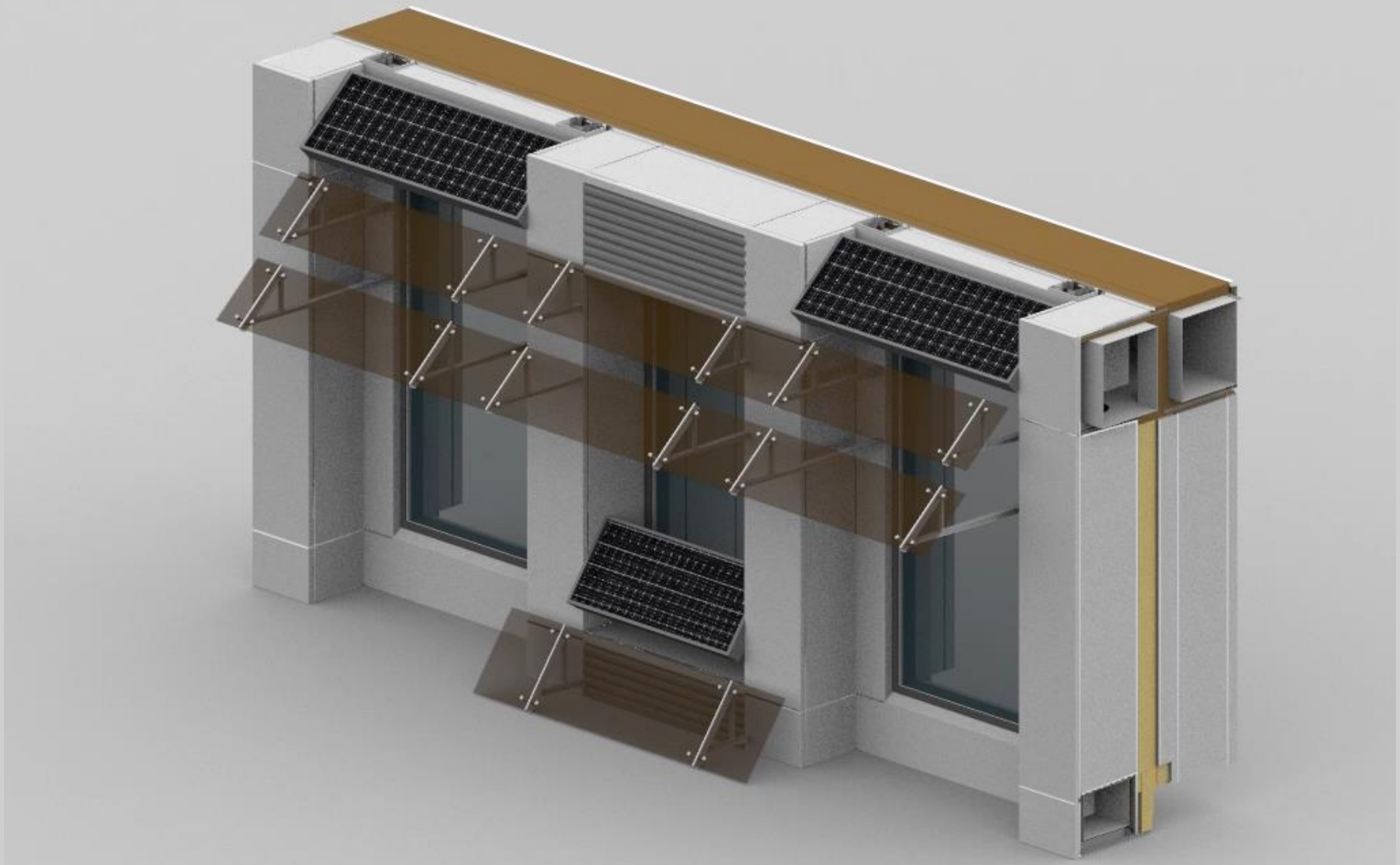
Buoyancy

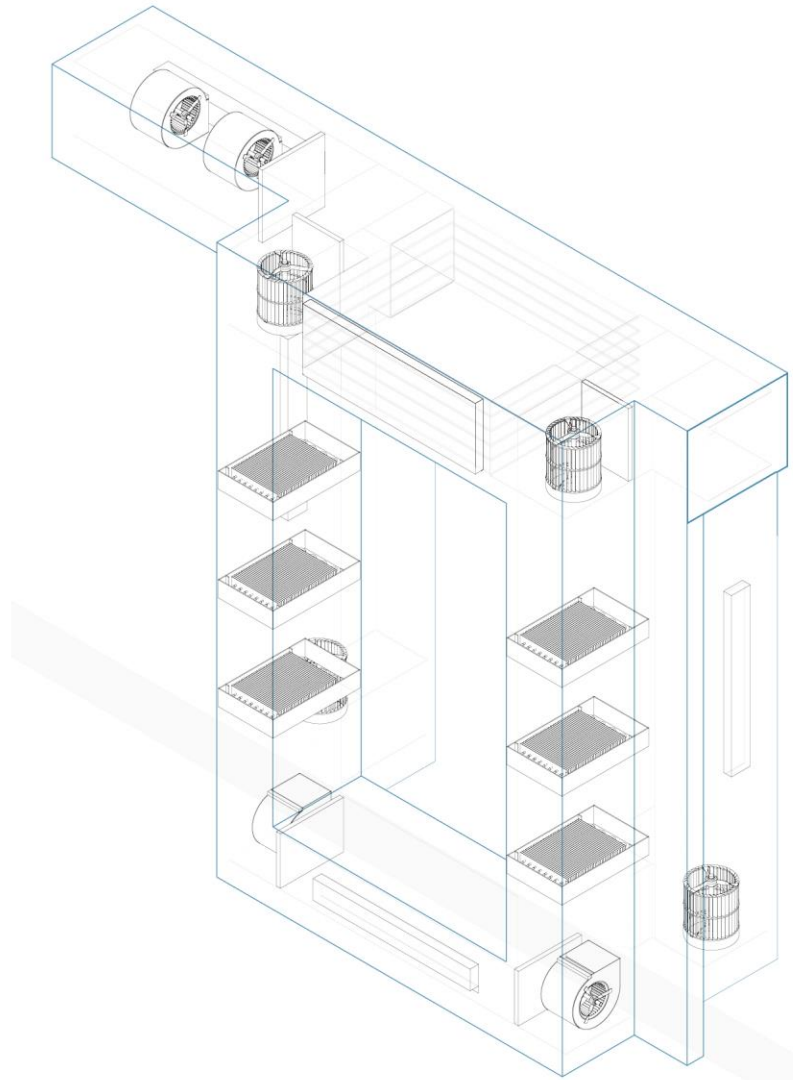
Roof Structure

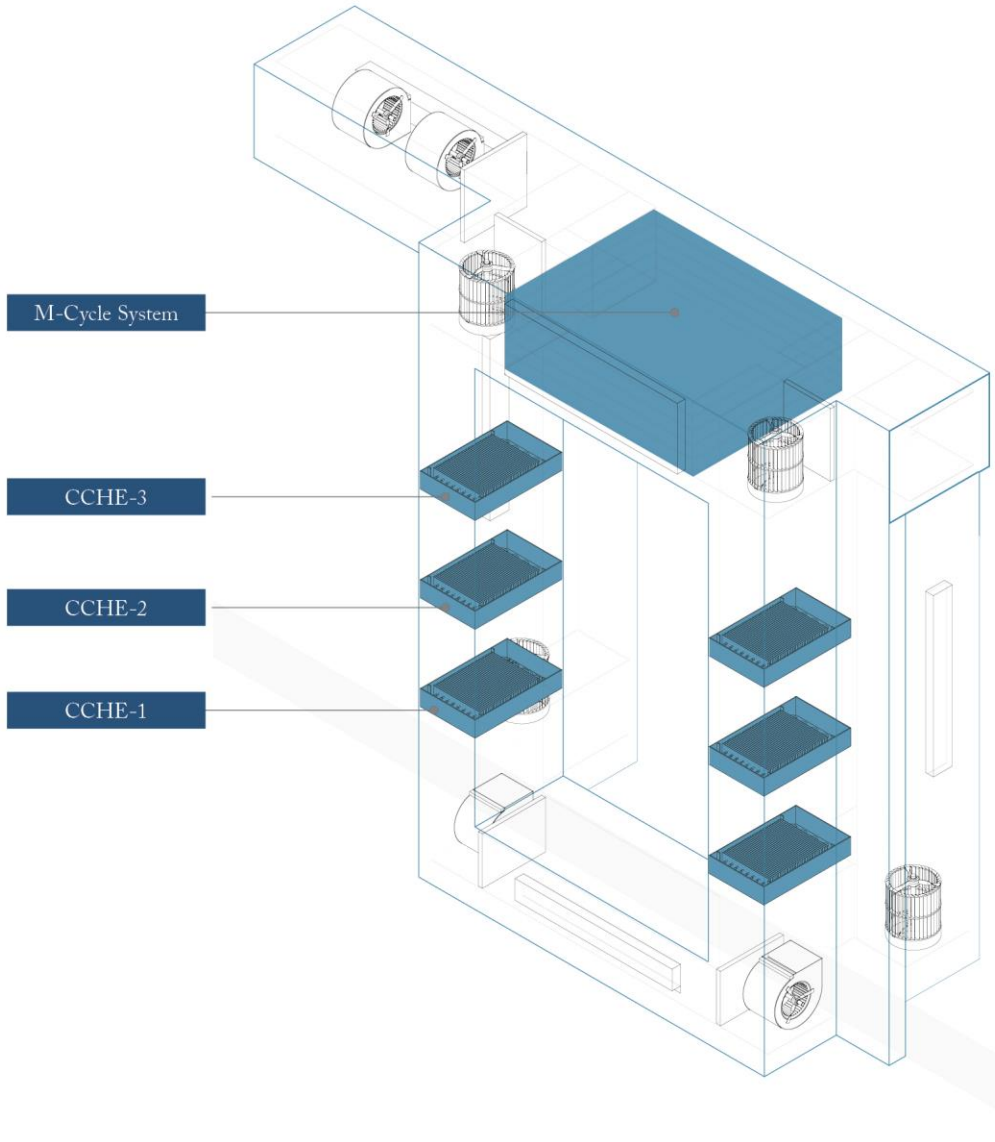


# ‘Desi-grated’

## Desiccant Integrated Facade System

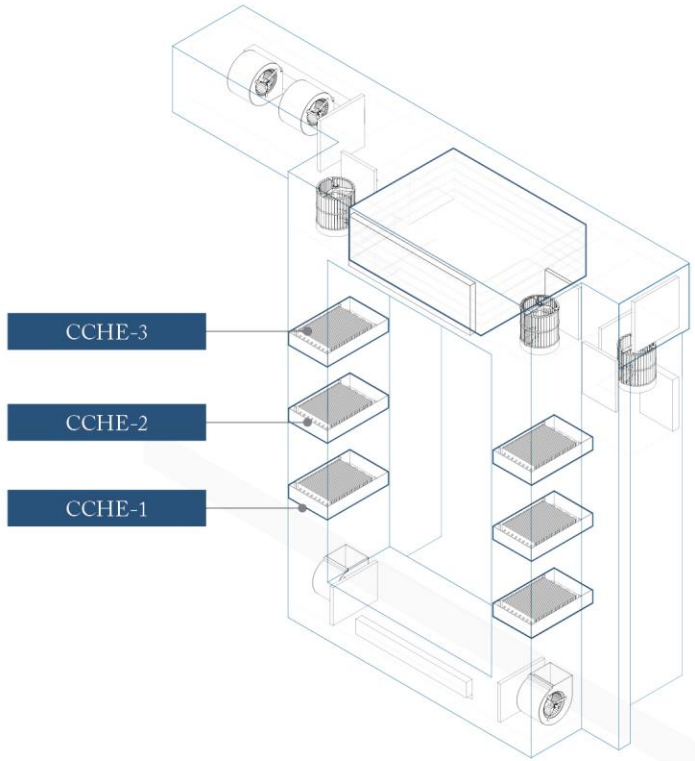


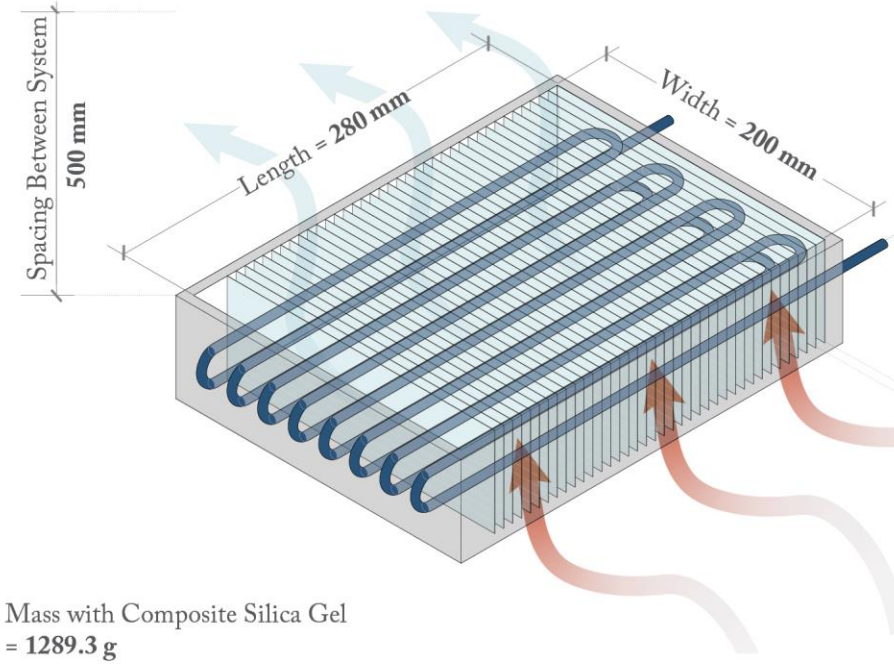



M-Cycle System
CCHE-3
CCHE-2
CCHE-1

# System Component
## Composite Silica Gel Heat Exchanger (CCHE)

Ge et al. 2017




Cross Section Area = **0.056m²**

ø Inner Diameter = **7.8 mm**
ø Outer Diameter = **8.8 mm**

Fin Thickness = **0.115mm**
Fin Spacing = **1.5mm**

Mass with Composite Silica Gel
= **1289.3 g**

**1.25** **kW**
Heat Transfer Value

**3.9** **g kg**
Humidity Difference

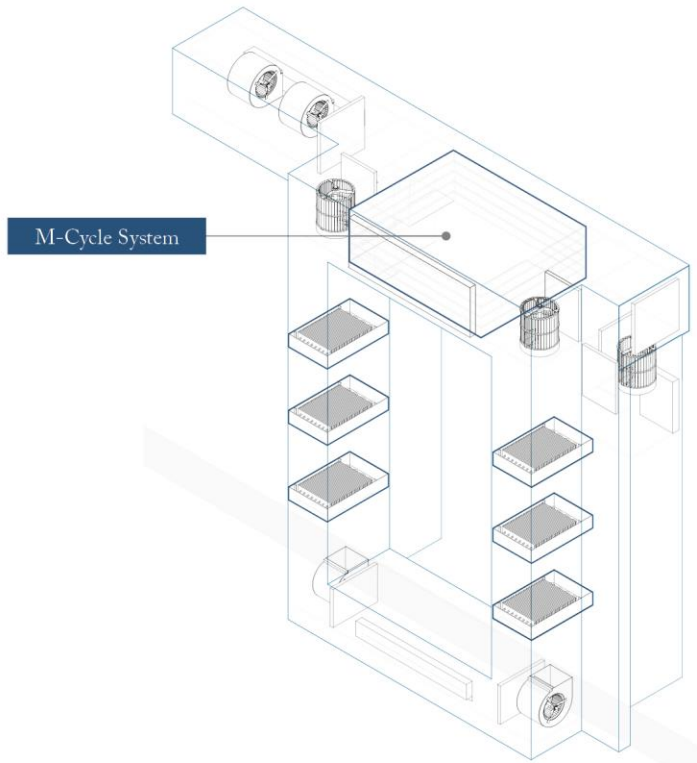
### CCHE System Configuration

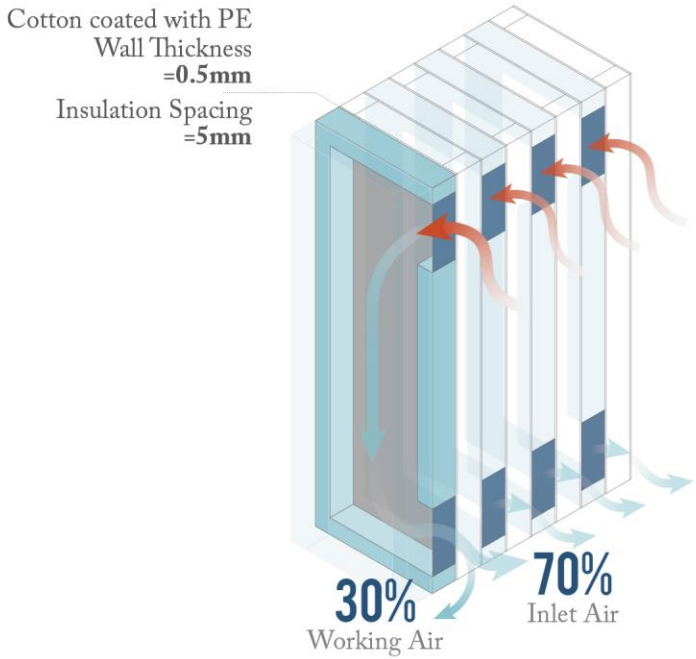
| Water Parameter | | | Air Parameter | | | |
|---|---|---|---|---|---|---|
| Cooling Water (°C) | Heating Water (°C) | Water Volume (L/h) | Inlet Air Temperature (°C) | Relative Humidity (%) | Flow Velocity (m/s) | Cycle Switch Period (mins) |
| **15** | **50** | **200** | **30** | **70** | **1.54** | **10** |

# System Component

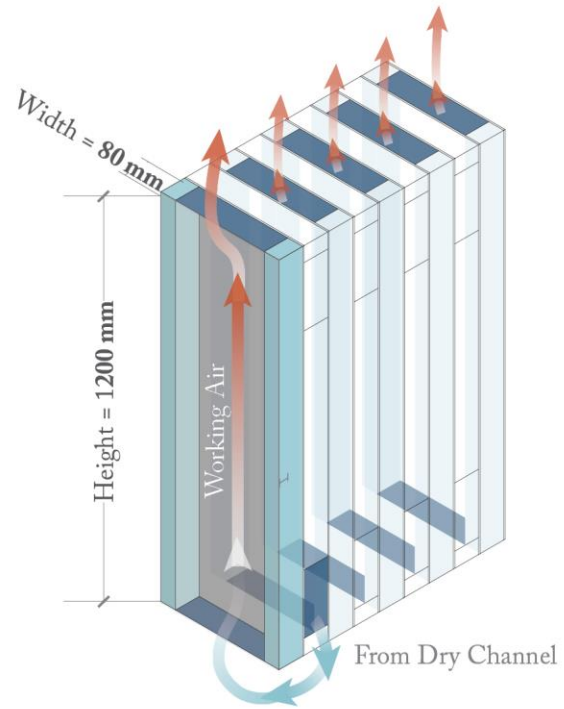
## M-Cycle - Cooling System

Riangvilaikul and Kumar




4-Dry Channel




5-Wet Channel

**101-104%**
Wet Bulb Effectiveness

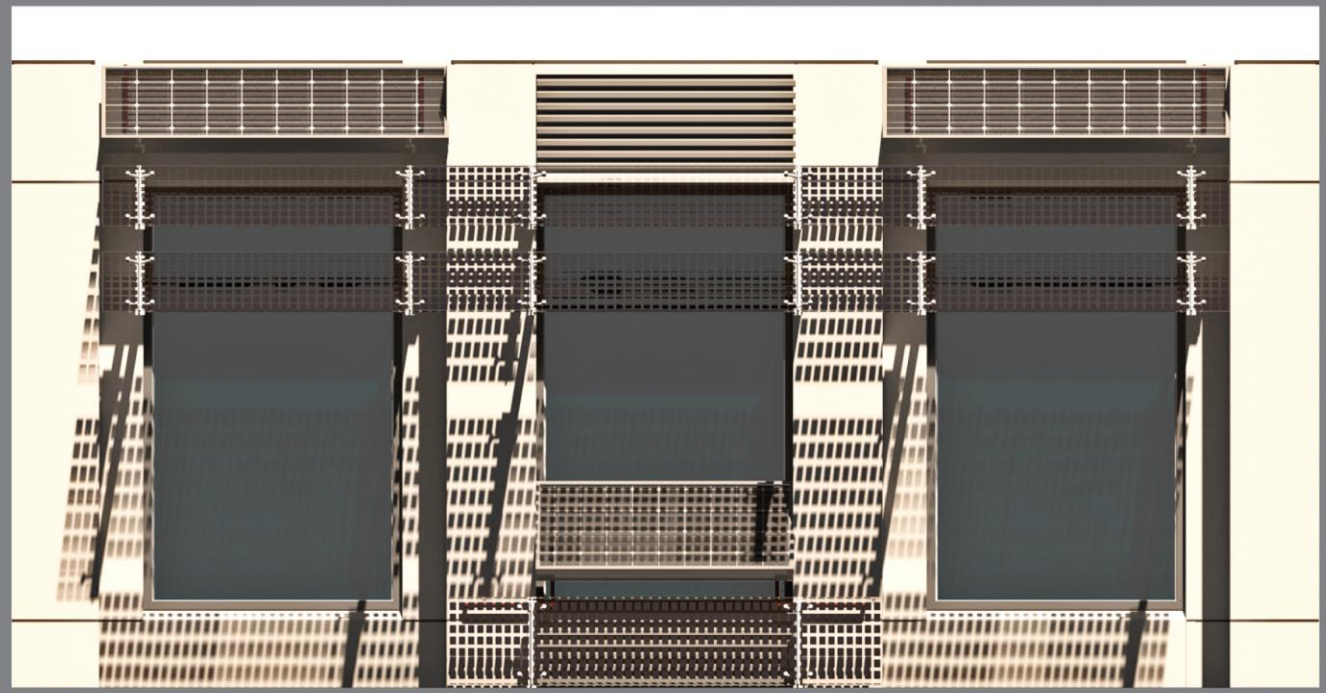
**75-79%**
Dew-point Effectiveness

### Dewpoint Indirect Evaporative System Configuration

| Water Parameter | Air Parameter | |
|---|---|---|
| Water Volume (g/h) | Flow Velocity (m/s) | Working Air (kg/kg) |
| **60** | **<2.4** | **0.33** |

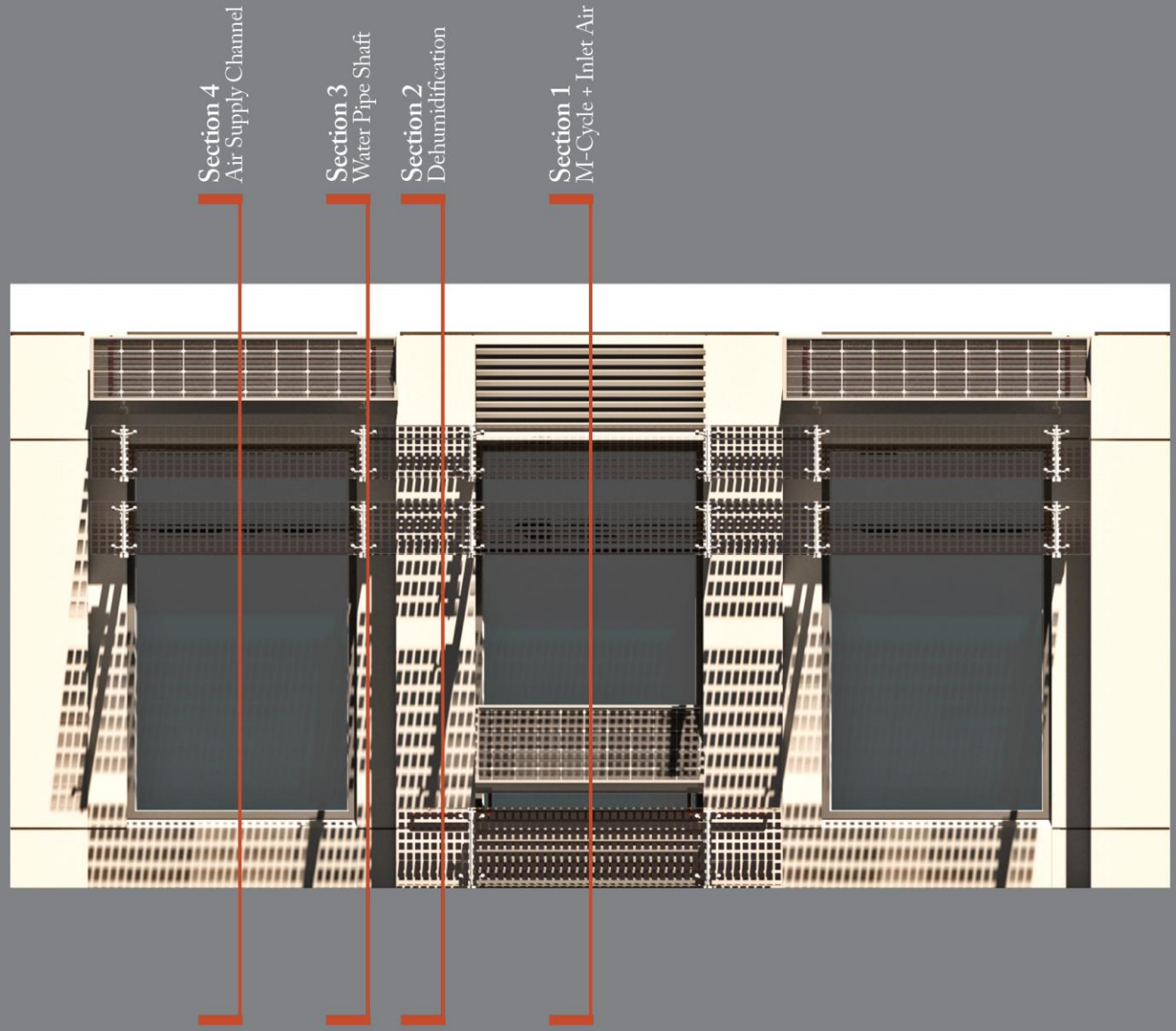
# ‘Desi-grated’

Desiccant Integrated Facade System



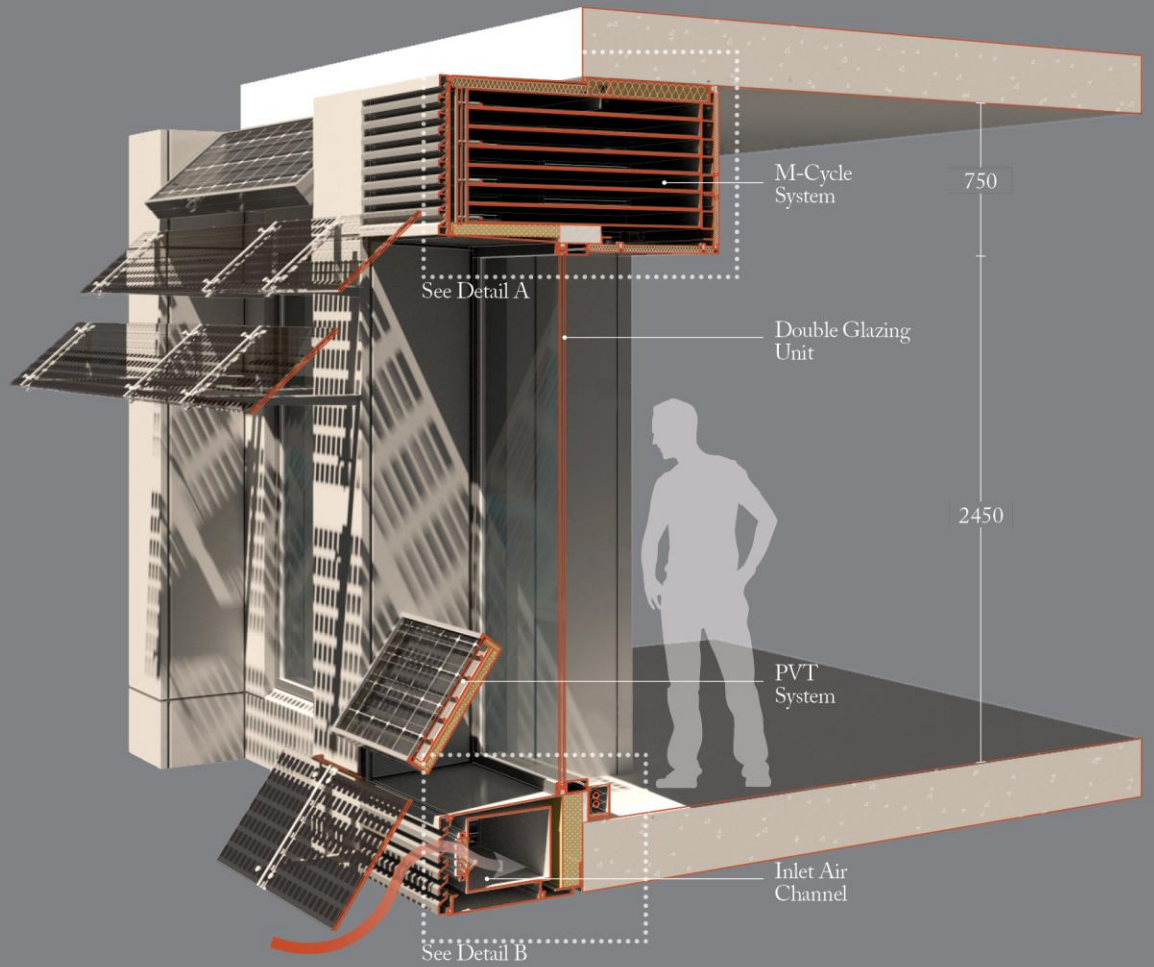
# ‘Desi-grated’

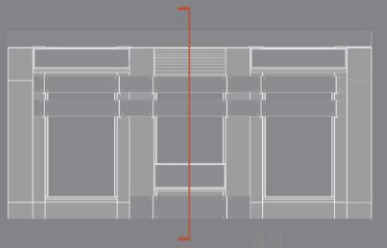
Desiccant Integrated Facade System



# Section 1

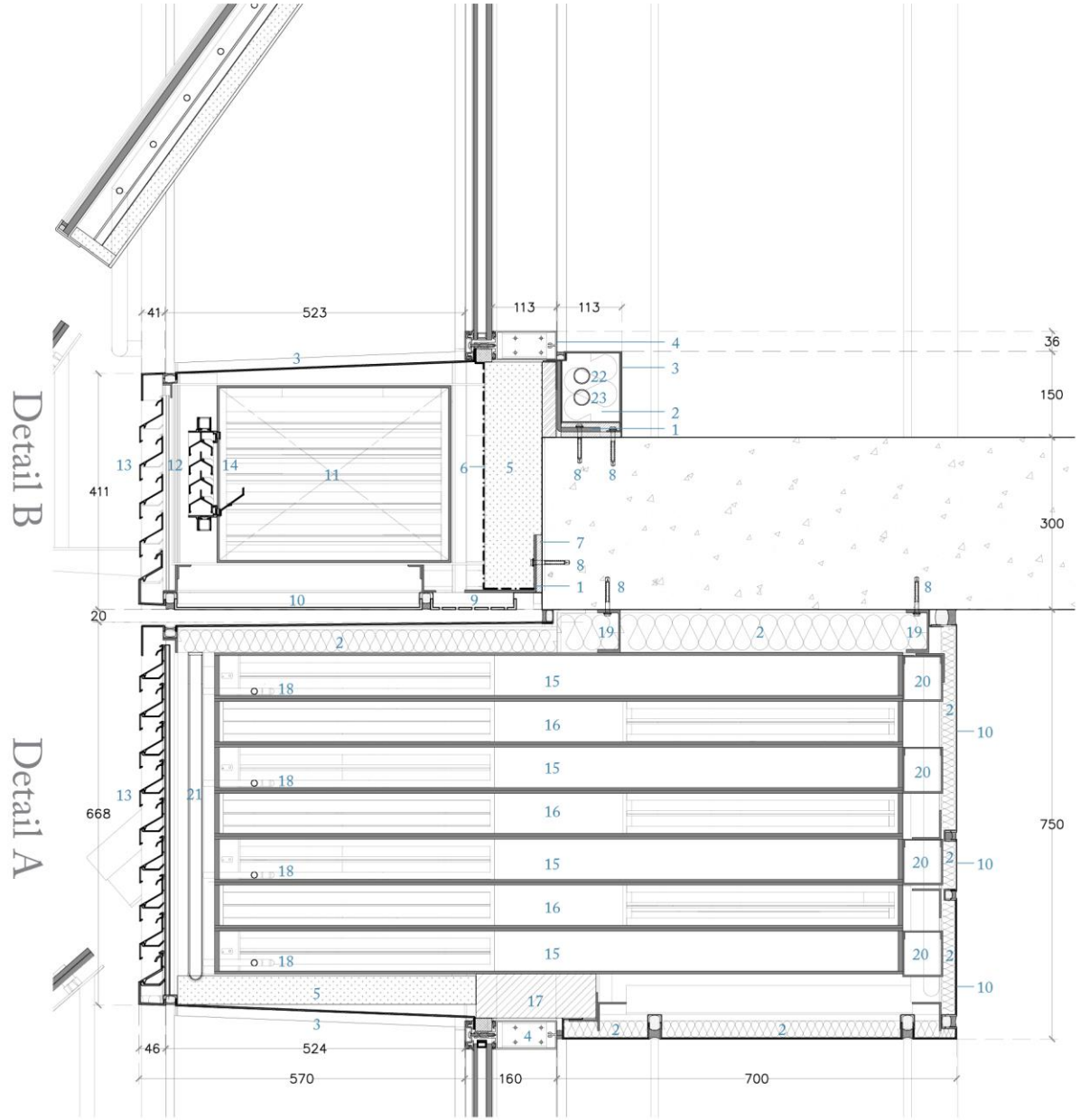
## M-Cycle + Supply Air Channel



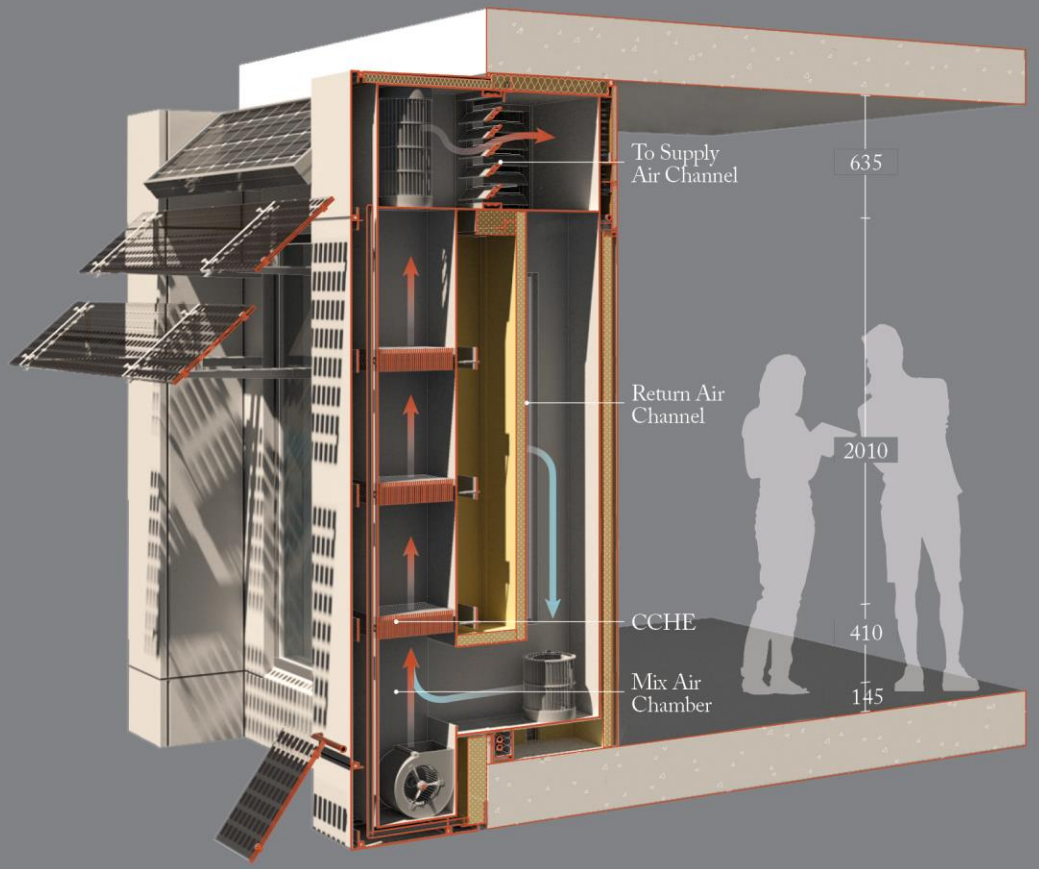
# Connection Detail

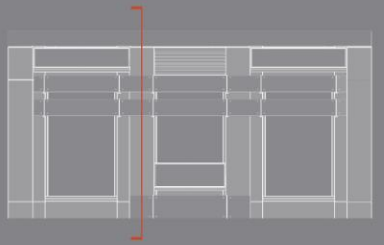
## M-Cycle Component




1. L-Bracket
2. Fiberwool Insulation
3. Aluminium Cladding
4. Transom
5. PUR Insulation
6. Waterproof Membrane
7. Thermalfoot
8. 10mm Concrete Bolt
9. Perforated Aluminium Cladding
10. Aluminium Composite Cladding
11. Inlet Air Channel
12. Inlet Aluminium Air Grill
13. Aluminium Facade Grill
14. Air Filter
15. M-cycle : Wet Channel
16. M-cycle : Dry Channel
17. Promatect Insulation
18. Water Sprinkler
19. C-Channel Bracket
20. Return Water Gutter
21. Inlet Cold Water Pipe
22. Return Main Hot Water Pipe
23. Supply Main Hot Watter Pipe

# Section 2
## Dehumidification Channel



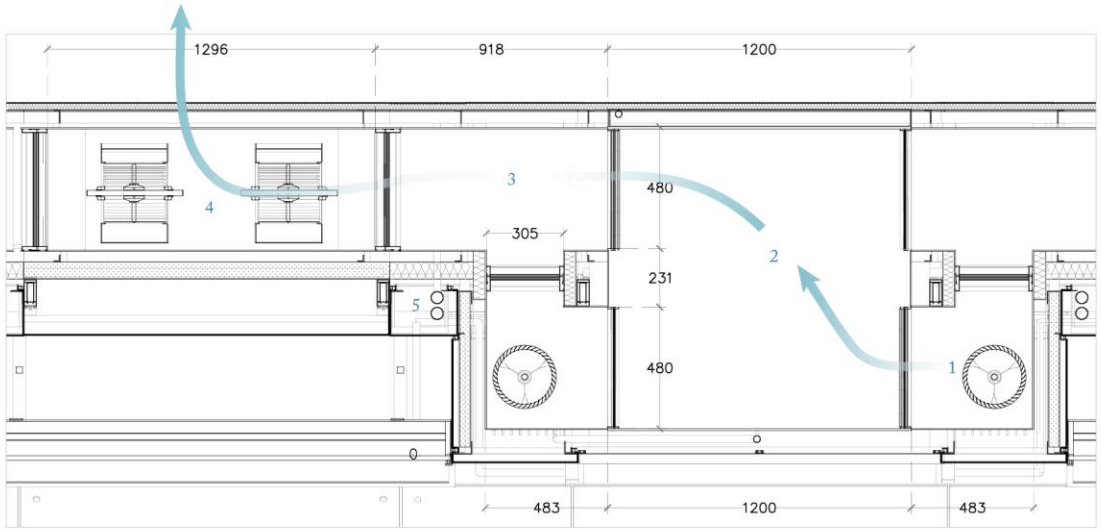



# M-Cycle Component

## Air Flow Schematic

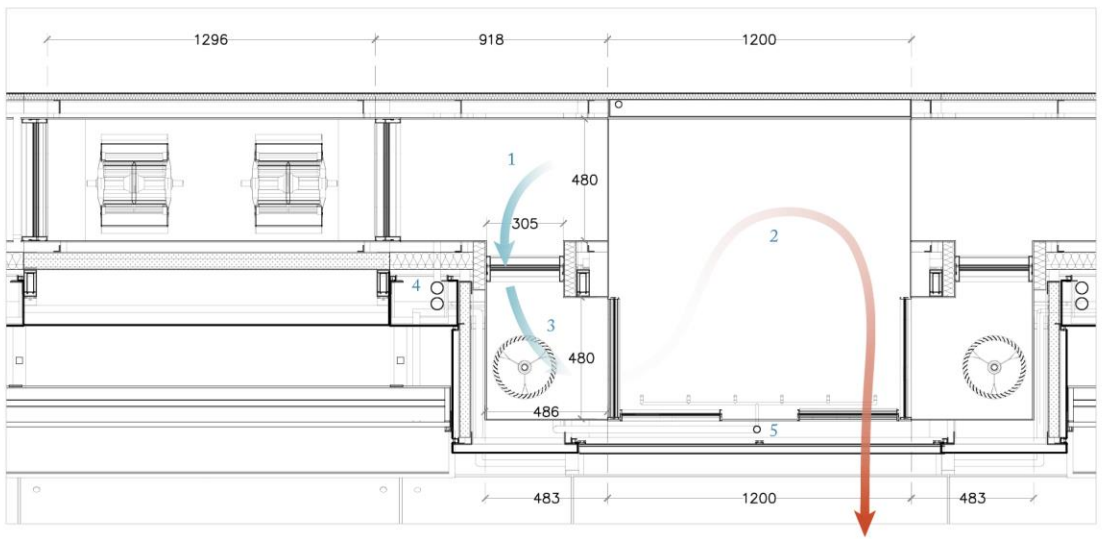
### M-Cycle : Supply Air Scheme

1. Inlet Air Chamber from CCHE
2. M-Cycle : Dry Channel
3. Air Channel
4. Supply Air Channel
5. Water Pipe Shaft

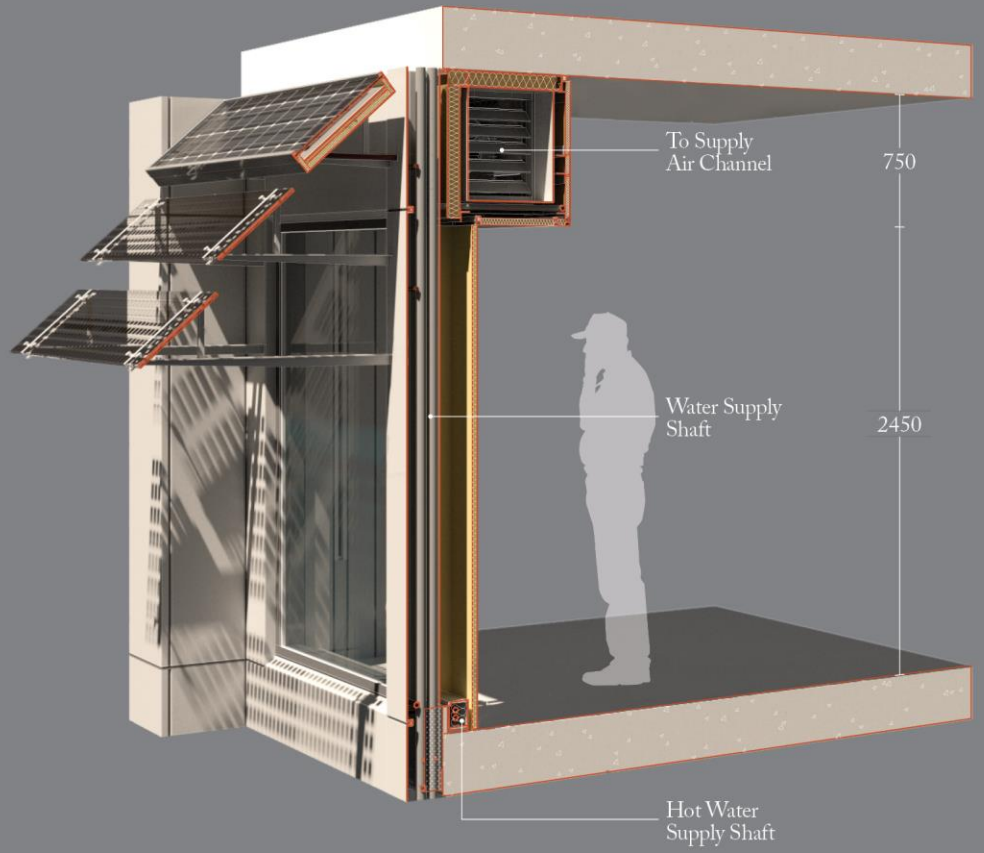


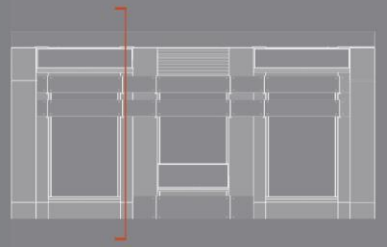

### M-Cycle : Working Air Scheme

1. Inlet Air Chamber from Dry Channel
2. M-Cycle : Wet Channel
3. Air Channel
4. Water Pipe Shaft
5. Cold Water Inlet Pipe



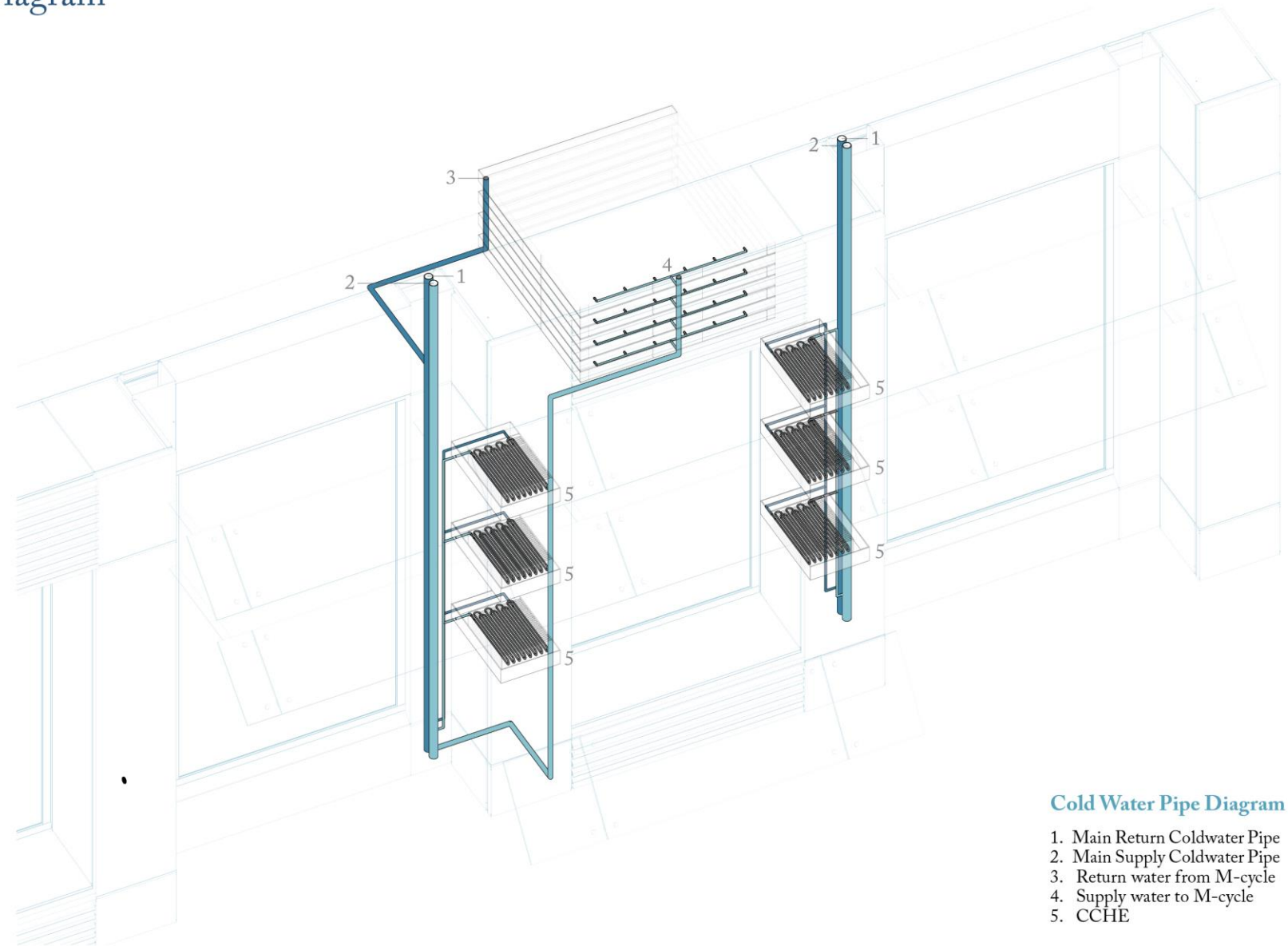
# Section 3
## Water Pipe Shaft



# Water Pipe Schematic

## Cold Water Pipe Diagram

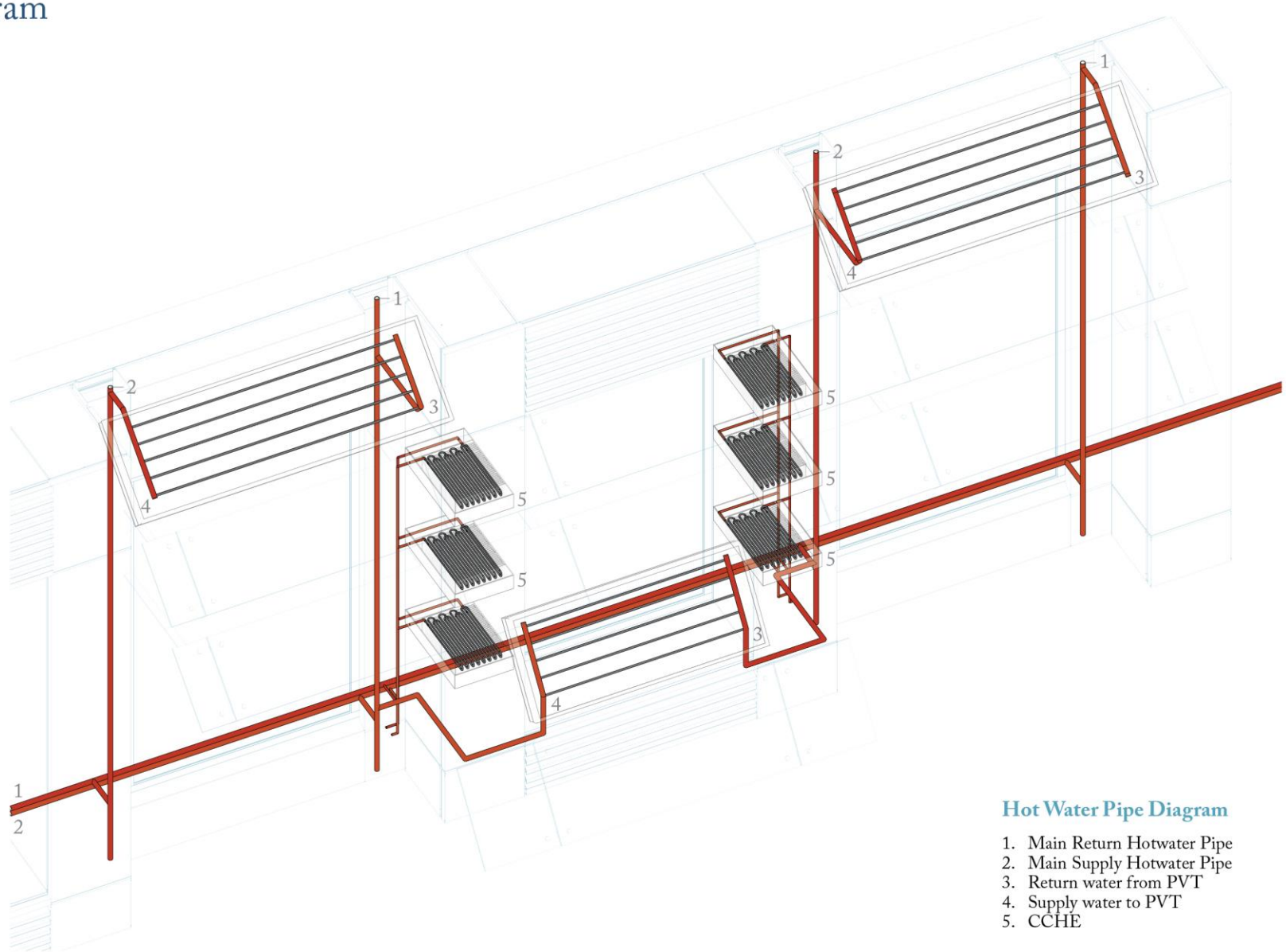



**Cold Water Pipe Diagram**

1. Main Return Coldwater Pipe
2. Main Supply Coldwater Pipe
3. Return water from M-cycle
4. Supply water to M-cycle
5. CCHE

# Water Pipe Schematic

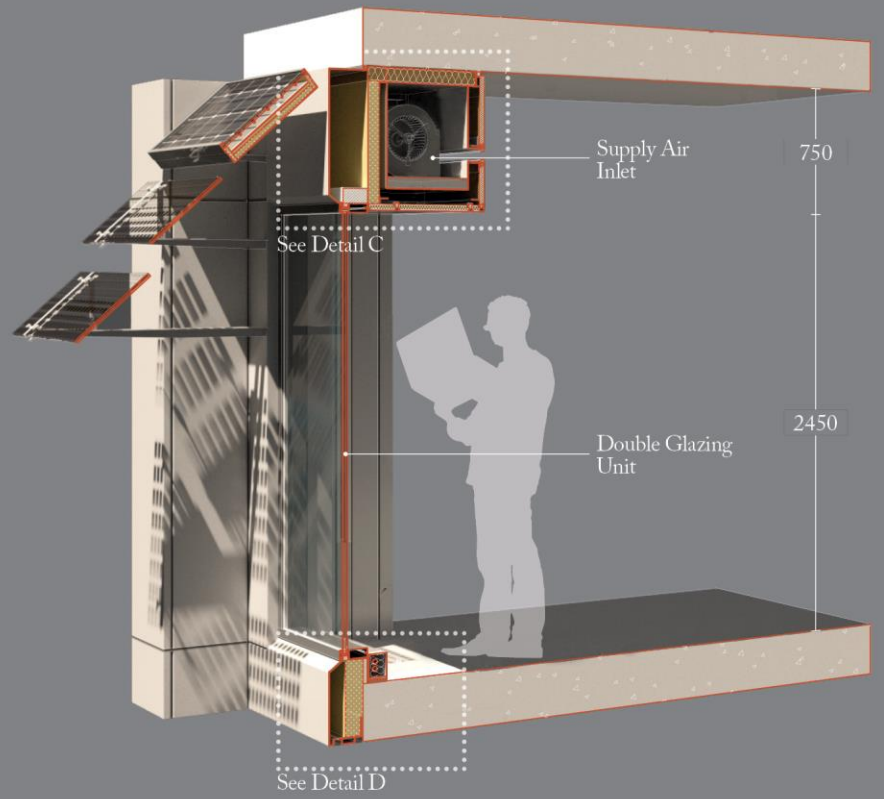
## Hot Water Pipe Diagram

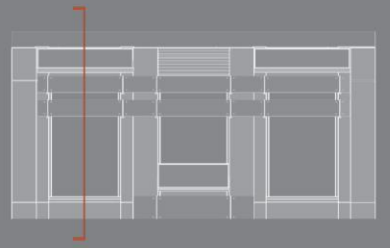



**Hot Water Pipe Diagram**

1. Main Return Hotwater Pipe
2. Main Supply Hotwater Pipe
3. Return water from PVT
4. Supply water to PVT
5. CCHE

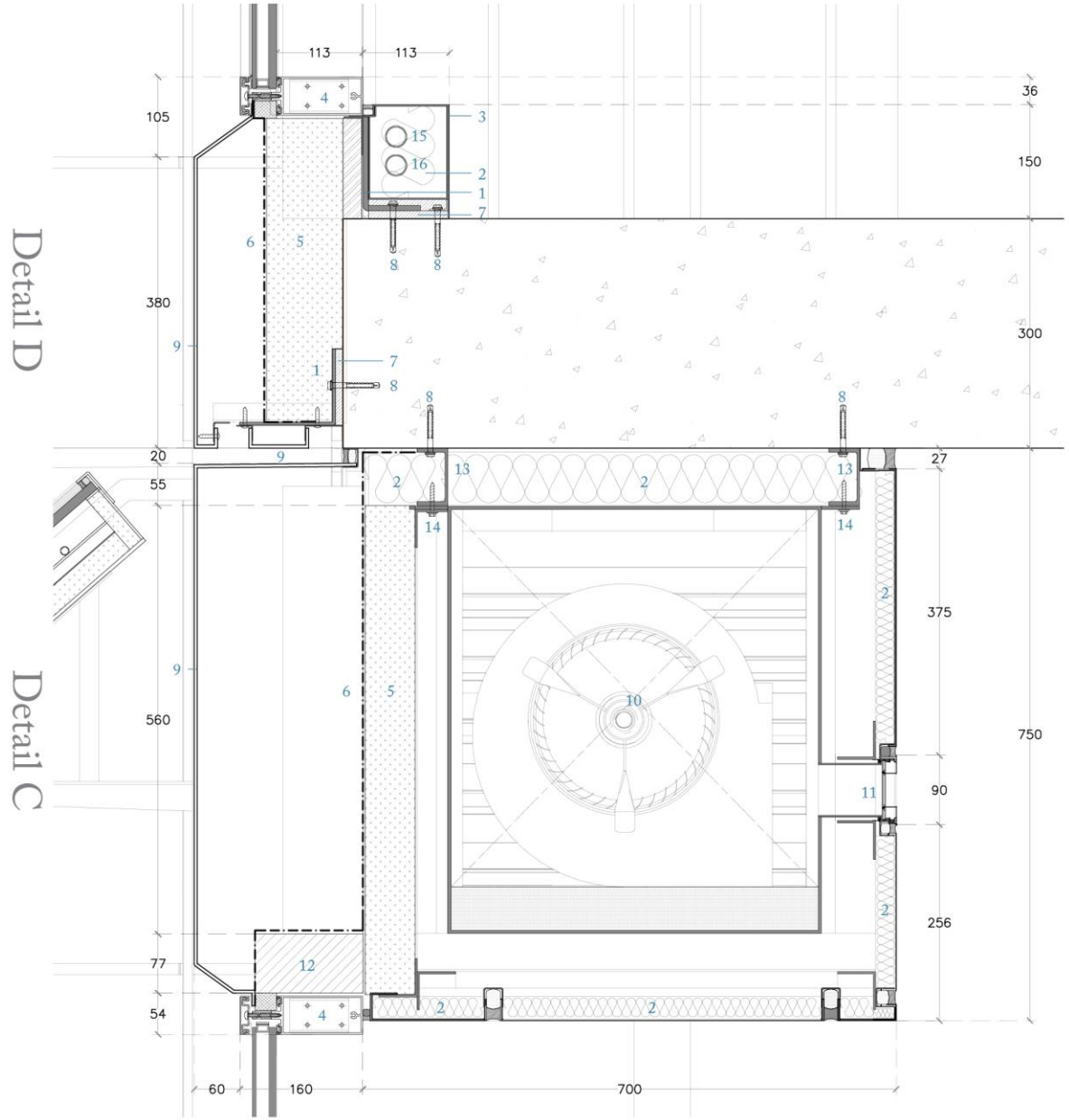
# Section 4
## Supply Air Unit



# Connection Detail

## Air Supply Component

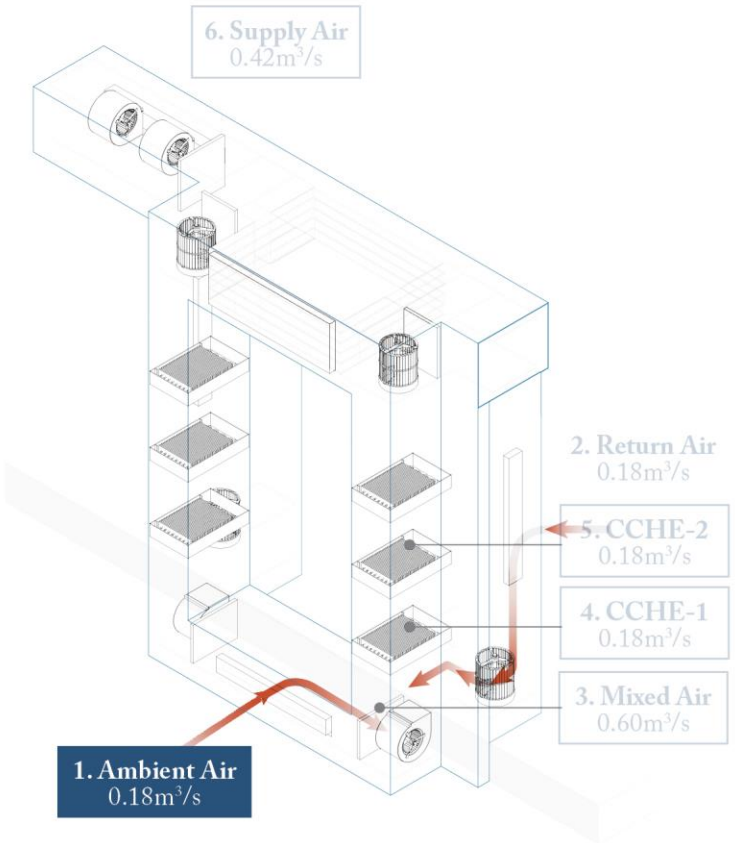


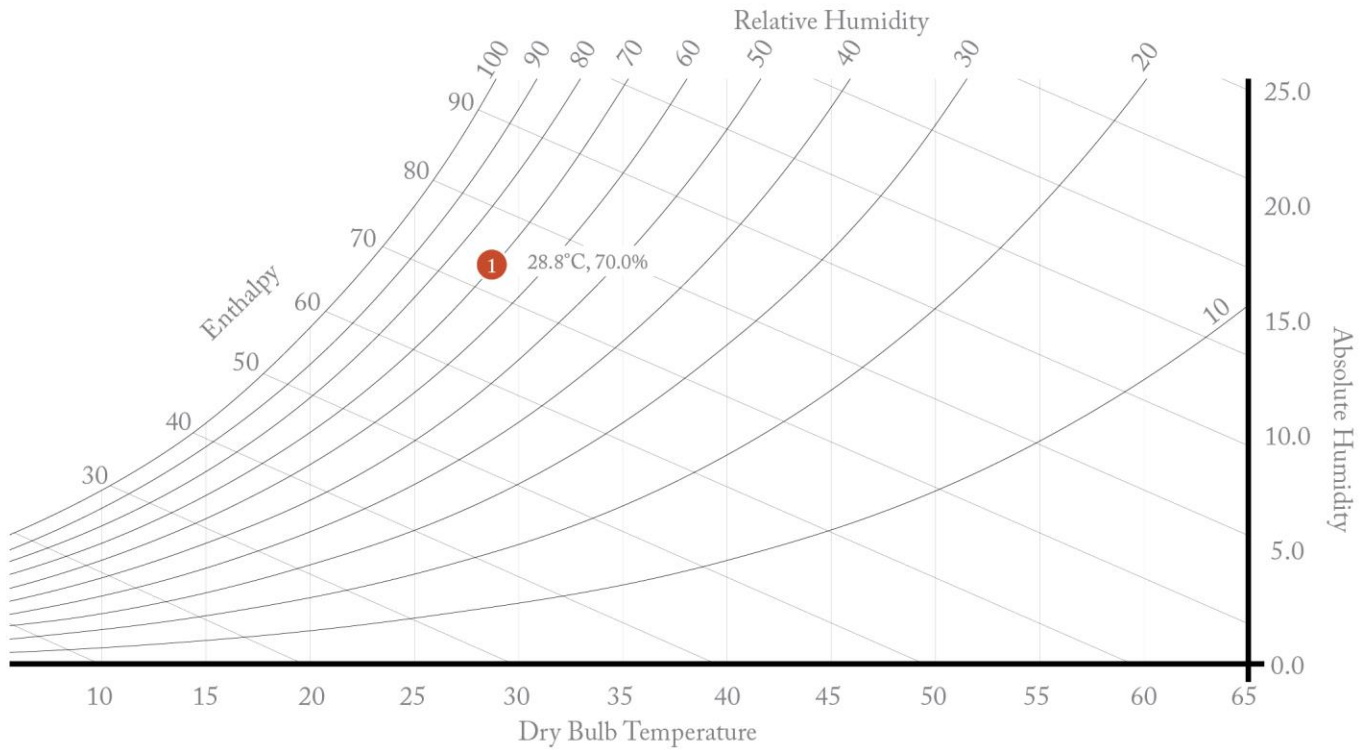

1. L-Bracket
2. Fiberwool Insulation
3. Aluminium Cladding
4. Transom
5. PUR Insulation
6. Waterproof Membrane
7. Thermalfoot
8. 10mm Concrete Bolt
9. Aluminium Composite Cladding
10. Supply Air Channel
11. Aluminium Supply Air Slot
12. Promatect Insulation
13. C-Channel Bracket
14. Metal Screw
15. Main Return Hot Water Pipe
16. Main Supply Hot Water Pipe

# How Does it Work?

# How does it work?

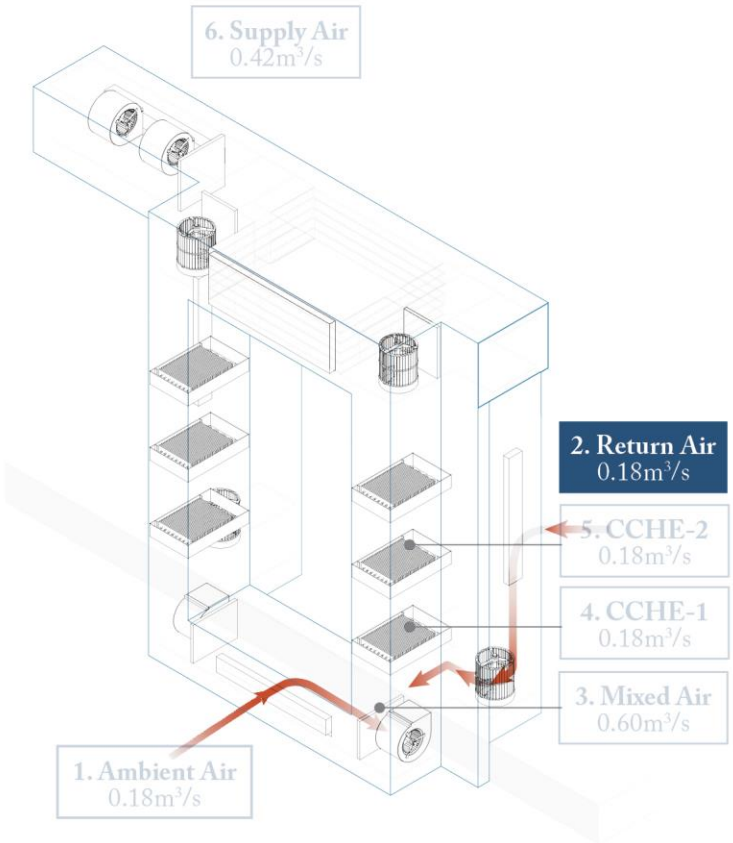
## Inlet Ambient Air

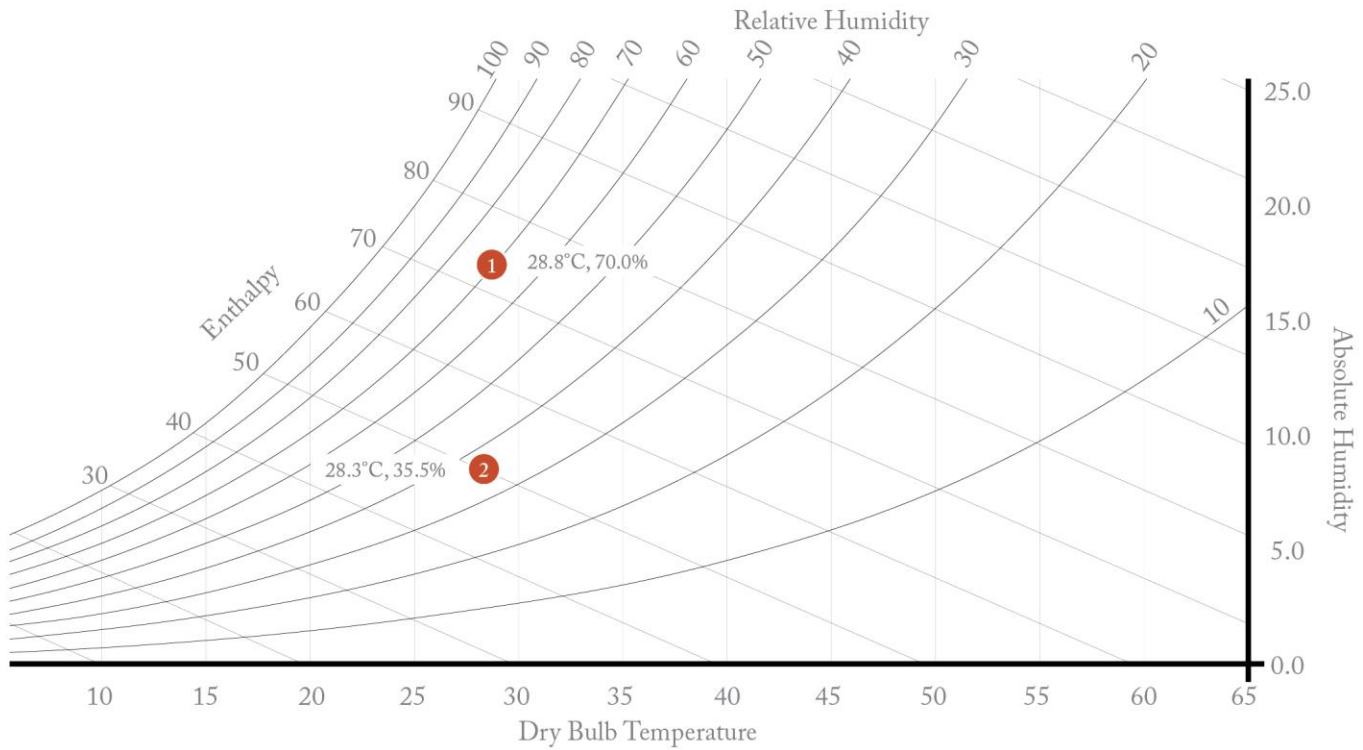


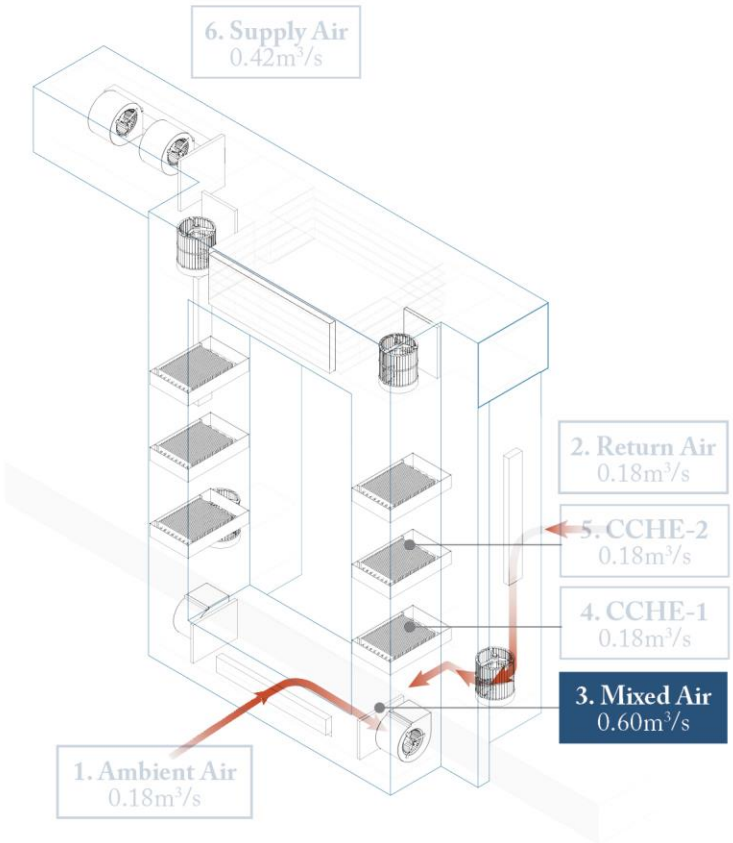
# How does it work?

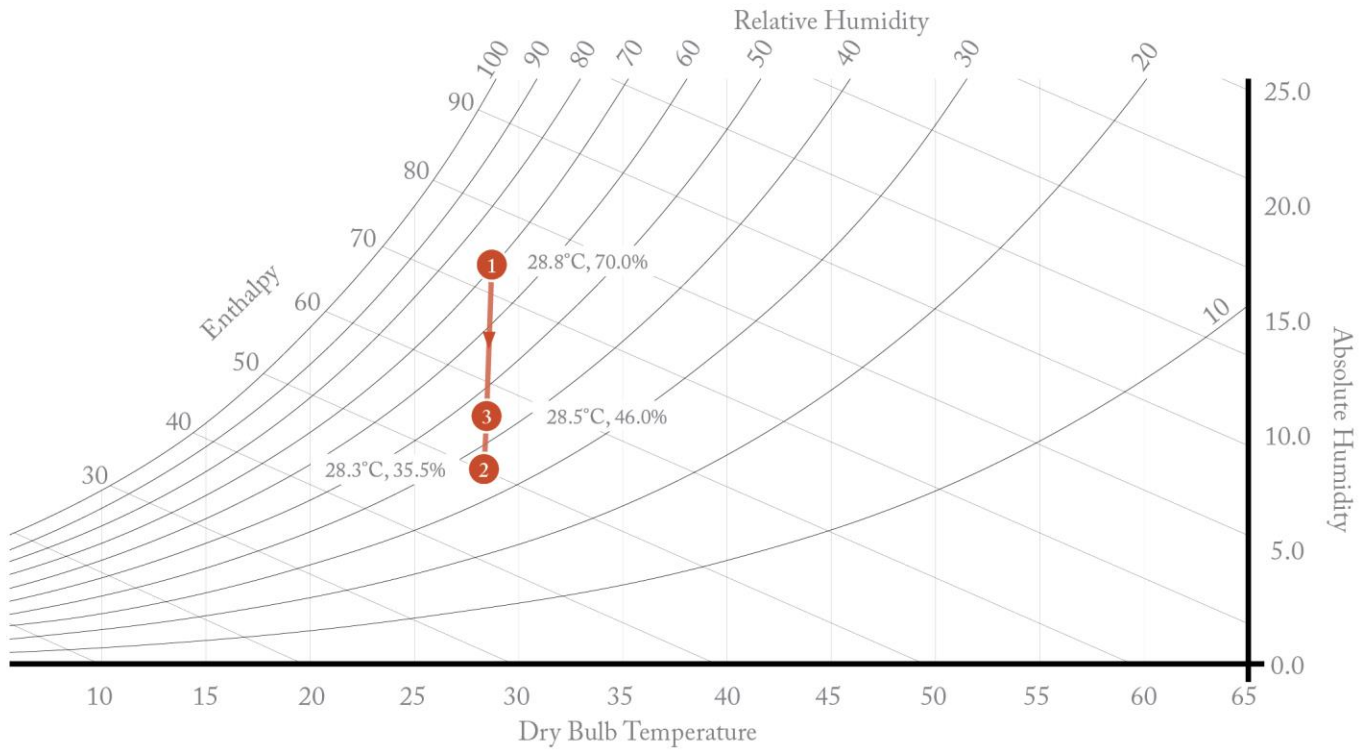
## Return Air



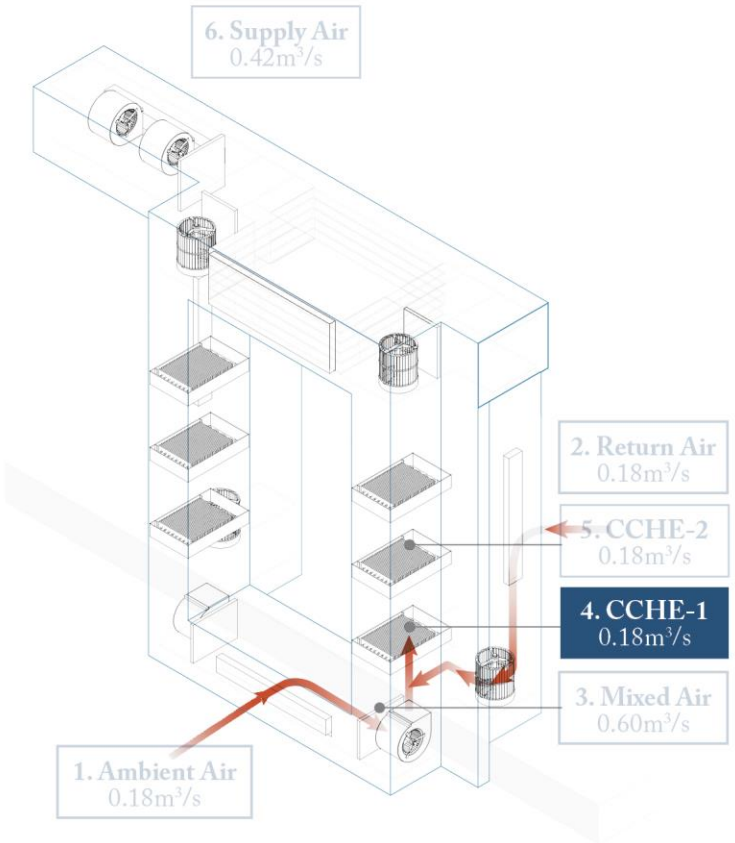



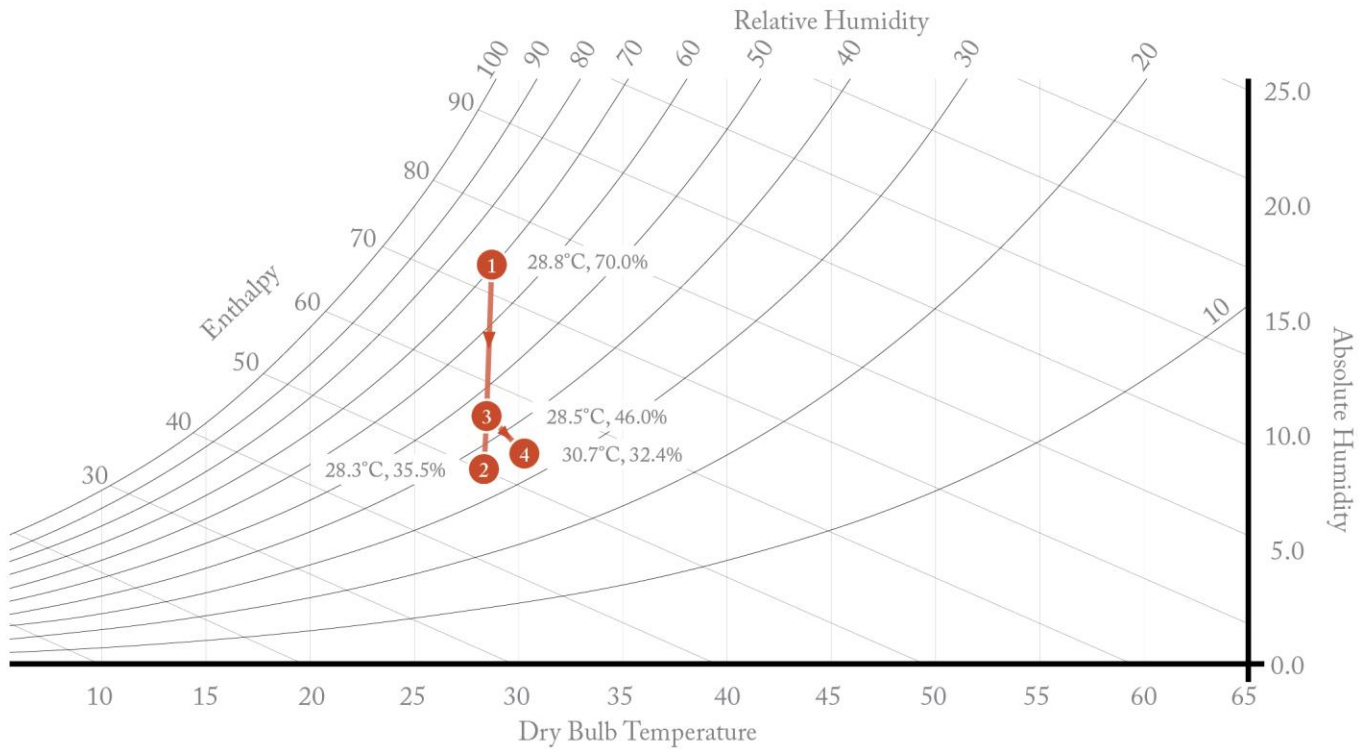
# How does it work?
## Mixed Air



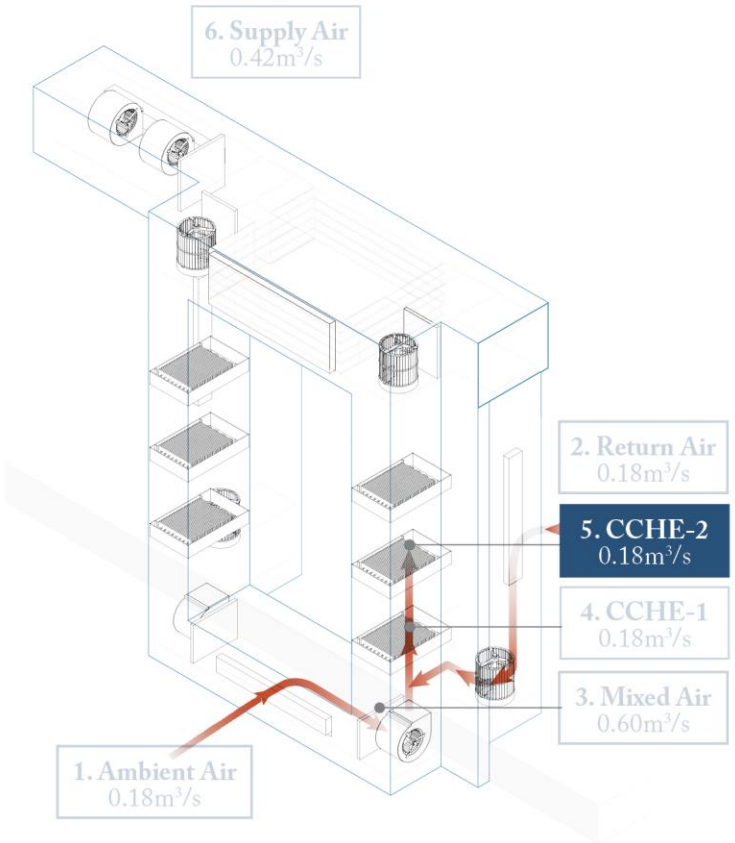



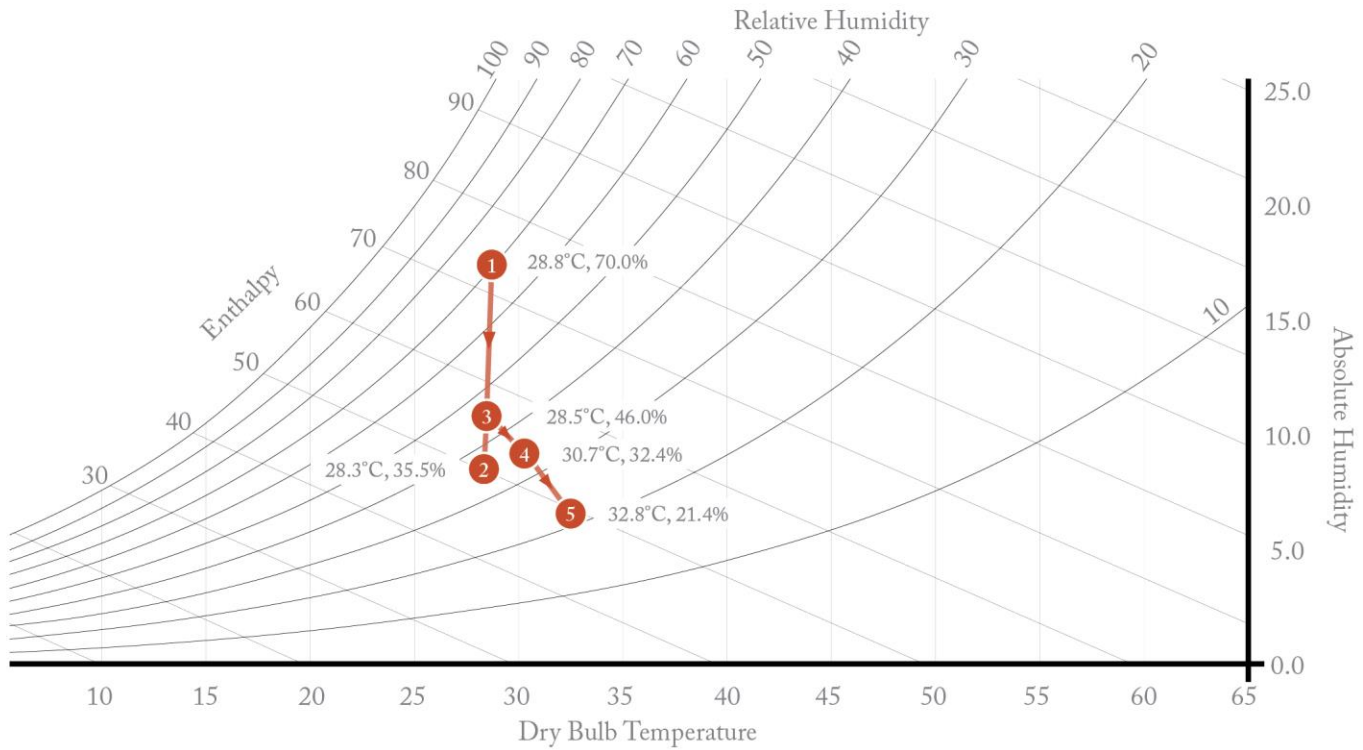
# How does it work?
## CCHE - 1



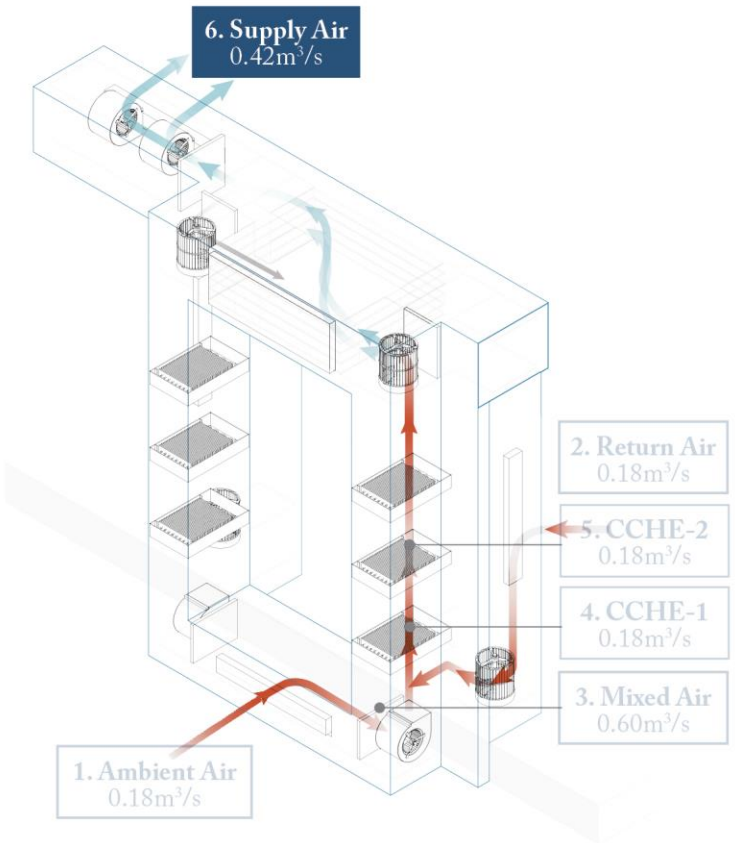
# How does it work?
## CCHE - 2

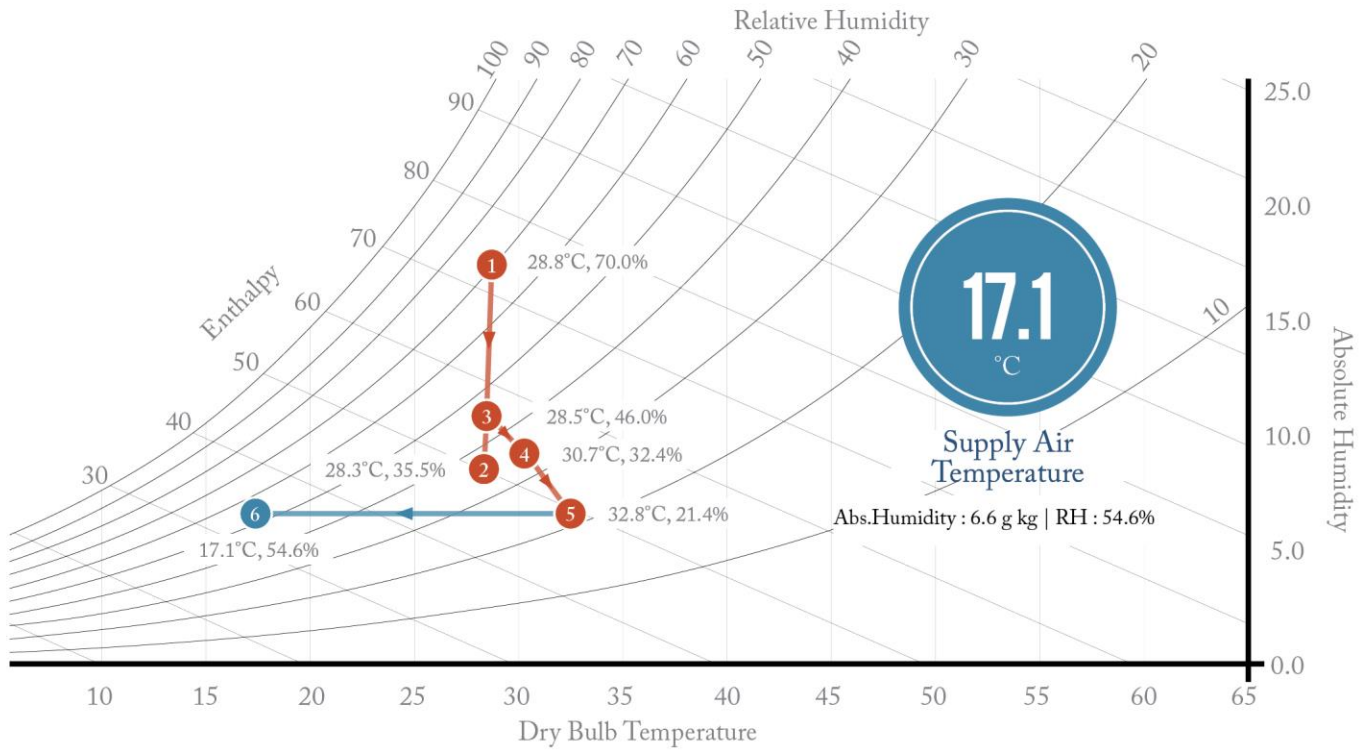


# How does it work?

## Supply Air

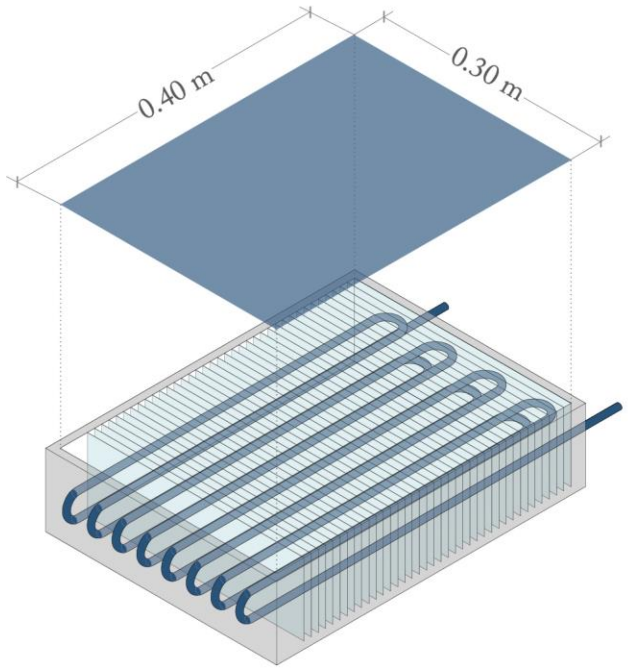


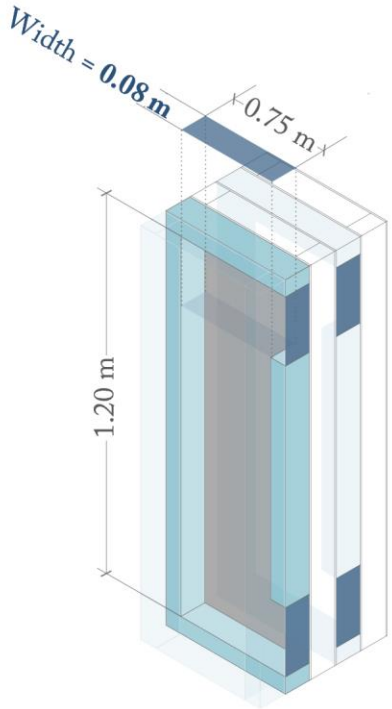
# Design Process

## Design Concept

# System Constraints
## System Sizing




Cross Section Area = **0.12 m²**




Cross Section Area = **0.06 m²**
No. of Dry Channel = **2**
Total Area = **0.12 m²**

### Mass Flow Rate

$m = \rho v A$

| | ρ Air Density (kg/m³) | v Air Velocity (m/s) | A Cross Section Area (m²) |
|---|---|---|---|
| **CCHE** | **1.17** | **1.54** | **0.12** |
| **M-Cycle** | **1.17** | **1.54** | **0.12** |

**0.22** kg/s
Mass Flowrate

### Volume Flow Rate

$Q = v A$

| | v Air Velocity (m/s) | A Cross Section Area (m²) |
|---|---|---|
| **CCHE** | **1.54** | **0.12** |
| **M-Cycle** | **1.54** | **0.12** |

**0.18** m³/s
Volume Flowrate

# System Constraints
## Fresh Air Ratio

### Fresh Air Ratio

| | 100% Fresh Air | 70 : 30 | 30 : 70 | 30 : 70* |
|---|---|---|---|---|
| | **0.13** $m^3/s$ | **0.18** $m^3/s$ | **0.20** $m^3/s$ | **0.42** $m^3/s$ |
| | Conditioned Air Volume Flowrate | Conditioned Air Volume Flowrate | Conditioned Air Volume Flowrate | Conditioned Air Volume Flowrate |
| | Air Velocity (m/s) | Air Velocity (m/s) | Air Velocity (m/s) | Air Velocity (m/s) |
| **2. CCHE** | 1.54 | 1.54 | 1.08 | **1.54** |
| **4. Mixed Air** | 0.97 | 1.54 | 2.40 | **2.40** |

*M-Cycle Cross Section:
= **0.25m²**

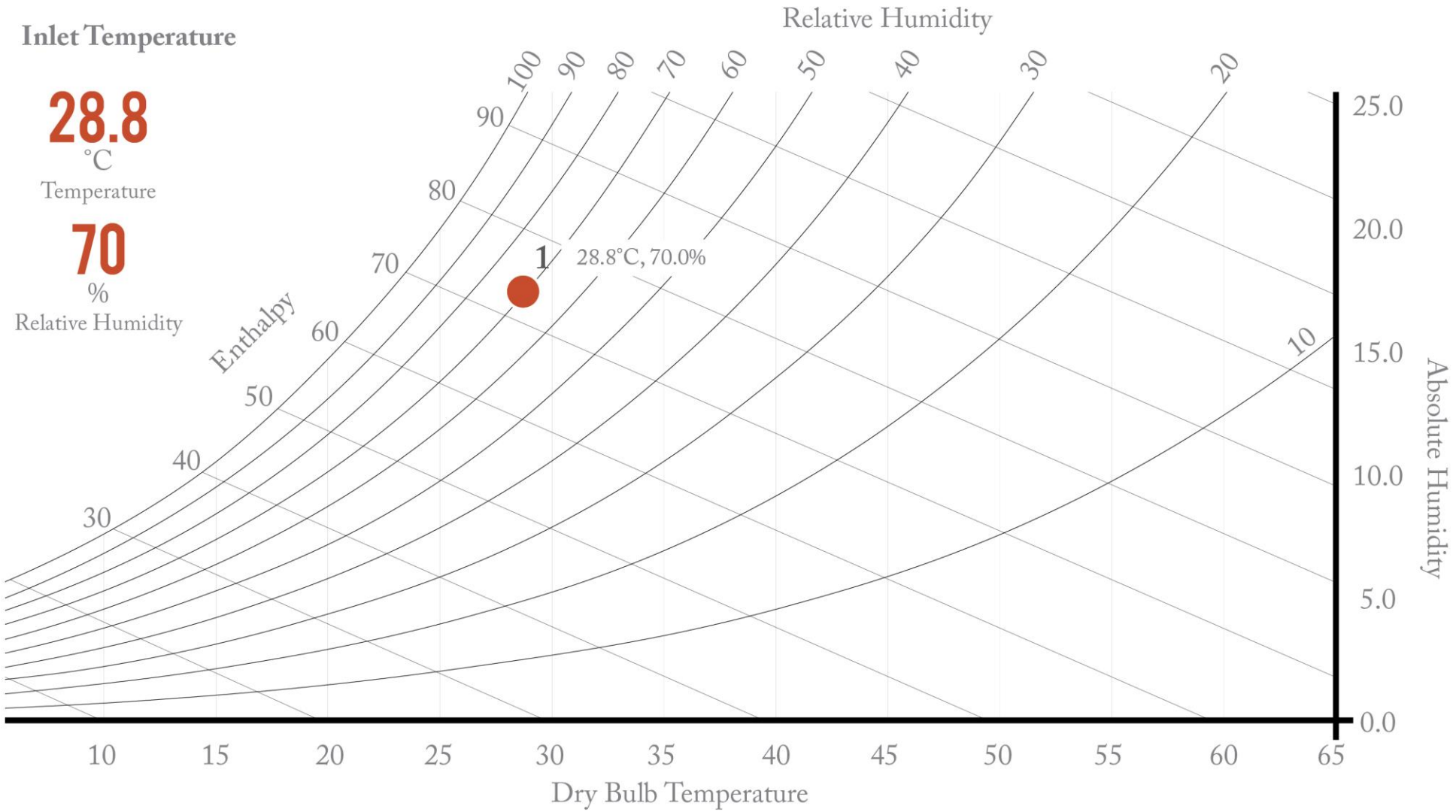
# System Constraints

## System Performance

### 1 Inlet Temperature

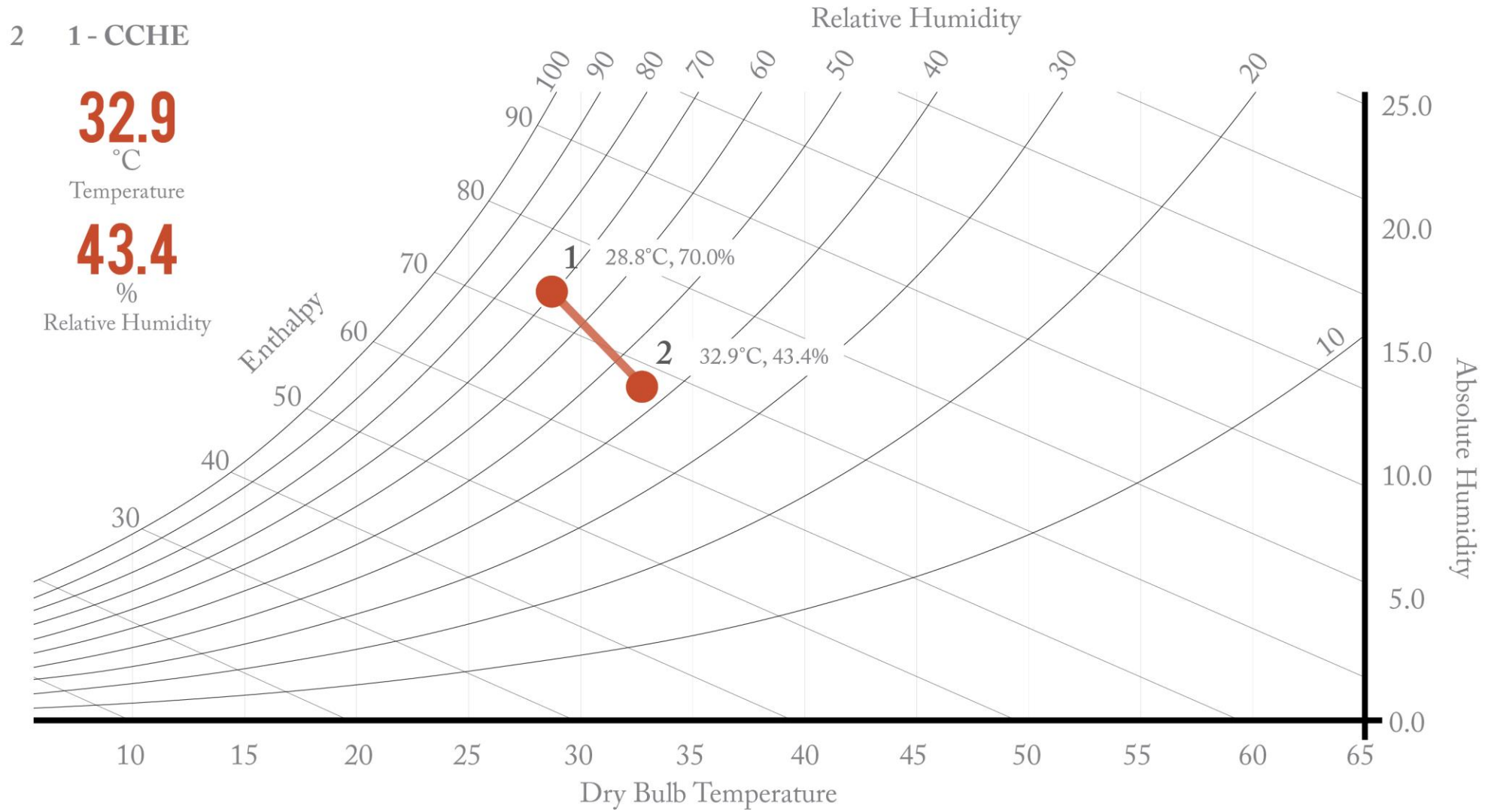
**28.8**
°C
Temperature

**70**
%
Relative Humidity



# System Constraints

## System Performance



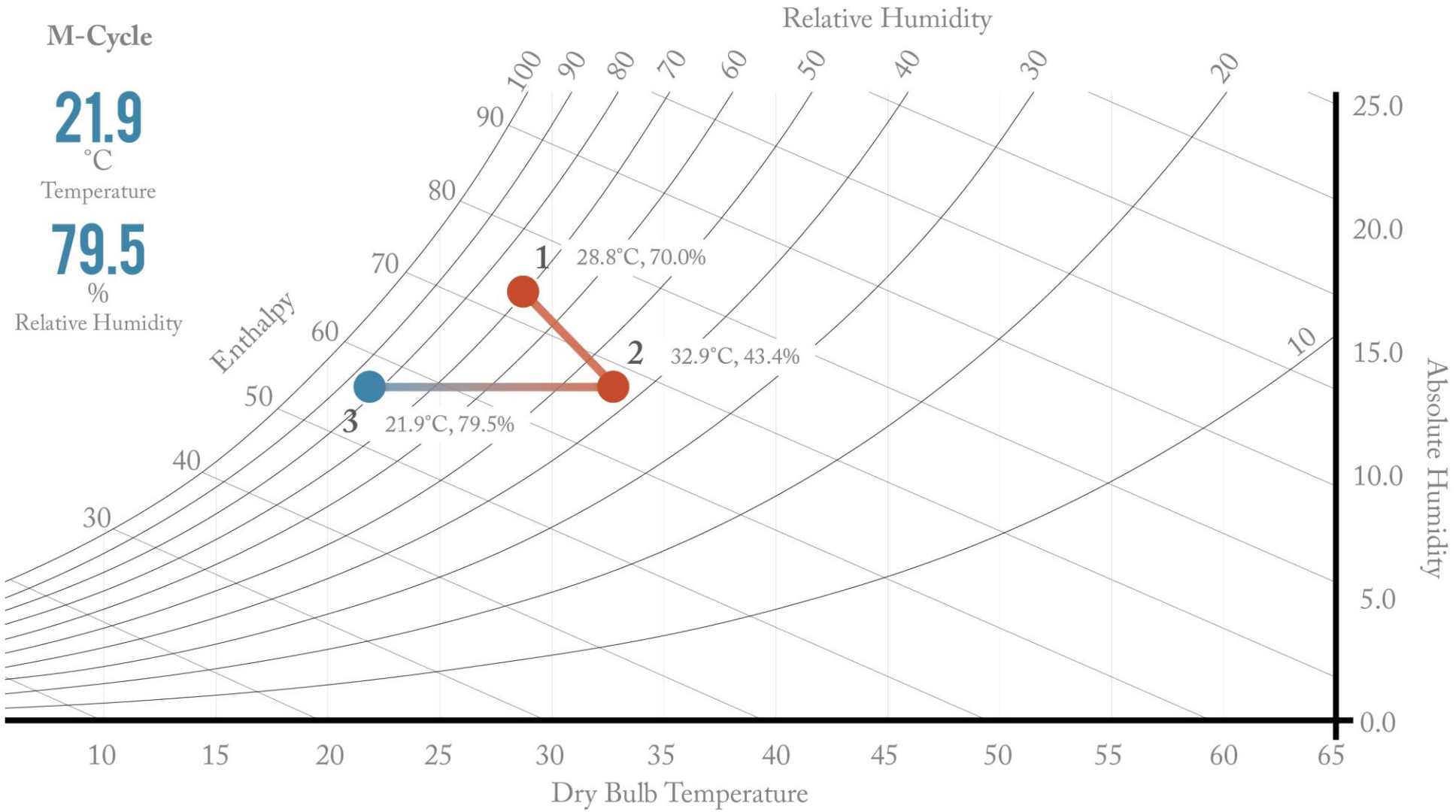
# System Constraints

## System Performance

3 **M-Cycle**

**21.9**
°C
Temperature

**79.5**
%
Relative Humidity



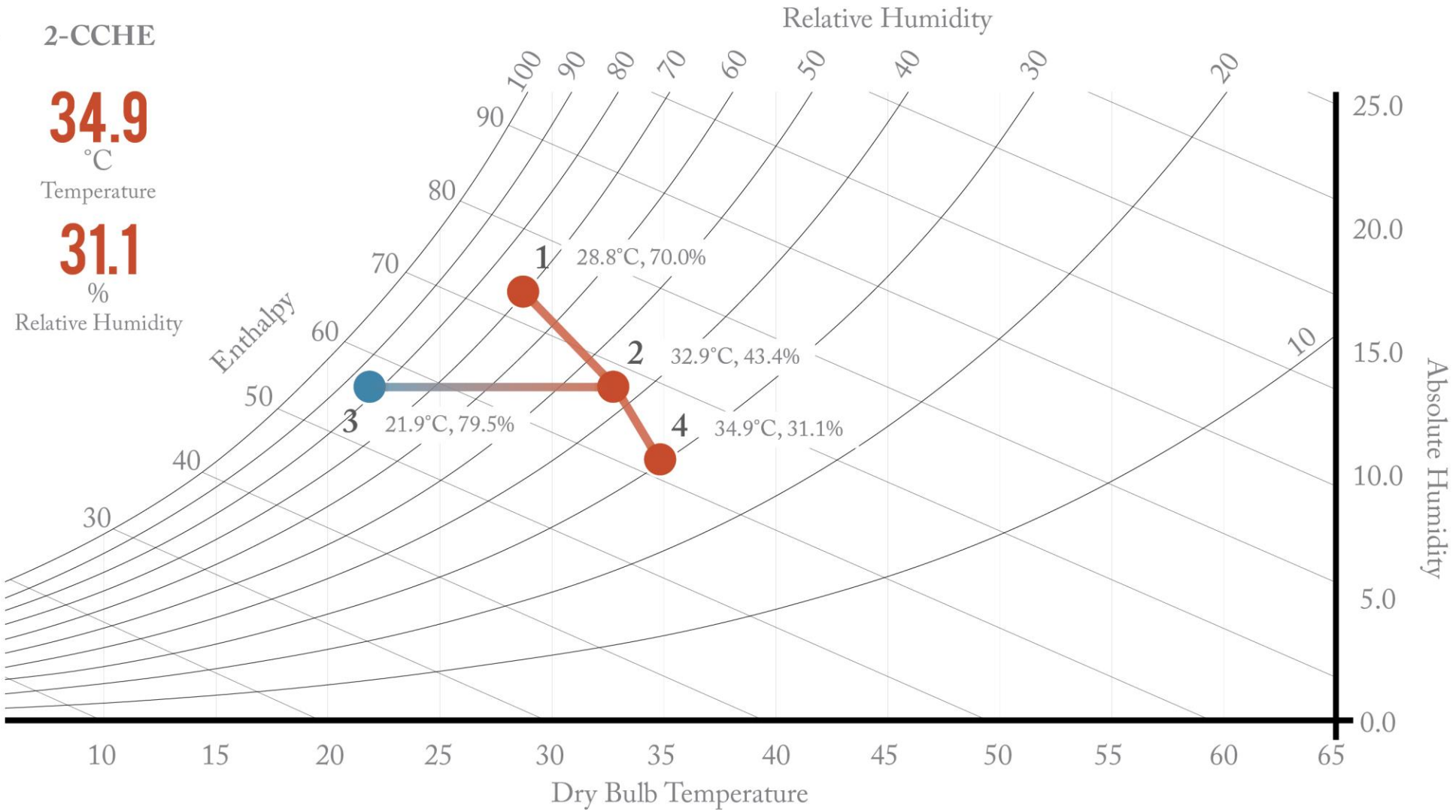
# System Constraints

## System Performance

4 2-CCHE

**34.9**
°C
Temperature

**31.1**
%
Relative Humidity



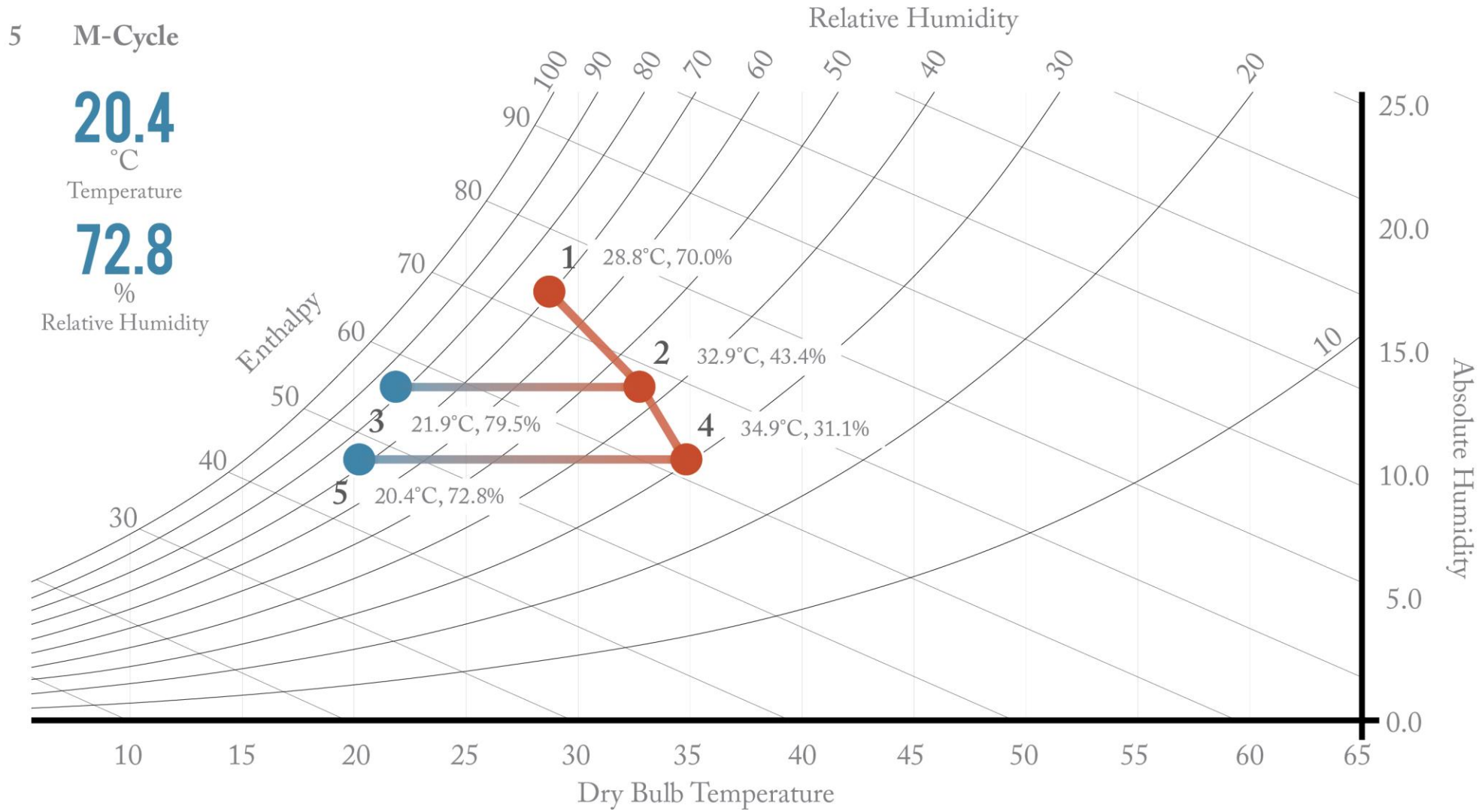
# System Constraints

## System Performance

5 **M-Cycle**

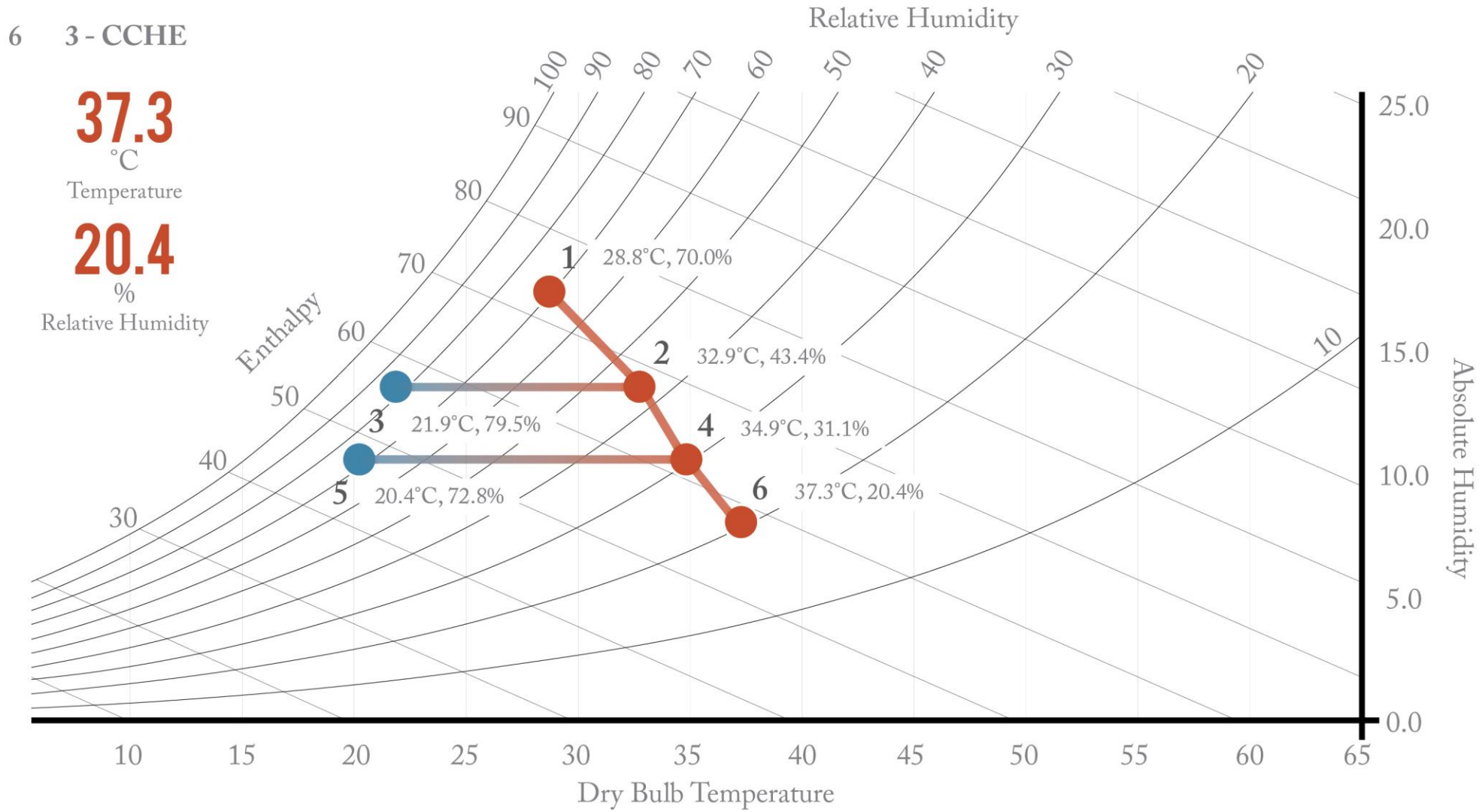
**20.4**
°C
Temperature

**72.8**
%
Relative Humidity



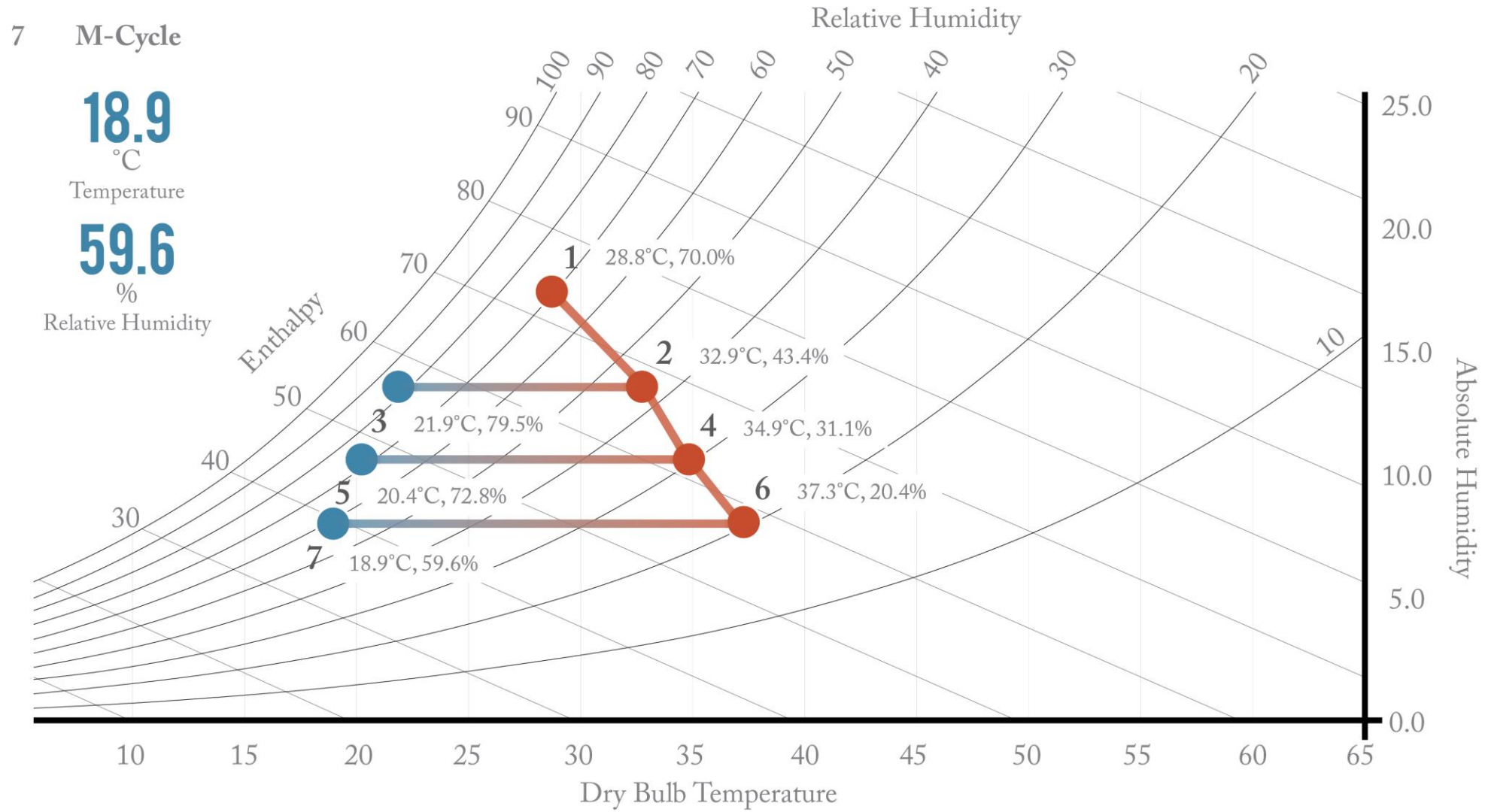
# System Constraints

## System Performance



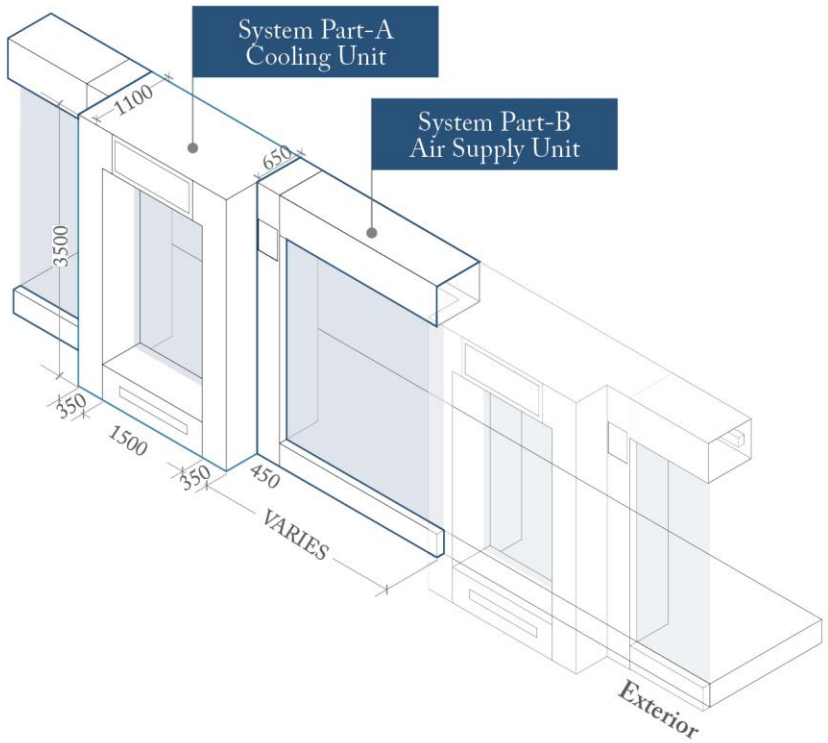
# System Constraints

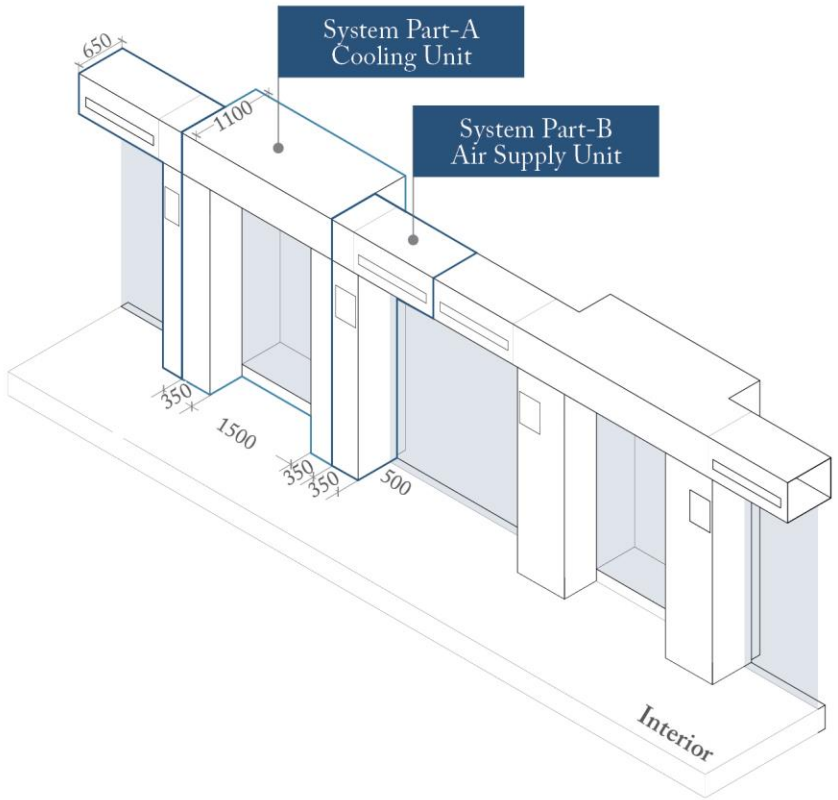
## System Performance



# Design Concept

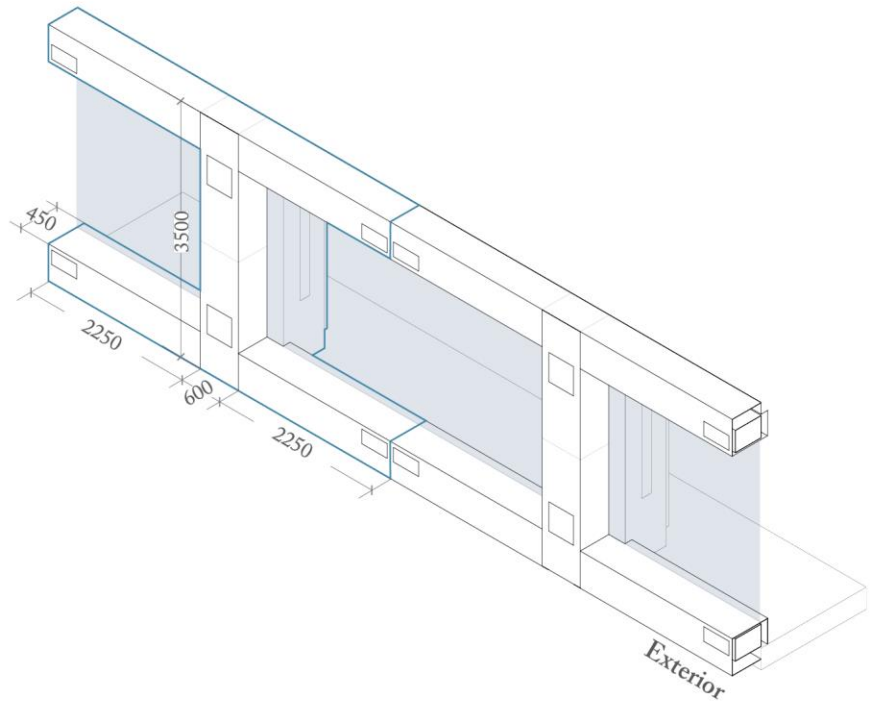
## Concept 1 : Compact System

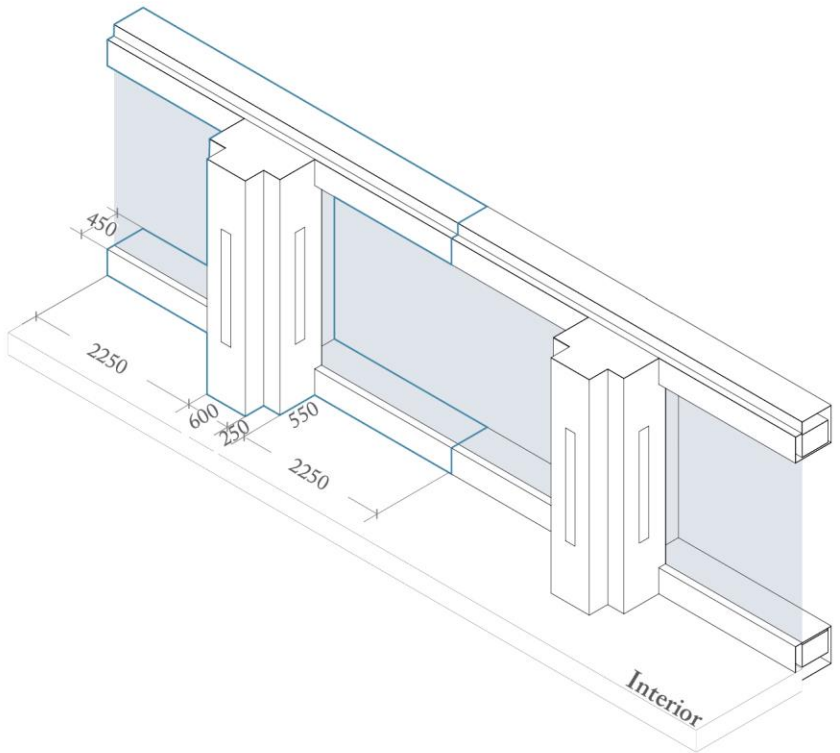


# Design Concept

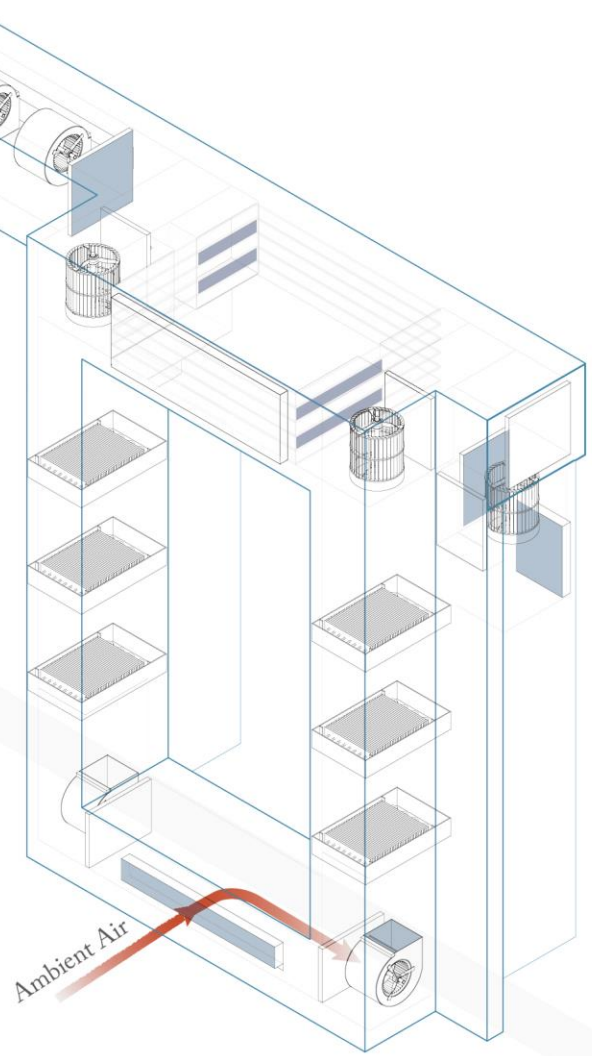
## Concept 2 : Extensive System

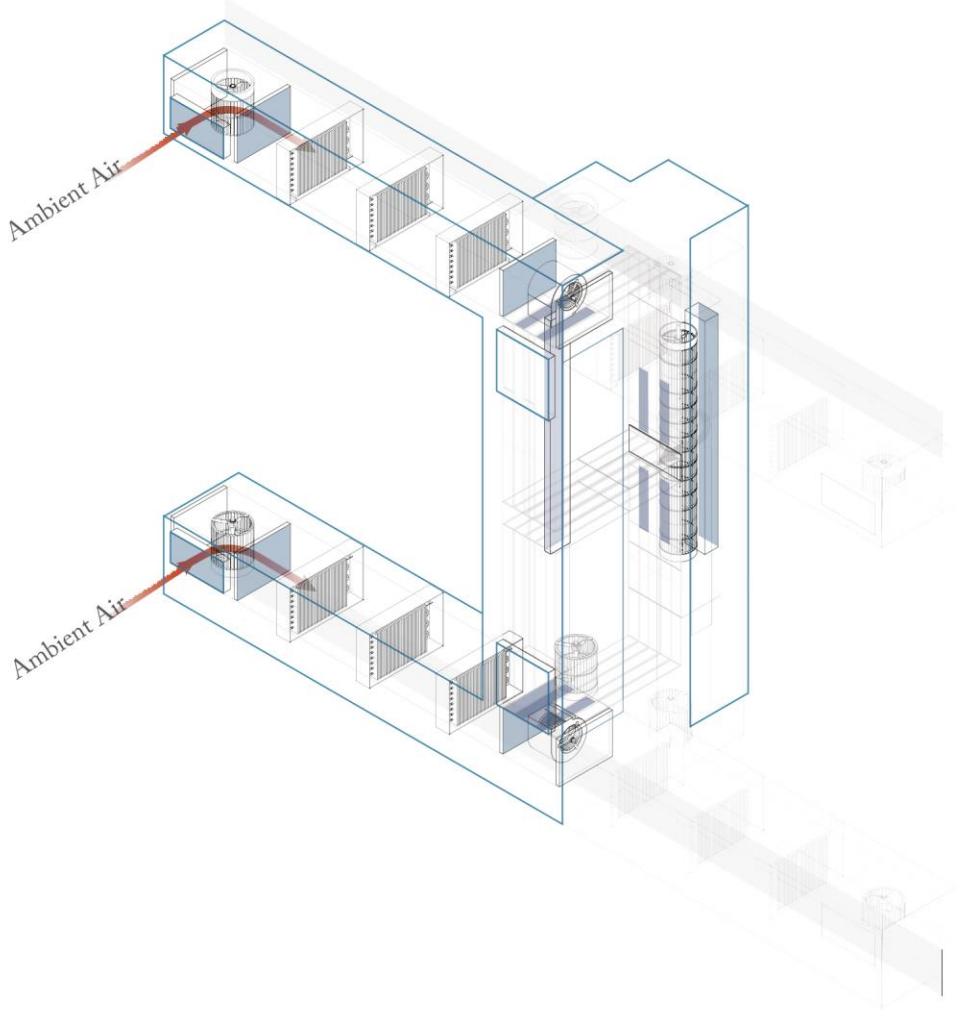


# Supply Air | Schematic Diagram

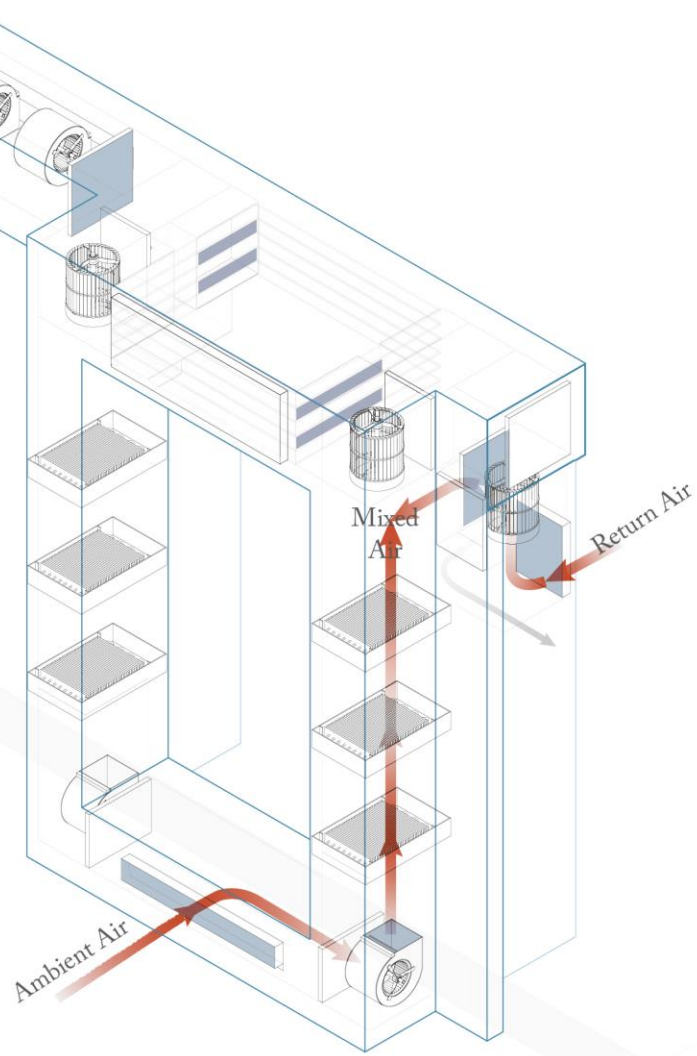
## Inlet Ambient Air

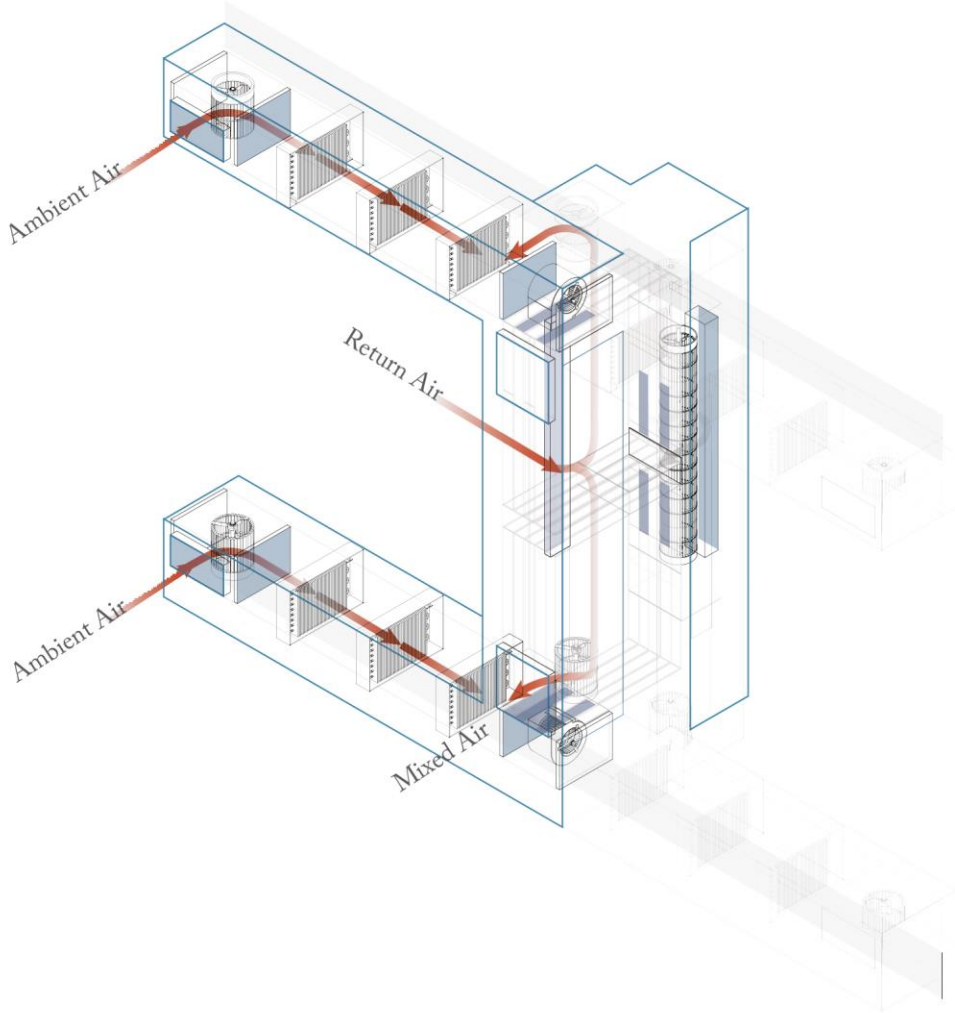


# Supply Air | Schematic Diagram

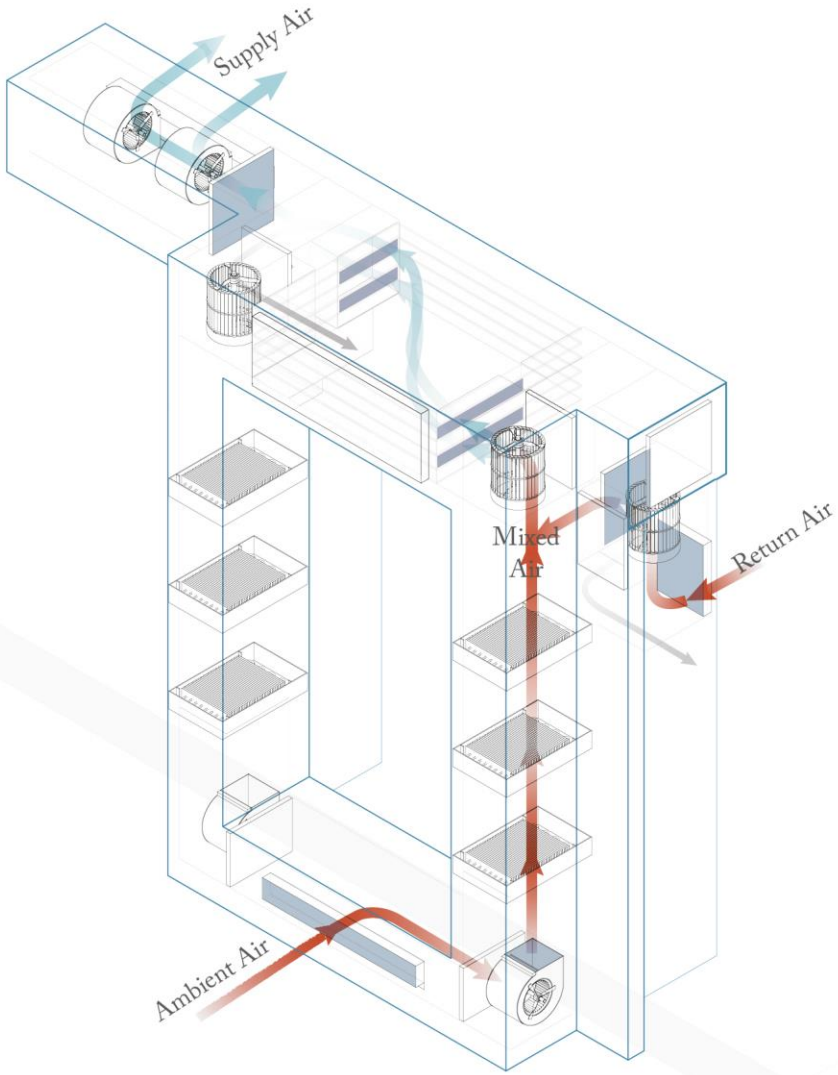
## Mixed with Return Air

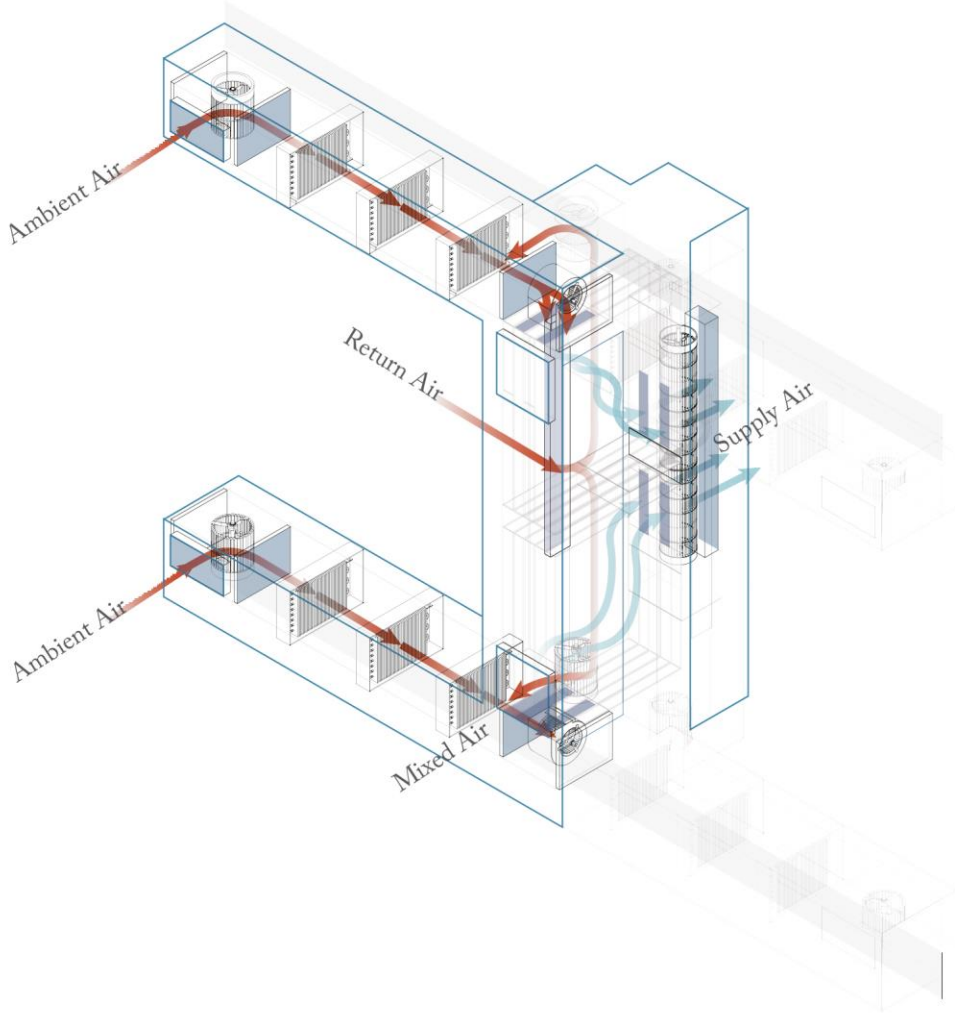


# Supply Air | Schematic Diagram

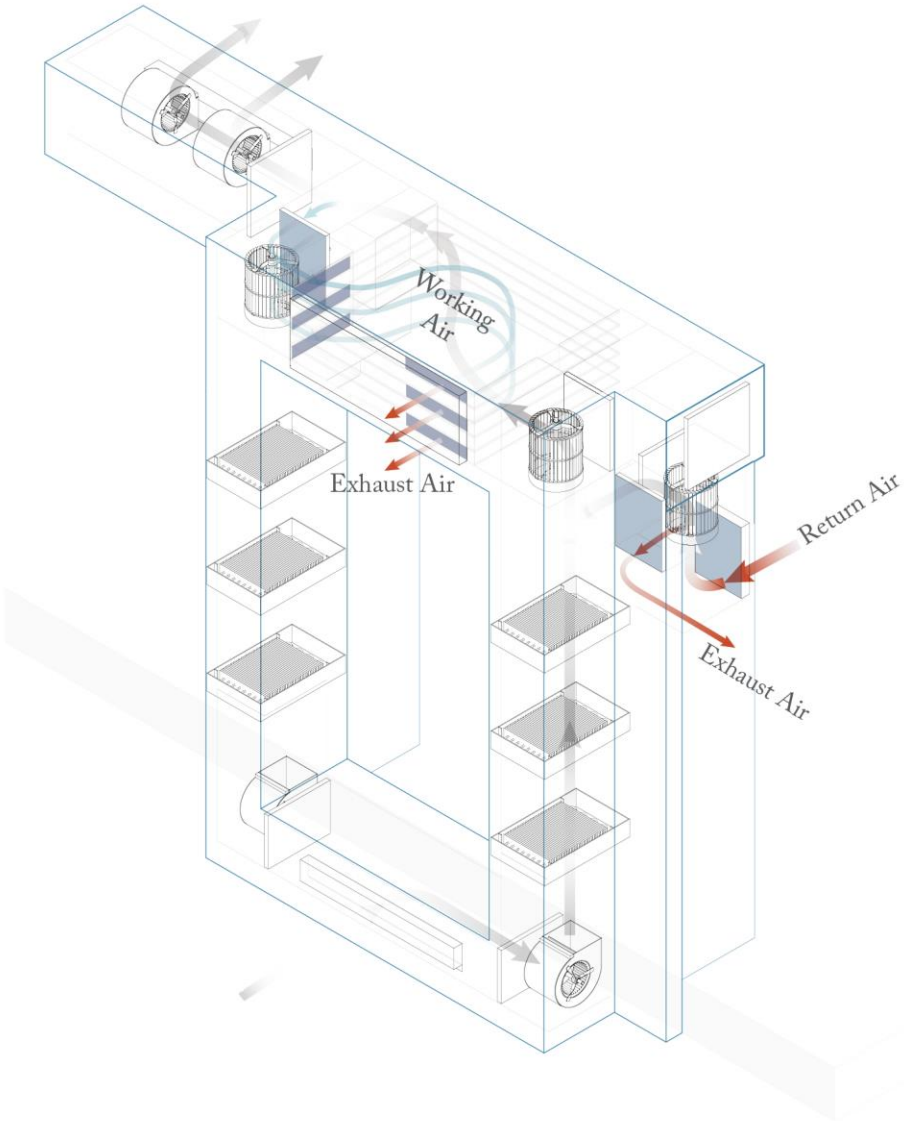
## Supply Air

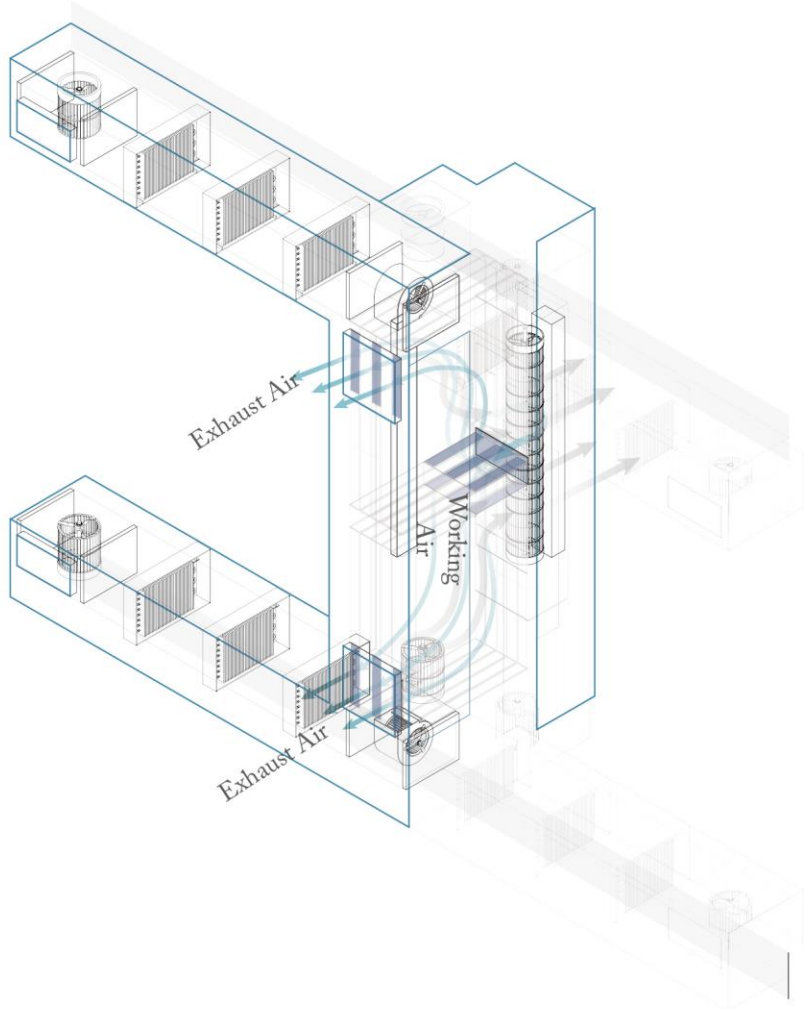


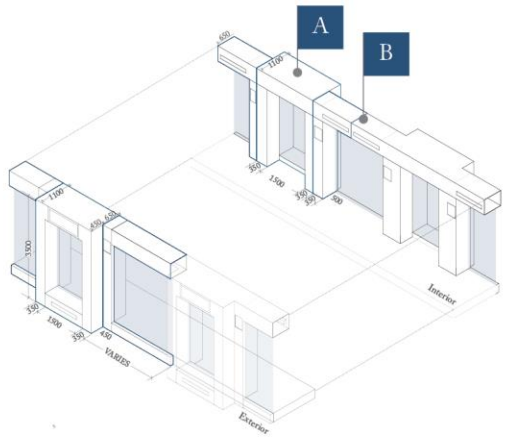
# Exhaust Air | Schematic Diagram

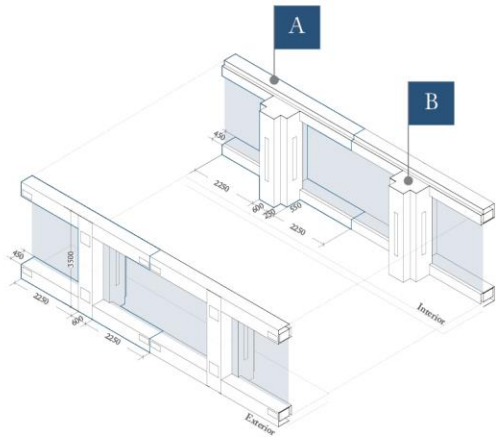
Inlet Ambient Air



# Design Concept
## Design Assessment




| | Exterior Dimension WxLxH (mm) | Interior Dimension WxLxH (mm) | Air Supply Position |
|---|---|---|---|
| **A** | 450 x 2200 x 3500 | 500 x 2200 x 3500 | - |
| **B** | 150 x 2200 x 3500 | 500 x 1800 x 3500 | At Ceiling Level |

**Application Aspect**

| | Exterior Dimension WxLxH (mm) | Interior Dimension WxLxH (mm) | Air Supply Position |
|---|---|---|---|
| **A** | 450 x 5100 x 3500 | - | - |
| **B** | - | 840 x 1100 x 3500 | At Body Level |

**Performance Aspect**

0.42 $m^3/s$
Conditioned Air Volume Flowrate

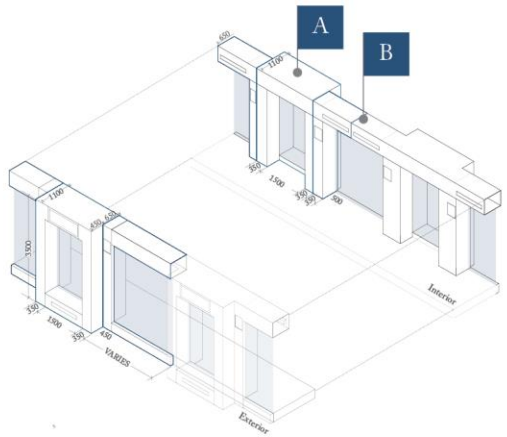
0.84 $m^3/s$
Conditioned Air Volume Flowrate

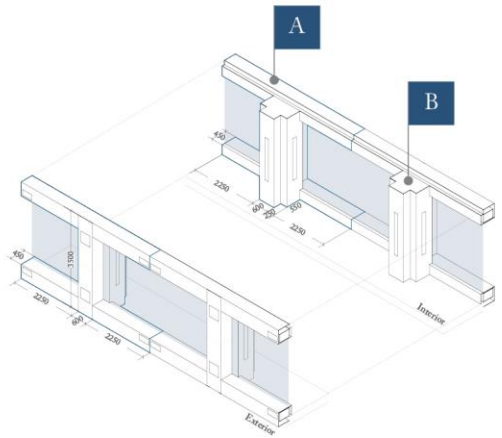
**Window to Wall Ratio**

49%

57%

# Design Concept
## Design Assessment




| | Exterior Dimension WxLxH (mm) | Interior Dimension WxLxH (mm) | Air Supply Position |
|---|---|---|---|
| **A** | 450 x 2200 x 3500 | 500 x 2200 x 3500 | - |
| **B** | 150 x 2200 x 3500 | 500 x 1800 x 3500 | At Ceiling Level |

**Application Aspect**

| | Exterior Dimension WxLxH (mm) | Interior Dimension WxLxH (mm) | Air Supply Position |
|---|---|---|---|
| **A** | 450 x 5100 x 3500 | - | - |
| **B** | - | 840 x 1100 x 3500 | At Body Level |

**Performance Aspect**

0.42 $m^3/s$
Conditioned Air Volume Flowrate

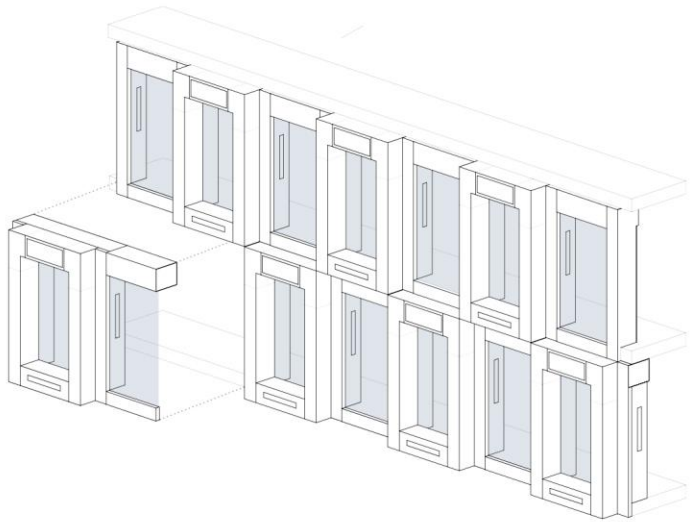
0.84 $m^3/s$
Conditioned Air Volume Flowrate

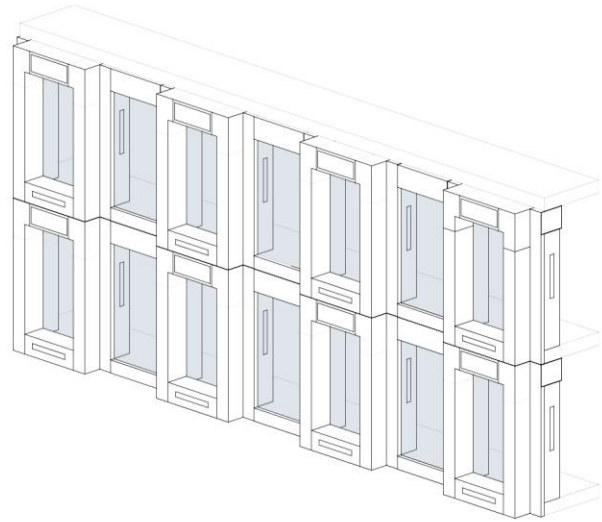
**Window to Wall Ratio**

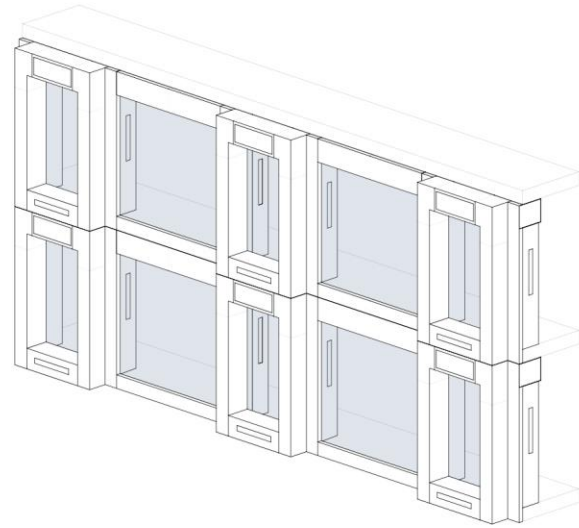
49%

57%

# Design Concept
## Design Assessment

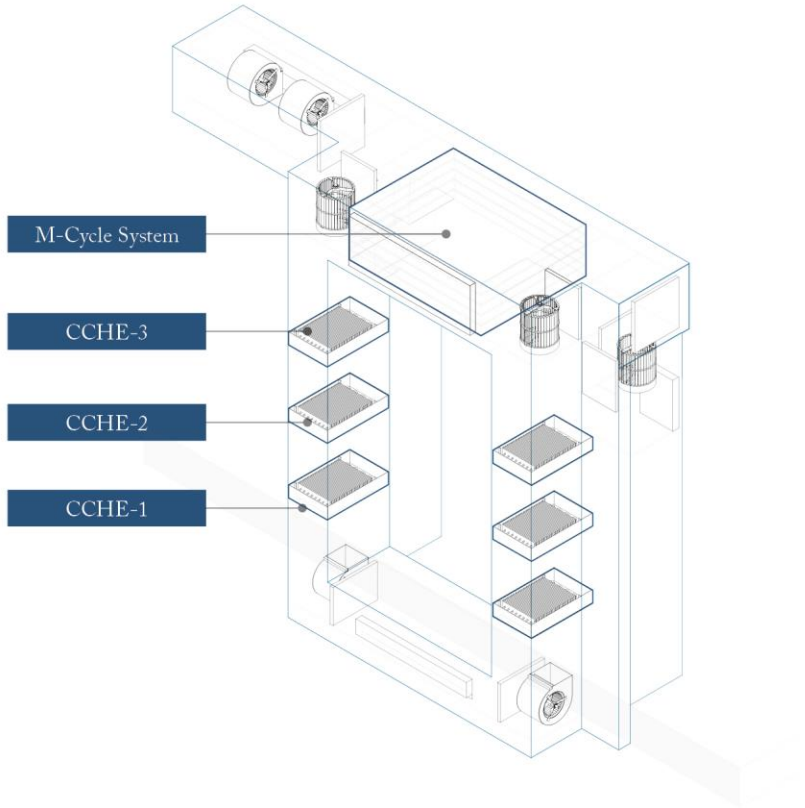






# System Requirement

## Water / Thermal Requirement




## Water Requirement for 3 - CCHE

**Case 1**
200 L/hr

600
L/hr

0.6 $m^3$/hr

**Case 2**
155 L/hr

465
L/hr

0.47 $m^3$/hr

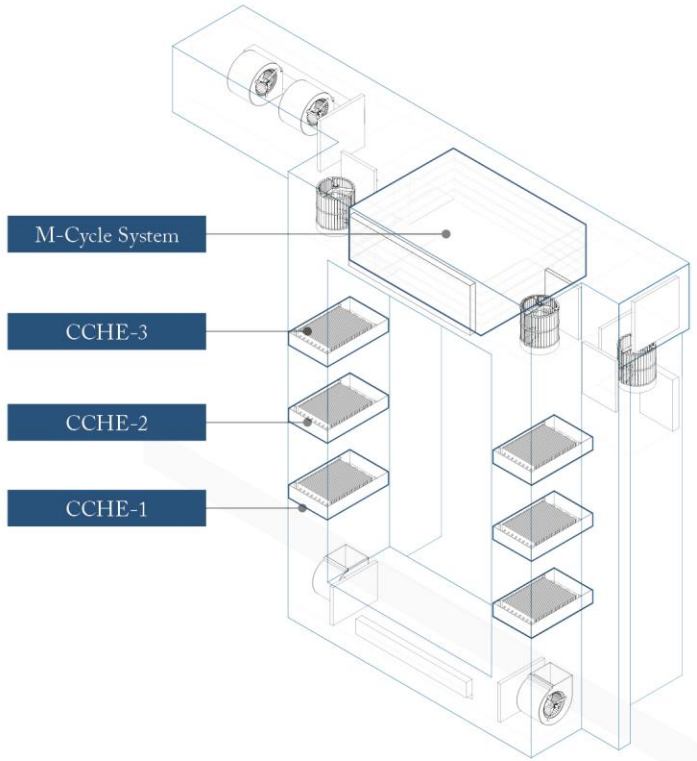
**Case 3**
60 L/hr

180
L/hr

0.18 $m^3$/hr

# System Requirement

## Water / Thermal Requirement




## Water Requirement for 3 - CCHE

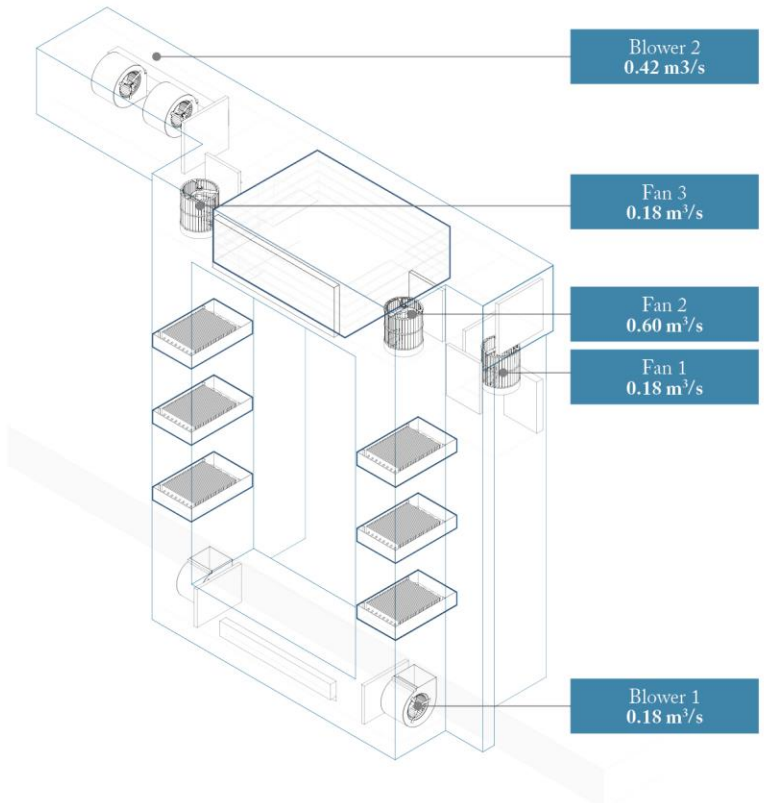
| Case 1 | Case 2 | Case 3 |
|---|---|---|
| 200 L/hr | 155 L/hr | 60 L/hr |
| 600 L/hr | 465 L/hr | 180 L/hr |
| 0.6 $m^3$/hr | 0.47 $m^3$/hr | 0.18 $m^3$/hr |

## Heating Requirement

$Q = V' C\rho (\Delta T)$

| Case 1 | Case 2 | Case 3 |
|---|---|---|
| 200 L/hr | 155 L/hr | 60 L/hr |
| 43.6 kWh/day | 33.8 kWh/day | 13.1 kWh/day |

# System Requirement
## Electricity Requirement



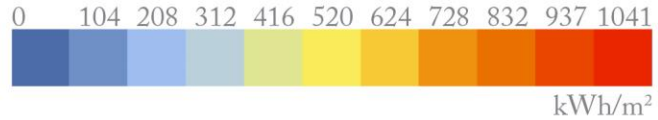

## Electricity Requirement

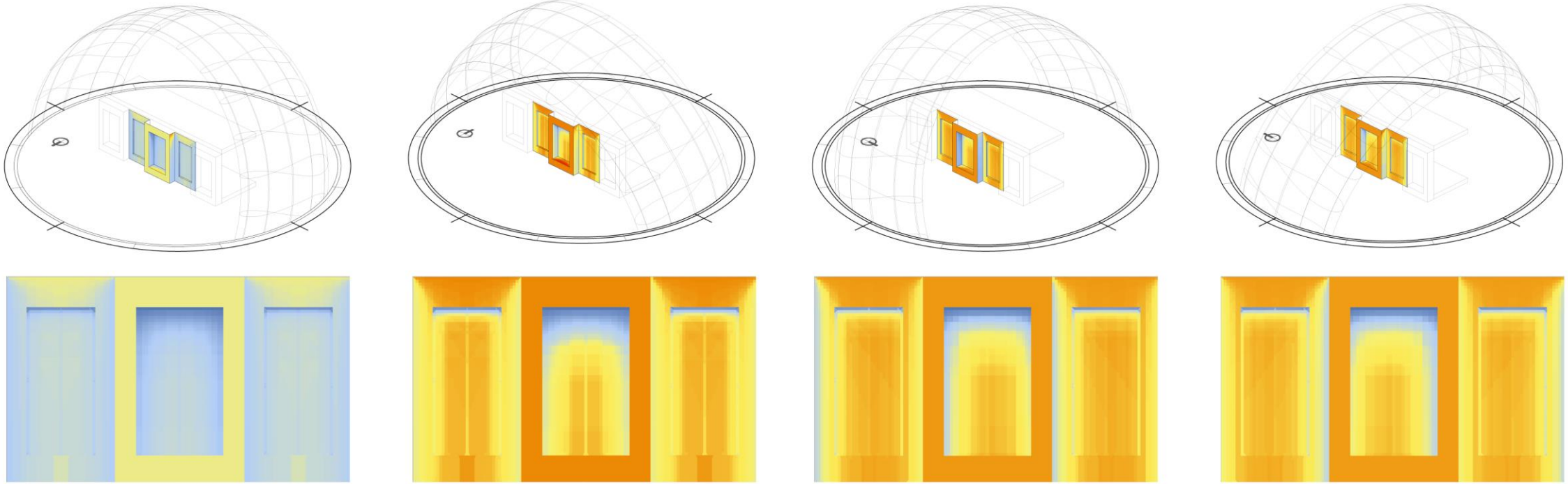
| | Integrated System | | | |
|---|---|---|---|---|
| | Volume Flowrate ($m^3/s$) | Volume Flowrate (cfm) | Energy Consumption (kWh) | Energy Consumption (kWh/day) (11 Hours) |
| **Blower 1** | 0.18 | 381 | 0.128 | 1.4 |
| **Blower 2** | 0.42 | 889 | 0.171 | 1.9 |
| **Fan 1** | 0.18 | 381 | 0.037 | 0.4 |
| **Fan 2** | 0.60 | 1271 | 0.117 | 1.3 |
| **Fan 3** | 0.18 | 381 | 0.037 | 0.4 |

**5.4**
kWh/day

Total Electricity Consumption

# Design Development
## Solar Study



North Facade

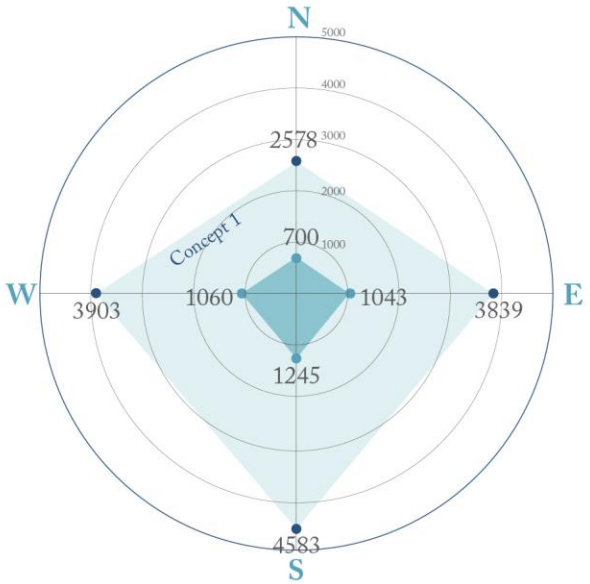
South Facade

East Facade

West Facade

# PVT Integration

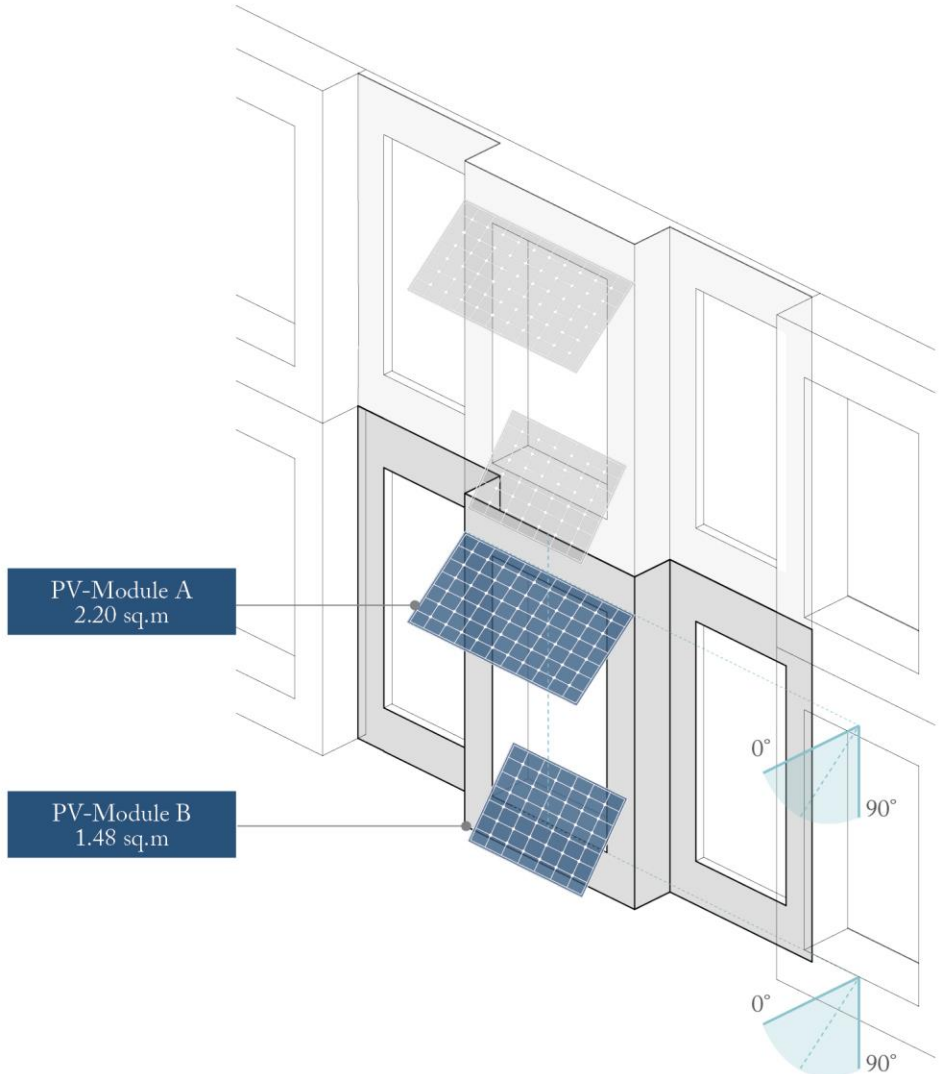
## Concept 1 : Horizontal Panel




### Concept 1 :Horizontal Orientation

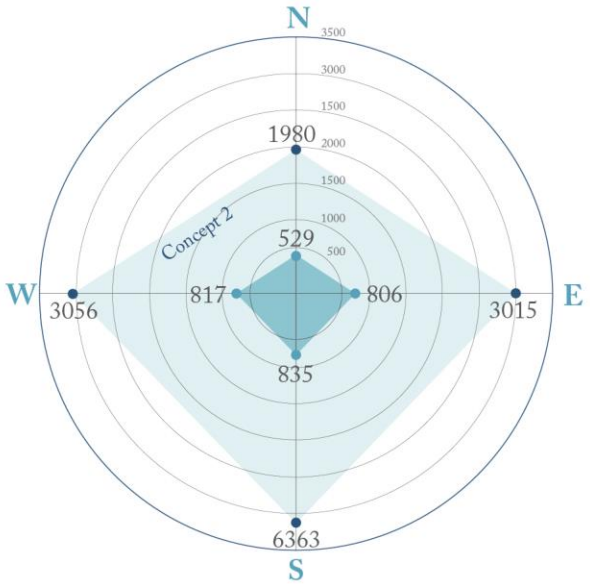
| Total Area | 3.68 sq.m | | | |
|---|---|---|---|---|
| Optimal HSA (°) | **N** | **E** | **S** | **W** |
| Module A | 27 | 41 | 34 | 42 |
| Module B | 56 | 57 | 48 | 54 |
| Average Daily Radiation (kWh) | 7.1 | 10.5 | 12.6 | 10.5 |

| **PVT Performance** | **N** | **E** | **S** | **W** |
|---|---|---|---|---|
| Average Daily AC Energy (kWh) | 1.2 | 1.4 | 1.6 | 1.4 |
| Average Daily Thermal Energy (kWh) | 4.9 | 7.5 | 8.8 | 7.4 |



# PVT Integration

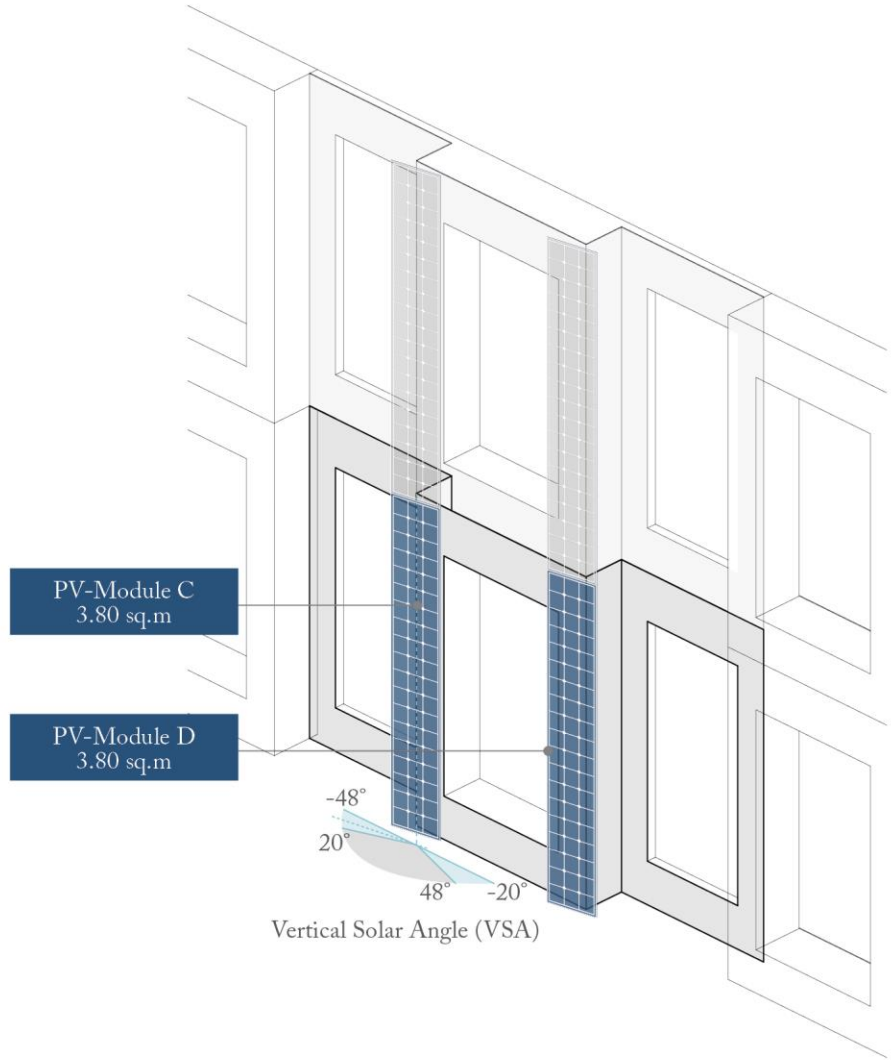
## Concept 2 : Vertical Panel




### Concept 2 : Vertical Orientation

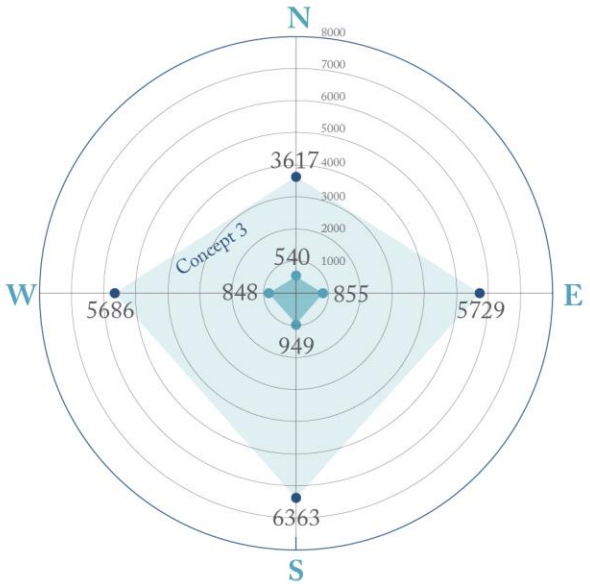
| Total Area | 3.74 sq.m | | | |
|---|---|---|---|---|
| Optimal HSA (°) | **N** | **E** | **S** | **W** |
| Module C | 312 | 109 | 161 | 243 |
| Module D | 48 | 115 | 158 | 251 |
| Average Daily Radiation (kWh) | 5.4 | 8.4 | 8.6 | 8.3 |

| PVT Performance | N | E | S | W |
|---|---|---|---|---|
| Average Daily AC Energy (kWh) | 0.7 | 0.9 | 0.9 | 0.9 |
| Average Daily Thermal Energy (kWh) | 3.8 | 5.9 | 6.0 | 5.8 |



# PVT Integration

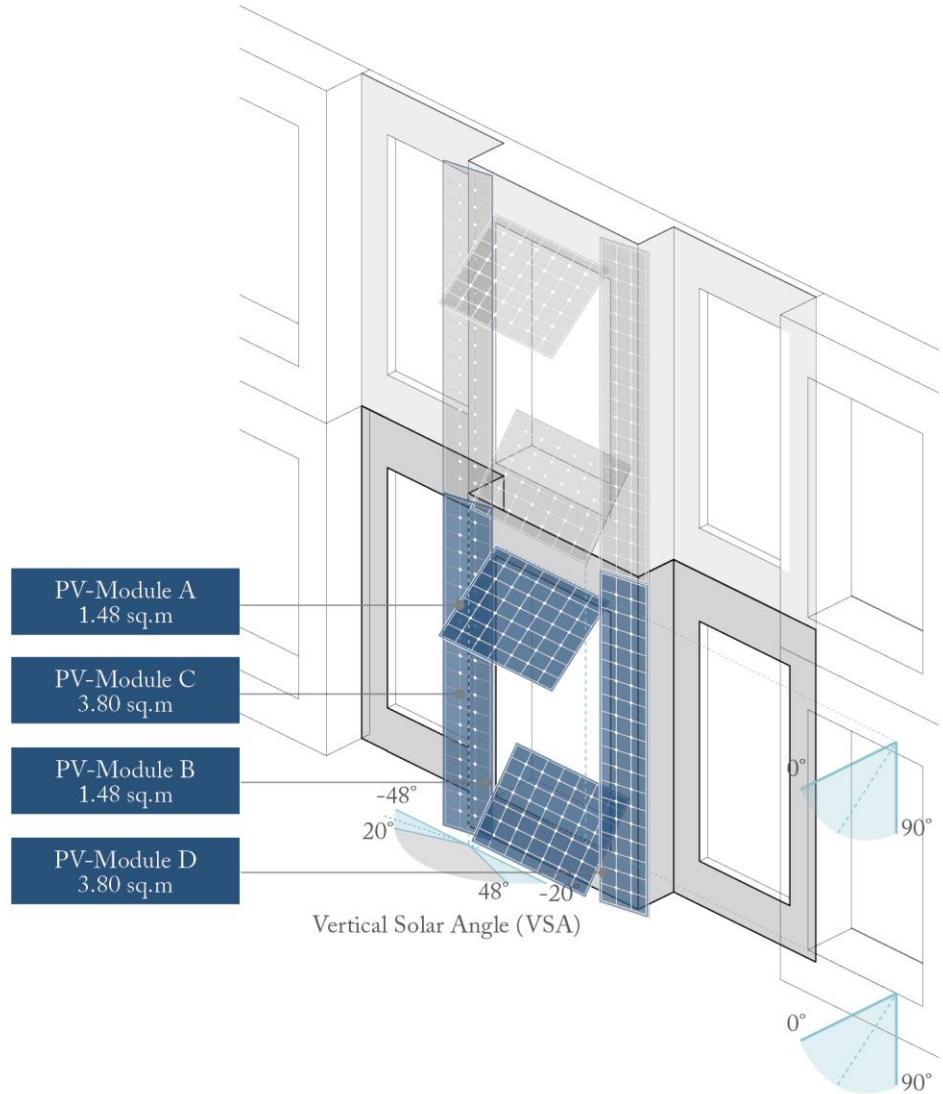
## Concept 3 : Mixed Panel




### Concept 3 : Horizontal + Vertical Orientation

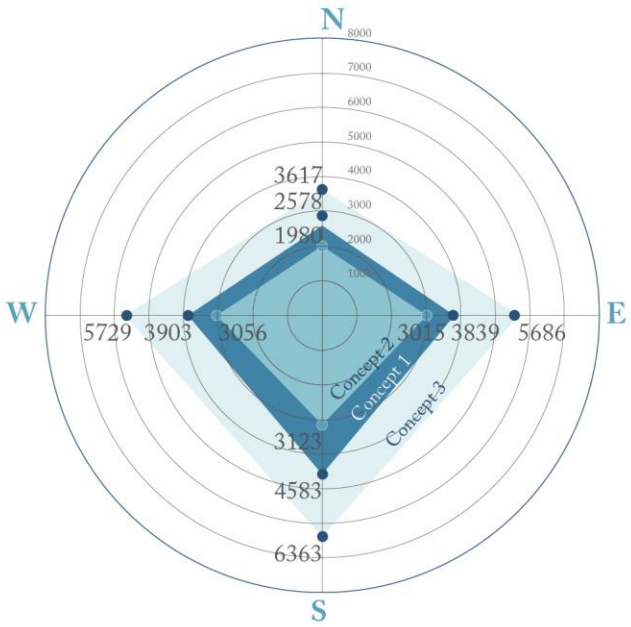
| Total Area | 6.70 sq.m | | | |
|---|---|---|---|---|
| Optimal HSA (°) | **N** | **E** | **S** | **W** |
| Module A | 35 | 47 | 32 | 41 |
| Module B | 56 | 51 | 56 | 61 |
| Module C | 48 | 111 | 199 | 262 |
| Module D | 312 | 110 | 168 | 247 |
| Average Daily Radiation (kWh) | 9.9 | 15.7 | 17.4 | 15.6 |

| PVT Performance | N | E | S | W |
|---|---|---|---|---|
| Average Daily AC Energy (kWh) | 1.6 | 2.0 | 2.1 | 1.9 |
| Average Daily Thermal Energy (kWh) | 6.9 | 11.0 | 12.2 | 10.9 |

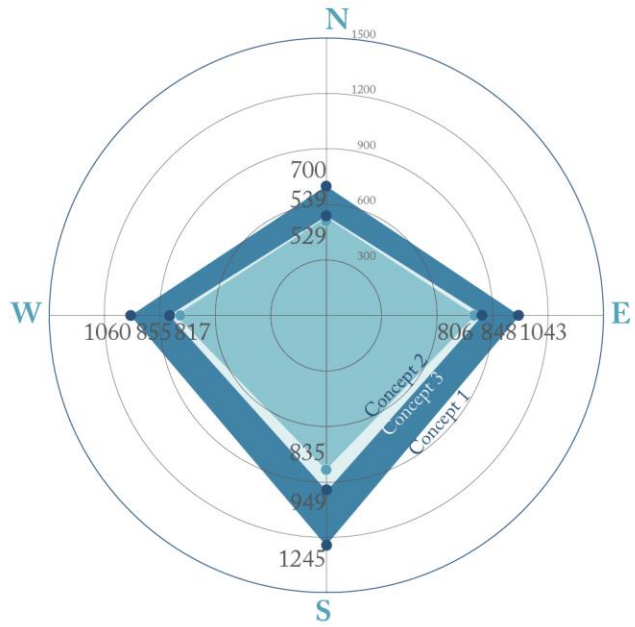


# PVT Integration

## Solar Radiation Assessment




**Annual Total Solar Radiation (kWh)**



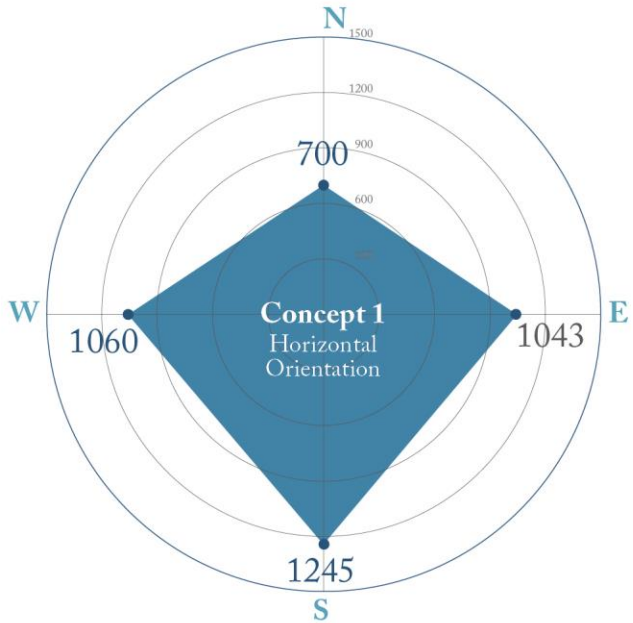

**Annual Average Solar Radiation per sq.m (kWh/m²)**

| | Concept 1 Horizontal Orientation | | | | Concept 2 Vertical Orientation | | | | Concept 3 Horizontal + Vertical Orientation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Area | 3.68 sq.m | | | | 3.74 sq.m | | | | 6.70 sq.m | | | |
| | N | E | S | W | N | E | S | W | N | E | S | W |
| Average Daily Radiation (kWh) | 7.1 | 10.7 | 12.6 | 10.5 | 5.4 | 8.4 | 8.6 | 8.3 | 9.9 | 15.7 | 17.4 | 15.6 |
| Average Daily Radiation per m² (kWh/m²) | 1.9 | 2.9 | 3.4 | 2.9 | 1.4 | 1.1 | 1.1 | 1.1 | 1.5 | 2.3 | 2.6 | 2.3 |

| PVT Performance | N | E | S | W | N | E | S | W | N | E | S | W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Daily AC Energy (kWh) | 1.2 | 1.4 | 1.6 | 1.4 | 0.7 | 0.9 | 0.9 | 0.9 | 1.6 | 2.0 | 2.1 | 1.9 |
| Average Daily Thermal Energy (kWh) | 4.9 | 7.5 | 8.8 | 7.4 | 3.8 | 5.9 | 6.0 | 5.8 | 6.9 | 11.0 | 12.2 | 10.9 |

# PVT Integration

## Solar Radiation Assessment



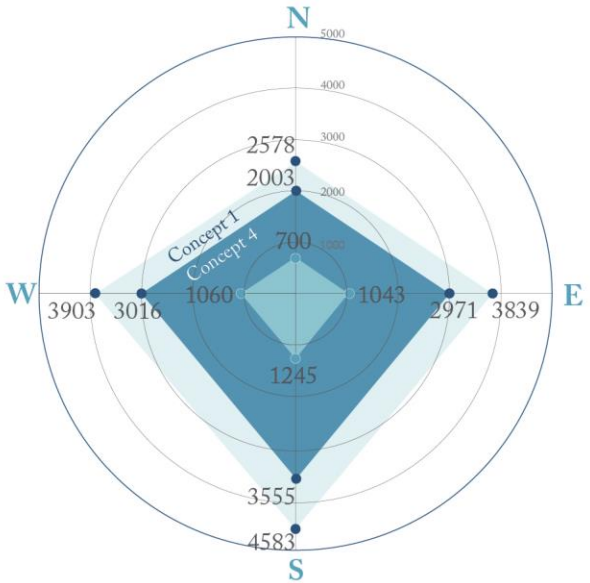

**Annual Average Solar Radiation per sq.m (kWh/m²)**

| | **Concept 1** Horizontal Orientation | | | | **Concept 2** Vertical Orientation | | | | **Concept 3** Horizontal + Vertical Orientation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Area | **3.68 sq.m** | | | | 3.74 sq.m | | | | 6.70 sq.m | | | |
| | **N** | **E** | **S** | **W** | N | E | S | W | N | E | S | W |
| Average Daily Radiation (kWh) | 7.1 | 10.7 | 12.6 | 10.5 | 5.4 | 8.4 | 8.6 | 8.3 | 9.9 | 15.7 | 17.4 | 15.6 |
| Average Daily Radiation per m² (kWh/m²) | 1.9 | 2.9 | 3.4 | 2.9 | 1.4 | 1.1 | 1.1 | 1.1 | 1.5 | 2.3 | 2.6 | 2.3 |

| **PVT Performance** | **N** | **E** | **S** | **W** | N | E | S | W | N | E | S | W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Daily AC Energy (kWh) | 1.2 | 1.4 | 1.6 | 1.4 | 0.7 | 0.9 | 0.9 | 0.9 | 1.6 | 2.0 | 2.1 | 1.9 |
| Average Daily Thermal Energy (kWh) | 4.9 | 7.5 | 8.8 | 7.4 | 3.8 | 5.9 | 6.0 | 5.8 | 6.9 | 11.0 | 12.2 | 10.9 |

# PVT Integration

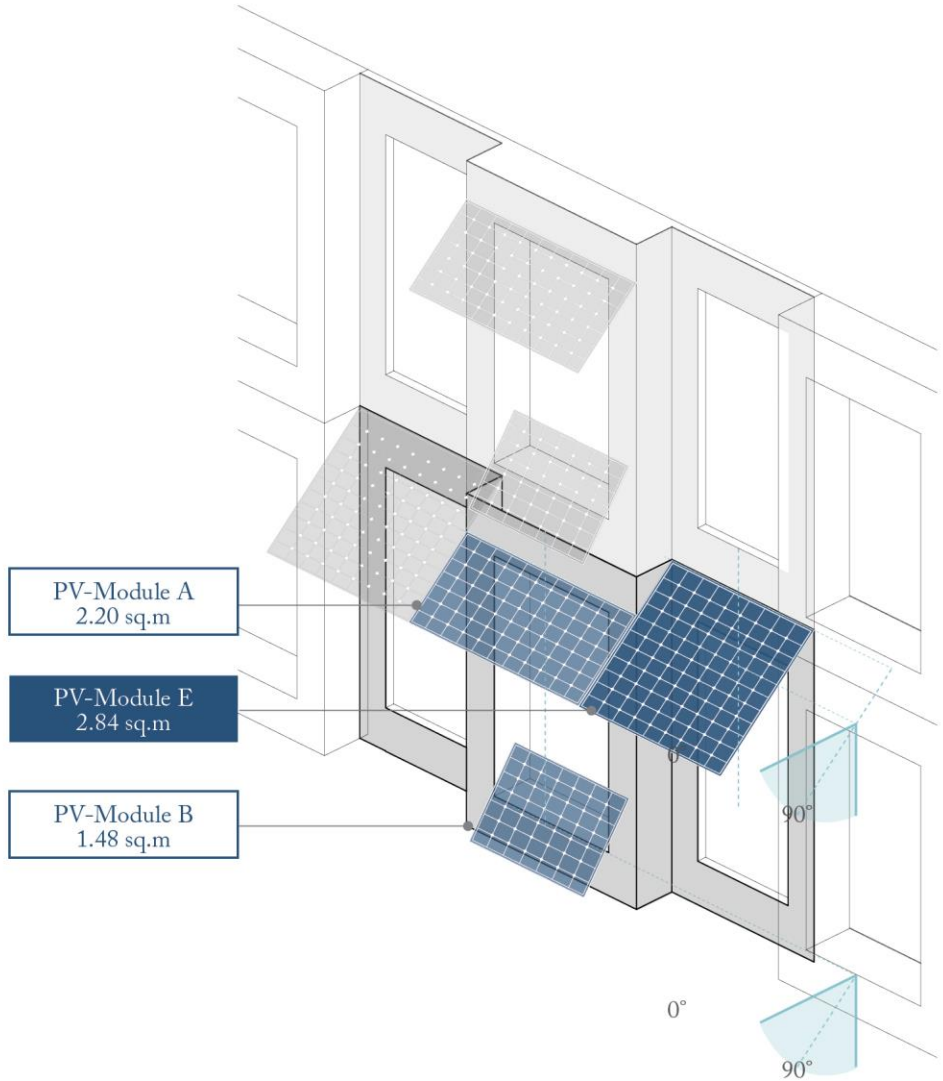
## Concept 4 : Additional Module




### Concept 4 : Additional Horizontal Orientation

| Total Area | **2.84 sq.m** (6.52 sq.m) | | | |
|---|---|---|---|---|
| HSA (°) | **N** | **E** | **S** | **W** |
| Module E | 27 | 41 | 34 | 42 |
| Average Daily Radiation (kWh) | 5.5 | 8.3 | 9.7 | 8.1 |

| **PVT Performance** | **N** | **E** | **S** | **W** |
|---|---|---|---|---|
| Average Daily AC Energy (kWh) | 1.1 | 1.1 | 1.3 | 1.1 |
| Combined with Concept 1 (kWh) | 2.3 | 2.5 | 2.9 | 2.5 |
| Average Daily Thermal Energy (kWh) | 3.8 | 5.8 | 6.8 | 5.7 |
| Combined with Concept 1 (kWh) | 8.7 | 13.3 | 15.6 | 13.1 |



# PVT Integration

## Energy Assessment

### Thermal Energy Requirements (kW/day)

| | N | E | S | W |
|---|---|---|---|---|
| Energy Production | 8.7 | 13.3 | 15.6 | 13.1 |
| Concept 1 + 4 | 1.34 kW/m² | 2.04 kW/m² | 2.39 kW/m² | 2.00 kW/m² |
| Case 1 Energy Required: | -34.9 | -30.3 | -28 | -25 |
| Case 1 Area Required: | +26.04 m² | +14.85 m² | +11.72 m² | +12.5 m² |
| Case 2 Energy Required: | -25.1 | -22.5 | -18.2 | -20.7 |
| Case 2 Area Required: | +18.73 m² | +6.52 m² | +6.53 m² | +10.35 m² |
| Case 3 Energy Required: | -4.4 | +0.2 | +2.5 | +0.0 |
| Case 3 Area Required: | +3.28 m² | - | - | - |

### Electricity Requirements (kW/day)

| | N | E | S | W |
|---|---|---|---|---|
| Energy Production | 2.3 | 2.5 | 2.9 | 2.5 |
| | 0.35 kW/m² | 0.39 kW/m² | 0.46 kW/m² | 0.39 kW/m² |
| Energy Required: | -3.1 | -2.9 | -2.5 | -2.9 |
| Area Required: | +7.95 m² | +7.44 m² | +5.4 m² | +7.44 m² |

# PVT Integration

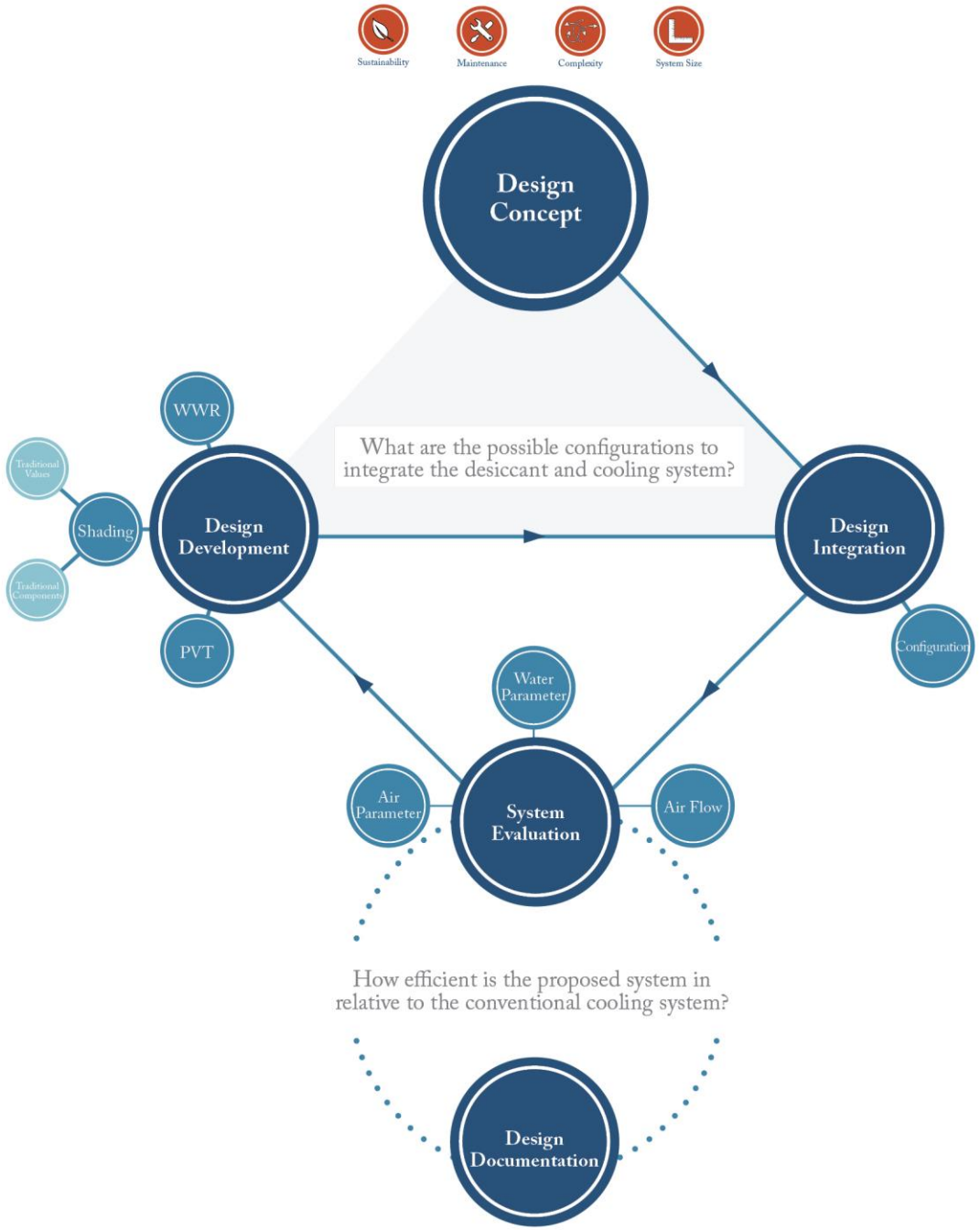
## Energy Assessment

### Thermal Energy Requirements (kW/day)

| | N | E | S | W |
|---|---|---|---|---|
| Energy Production | 8.7 | 13.3 | 15.6 | 13.1 |
| Concept 1 + 4 | 1.34 kW/m² | 2.04 kW/m² | 2.39 kW/m² | 2.00 kW/m² |
| Case 1 Energy Required: | -34.9 | -30.3 | -28 | -25 |
| Case 1 Area Required: | +26.04 m² | +14.85 m² | +11.72 m² | +12.5 m² |
| Case 2 Energy Required: | -25.1 | -22.5 | -18.2 | -20.7 |
| Case 2 Area Required: | +18.73 m² | +6.52 m² | +6.53 m² | +10.35 m² |
| Case 3 Energy Required: | -4.4 | +0.2 | +2.5 | +0.0 |
| Case 3 Area Required: | +3.28 m² | - | - | - |

### Electricity Requirements (kW/day)

| | N | E | S | W |
|---|---|---|---|---|
| Energy Production | 2.3 | 2.5 | 2.9 | 2.5 |
| | 0.35 kW/m² | 0.39 kW/m² | 0.46 kW/m² | 0.39 kW/m² |
| Energy Required: | -3.1 | -2.9 | -2.5 | -2.9 |
| Area Required: | +7.95 m² | +7.44 m² | +5.4 m² | +7.44 m² |


Sustainability
Maintenance
Complexity
System Size
Design Concept
What are the possible configurations to integrate the desiccant and cooling system?
WWR
Traditional Values
Shading
Traditional Components
Design Development
PVT
Design Integration
Configuration
Water Parameter
Air Parameter
System Evaluation
Air Flow
How efficient is the proposed system in relative to the conventional cooling system?
Design Documentation

# Design Application

## Integration to Benchmark

# Benchmark

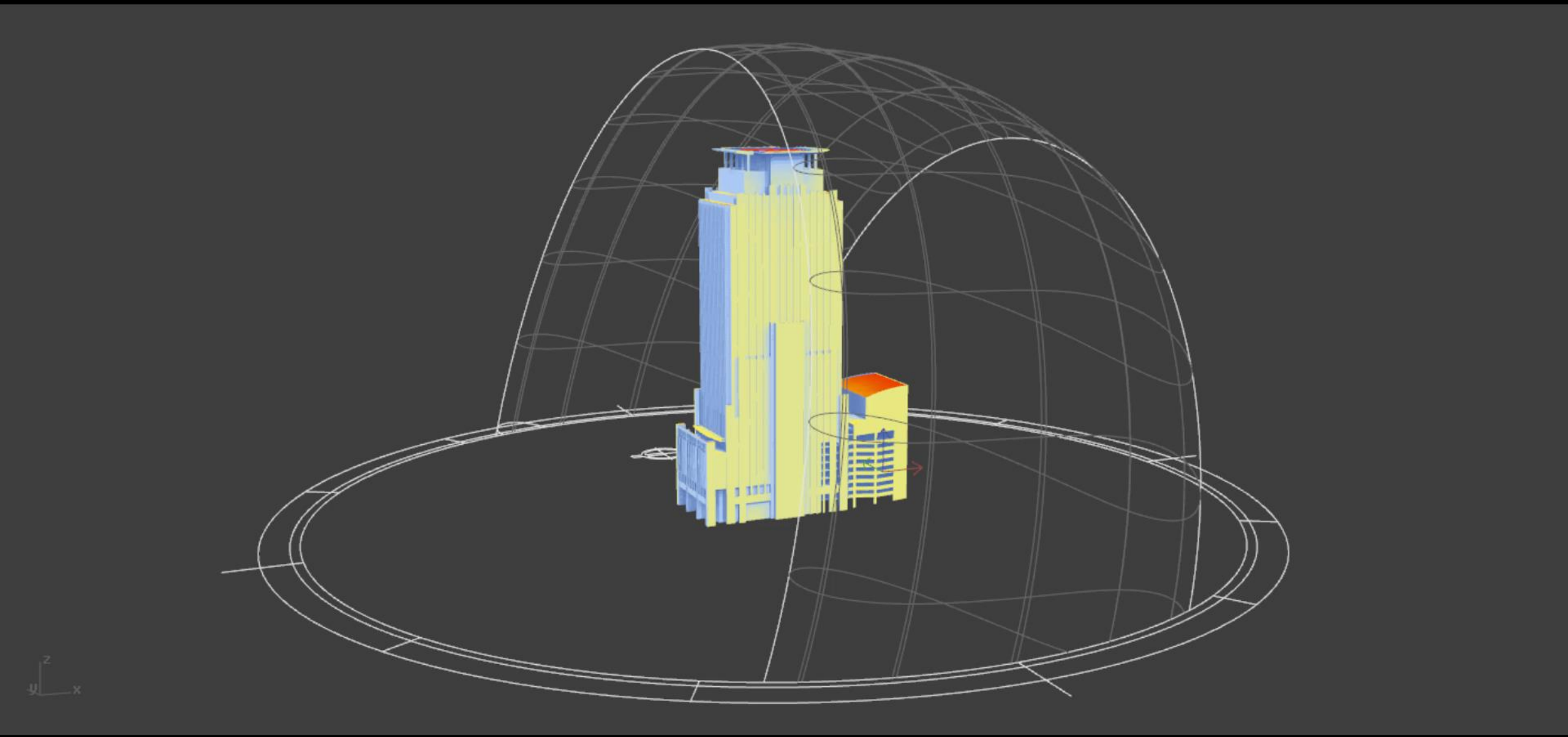
## Krungthai Bank - Sukhumvit Building

### General Information

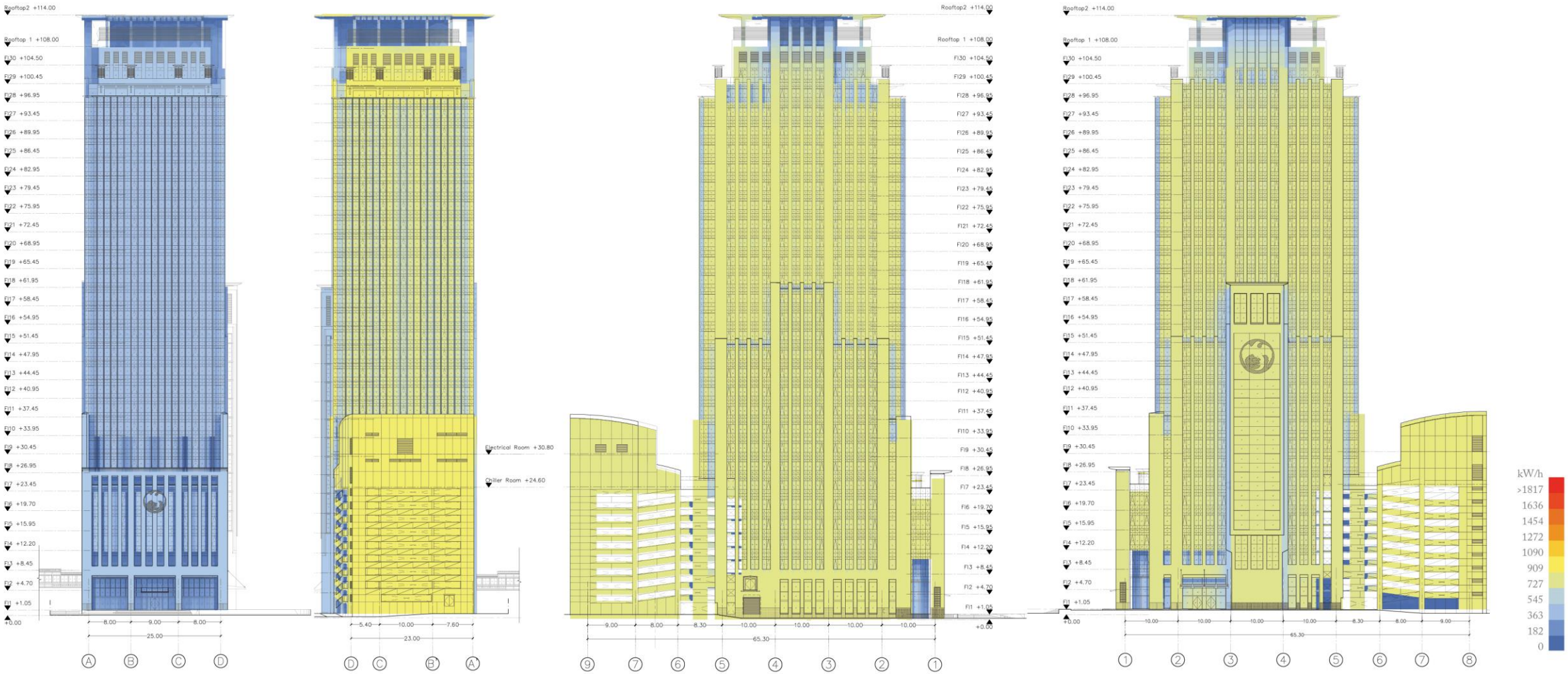
| | |
|---|---|
| Building Function | **Office Building** |
| Operation Hours per Day | **8** |
| Operation Days per Year | **246** |

### Area Distribution

| | $m^2$ |
|---|---|
| Total Floor Area | **38,857** |
| Floor Area | **27,731** |
| Air Conditioned Floor Area | **25,278** |
| Un-Conditioned Floor Area | **2,093** |
| Parking Area | **11,486** |

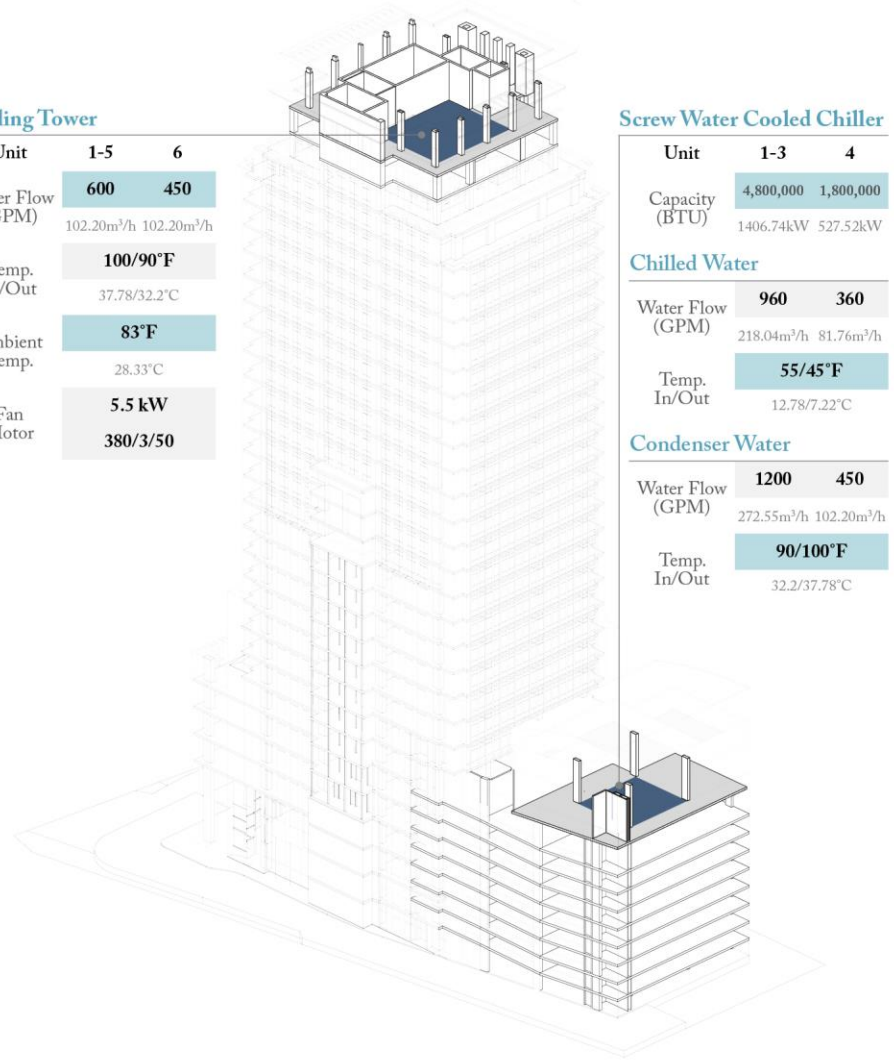

z
y
x

# Benchmark
## Solar Analysis




North Facade | South Facade | East Facade | West Facade

# Benchmark
## Central HVAC System



### Cooling Tower

| Unit | 1-5 | 6 |
|---|---|---|
| Water Flow (GPM) | 600 | 450 |
| | 102.20m³/h | 102.20m³/h |
| Temp. In/Out | 100/90°F | |
| | 37.78/32.2°C | |
| Ambient Temp. | 83°F | |
| | 28.33°C | |
| Fan Motor | 5.5 kW | |
| | 380/3/50 | |

### Screw Water Cooled Chiller

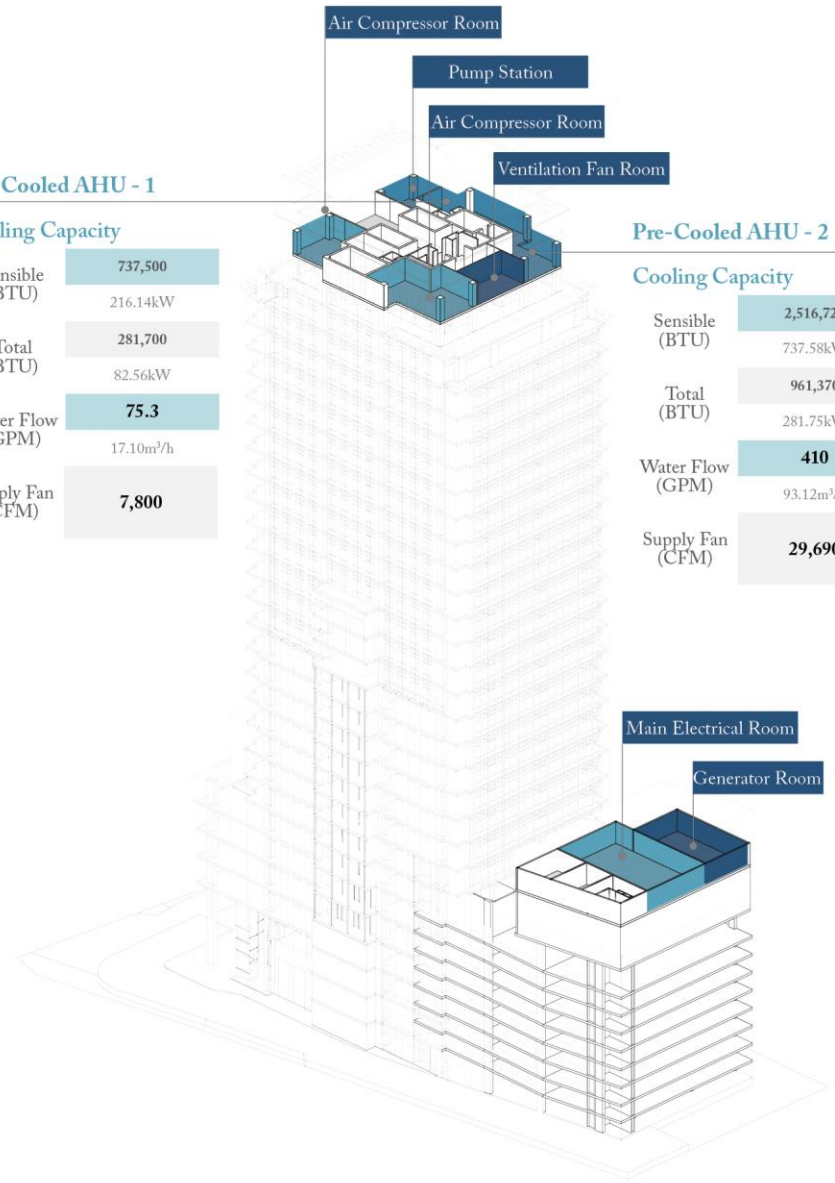
| Unit | 1-3 | 4 |
|---|---|---|
| Capacity (BTU) | 4,800,000 | 1,800,000 |
| | 1406.74kW | 527.52kW |

### Chilled Water

| | | |
|---|---|---|
| Water Flow (GPM) | 960 | 360 |
| | 218.04m³/h | 81.76m³/h |
| Temp. In/Out | 55/45°F | |
| | 12.78/7.22°C | |

### Condenser Water

| | | |
|---|---|---|
| Water Flow (GPM) | 1200 | 450 |
| | 272.55m³/h | 102.20m³/h |
| Temp. In/Out | 90/100°F | |
| | 32.2/37.78°C | |




### Pre-Cooled AHU - 1

#### Cooling Capacity

| | |
|---|---|
| Sensible (BTU) | 737,500 |
| | 216.14kW |
| Total (BTU) | 281,700 |
| | 82.56kW |
| Water Flow (GPM) | 75.3 |
| | 17.10m³/h |
| Supply Fan (CFM) | 7,800 |

### Pre-Cooled AHU - 2

#### Cooling Capacity

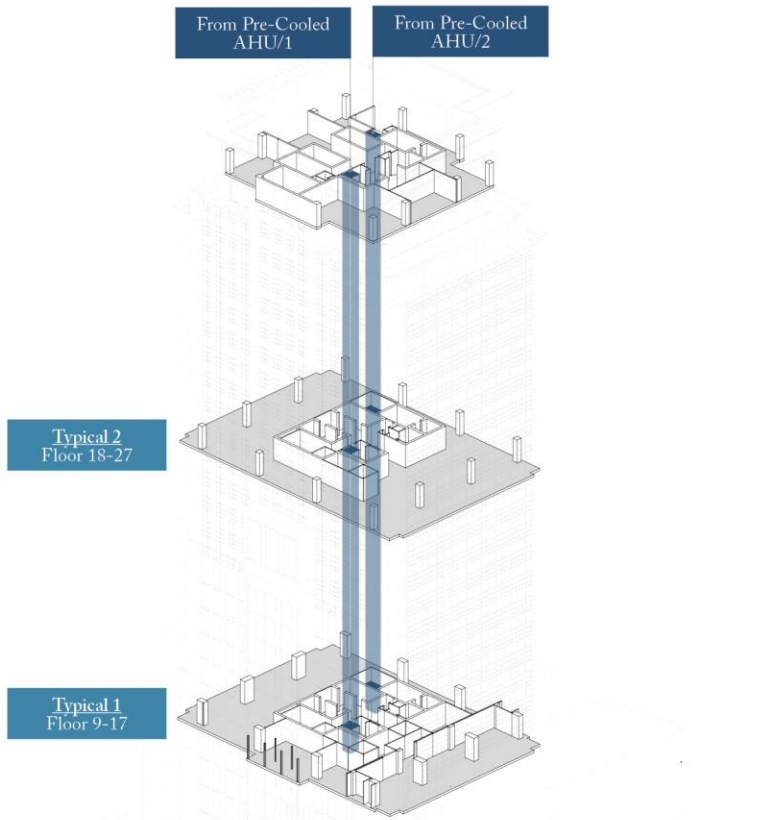
| | |
|---|---|
| Sensible (BTU) | 2,516,720 |
| | 737.58kW |
| Total (BTU) | 961,370 |
| | 281.75kW |
| Water Flow (GPM) | 410 |
| | 93.12m³/h |
| Supply Fan (CFM) | 29,690 |

# Benchmark

## Central HVAC System

# Benchmark

## Typical Floor Area




| Floor Area Distribution | m² |
|---|---|
| Main Office Area | 695.0 |
| Secondary Office Area | 29.4 |
| Floor Entrance Foyer | 36.6 |
| Service Area | 172.0 |

| | m² |
|---|---|
| MEP Shaft | 7.0 |
| AHU Room | 24.1 |
| Fresh air Shaft | 2.4 |
| Electrical and Computer Room | 8.5 |

# Benchmark

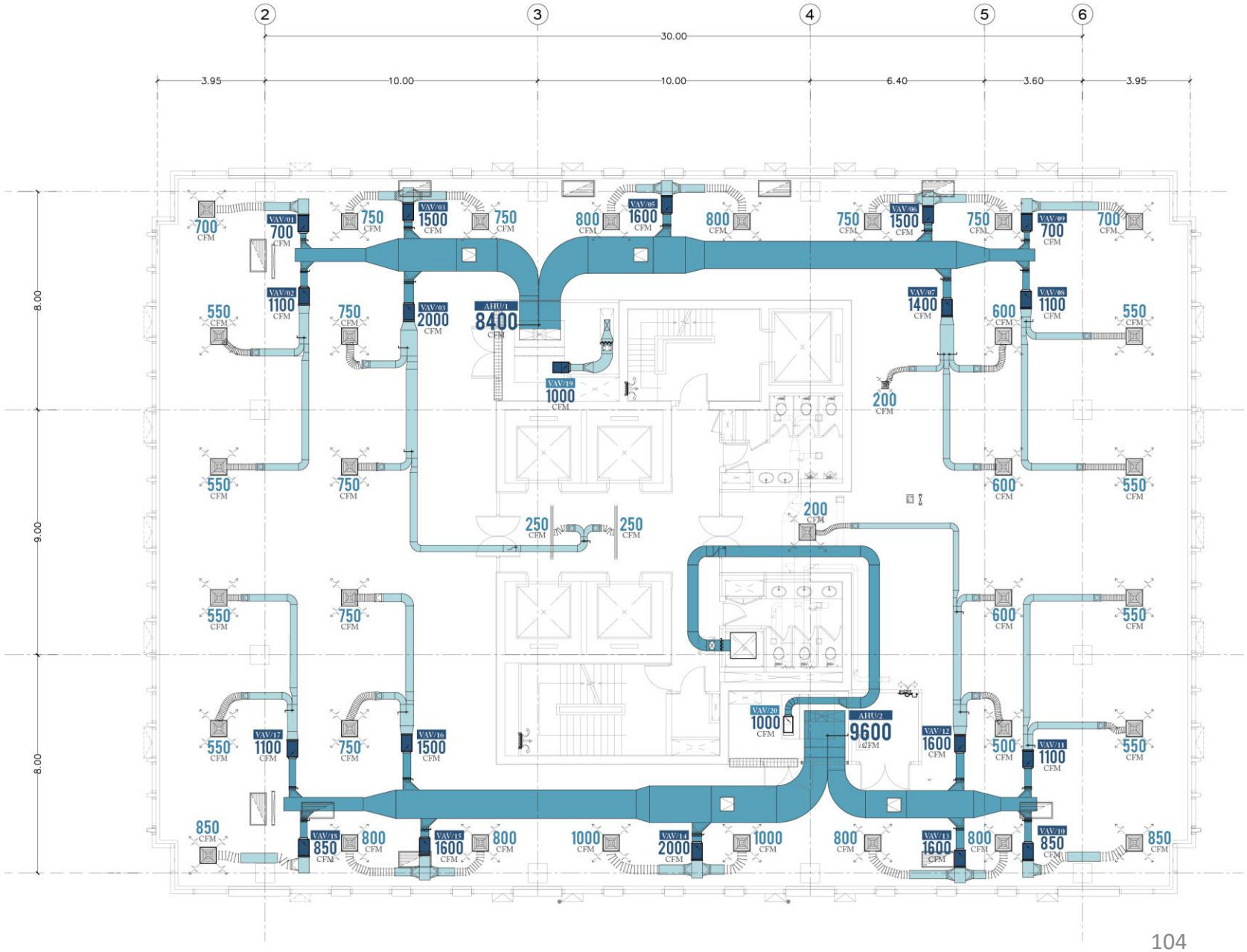
## Typical Floor Area - AHU System

**8400**
CFM

AHU - 1

**9600**
CFM

AHU - 2



# Benchmark

## Typical Floor Area - AHU System Energy Consumption

### Air Handling Unit Schedule - 19th Floor

| Unit No. | Chilled Water Requirement | Energy Consumption | |
|---|---|---|---|
| | GPM | kWh/Year | kWh/day (246days) |
| AHU/1 | 47.76 | 17,670 | 71.83 |
| | 10.85 $m^3/hr$ | | |
| AHU/2 | 54.5 | 13,732 | 55.82 |
| | 12.38 $m^3/hr$ | | |

127.65 kWh/day

Air Handling Units

### Centralized System Energy Consumption - 19th Floor

Considering 10.6% of Energy Consumption

| System | Average CDS \| CHS | Total Avg. Energy Consumption | 19th Floor Avg. Energy Consumption |
|---|---|---|---|
| | GPM | kWh/day | kWh/day |
| Screw Water Cooled Water Chiller | 960 | 2240.89 | 237.5 |
| | 10.85 $m^3/hr$ | | |
| Cooling Tower | 570 | 58.67 | 6.22 |
| | 10.85 $m^3/hr$ | | |

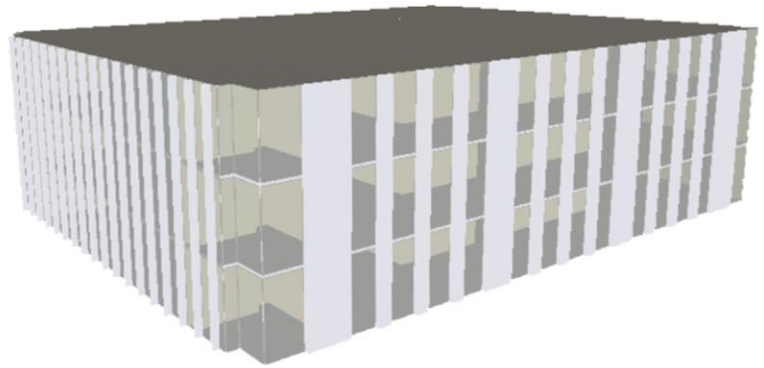
244.95 kWh/day

Centralized Cooling Systems

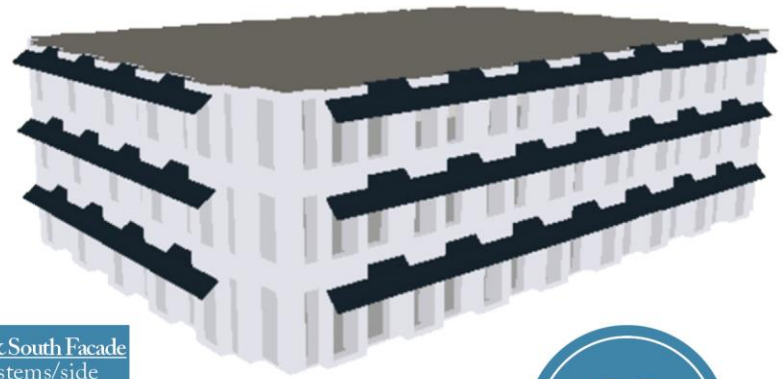
# Benchmark

## Energy Simulation

### Existing Building Model



### Proposed Application Model



North & South Facade
5 Systems/side

East & West Facade
8 Systems/side

26
Systems

Maximum no.
of Facade Integration

### Preliminary Simulation Results - Existing Condition

Supply Air Condition

| Min. Supply Air temp. (°C) | Supply Humidity Ratio (g/g) | Air Change Rate (ach) |
|---|---|---|
| 12.0 | 0.0077 | 1.75 |

**134.31** kW
Design Capacity

**6.51** $m^3/s$
Design Flowrate

### Preliminary Simulation Results - Proposed System

Supply Air Condition

| Min. Supply Air temp. (°C) | Supply Humidity Ratio (g/g) | Air Change Rate (ach) |
|---|---|---|
| 18.9 | 0.0081 | - |

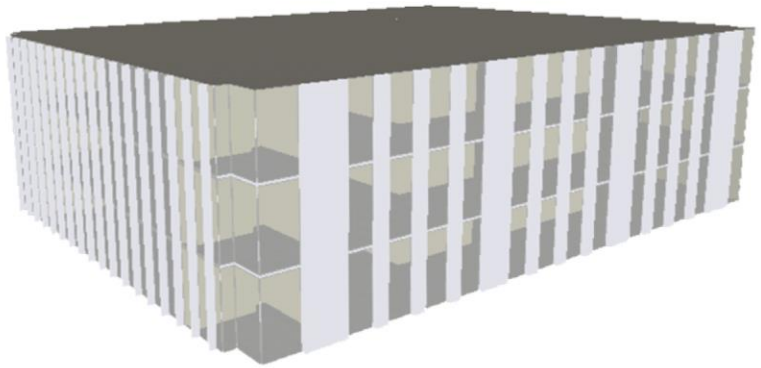
**82.24** kW
Design Capacity

**4.42** $m^3/s$
Design Flowrate

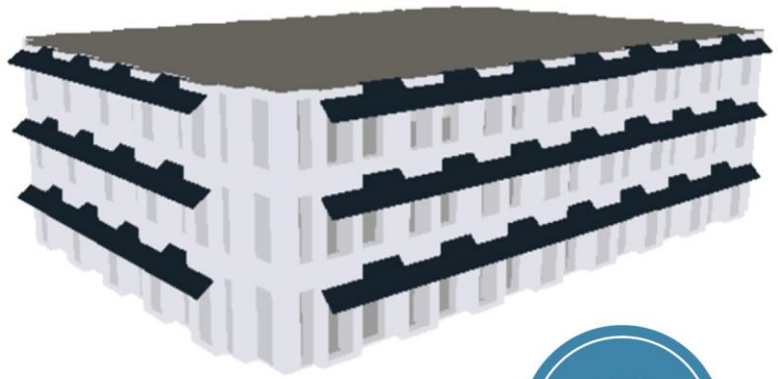
# Benchmark

## Energy Simulation

### Existing Building Model



### Proposed Application Model



11
Systems

No. of Facade System Required

### Preliminary Simulation Results - Existing Condition

Supply Air Condition

| Min. Supply Air temp. (°C) | Supply Humidity Ratio (g/g) | Air Change Rate (ach) |
|---|---|---|
| 12.0 | 0.0077 | 1.75 |

**134.31** kW
Design Capacity

**6.51** $m^3/s$
Design Flowrate

### Preliminary Simulation Results - Proposed System

Supply Air Condition

| Min. Supply Air temp. (°C) | Supply Humidity Ratio (g/g) | Air Change Rate (ach) |
|---|---|---|
| 18.9 | 0.0081 | - |

**82.24** kW
Design Capacity

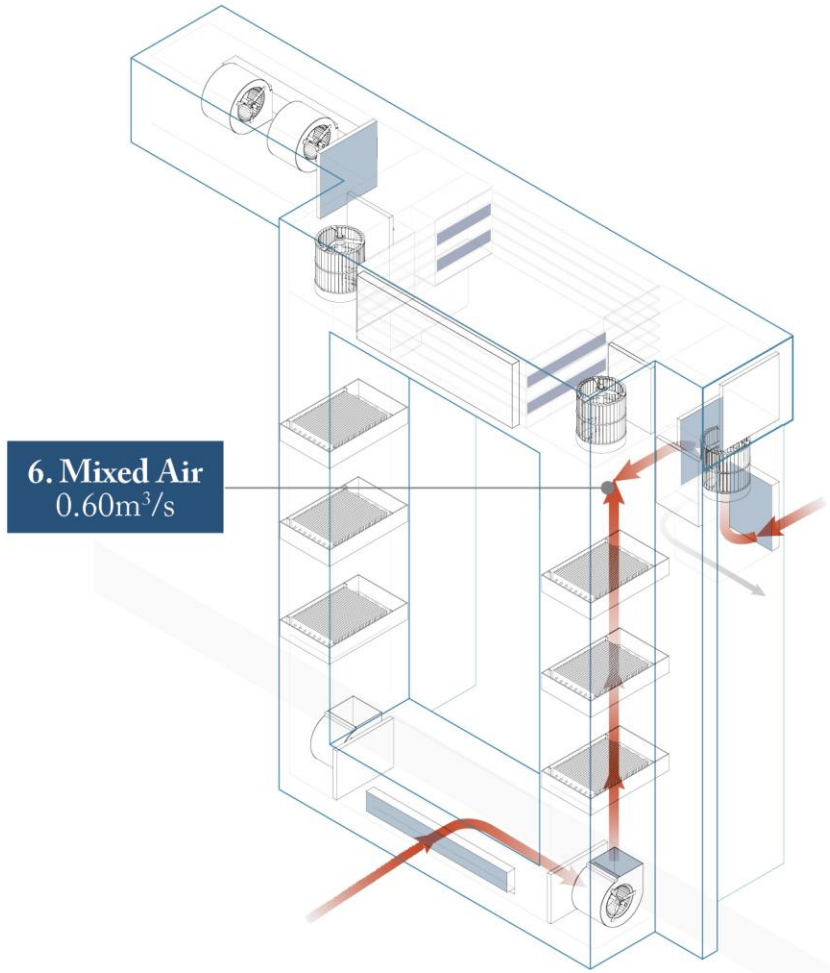
**4.42** $m^3/s$
Design Flowrate

**-52.07** kW
Design Capacity Reduction

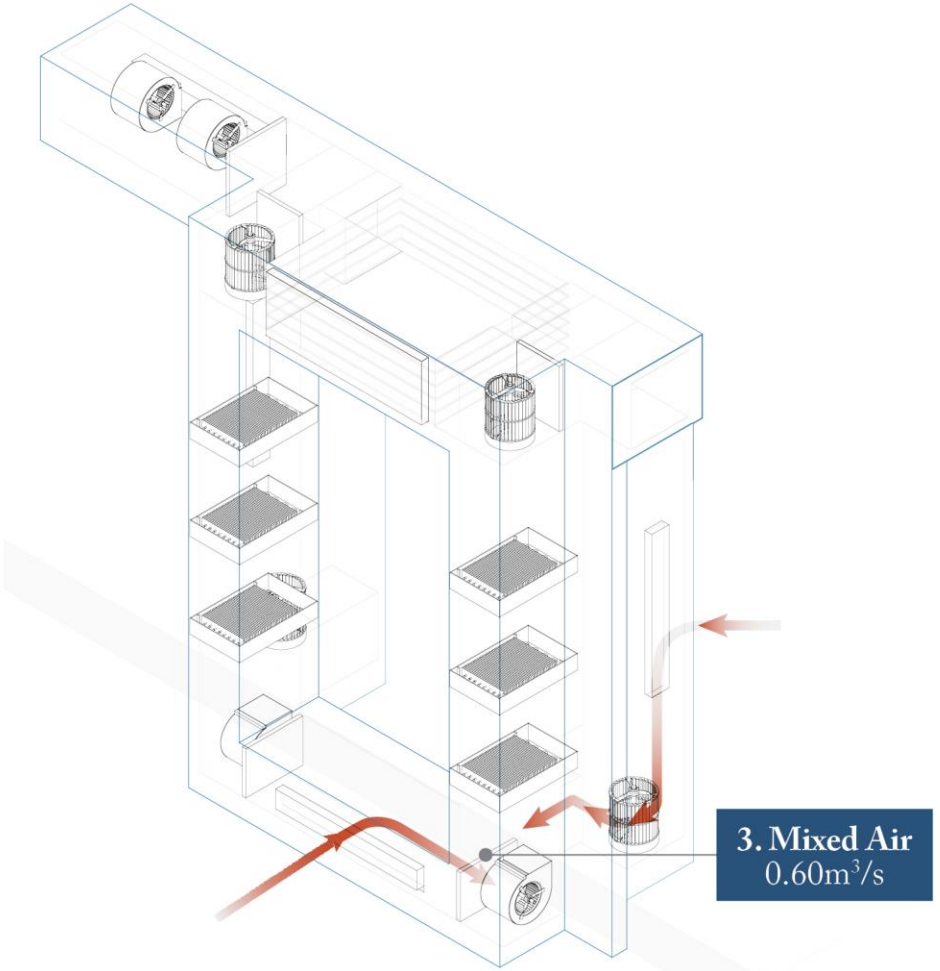
**-2.09** $m^3/s$
Design Flowrate Reduction

# System Application and Performances

## Return air - Concept



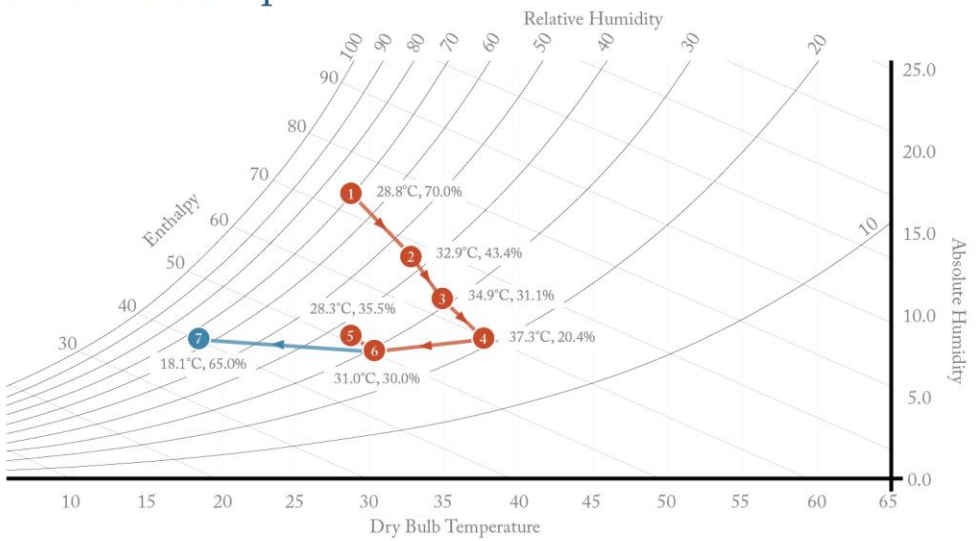

Concept 1

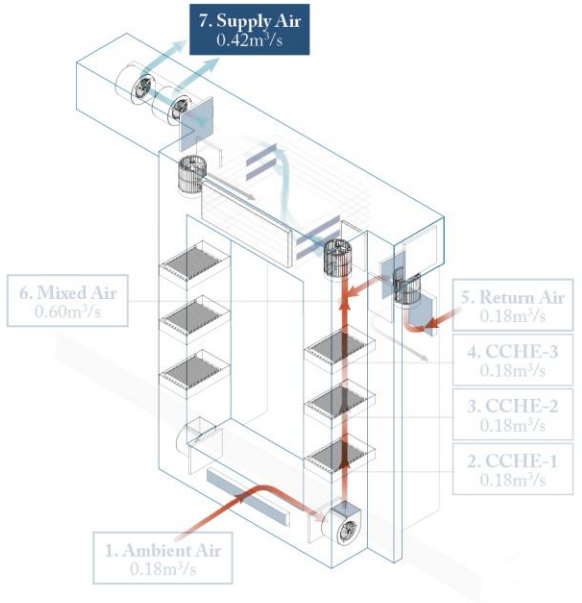



Concept 2

# System Application and Performances

## Return air - Concept



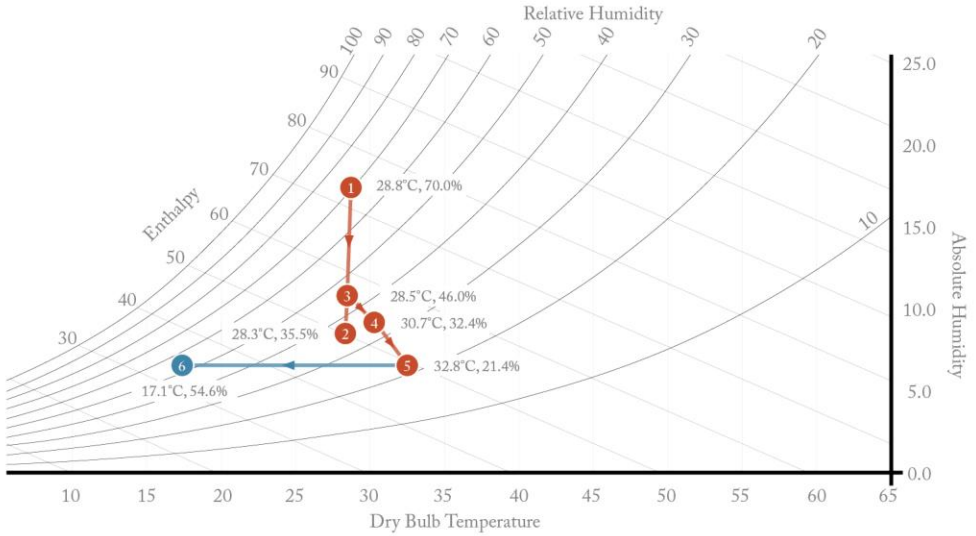



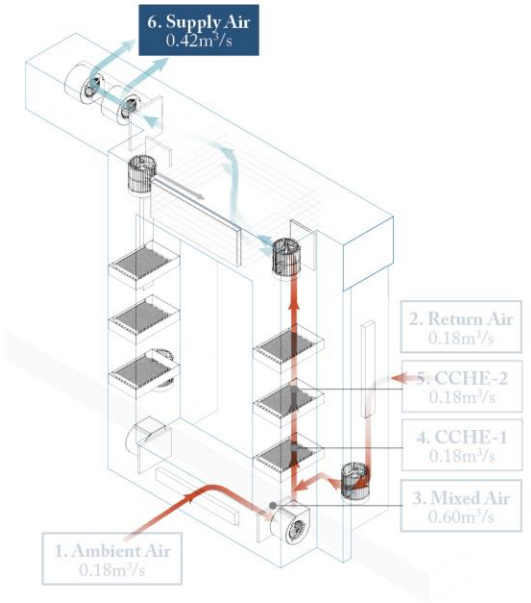

18.1 °C

Supply Air Temperature

Abs.Humidity : 8.4 g kg

RH : 65.0%




17.1 °C

Supply Air Temperature

Abs.Humidity : 6.6 g kg

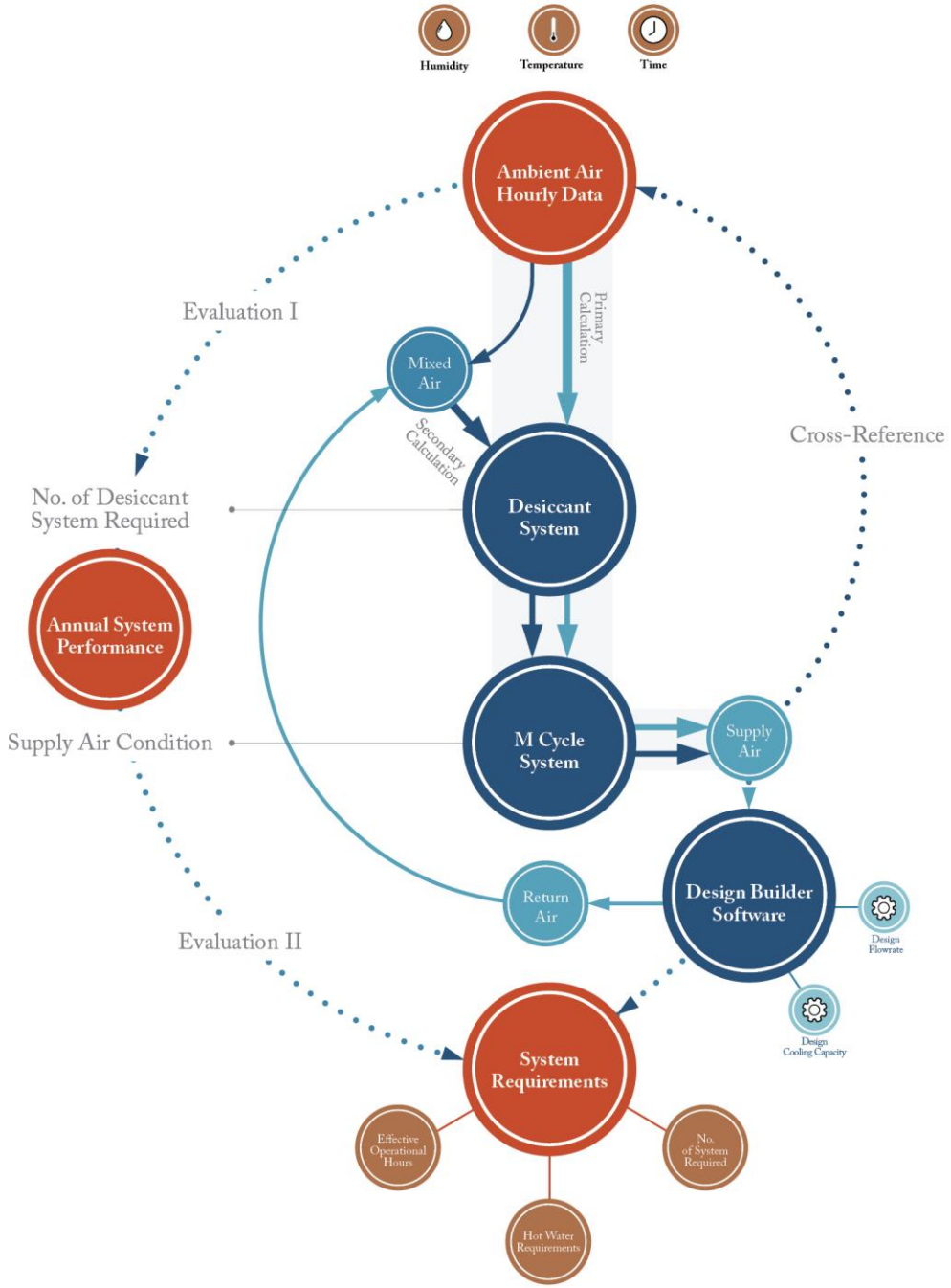
RH : 54.6%

# System Evaluation

## Calculation | Cross-Referencing

# System Evaluation

## Calculation Strategy



# System Evaluation

## Hourly Ambient Data

### Hourly Ambient Air Data based on 8.00 - 18.00

| Humidity Range | Temperature Range | | | | | |
|---|---|---|---|---|---|---|
| | <22.5°C | **25°C** ≥22.5 - < 27.5 (°C) | **30°C** ≥27.5 - < 32.5 (°C) | **35°C** ≥32.5 - ≤37.5 (°C) | >37.5°C | |
| >75% | 6 | 300 | 329 | - | - | 629 |
| **70%** ≥65 - ≤75% | 12 | 99 | 806 | 13 | - | 918 |
| **60%** ≥55 - <65% | 22 | 72 | 750 | 374 | - | 1196 |
| **50%** ≥45 - <55% | 7 | 55 | 307 | 537 | - | 899 |
| <45% | - | 29 | 136 | 154 | 7 | 319 |
| | 6 | 555 | 2328 | 1078 | 7 | |

# System Evaluation

## Cross Referencing to Hourly Ambient Data

### CCHE System Required

| Ambient Humidity Range | Ambient Temperature Range: 25°C (≥22.5 - < 27.5 (°C)) | 30°C (≥27.5 - < 32.5 (°C)) | 35°C (≥32.5 - ≤37.5 (°C)) |
|---|---|---|---|
| 70% (≥65 - ≤75%) | **1** 17.8°C<br>6.1 g kg \| 53.0% | **3** 17.2°C<br>5.3 g kg \| 40.8% | 3 **16.4°C**<br>9.2g kg \| 65.5% |
| 60% (≥55 - <65%) | **1** 16.7°C<br>6.6 g kg \| 44.4% | **2** 16.8°C<br>5.4 g kg \| 38.0% | **3** 17.4°C<br>6.3 g kg \| 50.5% |
| 50% (≥45 - <55%) | **1** 19.4°C<br>5.0 g kg \| 33.0% | **1** 17.6°C<br>6.0 g kg \| 45.5% | **2** 18.0°C<br>6.8 g kg \| 53.1% |

# System Evaluation

## Cross Referencing to Hourly Ambient Data

### Cross Reference with Hourly Ambient Data

| Humidity Range | Temperature Range: <22.5°C | | 25°C (≥22.5 - < 27.5 (°C)) | | 30°C (≥27.5 - < 32.5 (°C)) | | 35°C (≥32.5 - ≤37.5 (°C)) | | >37.5°C | |
|---|---|---|---|---|---|---|---|---|---|---|
| >75% | - | 6 | - | 300 | - | 329 | - | - | - | - |
| 70% (≥65 - ≤75%) | - | 12 | 2 | 99 | 3 | 806 | - | 13 | - | - |
| 60% (≥55 - <65%) | - | 22 | 1 | 72 | 2 | 750 | 3 | 374 | - | - |
| 50% (≥45 - <55%) | - | 7 | 1 | 55 | 1 | 307 | 2 | 537 | - | - |
| <45% | - | - | 1 | 29 | 1 | 136 | 2 | 154 | - | 7 |

# System Evaluation

## Cross Referencing to Hourly Ambient Data

### Cross Reference with Hourly Ambient Data

| Humidity Range | Temperature Range <22.5°C | 25°C ≥22.5 - < 27.5 (°C) | 30°C ≥27.5 - < 32.5 (°C) | 35°C ≥32.5 - ≤37.5 (°C) | >37.5°C |
|---|---|---|---|---|---|
| >75% | - 6 | - 300 | - 329 | - - | - - |
| 70% ≥65 - ≤75% | - 12 | 2 99 | 3 806 | - 13 | - - |
| 60% ≥55 - <65% | - 22 | **1** 72 | 2 750 | 3 374 | - - |
| 50% ≥45 - <55% | - 7 | **1** 55 | **1** 307 | 2 537 | - - |
| <45% | - - | **1** 29 | **1** 136 | 2 154 | - 7 |

**14.9%**
599 Hours

1 - CCHE

# System Evaluation

## Cross Referencing to Hourly Ambient Data

### Cross Reference with Hourly Ambient Data

| Humidity Range | Temperature Range: <22.5°C | | 25°C (≥22.5 - < 27.5 °C) | | 30°C (≥27.5 - < 32.5 °C) | | 35°C (≥32.5 - ≤37.5 °C) | | >37.5°C | |
|---|---|---|---|---|---|---|---|---|---|---|
| >75% | - | 6 | - | 300 | - | 329 | - | - | - | - |
| 70% (≥65 - ≤75%) | - | 12 | **2** | 99 | **3** | 806 | - | 13 | - | - |
| 60% (≥55 - <65%) | - | 22 | **1** | 72 | **2** | 750 | **3** | 374 | - | - |
| 50% (≥45 - <55%) | - | 7 | **1** | 55 | **1** | 307 | **2** | 537 | - | - |
| <45% | - | - | **1** | 29 | **1** | 136 | **2** | 154 | - | 7 |




1 - CCHE


2 - CCHE

# System Evaluation

## Cross Referencing to Hourly Ambient Data

### Cross Reference with Hourly Ambient Data

| Humidity Range | Temperature Range: <22.5°C | 25°C (≥22.5 - < 27.5 °C) | 30°C (≥27.5 - < 32.5 °C) | 35°C (≥32.5 - ≤37.5 °C) | >37.5°C |
|---|---|---|---|---|---|
| >75% | - 6 | - 300 | - 329 | - - | - - |
| 70% (≥65 - ≤75%) | - 12 | **2** 99 | **3** 806 | - 13 | - - |
| 60% (≥55 - <65%) | - 22 | **1** 72 | **2** 750 | **3** 374 | - - |
| 50% (≥45 - <55%) | - 7 | **1** 55 | **1** 307 | **2** 537 | - - |
| <45% | - - | **1** 29 | **1** 136 | **2** 154 | - 7 |


1 - CCHE | 2 - CCHE | 3 - CCHE

# System Evaluation

## Cross Referencing to Hourly Ambient Data

### Cross Reference with Hourly Ambient Data

| Humidity Range | Temperature Range <22.5°C | | 25°C ≥22.5 - < 27.5 (°C) | | 30°C ≥27.5 - < 32.5 (°C) | | 35°C ≥32.5 - ≤37.5 (°C) | | >37.5°C | |
|---|---|---|---|---|---|---|---|---|---|---|
| >75% | - | 6 | - | 300 | - | 329 | - | - | - | - |
| 70% ≥65 - ≤75% | - | 12 | 2 | 99 | 3 | 806 | - | 13 | - | - |
| 60% ≥55 - <65% | - | 22 | 1 | 72 | 2 | 750 | 3 | 374 | - | - |
| 50% ≥45 - <55% | - | 7 | 1 | 55 | 1 | 307 | 2 | 537 | - | - |
| <45% | - | - | 1 | 29 | 1 | 136 | 2 | 154 | - | 7 |

# Energy Assessment
## Heat Pump Requirements

### Heating Energy Requirement Based on Operable Hours

| Component | No. of Operable Hours | Energy Consumption | | |
|---|---|---|---|---|
| | Hours | kWh/day (11 Hours) | kWh | kWh/year |
| 1 - CCHE | 599 | 4.4 | 0.128 | 239.6 |
| 2 - CCHE | 1540 | 8.7 | 0.171 | 1218.0 |
| 3 - CCHE | 1180 | 13.1 | 0.037 | 1405.3 |
| Total | 3319 | | | |


Average Thermal Requirements

### Heating with Air to Water Heat Pump Energy Consumption

COP = 3.5

| Component | Energy Required | Energy Consumption |
|---|---|---|
| | kWh/year | kWh/year |
| 1 - CCHE | 239.6 | 68.5 |
| 2 - CCHE | 1218.0 | 348.0 |
| 3 - CCHE | 1405.3 | 401.5 |
| Total | 2862.9 | 818 |


Average Energy Requirment

# Energy Assessment

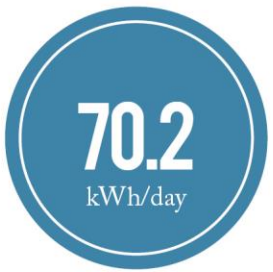
**26**
Systems

Maximum no.
of Facade Integration

5.40 kWh/day


Facade Integrated
Components

2.70 kWh/day




Air to Water
Heat Pump


Total EnergyConsumption

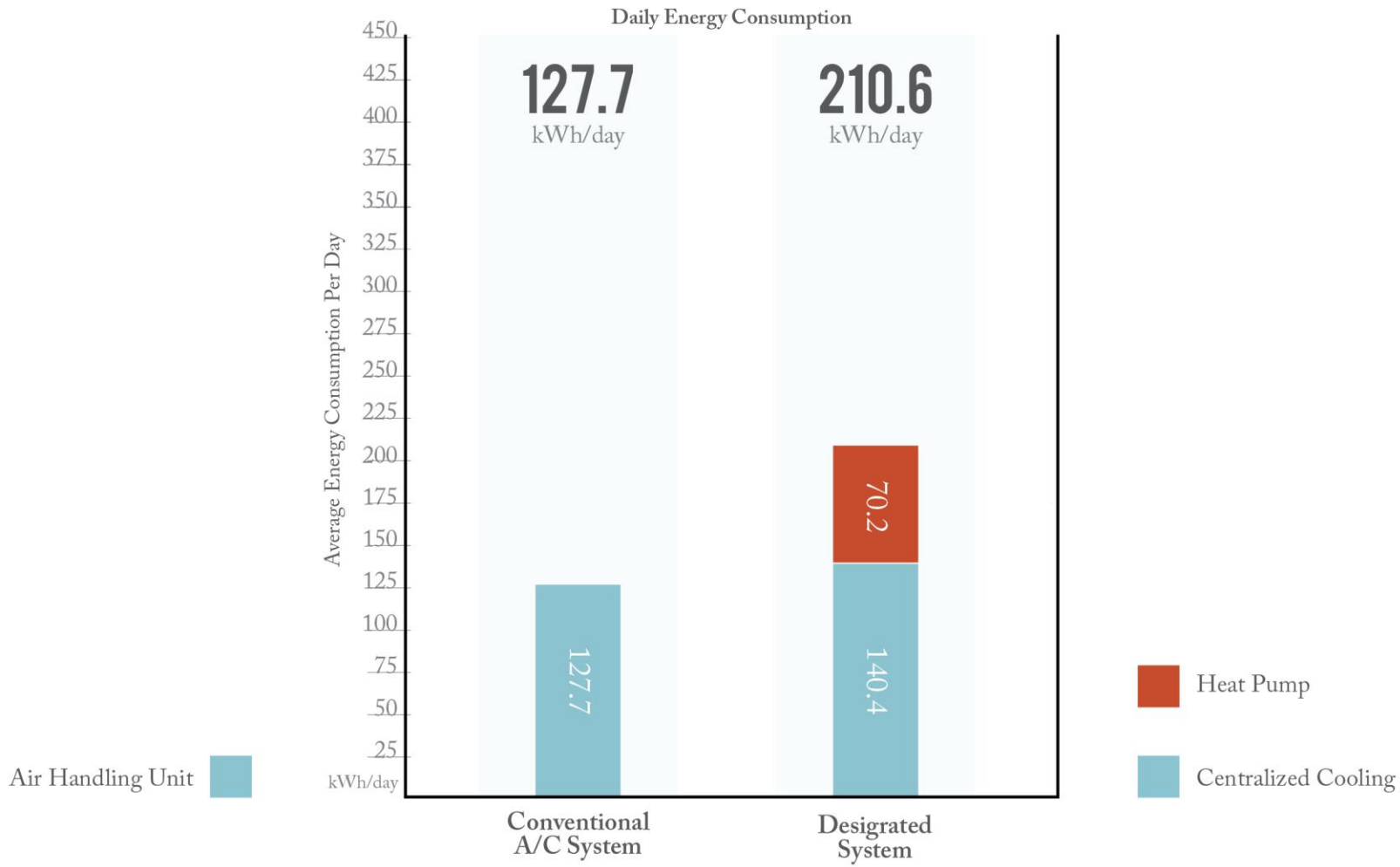
# Energy Consumption Assessment

## Daily Energy Consumption

Energy Consumption Reduction
in comparison to AHU

**+64.9%**

kWh/day



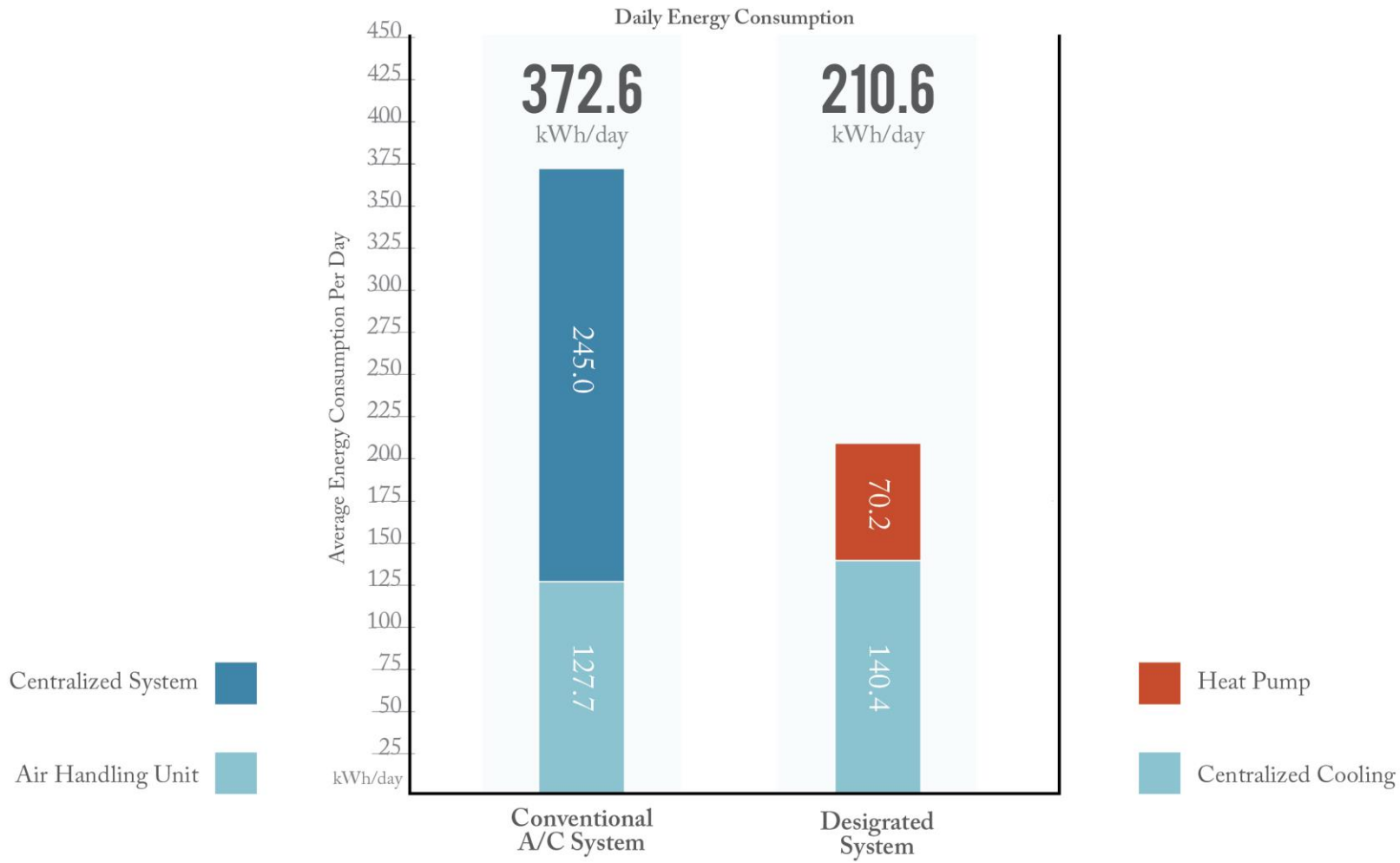
# Energy Consumption Assessment

## Daily Energy Consumption

Energy Consumption Reduction
in comparison to Conventional System

**-43.4%**

kWh/day



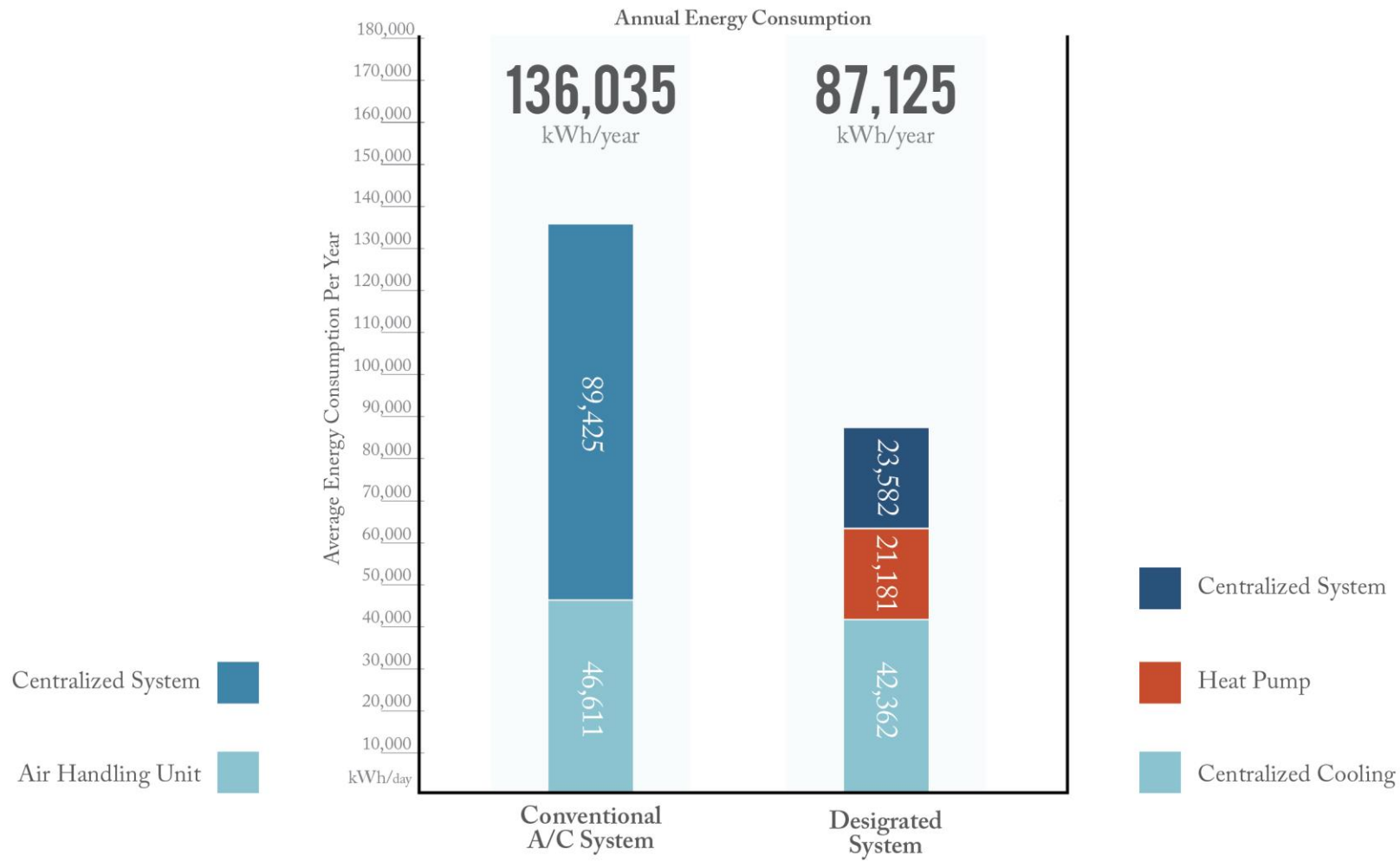
# Energy Consumption Assessment

## Annual Energy Consumption

Energy Consumption Reduction
in comparison to Conventional System

**-36%**

kWh/year

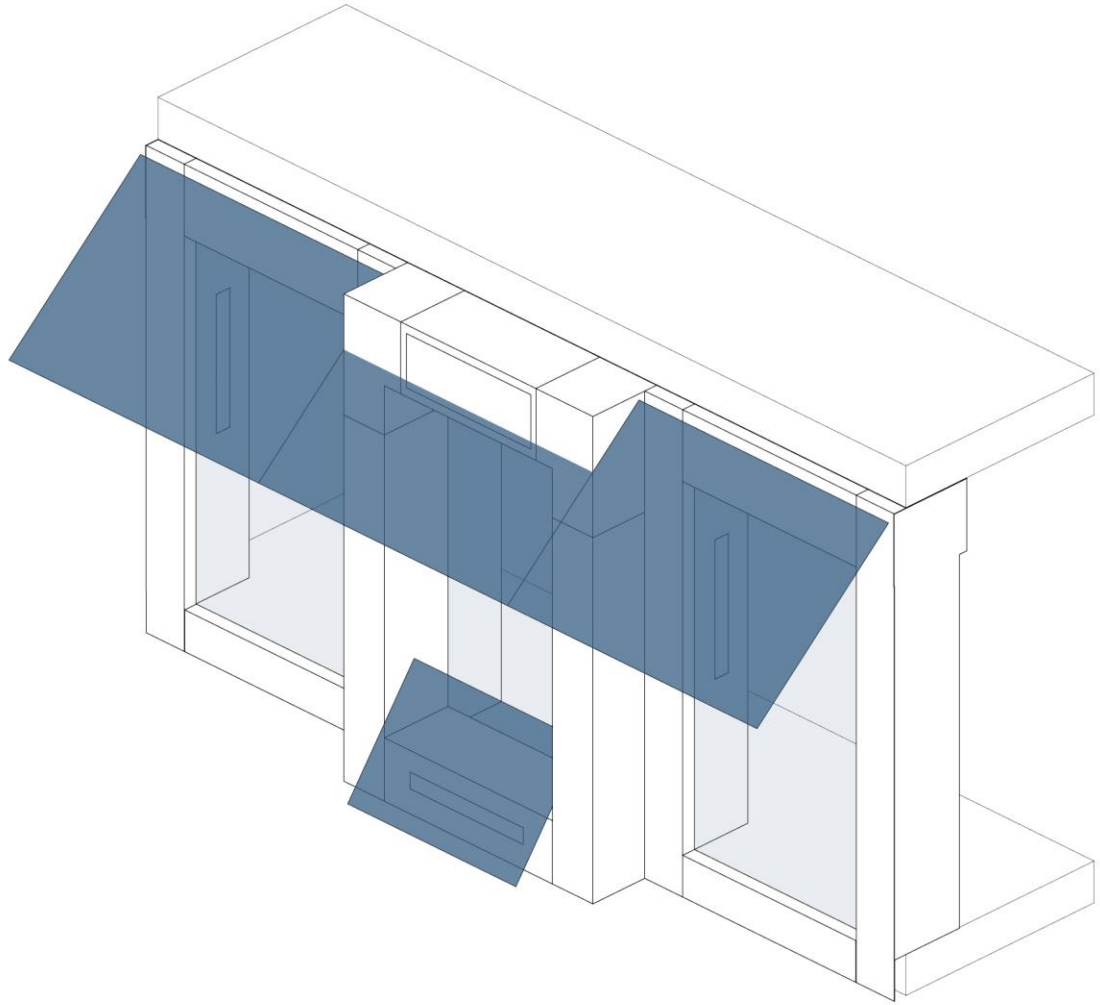


# Design Development

## Design Possibilities

# Design Development

## Design Base

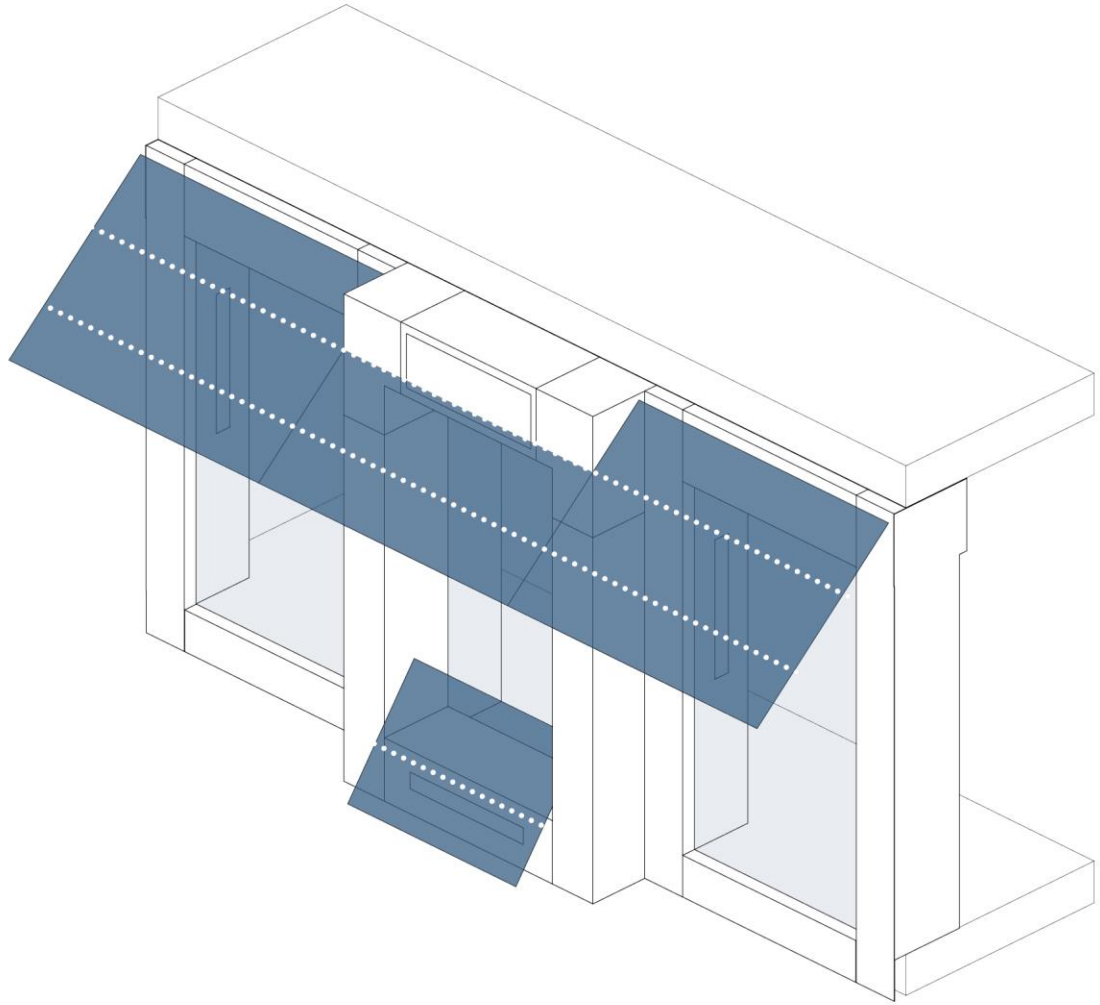


# Design Development

## Achieving Buoyancy

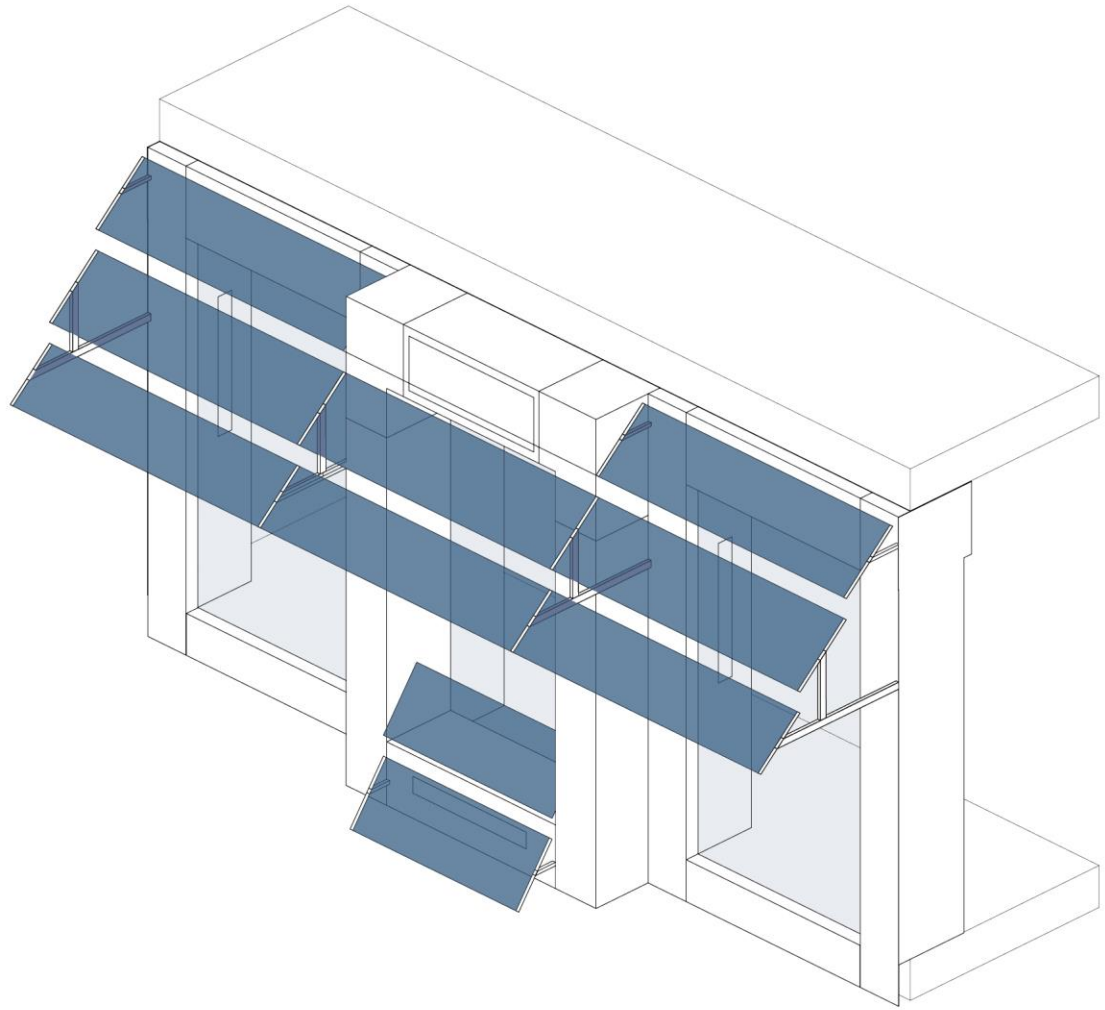
# Design Development

## Achieving Buoyancy



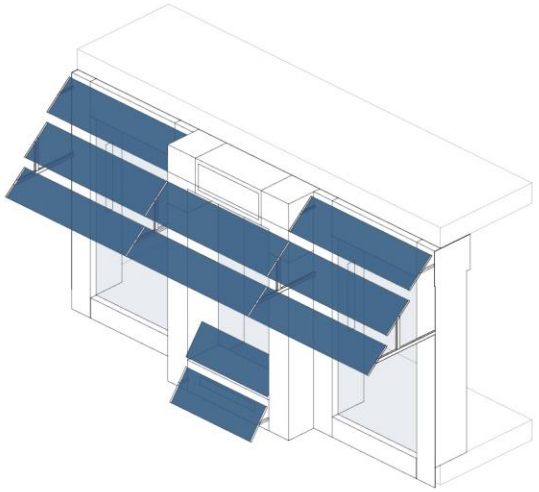
# Design Development

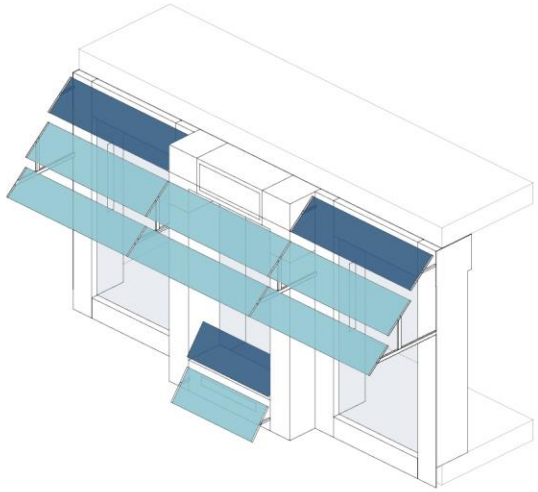
## Achieving Buoyancy

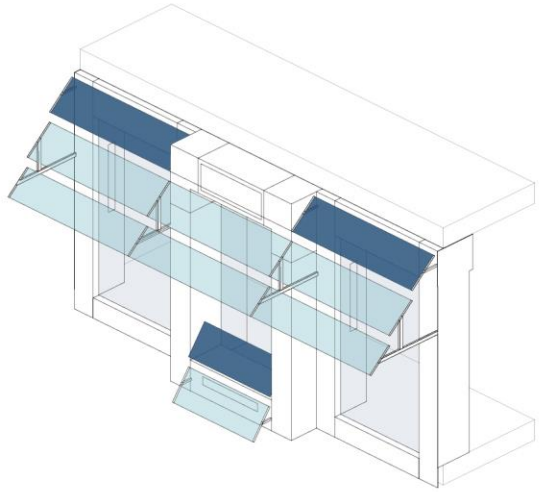


# Performance Assessment

## PVT Concepts







| | Concept 1 | | Concept 2 | | Concept 3 | |
|---|---|---|---|---|---|---|
| | PVT | | PVT | PV | PVT | PV |
| | 7.7 sq.m | | 2.0 sq.m | 5.7 sq.m | 2.0 sq.m | 5.7 sq.m |
| | 100% Coverage Area | | 100% Coverage Area | 100% Coverage Area | 100% Coverage Area | 50% Coverage Area |
| Total Energy Production kWh/day | 392.5 Thermal Energy | 79.2 Electricity Energy | 196.2 Thermal Energy | 39.6 Electricity Energy | 101.9 Thermal Energy | 29.3 Electricity Energy |

**Net Zero**

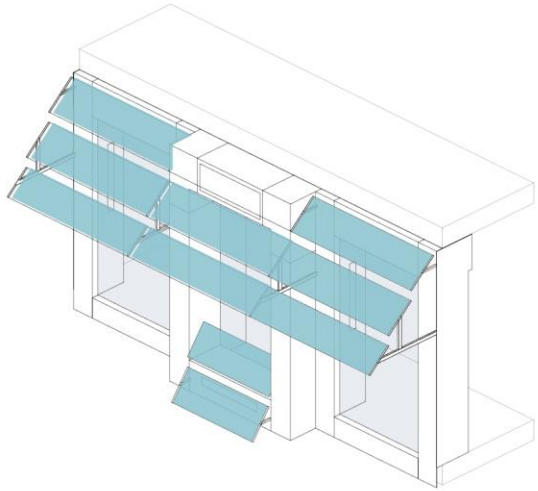
71% Electricity Reduction Ratio

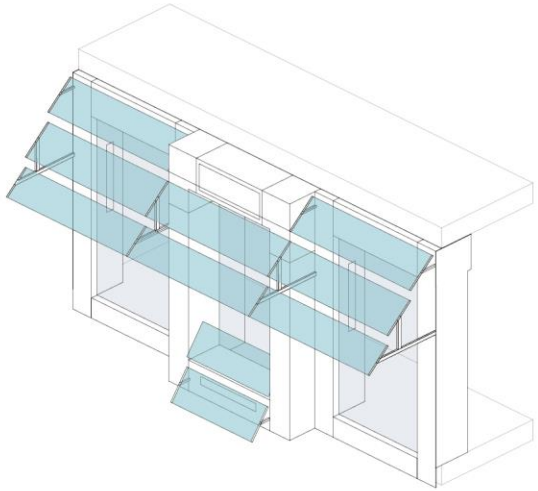
42% Electricity Reduction Ratio

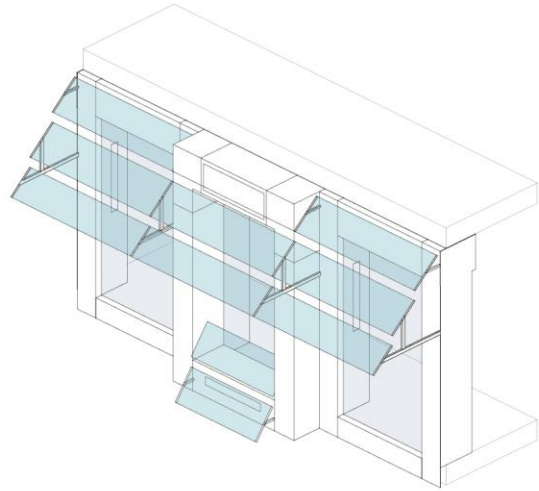
28% Electricity Reduction Ratio

# Performance Assessment

## PV Concepts







| | Concept 3 | Concept 4 | Concept 5 |
|---|---|---|---|
| | PV **7.7** sq.m | PV **7.7** sq.m | PV **7.7** sq.m |
| | **100%** Coverage Area | **87%** Coverage Area | **50%** Coverage Area |
| Total Energy Production kWh/day | **58.7** Thermal Energy | **51.0** Thermal Energy | **25.5** Thermal Energy |
| | **28%** Electricity Reduction Ratio | **24%** Electricity Reduction Ratio | **14%** Electricity Reduction Ratio |

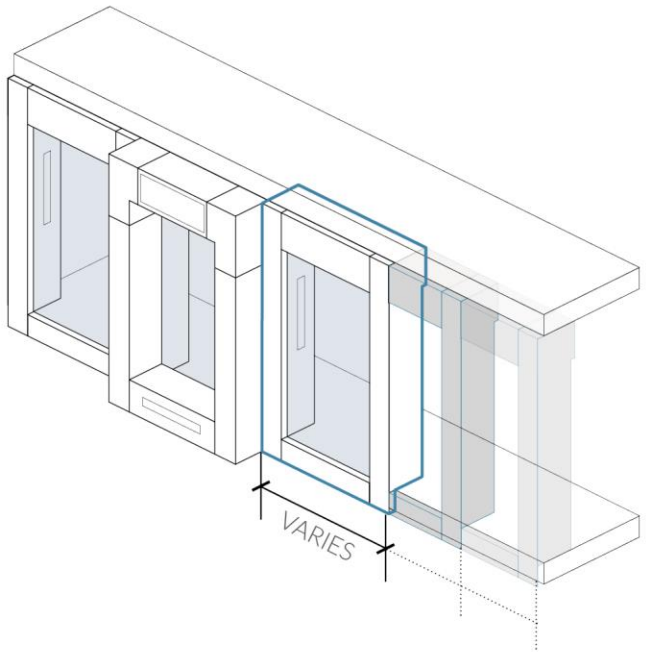
**Versatility**

# Design Integration

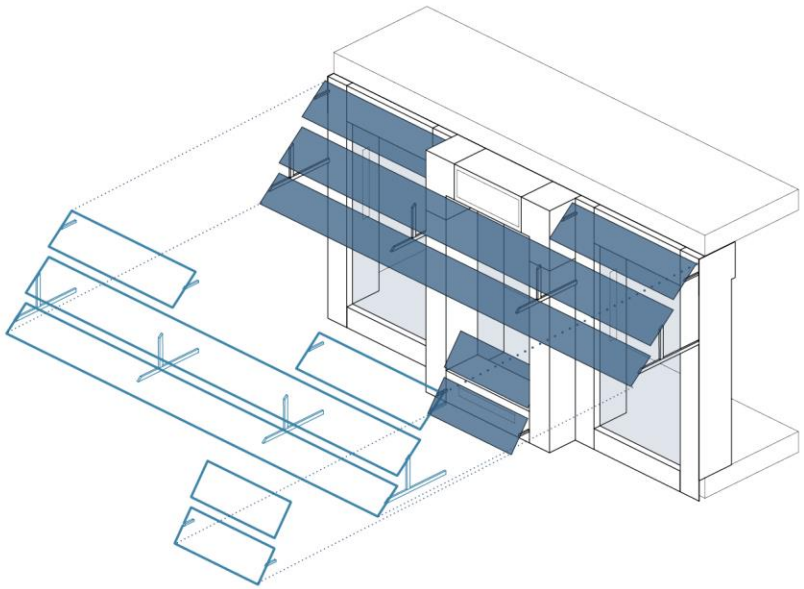
## Design Possibilities

# System Application

## System Component Alteration



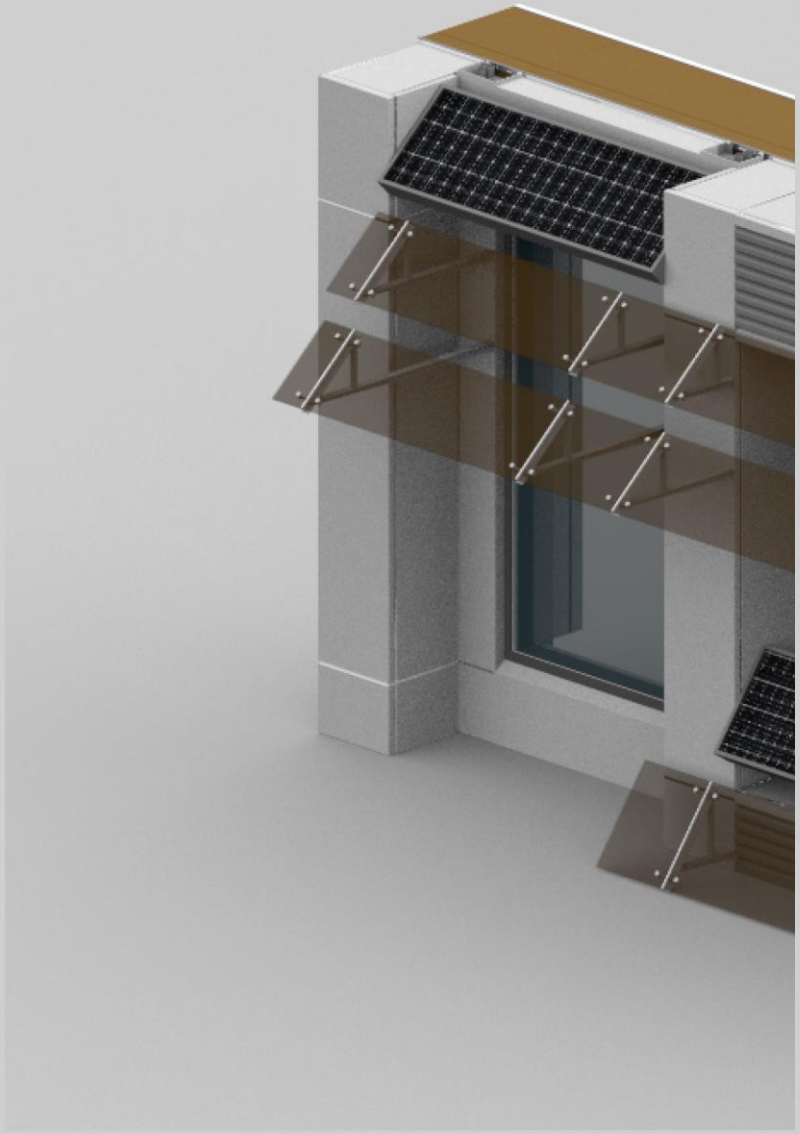

Resizing



Shading Alteration

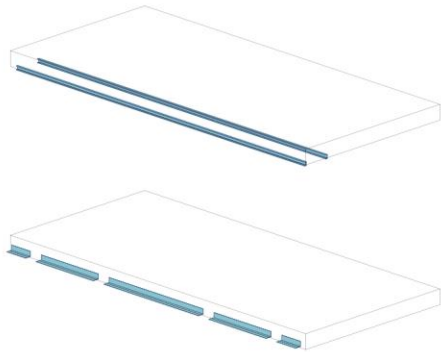
# System Application

## System Assembly

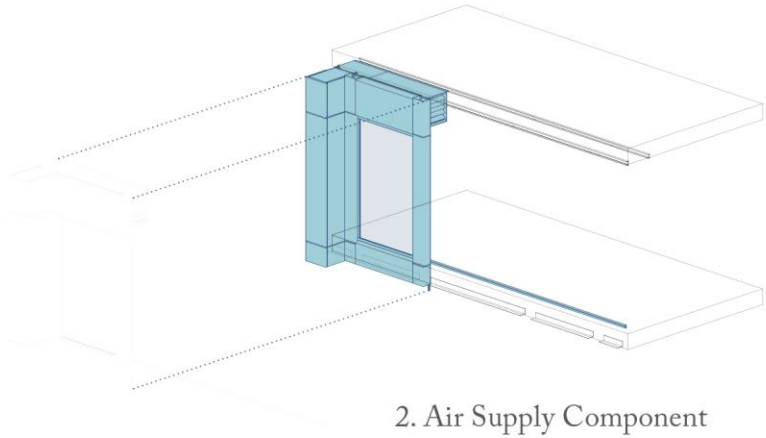


# System Application

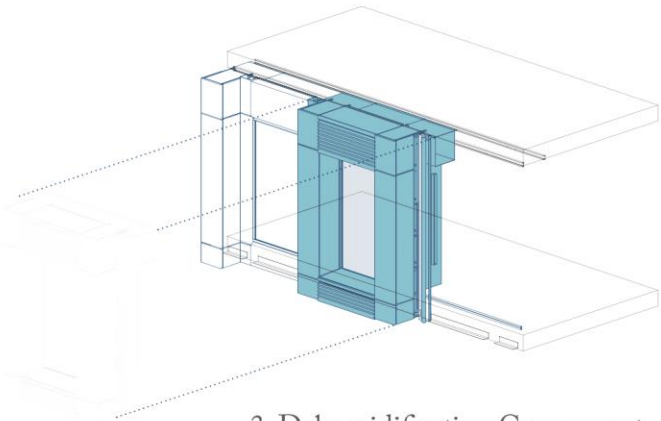
## System Assembly - Prefabricated Component



1. Facade Bracket



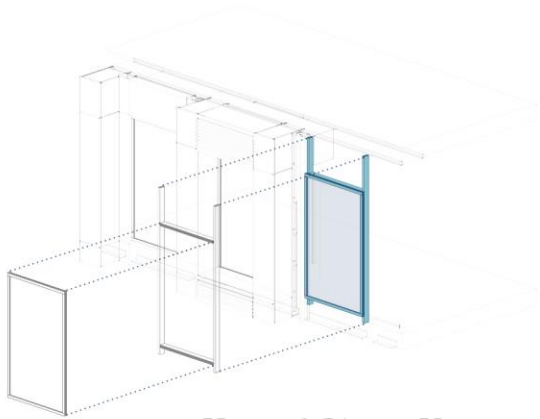
2. Air Supply Component



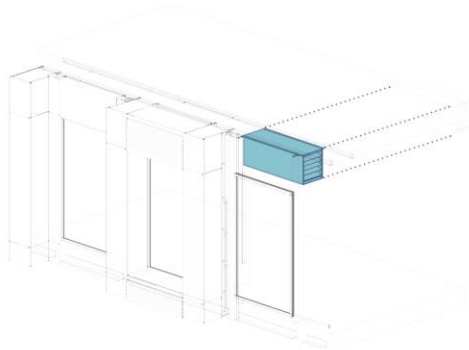
3. Dehumidification Component

# System Application

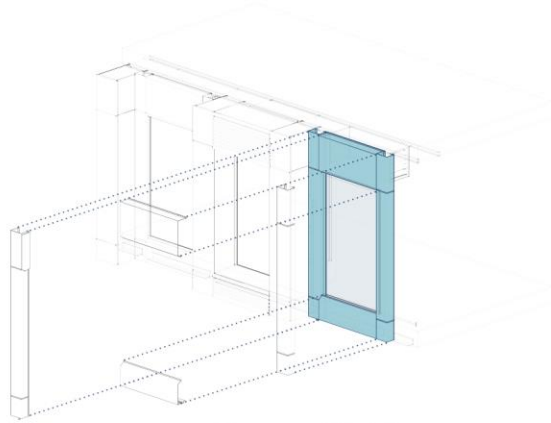
## System Assembly - On-Site Adjustment



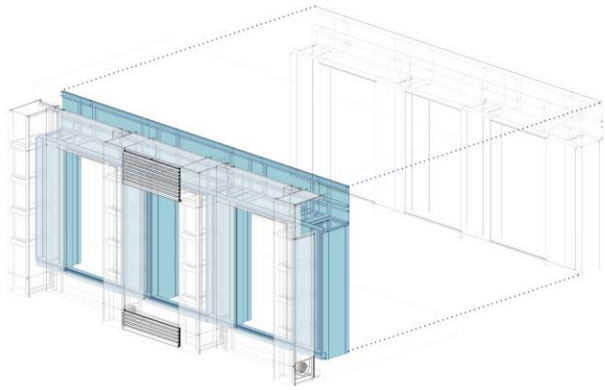
1. Unitized Glazing Unit



2. Air Supply Duct



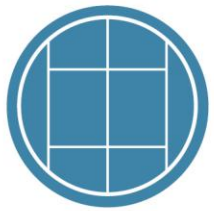
3. Exterior Cladding



4. Interior Cladding

# System Application

## Concept 1 : Symmetrical Array Pattern



**Symmetrical Array Pattern**

Every Floor

Standard Supply Unit

# System Application

## Concept 2 : 'Pakon' Alternating Pattern

# System Application

## Concept 2 : 'Pakon' Alternating Pattern

'Pakon'
Alternating Pattern

Every OtherFloor

Resized - Supply Unit

# System Application

## Concept 3 : Abstraction of Thai Pattern

# System Application

## Concept 3 : Abstraction of Thai Pattern

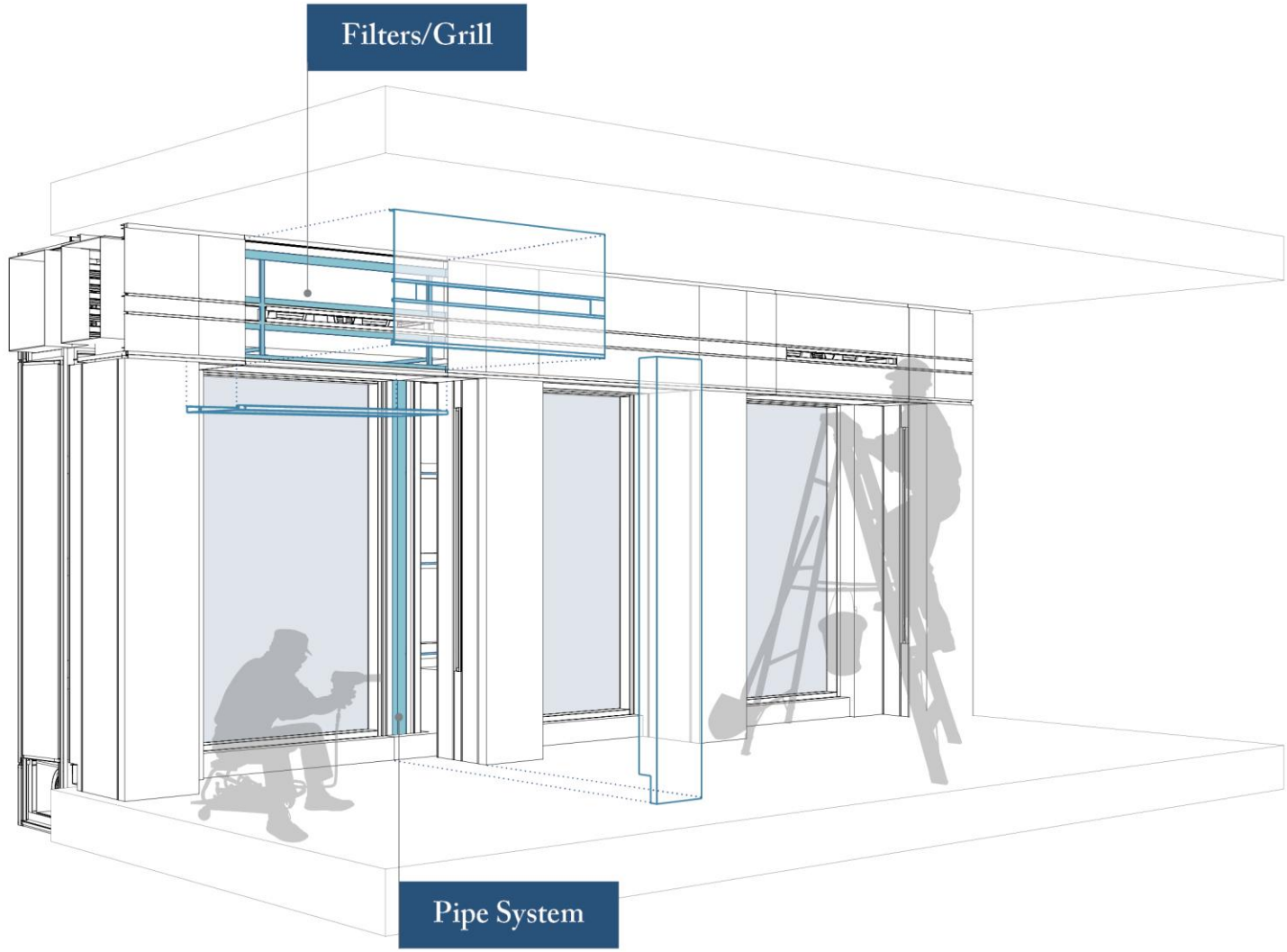
**Abstraction of Thai Pattern**

Placement according to design

Non-modular

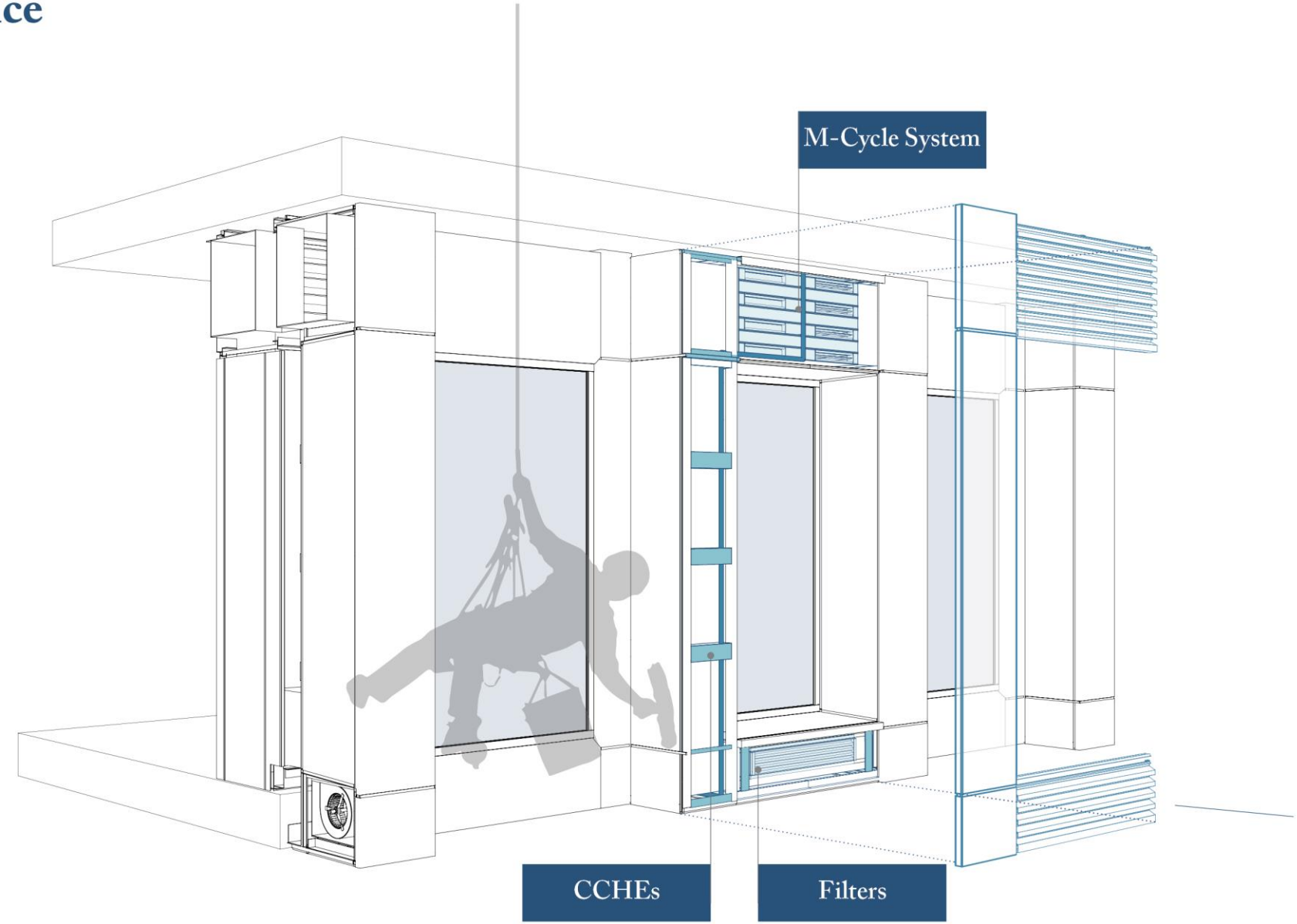
# System Maintenance

## Interior Maintenance



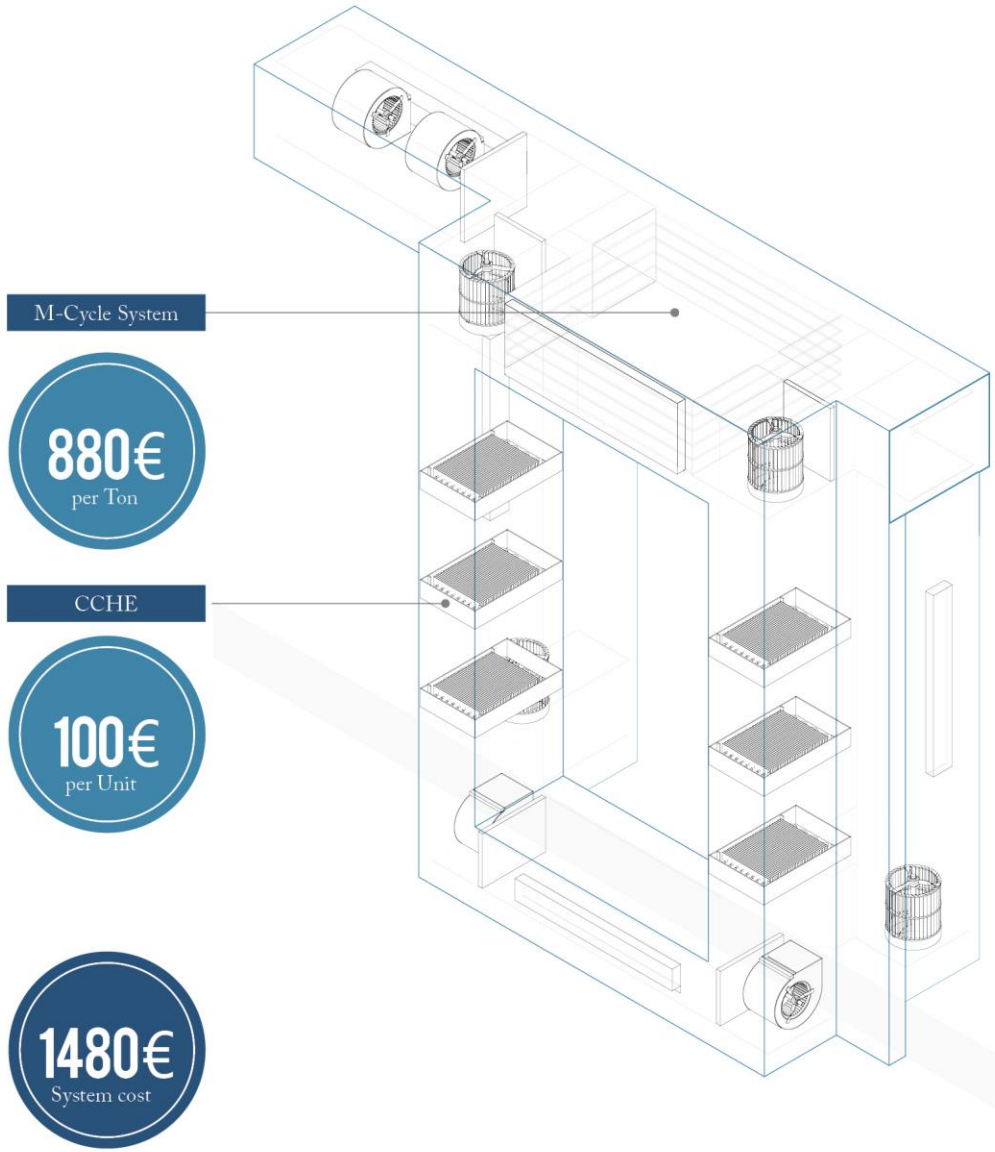
# System Maintenance

## Exterior Maintenance



# System Feasibility

## Initial Investment




Labor Cost

Assembly Cost

Additional Structure

# Conclusion

## Limitations / Recommendations

**Limitations of performance data**

**Solar radiation analysis**


Energy Consumption Reduction
in comparison to Conventional System

**System operation scheduling**

Cost consideration

Architectural Application

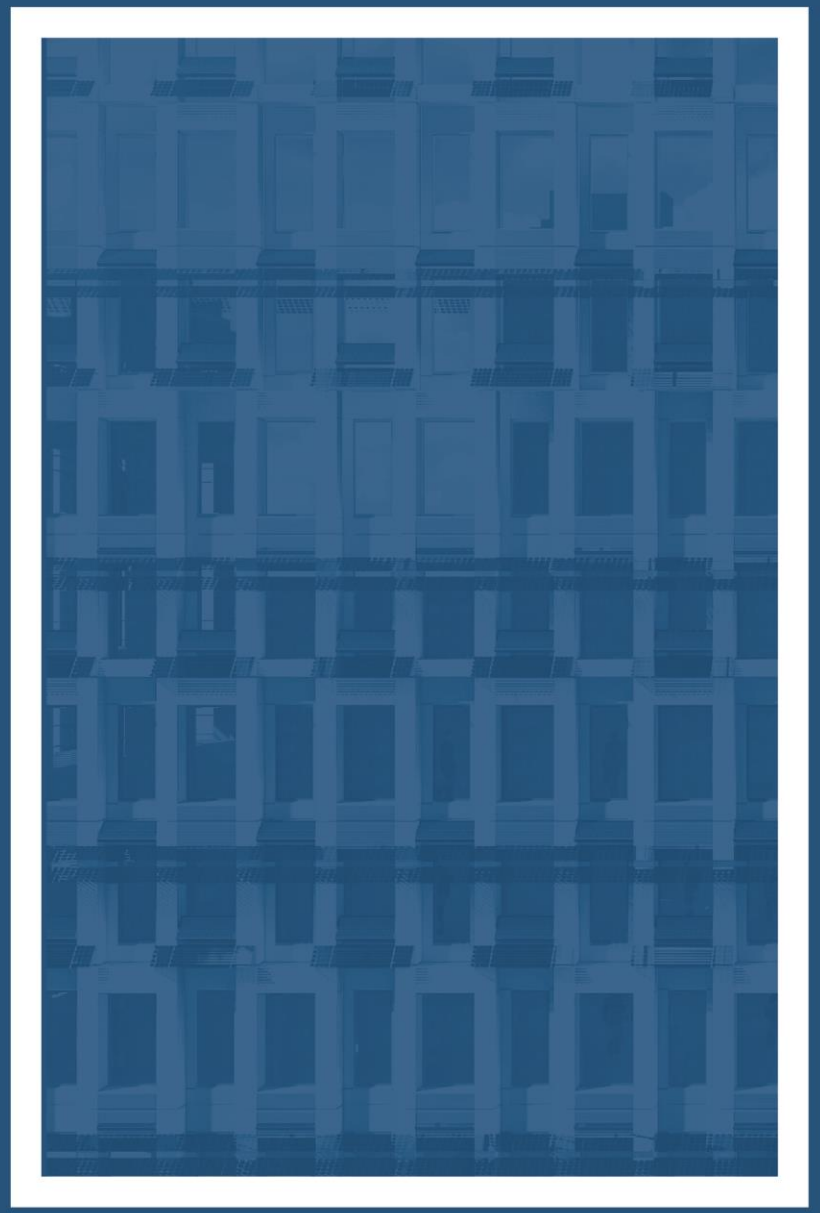
0
Net Zero Approach

Maintenance aspects

*"Achieving Su[illegible] not as simple as snapp[illegible]s……"*

*“But we are on track,*
*Paving a way for a sustainable future.”*

# Thank You



**D**esiccant **I**ntegrated
**F**acade System

**P5 Presentation**

Natchai Suwannapruk
4738128

**9 July 2019**