REHVA
Federation of European Heating, Ventilation and Air Conditioning Associations

公益社団法人空気調和・衛生工学会
The Society of Heating,Air-Conditioning and Sanitary Engineers of Japan

# REHVA-SHASE workshop on NZEB and ZEB Ready concepts in Europe and Japan

## Japanese energy assessment procedure and performance levels

Special Committee for Joint Study on nZEB between SHASE and REHVA
The Society of Heating, Air-Conditioning and Sanitary Engineering of Japan

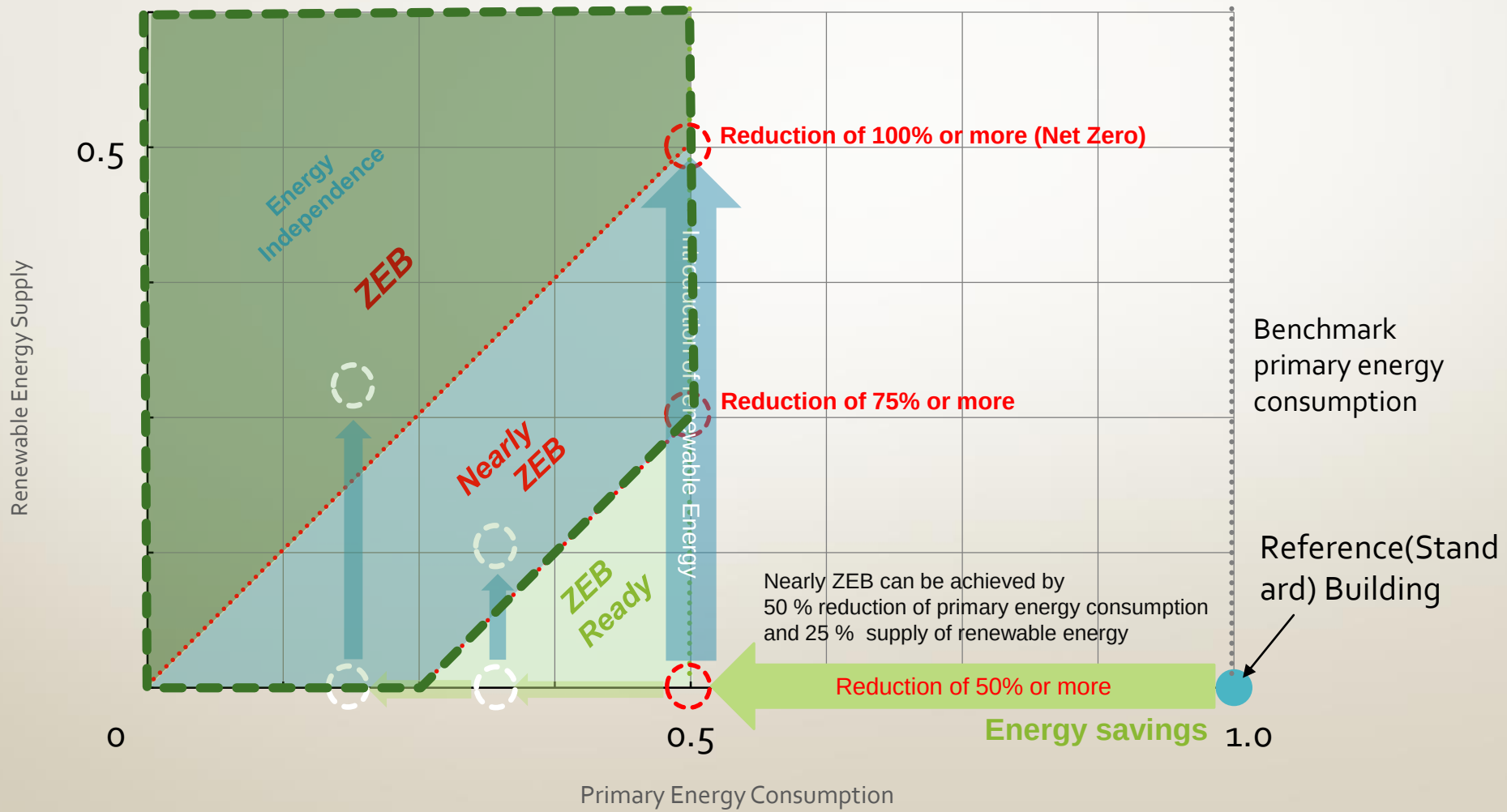
Gyuyoung Yoon, Makiko Ukai

CLIMA 2019
Built environment facing climate change
REHVA 13th HVAC World Congress
26 - 29 May, Bucharest, Romania

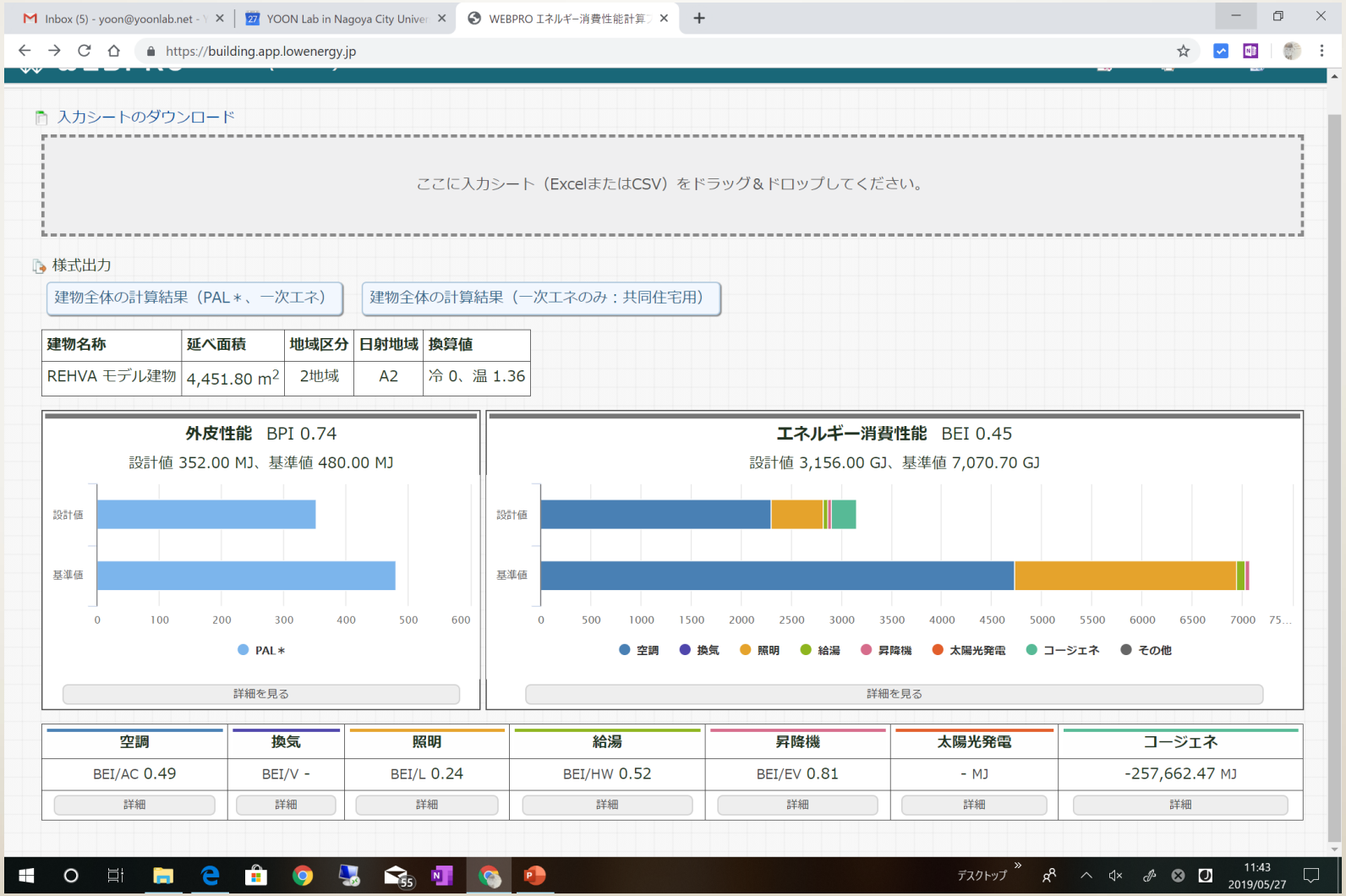
# Contents

- ZEB Definition in Japan
- Simulation of Energy Consumption on ZEB Definition (by using WEBPRO)
- Design of HVAC system for a Model building
  - **Case Study of Heat Load for a Model building**
  - HVAC system Design for Model Building
- **Feasibility Study for ZEB on a Model Building**
- Discussion and Conclusions

# ZEB Definition in Japan

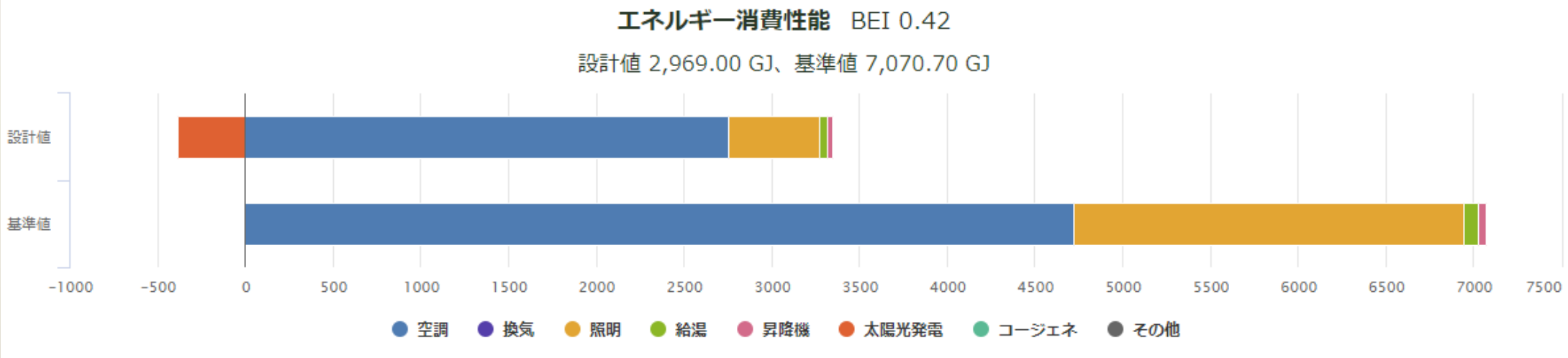


# Simulation of Energy Consumption on ZEB Definition (WEBPRO)




WEBPRO is not a design tool, but a certification tool for building regulation

# Simulation of Energy Consumption on ZEB Definition (WEBPRO)



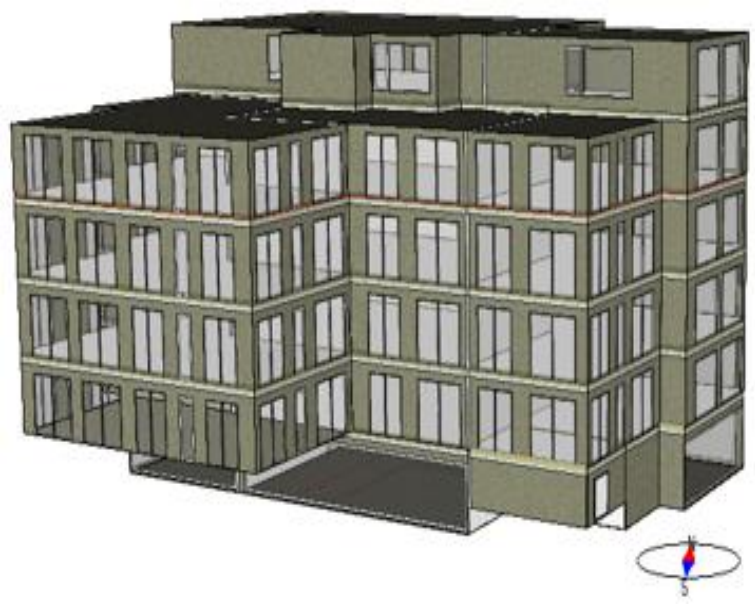

WEBPRO counts for ;

- HVAC system
- Ventilation
- Lighting
- Hot-water supply
- Elevator
- PV
- CHP
- Appliance(excluded at ZEB definition)

INPUT DATA

| | |
|---|---|
| Occupant, $m^2$/person | 10 |
| Appliances, W/$m^2$ | 12 |
| Lighting, W/$m^2$ | 12 |
| Appliances & lighting operation hour*1) | 8:00-21:00 |
| Air-Conditioning Hour | 7:00-21:00 |
| Usage factor*1) | 0.89 |
| Hot water consumption, l/$m^2$ a | 91.58 |
| Fan operation hour | 7:00-21:00 |
| Ventilation rate, l/$m^2$ s | 1.39 |
| Heating set point, °C | 22 |
| Relative Humidity %rh *3) | 40 |
| Cooling set point, °C | 26 |
| Relative Humidity %rh *3) | 50 |

# Design of HVAC system for Model building

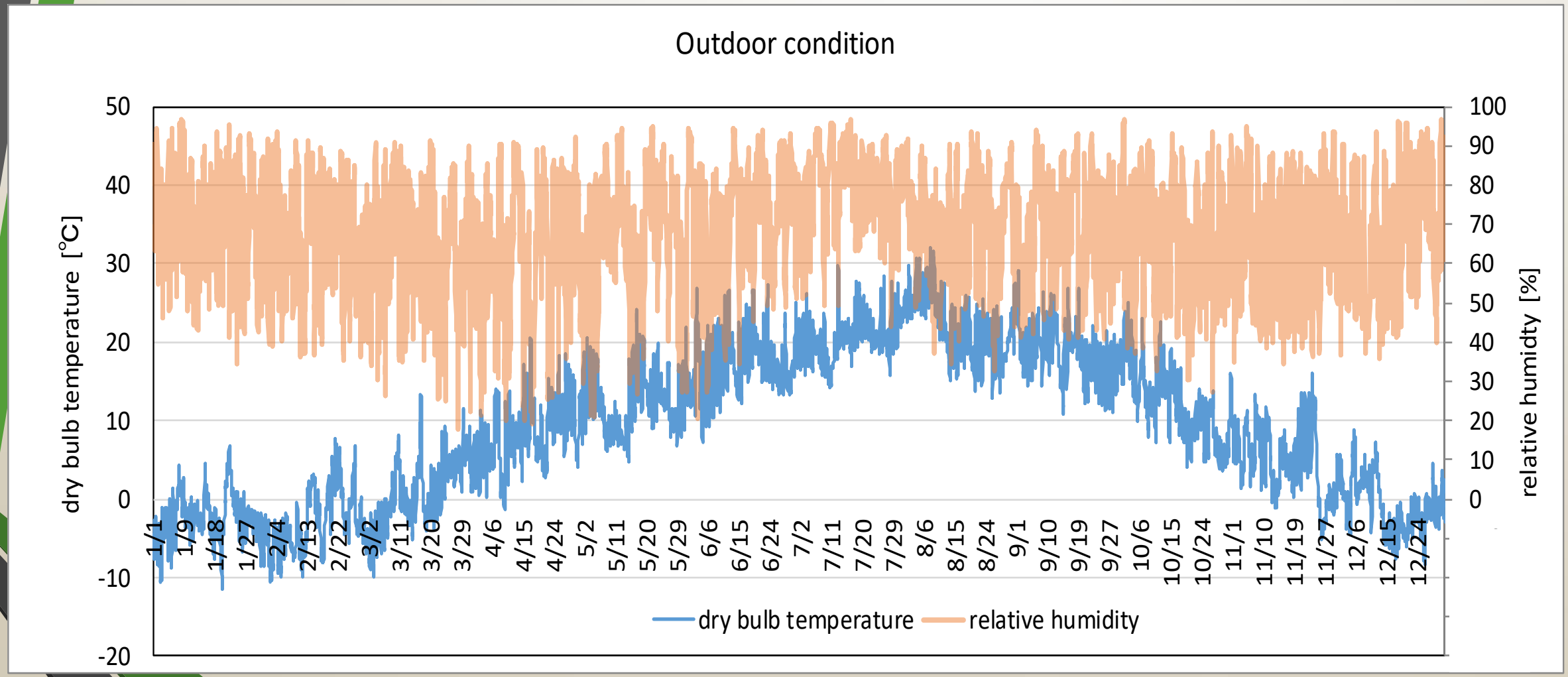


Location : Sapporo, Japan
Office building
Gross floor area：4451.8㎡
Ceiling hight：3.0m
Floor hight：4.0m
BF1+6F
Structure : RC

| | Outdoor wall | Roof | Windows | |
|---|---|---|---|---|
| | W/m²K | W/m²K | W/m²K | SC value |
| Case R | 0.27 | 0.18 | 0.82 | 0.38 |
| Case W | 0.34 | 0.65 | 0.82 | 0.14 |
| Case T | 0.35 | 0.38 | 1.81 | 0.49 |

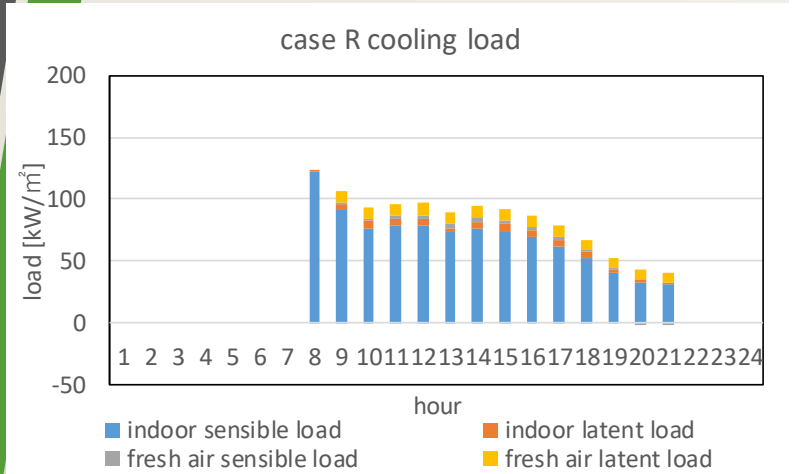
# Climate Conditions in Sapporo

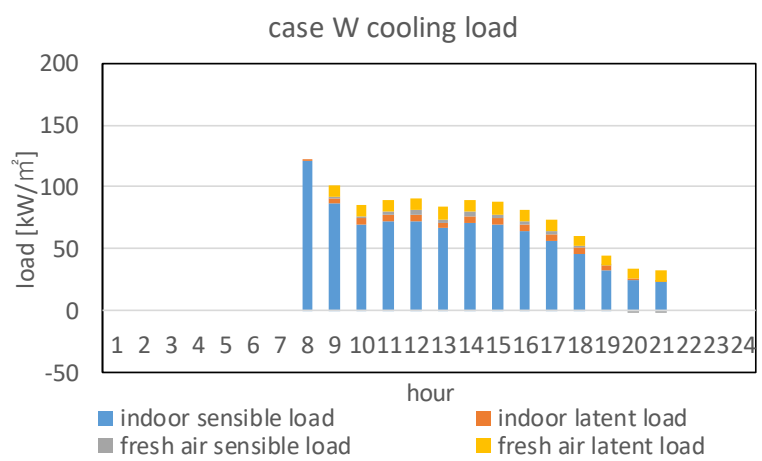
MAX: 32°C, MIN:-11.4°C
Heating DD : 3455.2 (18/18)
Cooling DD : 7.9 (27/24)

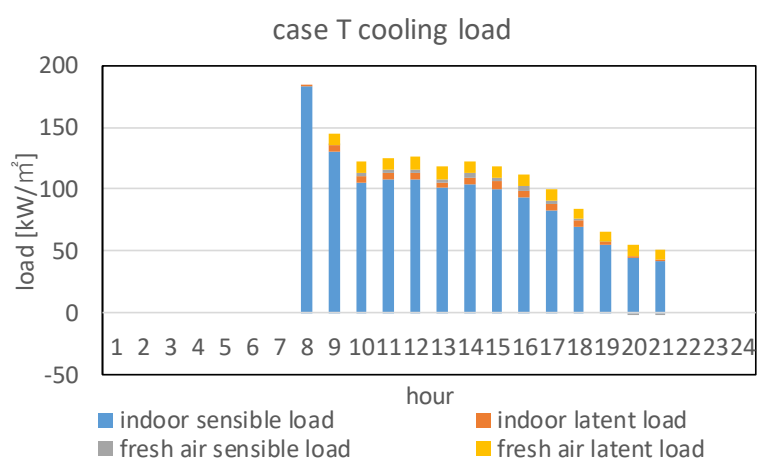


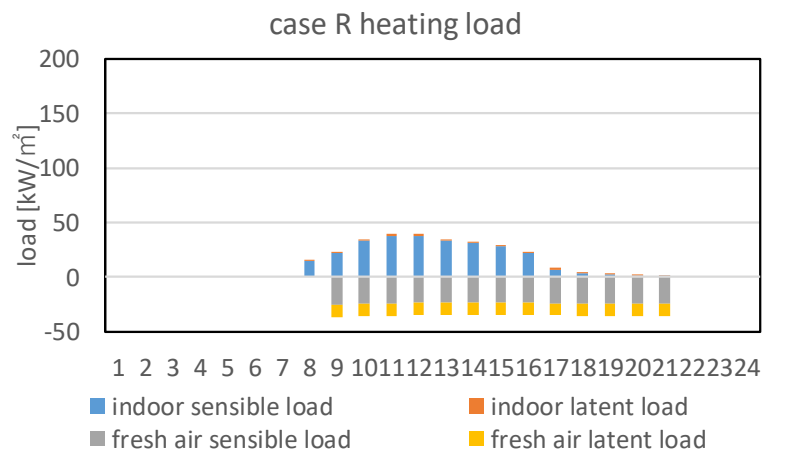
# Cooling and Heating Load for Peak Day

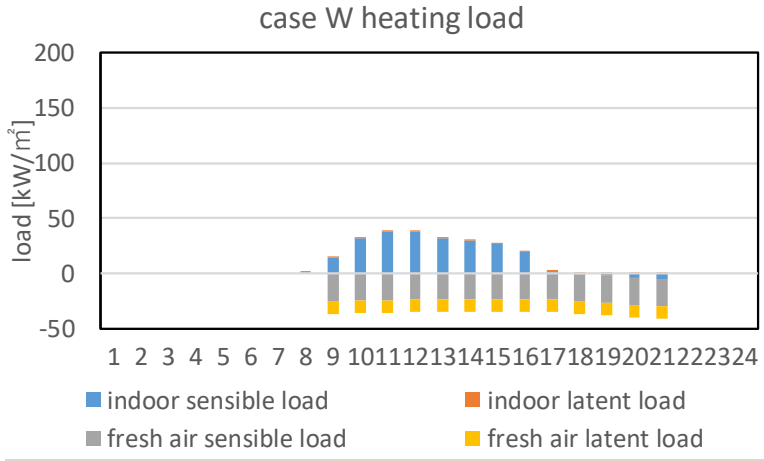
## calculated by HASP program (Response factor method)

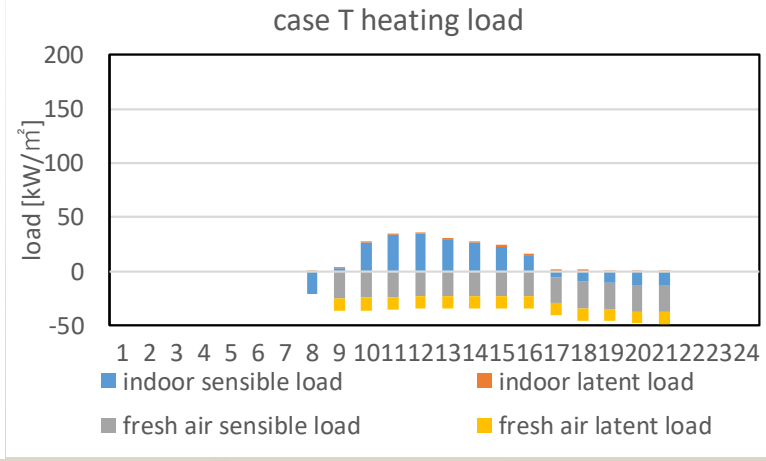


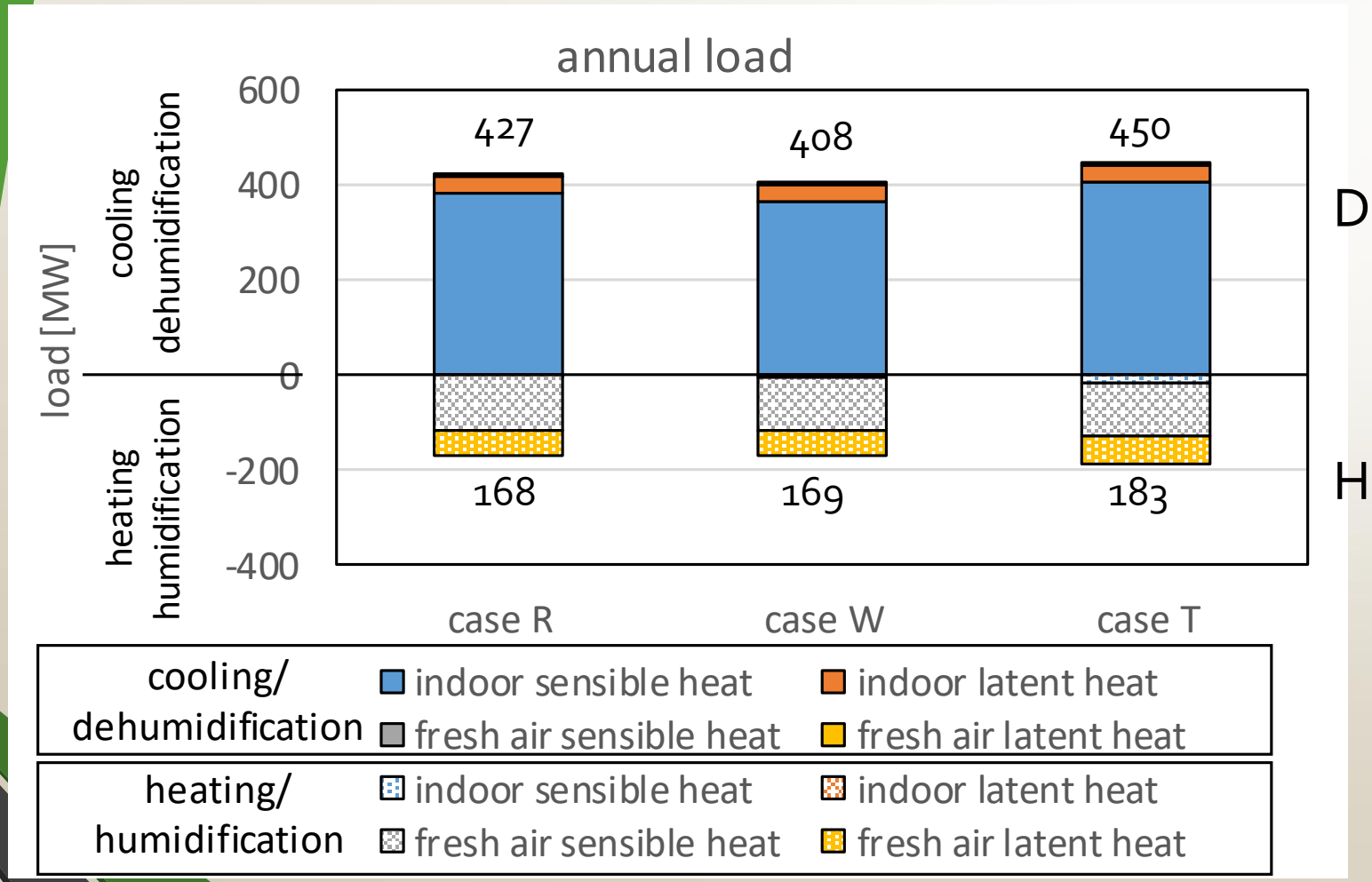




Case T: the performance of the windows are not good compared to the case R and case W, so it results in larger cooling load ad heating load

Case R and Case W are similar

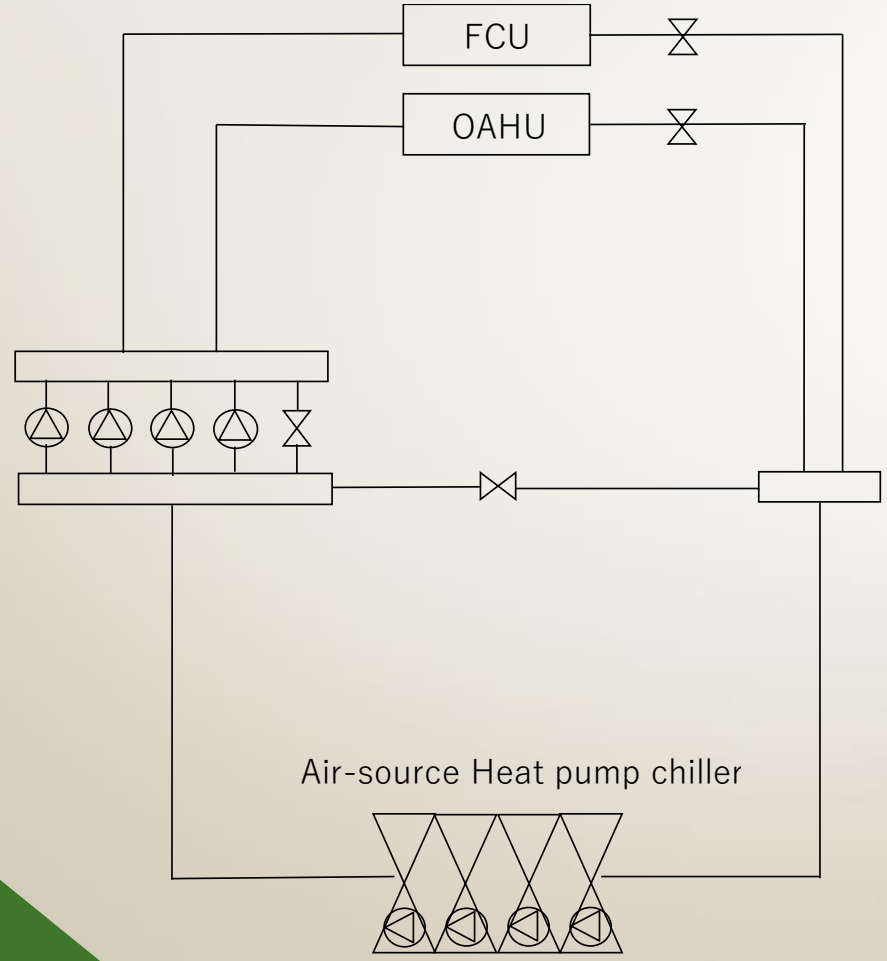
# Annual load for cooling/heating and dehumidification/humidification




Dehumidification = 10%

Humidification =30%

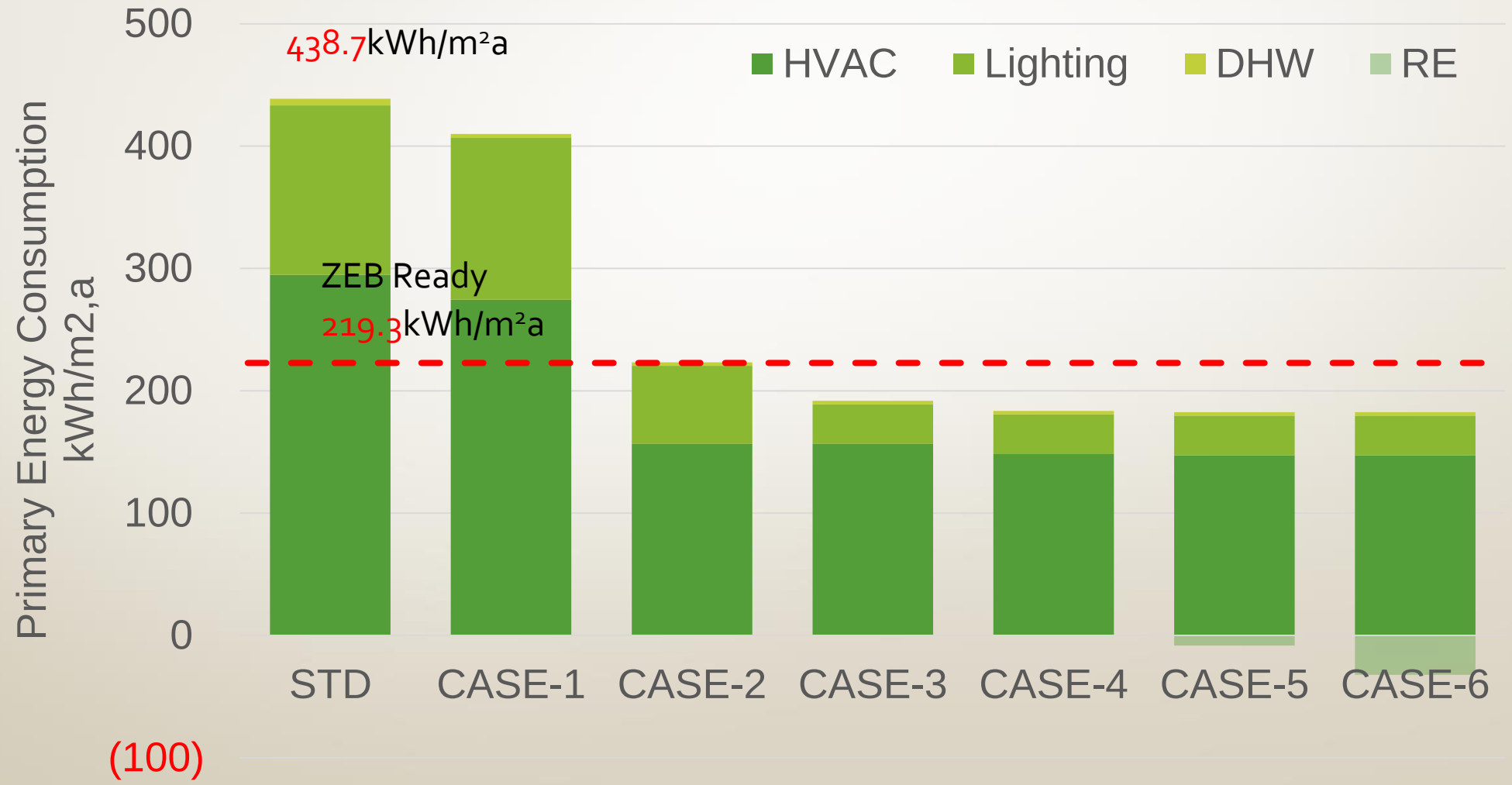
# Design of HVAC system for Model building



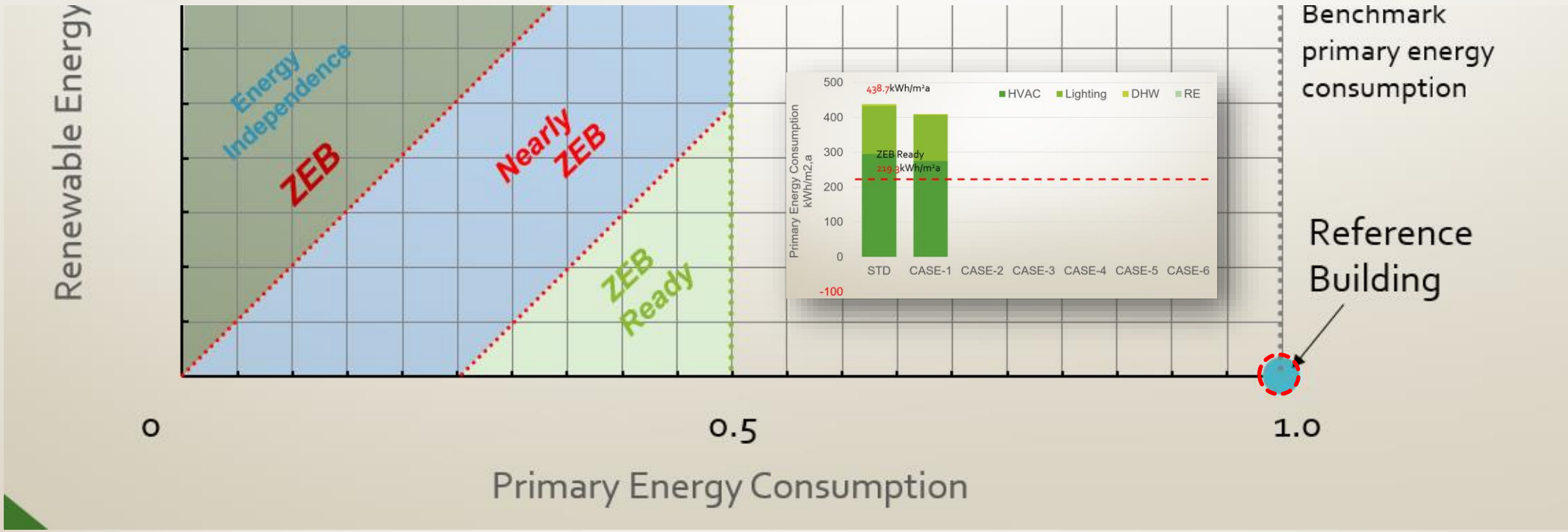

Primary Equipment Load
Cooling Load : 120.0 W/m²
Heating Load : 42.3 W/m²

- Air Side
  - Outdoor Air Handling Unit with Air-to-Air heat exchanger: 1 unit, 1.39l/m²,s
  - Fan coil Units : 102 units
  - Humidify by evaporation
- Water Side
  - Air-source Heat Pump Module Chillers : 8 units, Rated Cooling COP : 4.14
  - Chilled Water Pumps : 4 units

# Feasibility Study for ZEB on Model Building



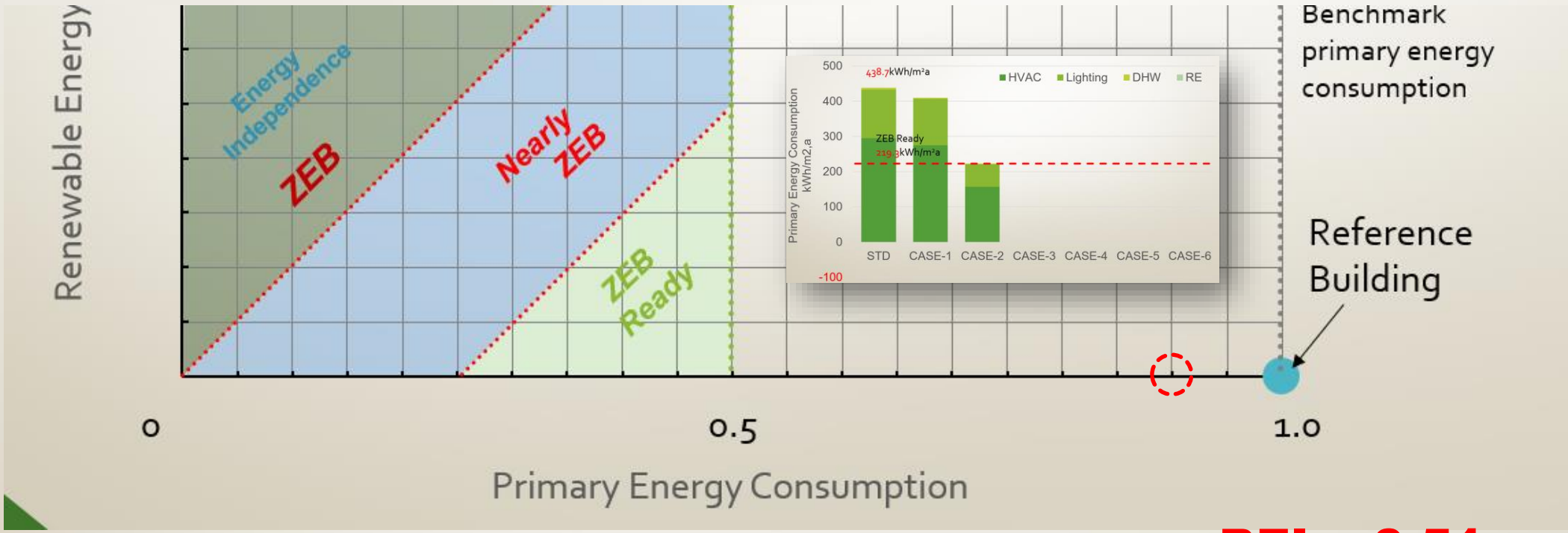
# ZEB Evaluations and Energy-saving Techniques




**BEI = 0.93**

- Improving Building Fabric (U value : 0.34->0.27)

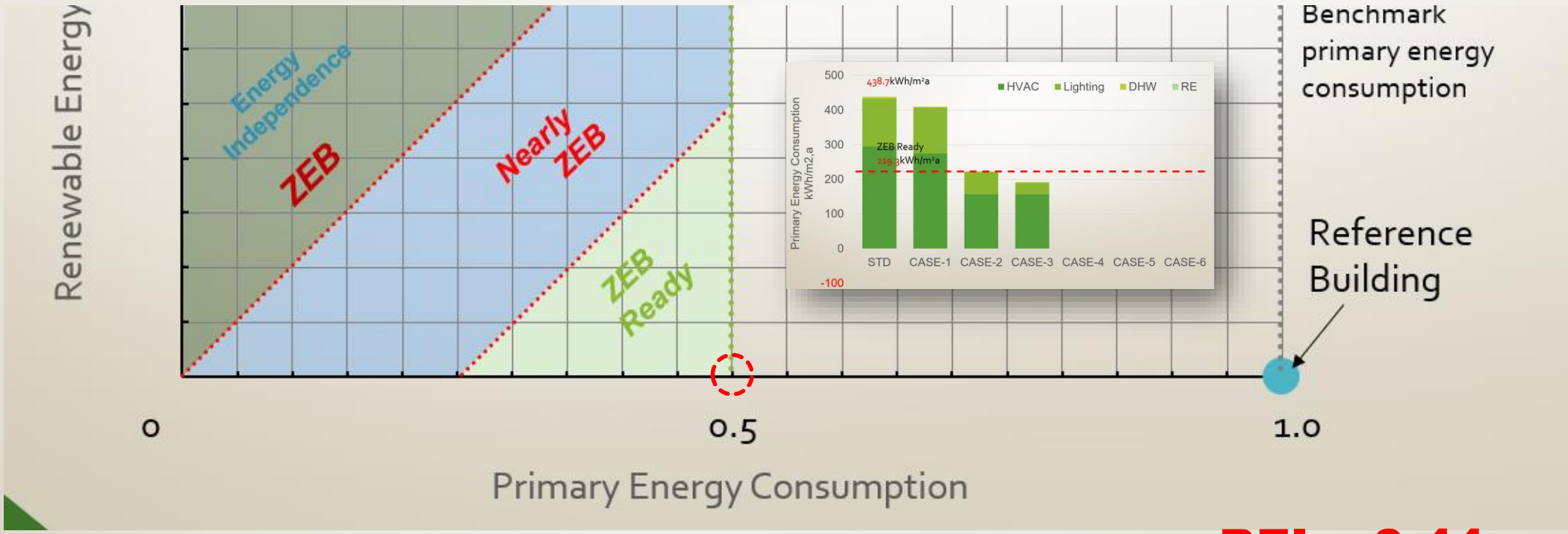
# ZEB Evaluations and Energy-saving Techniques




**BEI = 0.51**

- Improving Building Fabric (U value : 0.34->0.27)
- High Performance  Heat Source Equipment (COP : 3.24->4.14)
- Reasonable HVAC Capacity

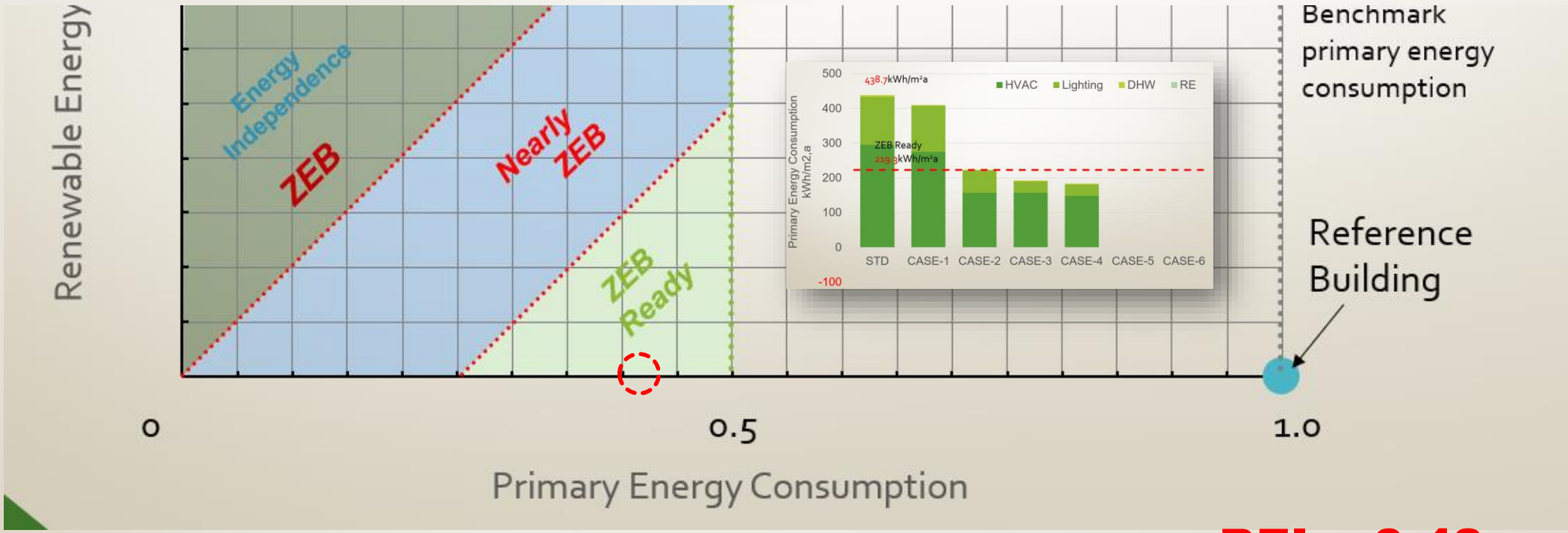
# ZEB Evaluations and Energy-saving Techniques




- Improving Building Fabric (U value : 0.34->0.27)
- High Performance  Heat Source Equipment (COP : 3.24->4.14)
- Reasonable HVAC Capacity
- LED Lighting & Control
  - Human Detecting Sensor, Illumination Sensor, Time schedule Lighting, Initial Illumination Modifying

**BEI = 0.44**

# ZEB Evaluations and Energy-saving Techniques



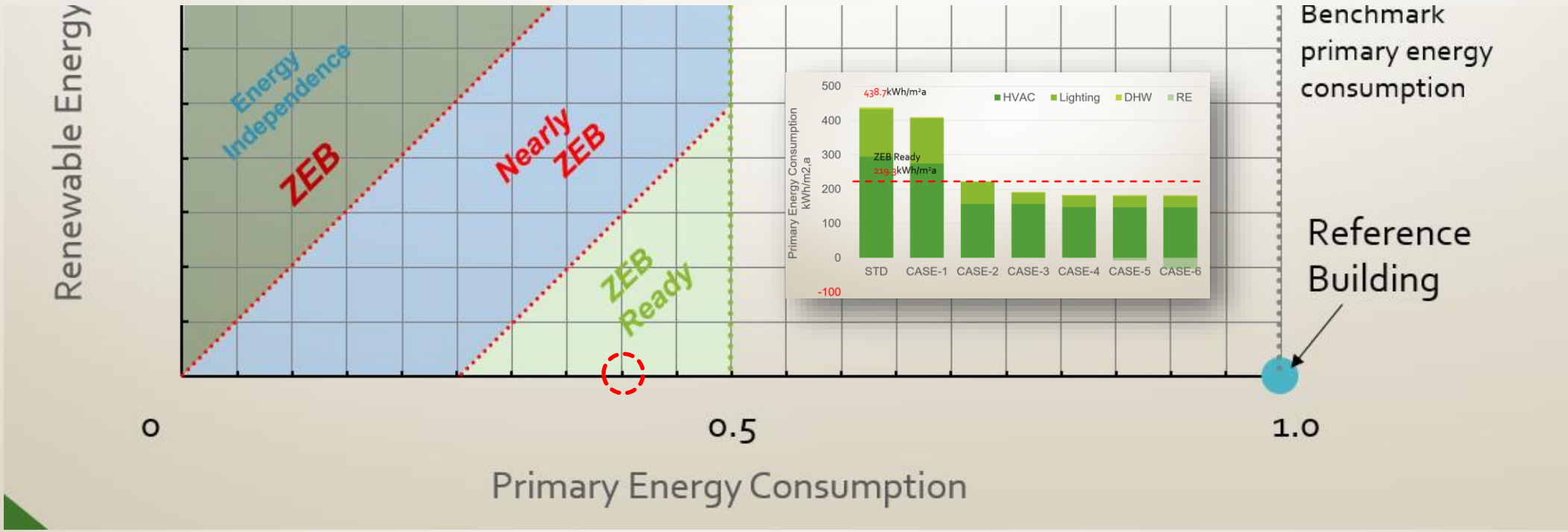

- Control Scheme for Energy-saving
  - Larger Chilled Water Temperature, Raising of hot water temperature (45C->40C)
  - Passive Cooling by Outdoor Air, Improving Efficiency of Air-to-Air Heat Exchanger (60%->77%)

**BEI = 0.43**

- Introducing Ground-source heat pump
  - 1 unit of Ground-source heat pump, Rated Cooling COP = 5.4
  - Bore Hole Heat Exchanger by Double U-tube 150m

**BEI = 0.42**

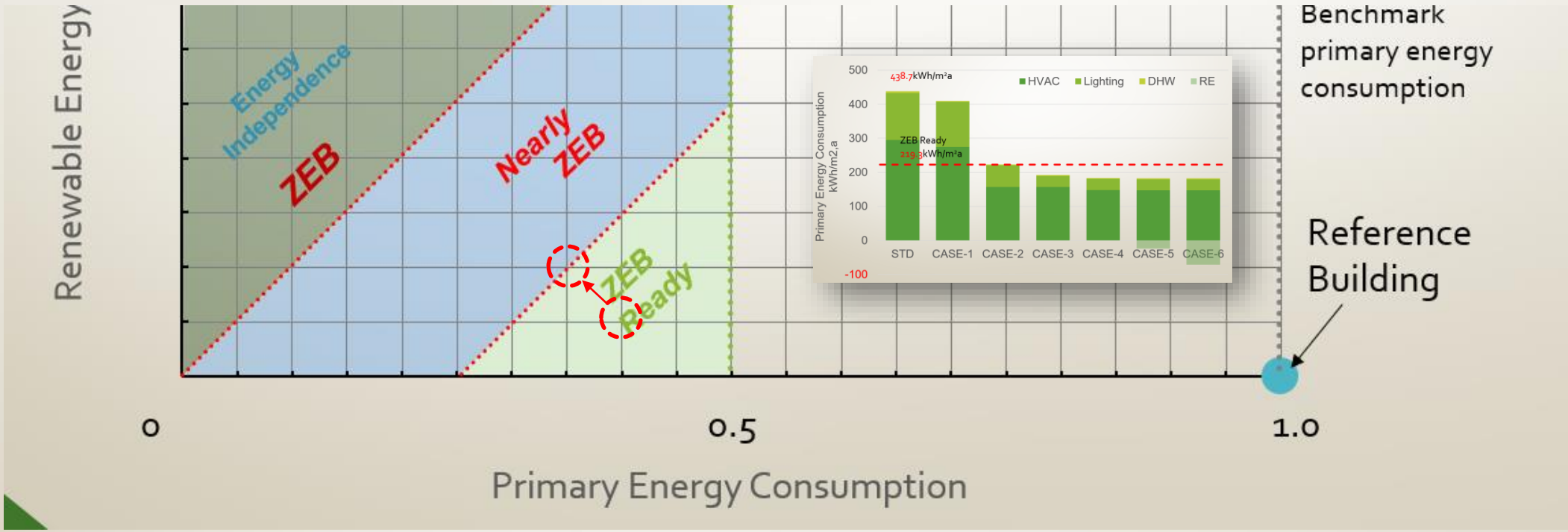
# ZEB Evaluations and Energy-saving Techniques




- Introducing Combined Heat & Power
  - 34kW of Gas Engine
  - Generated Heat is used for Space Heating

**BEI = 0.40**

# ZEB Evaluations and Energy-saving Techniques




- Introducing Photovoltaic Panel
  - 30% of Roof area, 43.5 kW, 43 degree tilt angel
  - 90% around of Roof area, 130.5kW

**BEI = 0.34**

**BEI = 0.25**

# ZEB techniques in this case-study

- Improving Building Fabric (U value : 0.34->0.27)
- High Performance  Heat Source Equipment (COP : 3.24->4.14)
- Reasonable HVAC Capacity
- LED Lighting & Control
  - Human Detecting Sensor, Illumination Sensor, Time schedule Lighting, Initial Illumination Modifying
- Control Scheme for Energy-saving
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- Introducing Combined Heat & Power
  - 34kW of Gas Engine
  - Generated Heat is used for Space Heating
- Introducing Photovoltaic Panel
  - 30% of Roof area, 43.5 kW, 43 degree tilt angel

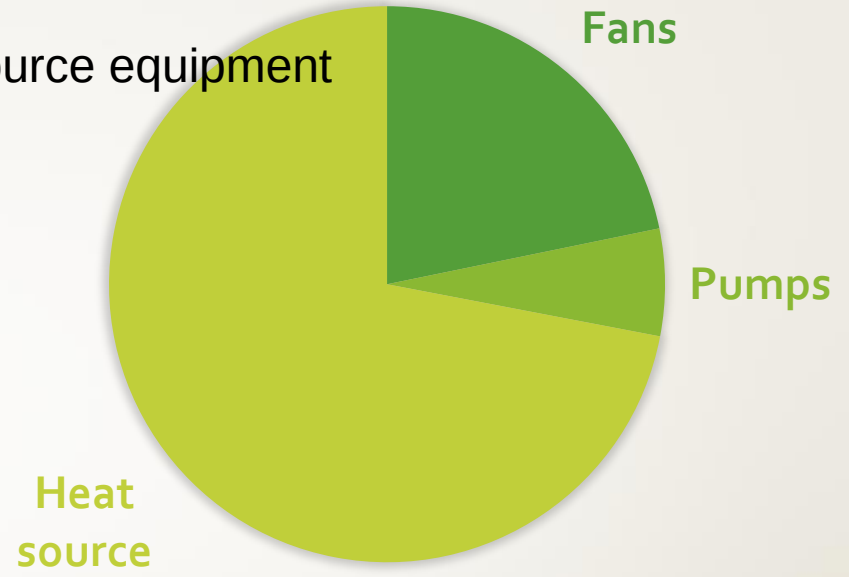
*Natural Ventilation, Fresh Air Variable Control by $CO_2$ concentration were not considered caused by simulation restriction.

# Conclusions

- Cooling peak load is larger than heating peak load, so the HVAC system capacity is determined by cooling peak load. Annual cooling load is three times of annual heating load.
- For heating season, most of heating load comes from fresh air load and almost 30% of that is caused by humidification.
- Feasibility study on ZEB for Model building was done by using WEBPRO which is regulated by national regulation, appeared that it is no so easy to achieve ZEB although almost affordable techniques were adapted.
- For achieving even or more than Nealry ZEB performance, it is needed to introduce new kinds of HVAC system such as radiation heating and cooling, decoupling sensible & latent heat. …

Acknowledge : Special Committee for Joint Study on nZEB between SHASE and REHVA
The Society of Heating, Air-Conditioning and Sanitary Engineering of Japan, Chairperson Dr. Hideharu Niwa

Mean COP for Heat source equipment
Cooling season : 2.00
Heating season : 1.09



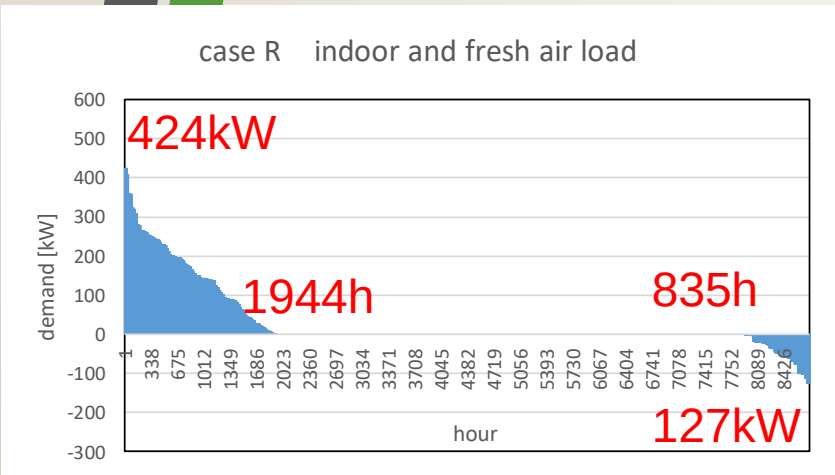

# What can we do for next ?

- How to reduce power consumption for Heat source ?
- How to improve energy efficiency for heating operation ?
- How to handle fresh air load high efficiency ?
- How to reduce Fans's power ?

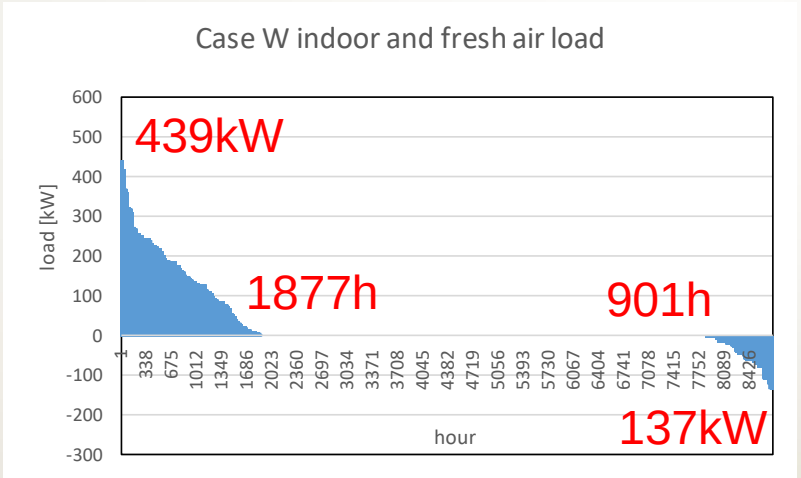
# APPENDIX

# Duration curve of indoor and fresh air load for 1 year

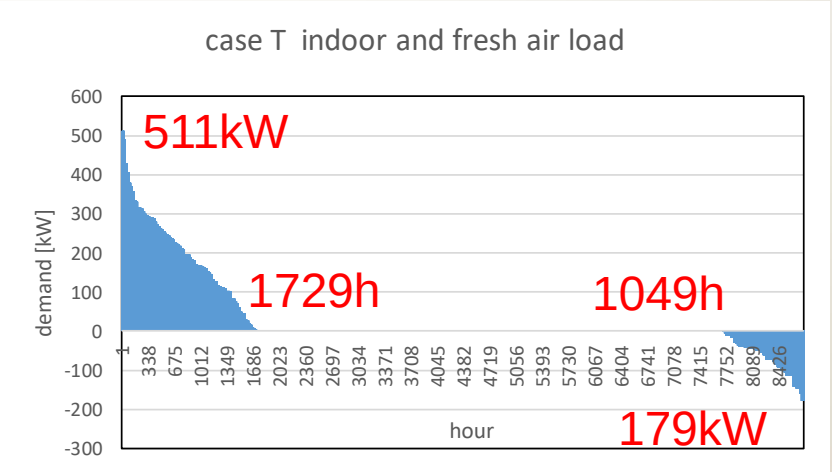
Total: 343,197kW




Total: 331,912kW




Total: 418,027kW

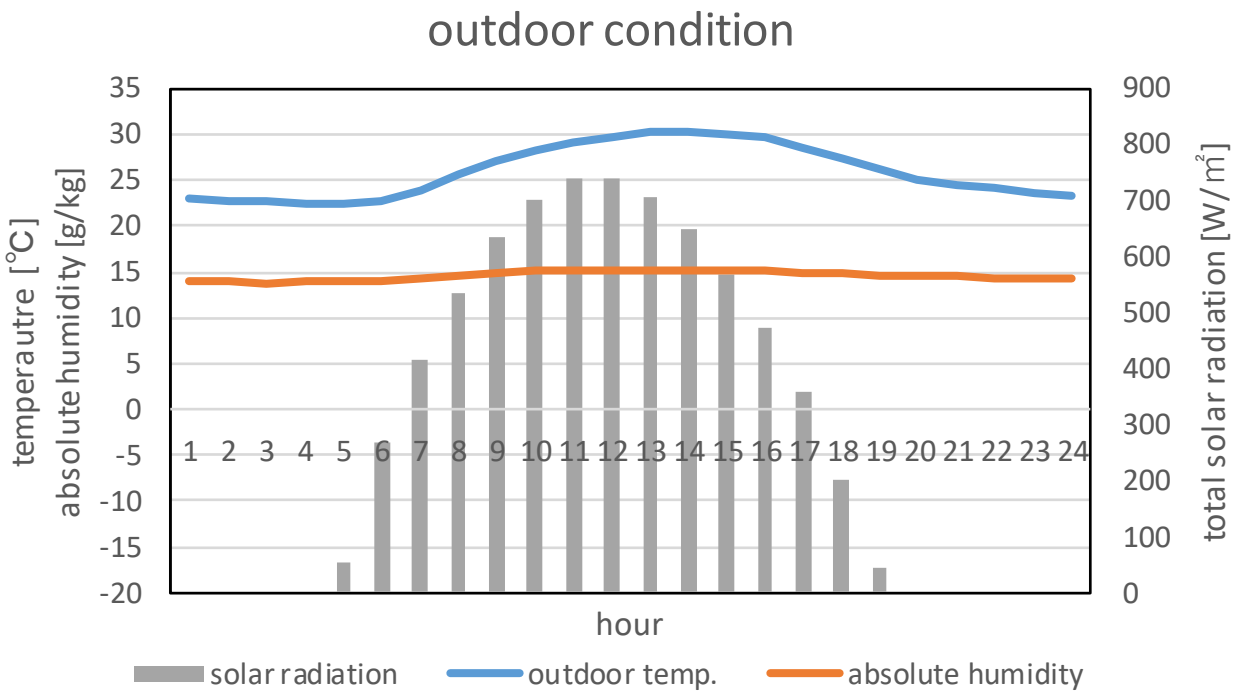


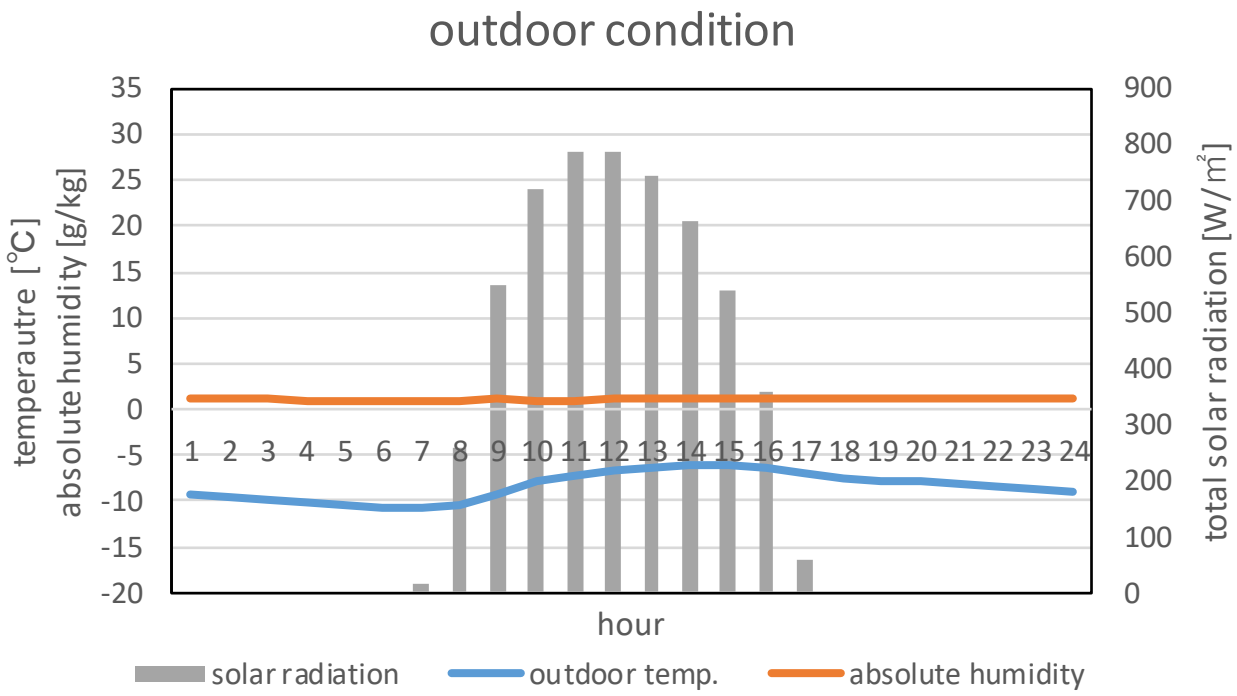

Improvement of the insulation performance results in;

1) larger maximum cooling load than maximum heating load
2) lower annual accumulated cooling and heating load, but cooling period gets longer

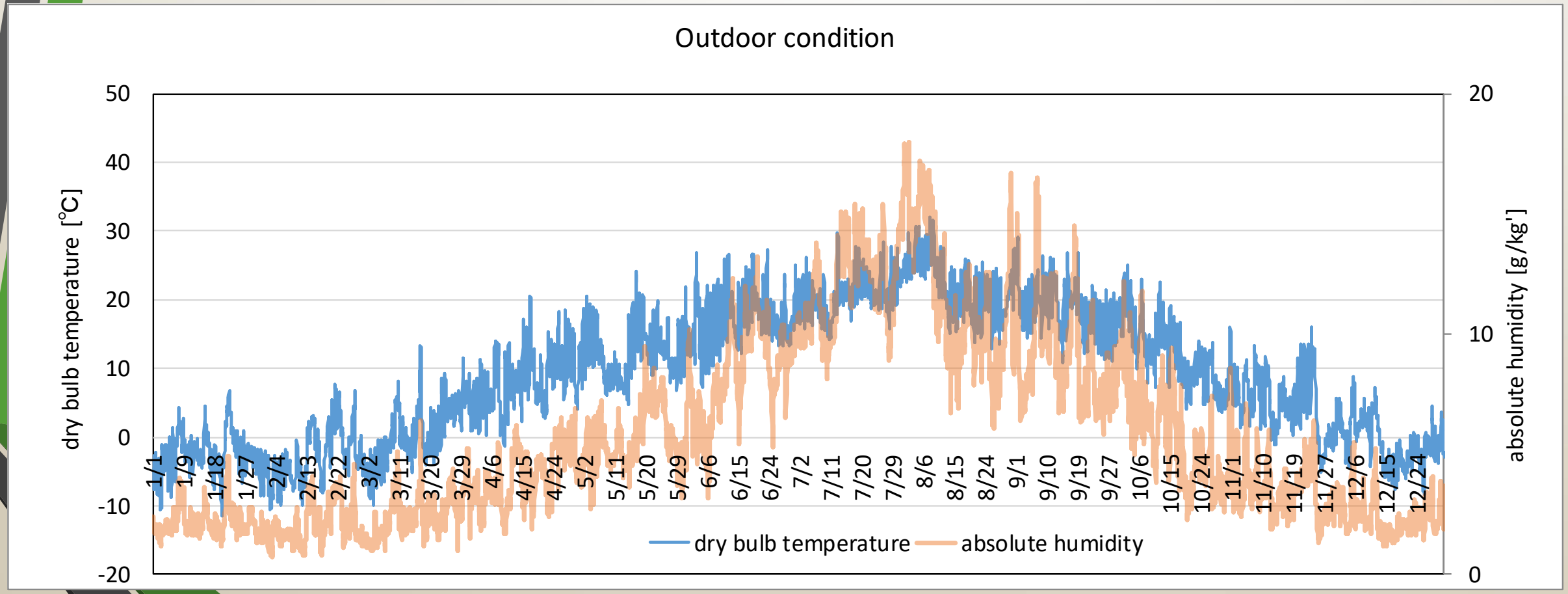
# Appendix

- Outdoor condition for Load calculation



# Appendix

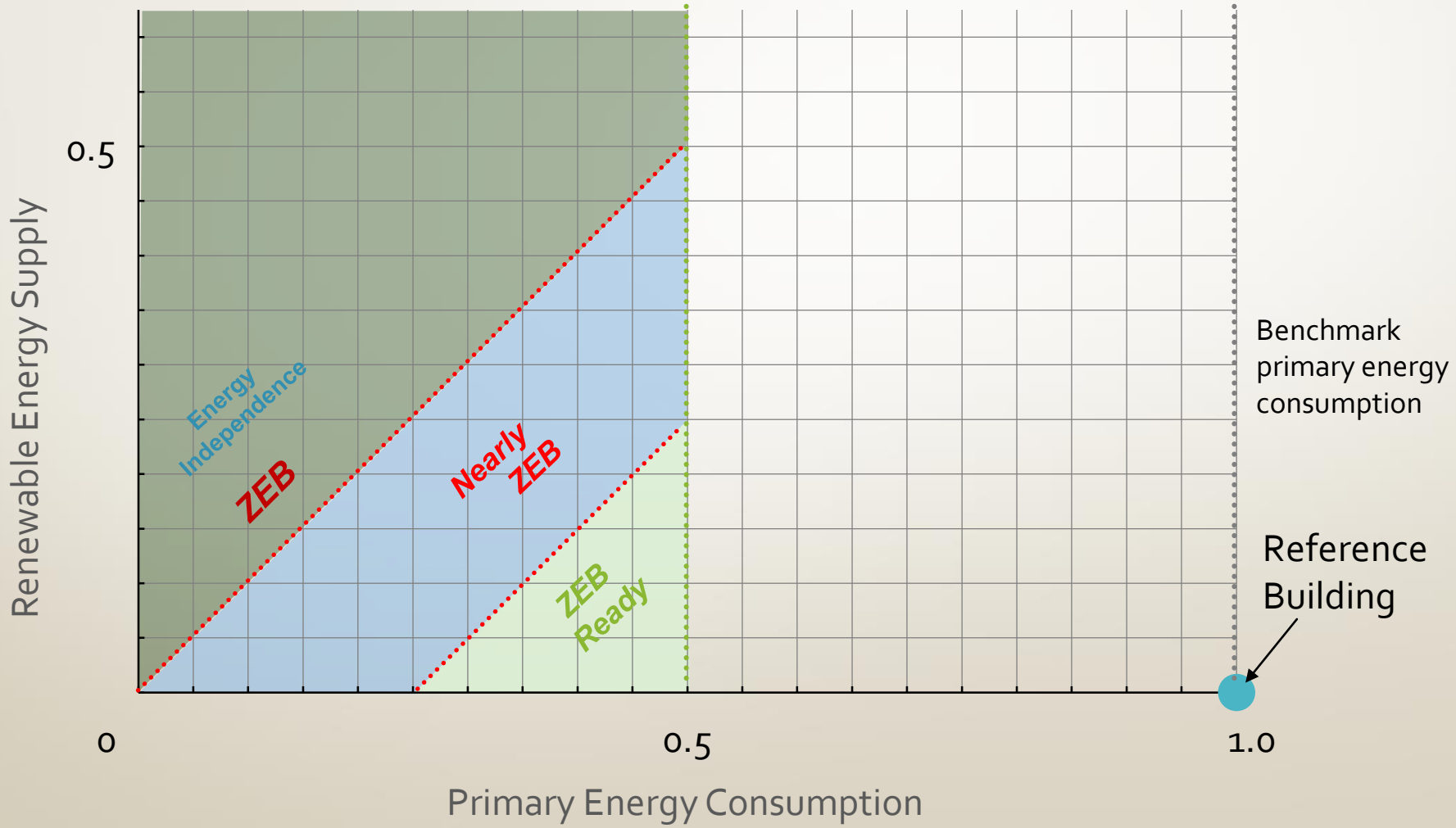

Outdoor condition
dry bulb temperature [°C]
absolute humidity [g/kg']
50
40
30
20
10
0
-10
-20
20
10
0
1/1
1/9
1/18
1/27
2/4
2/13
2/22
3/2
3/11
3/20
3/29
4/6
4/15
4/24
5/2
5/11
5/20
5/29
6/6
6/15
6/24
7/2
7/11
7/20
7/29
8/6
8/15
8/24
9/1
9/10
9/19
9/27
10/6
10/15
10/24
11/1
11/10
11/19
11/27
12/6
12/15
12/24
dry bulb temperature
absolute humidity

# Appendix

- Outdoor condition for Load calculation

Reduction of 75% or more

# ZEB Definition in Japan



# Feasibility Study for ZEB on Model Building

１．外皮性能向上、高効率照明、高効率熱源でZEBReady達成
２．照明制御、温水緩和でさらに改善
３．Nearl ZEB達成のためのPVは約167kW設置必要（950m2）、屋根面積を上回る