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CHIANG MAI HEALTH CARE CENTER

Energy Efficiency Study, Chiang Mai, January 19, 2017

Unexpected Co., Ltd.

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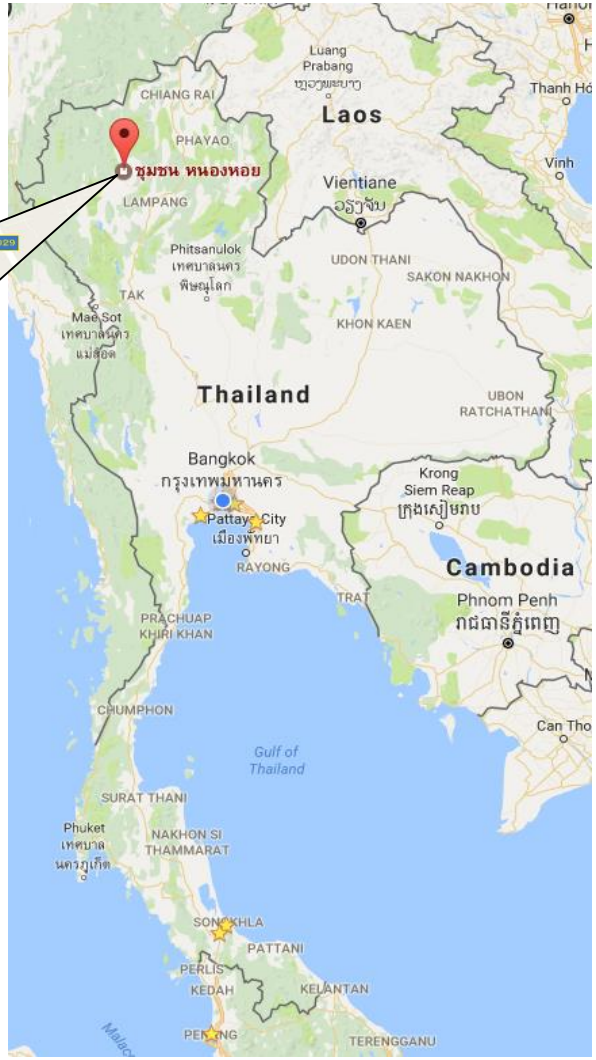
Chiang Mai Health Care Center,

Project location, **18°45'47.2"N / 99°00'40.9"E**



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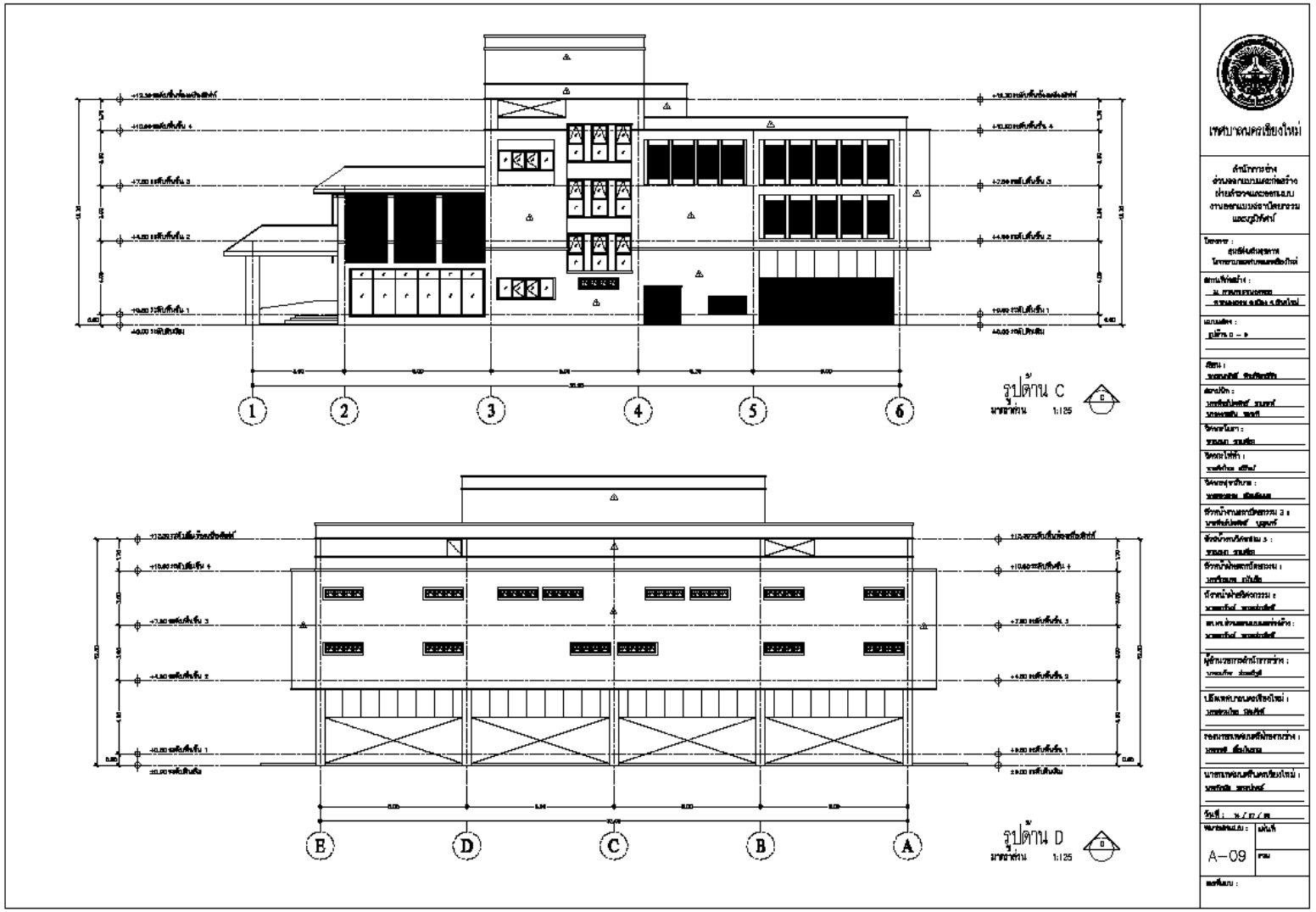
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รูปด้าน D
มาตราส่วน 1:125
เทศบาลนครเชียงใหม่
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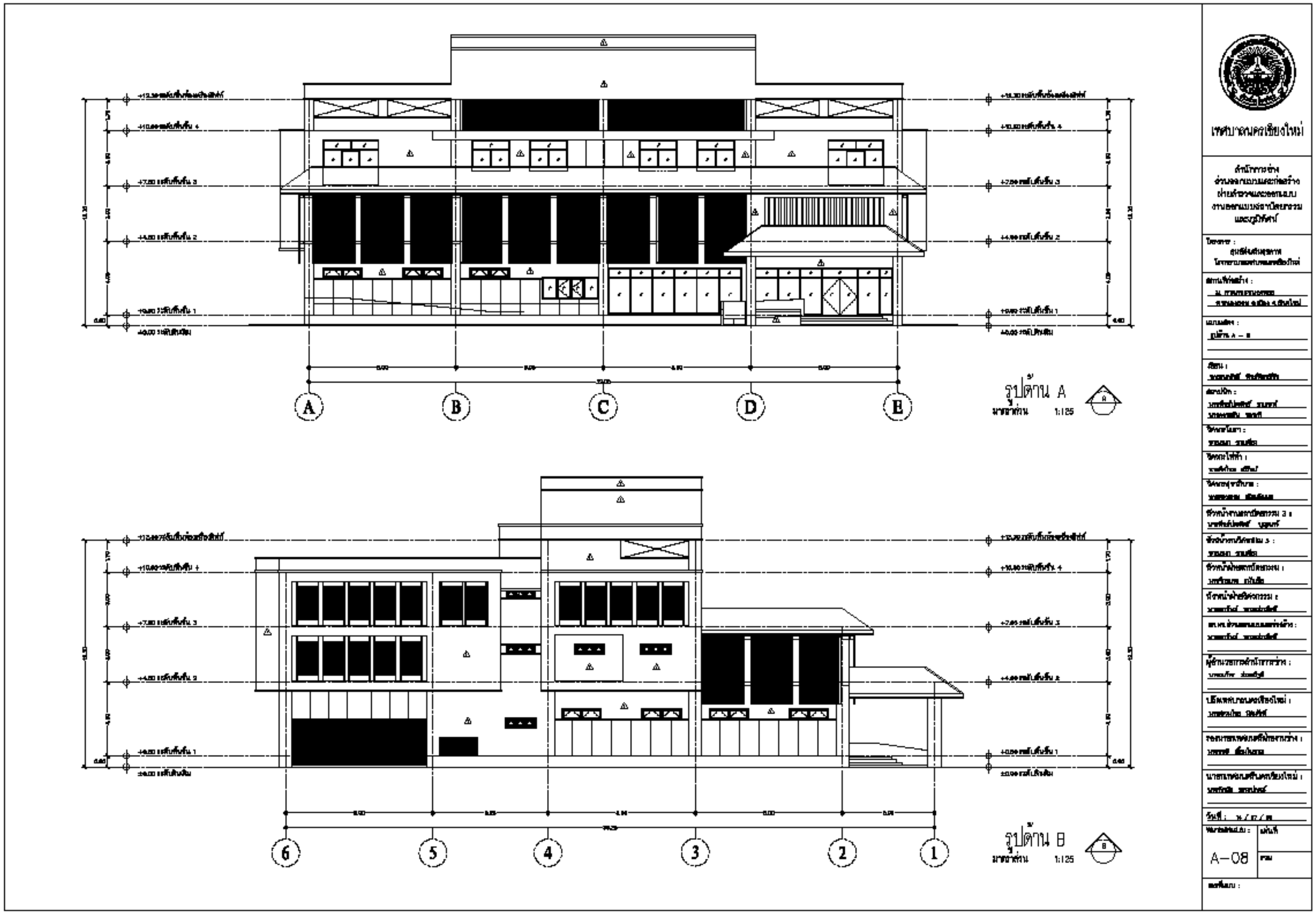

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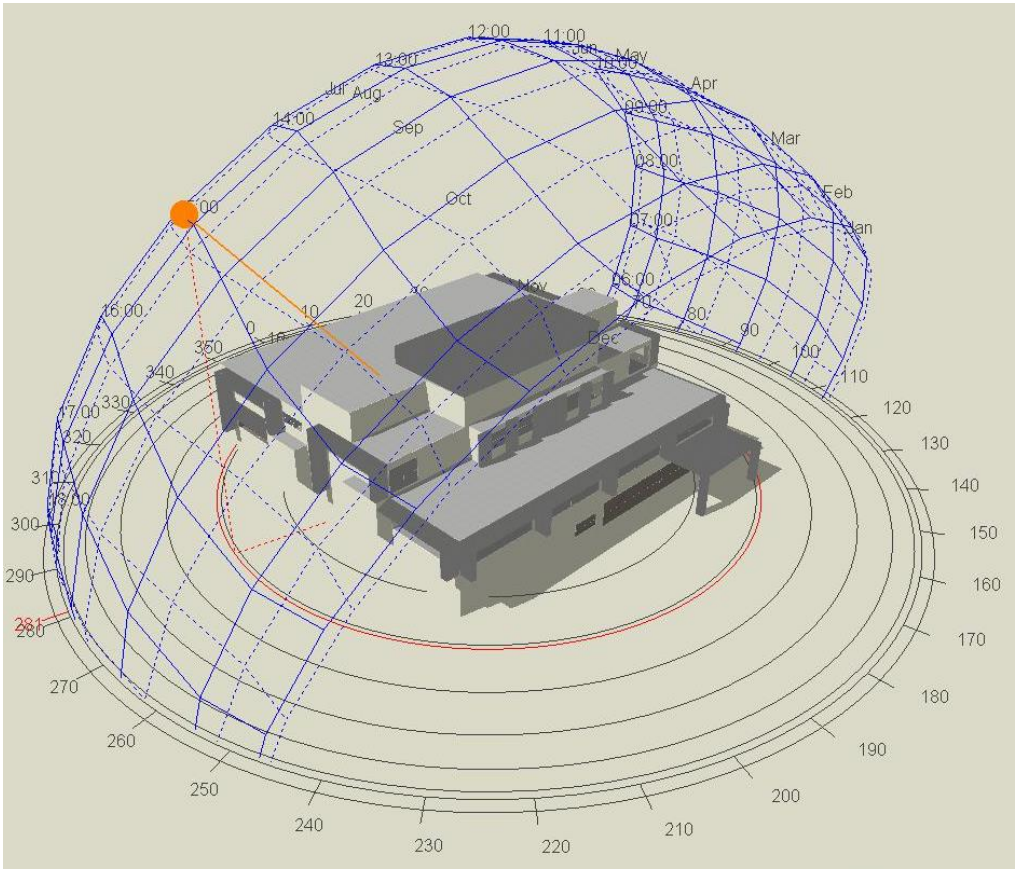
Chiang Mai Health Care Center,

Energy simulation model

	Area m²
Gross Floor Area	2,670
Air Conditioned Building Area	1,631
Unconditioned Building Area	1,039



Simulated EE Measures

- Installation of PV System
- HVAC Evaporator with Inverter
- Lighting Control System

- Exterior Shading for East Façade
- Improvement of façade openings
- Roof Surface Reflective Coating
- Insulation Ceiling
- Insulation Exterior Walls

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Chiang Mai Health Care Center,

Building information: Boundary conditions

Use pattern of the building:

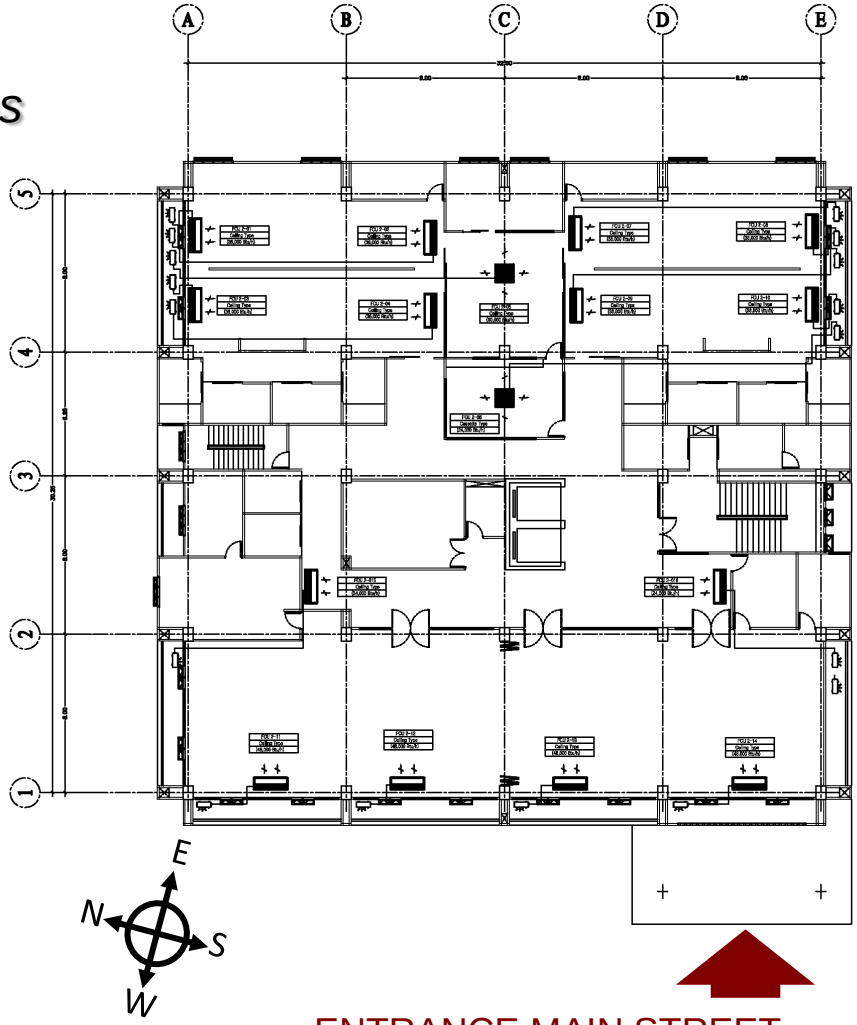
- Number of occupant: 110 persons per day
- Density : 0.041 persons/m^2_{GFA}
- Building operation hours: 8.30-18.00
- Lighting (5.35 W/m^2_{GFA}) in all from 8.30-18.00

Equipment:

- TV & Devices: On 8.30-18.00: 3 W/m^2_{GFA}
- Refrigerator (10 W): always on
- WLAN (5.3 W): = 0.057 W/m^2_{GFA}

Cooling:

- AC split type (follow Technical Drawing E03)
- COP: 3.2 (EER: 11)
- Set Operative Temperature : 25ºC



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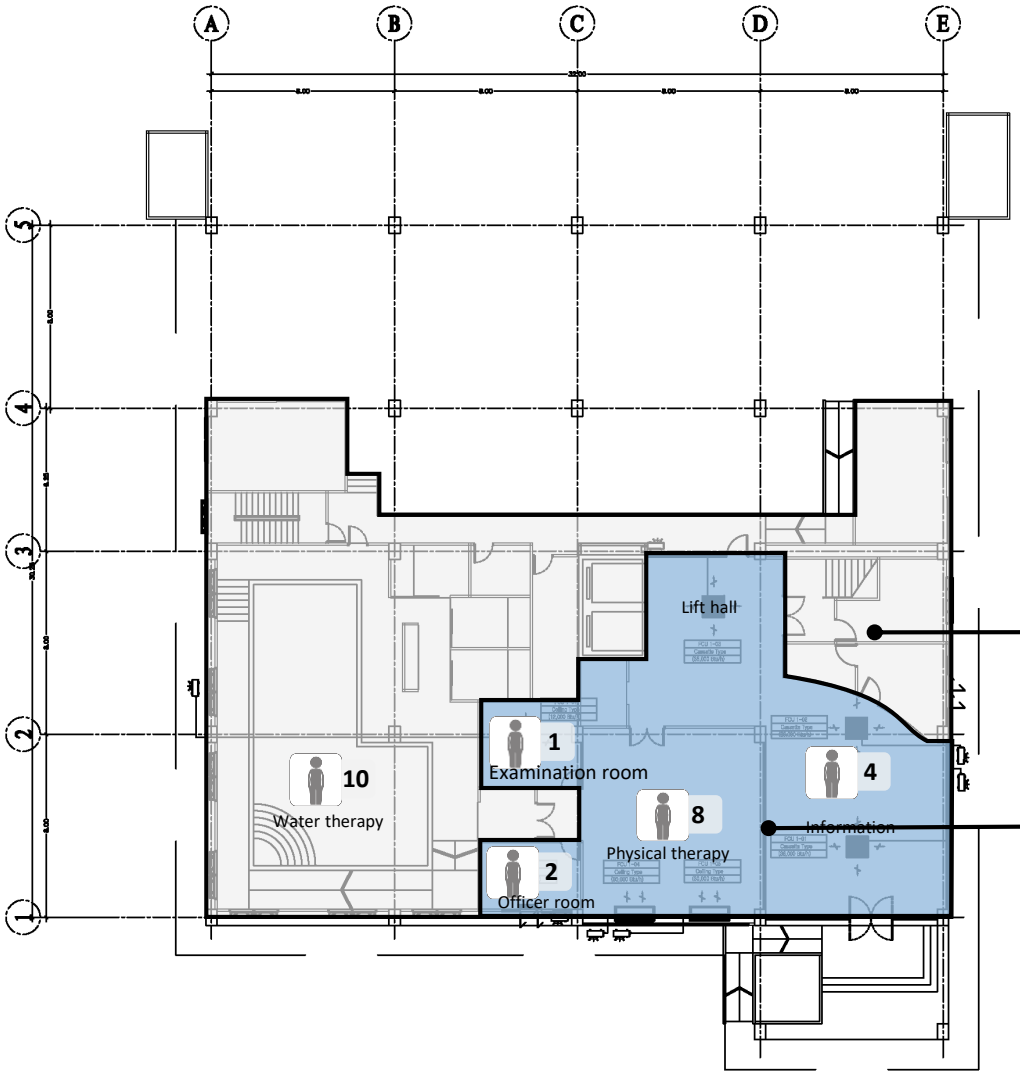
Thermal zone, 1st floor



Non AC Zone

AC Zone A :
- Operative Temperature: 25°C
- Number of people: 25

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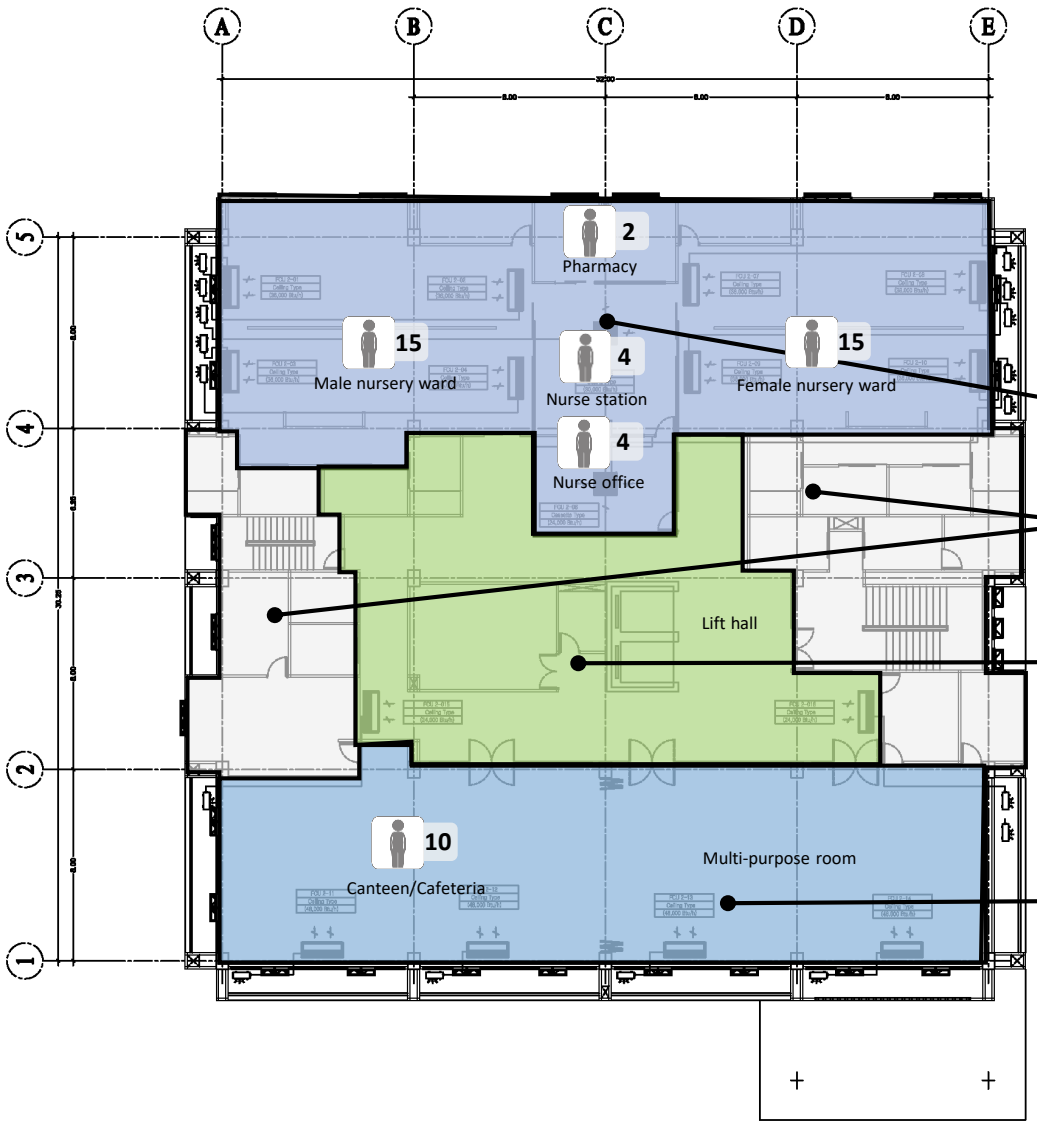
Chiang Mai Health Care Center,

Thermal zone, 2nd floor



AC Zone B:
- Operative Temperature: 25°C
- Number of people: 40

Non AC Zone

AC Zone C:
- Operative Temperature: 25°C

AC Zone A:
- Operative Temperature: 25°C
- Number of people: 10

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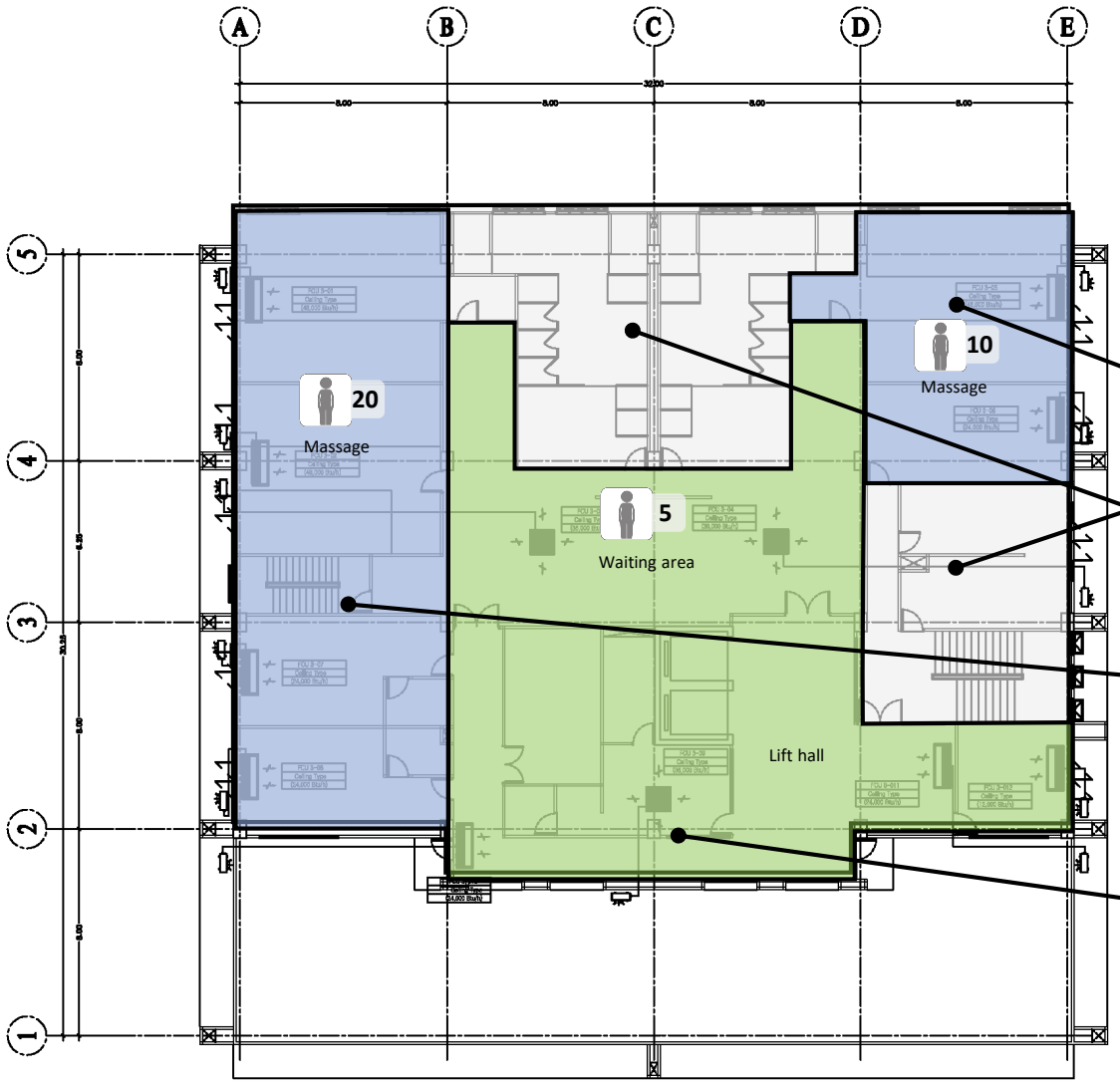
Chiang Mai Health Care Center,

Thermal zone, 3rd floor



AC Zone B:
- Operative Temperature: 25°C
- Number of people: 10

Non AC Zone

AC Zone B:
- Operative Temperature: 25°C
- Number of people: 20

AC Zone C:
- Operative Temperature: 25°C
- Number of people: 5

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Simulation boundary conditions for baseline model

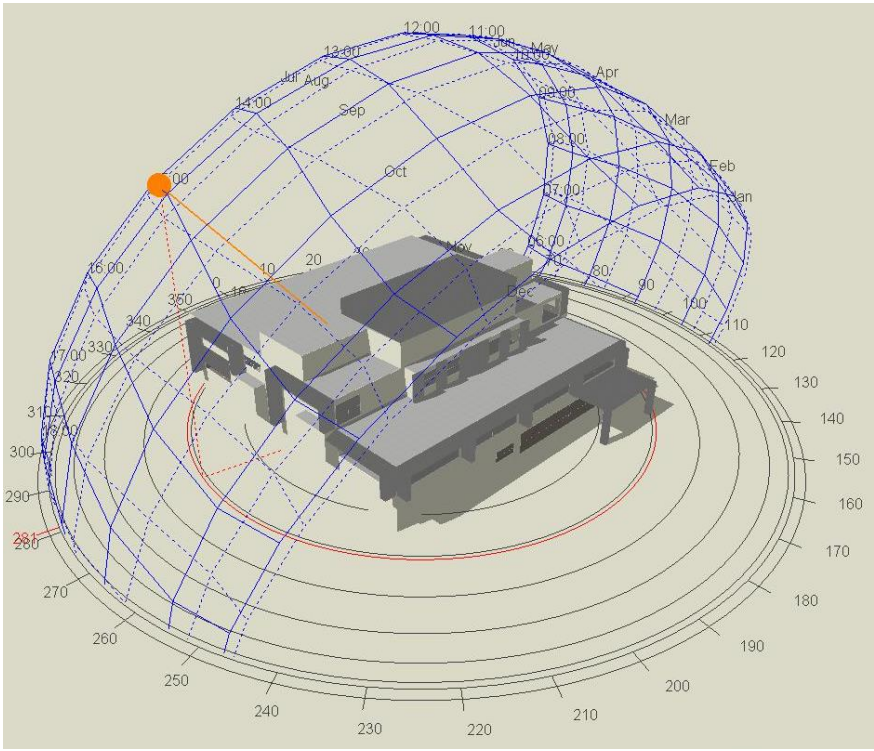
- **Weather data:** Chiang Mai, hourly weather data
- **Only Zone A, B and C considered to be air-conditioned:**
  - Zone A: Active room (e.g. meeting room, therapy room, reception)
  - Zone B: Non-Active room (e.g. nursing room)
  - Zone C: Corridor
- **Geometry according to architectural drawing set provided by CM Municipality**
- **Building envelope:**
  - **External Wall:** Traditional concrete block (no insulation): 100 mm (U= 2.85 W/m^2K)
  - **Roof:** Traditional concrete slab (no insulation) 100 mm (U= 4.3 W/m^2K)
  - **Window:** Single glazing 6 mm (U= 5.91 W/m^2K, SHGC = 0.8)
- **Infiltration (air-leakage):** 0.7 h^{-1}
- **Gross floor area:** 2,670 m^2_{GFA}

Chiang Mai Health Care Center,

Economic boundary for life cycle calculation (LCC)

- **Energy Price :** 4.5 THB/kWh
- **Interest Rate :** 5 %

- **Life Time of Equipment for LCC analysis based on VDI 2067**
  - LED lighting: 10 years
  - Glazing: 20 years
  - Shading: 20 years
  - Roof Insulation (Fiberglass): 20 years
  - Inverter type split units: 12 years
  - Solar PV: 20 years



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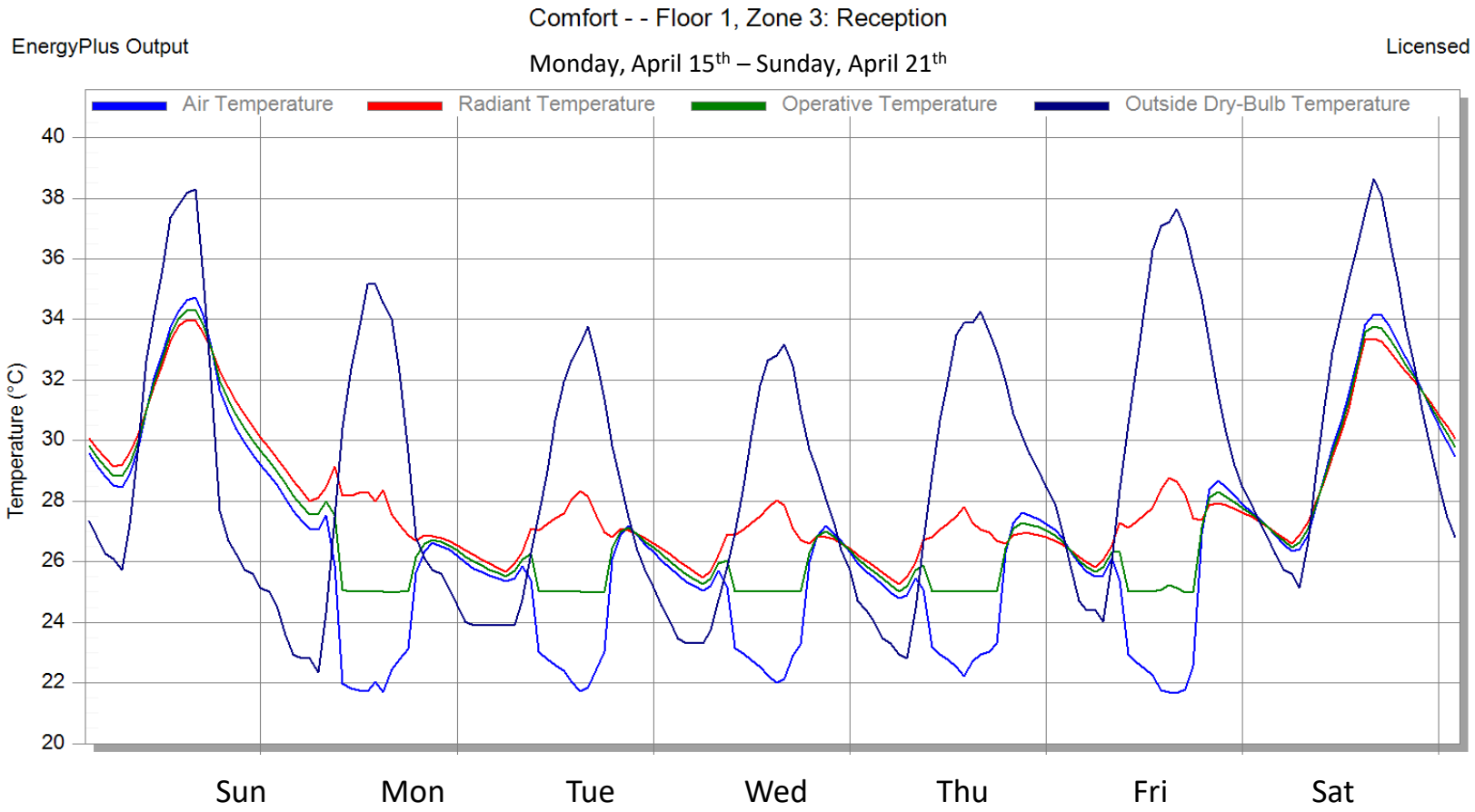
Baseline results: Thermal comfort



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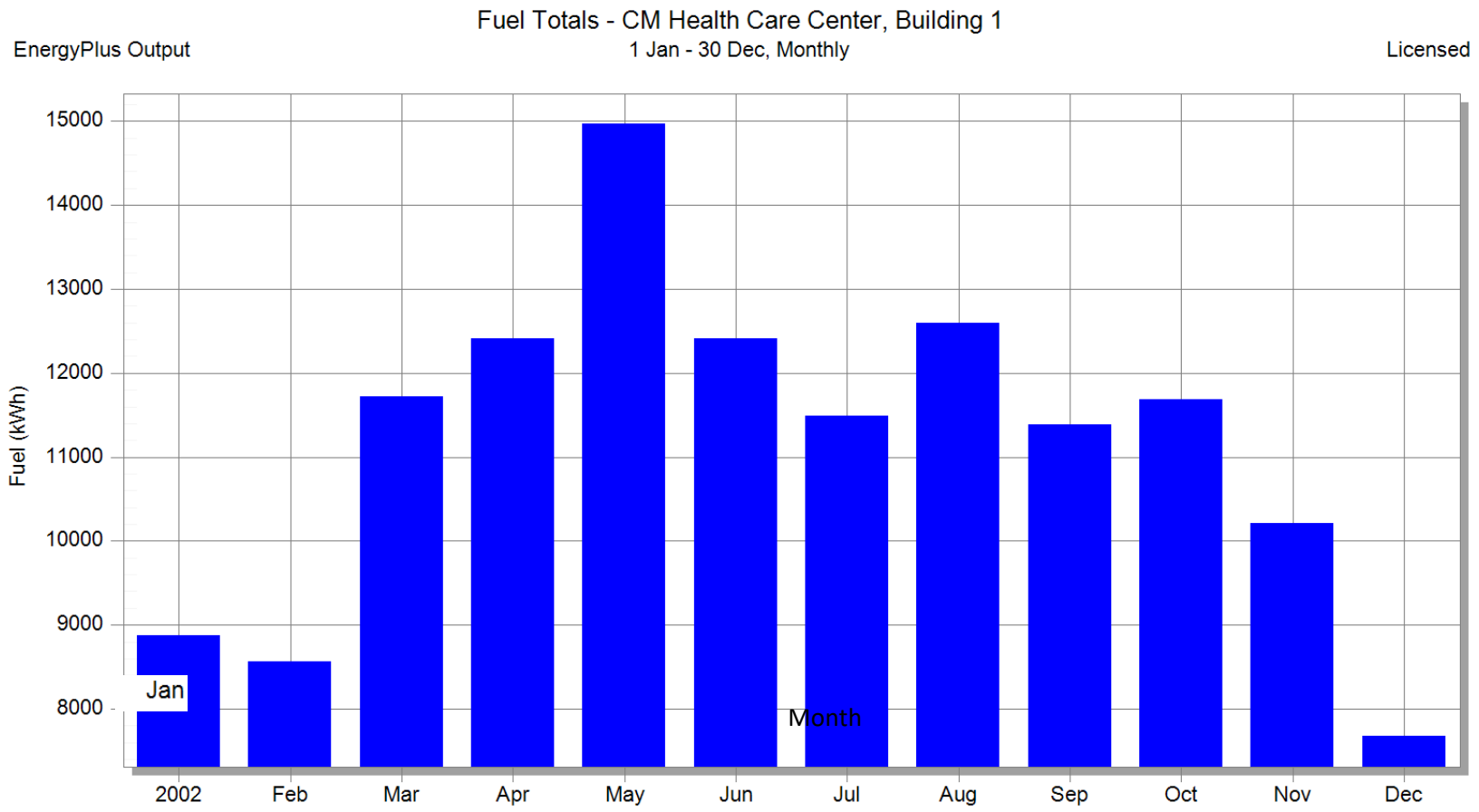
Baseline results: Energy use



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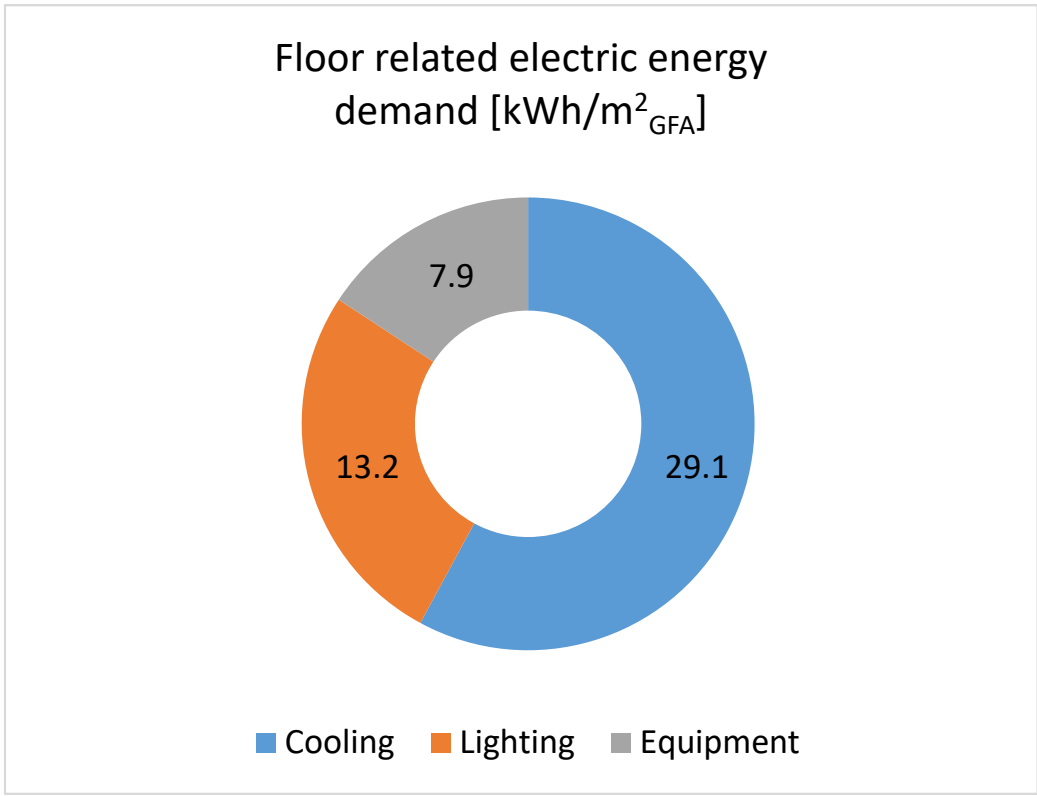
Baseline: Electrical energy demand

Electric Energy Demand	
Energy Per Total Building Area [kWh/m^2_{GFA}]	**50.2**
Energy Per Total A/C Area [kWh/m^2_{ac}]	**82.2**



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Simulation options

Options	Description
Option 1	Improve lighting system (from fluorescent to LED lighting)
Option 2.1	Improve window glazing (from clear single to tinted glazing)
Option 2.2	Improve window glazing (from clear single to Low-E glazing)
Option 3	Adding roof insulation (fiberglass)
Option 4	Additional shading and openings
Option 5	Better AC System: Inverter
Option 6	Photovoltaic
Option 7	Set operative temperature at 26 ^{o}C in Non-Active Room

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Chiang Mai Health Care Center,

Option 1:Improved lightning system

Designed lighting

Watts of electricity used

Fluorescents 99.8%

LED (Downlight) 0.2%

Lightning Power Density

LPD = 5,35 W/m^2 GFA

Recommended lighting

Watts of electricity used

LED 100%

Lightning Power Density

LPD = 3,08 W/m^2 GFA

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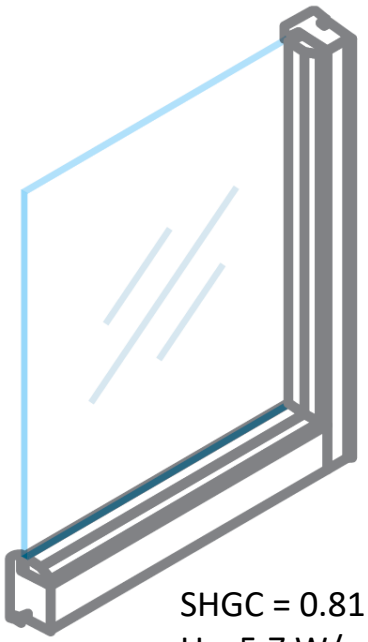
Option 2.1: Improved window glazing: tinted glazing

The **SHGC** is the fraction of incident solar radiation admitted through a window, both directly transmitted and absorbed and subsequently released inward.

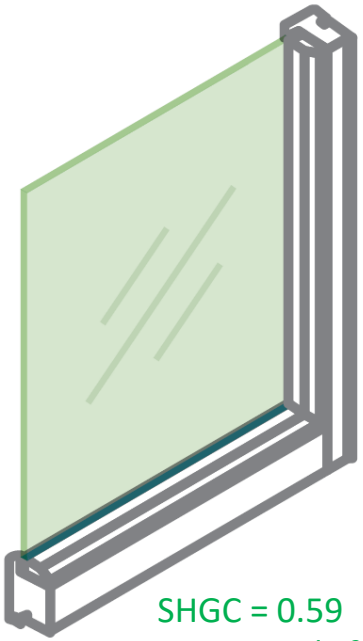
SHGC is expressed as a number between 0 and 1. The lower a window's solar heat gain coefficient, the less solar heat it transmits.

Clear Single glazing



SHGC = 0.81
U = 5.7 W/m^{2}K

Tinted glazing



SHGC = 0.59
U = 5.7 W/m^{2}K

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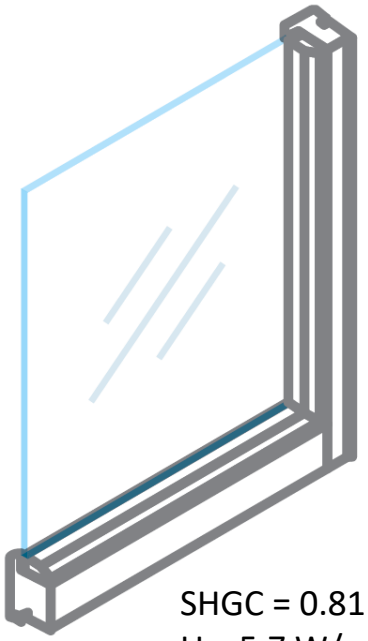
Option 2.1: Double glazing with low-E coating

Low-E coatings have been developed to minimize the amount of ultraviolet and infrared light that can pass through glass without compromising the amount of visible light that is transmitted.

Windows, radiate heat in the form of long-wave, infrared energy depending on the emissivity and temperature of their surfaces. Radiant energy is one of the important ways heat transfer occurs with windows. **Reducing the emissivity** of one or more of the window glass surfaces **improves** a window's **insulating** properties.

Clear Single glazing



SHGC = 0.81
U = 5.7 W/m^{2}K

Low-E glazing

SHGC = 0.34
U = 2.5 W/m2.K

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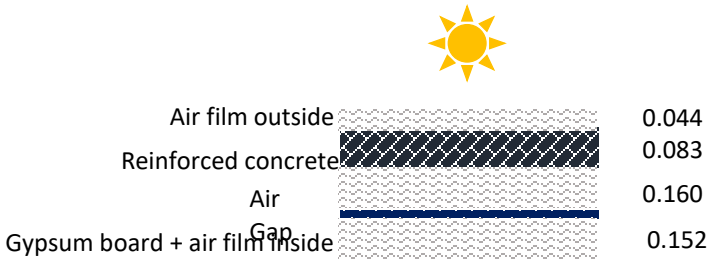
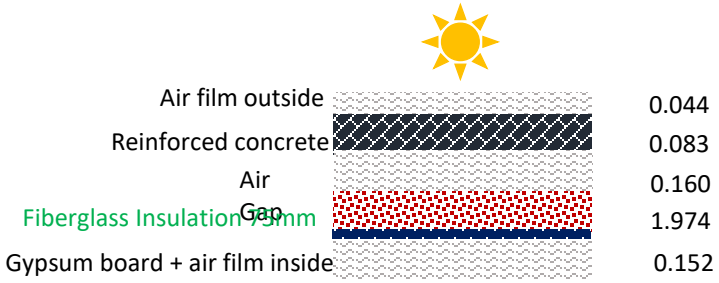
Thermal Resistance of Roof without Insulation (R)

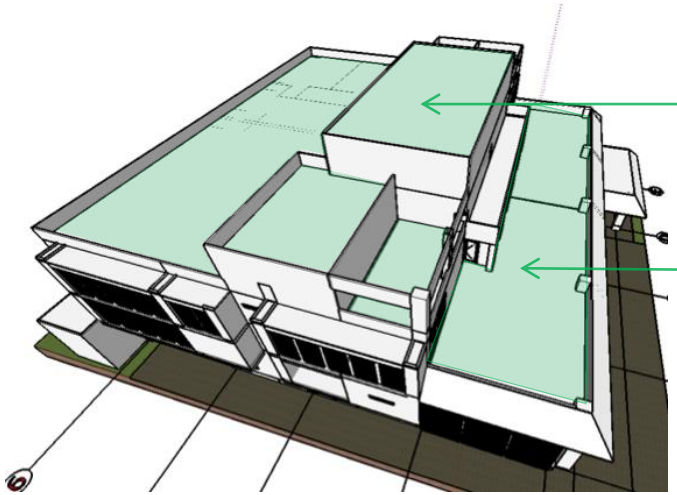


Total thermal resistance(R) = 0.44 m^2k/W
U = 2.28 W/m^2k

Thermal Resistance of Roof with Insulation (R)



Total thermal resistance(R) = 2.40 m^2k/w
U = 0.41 W/m^2k



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Option 3: Roof insulation

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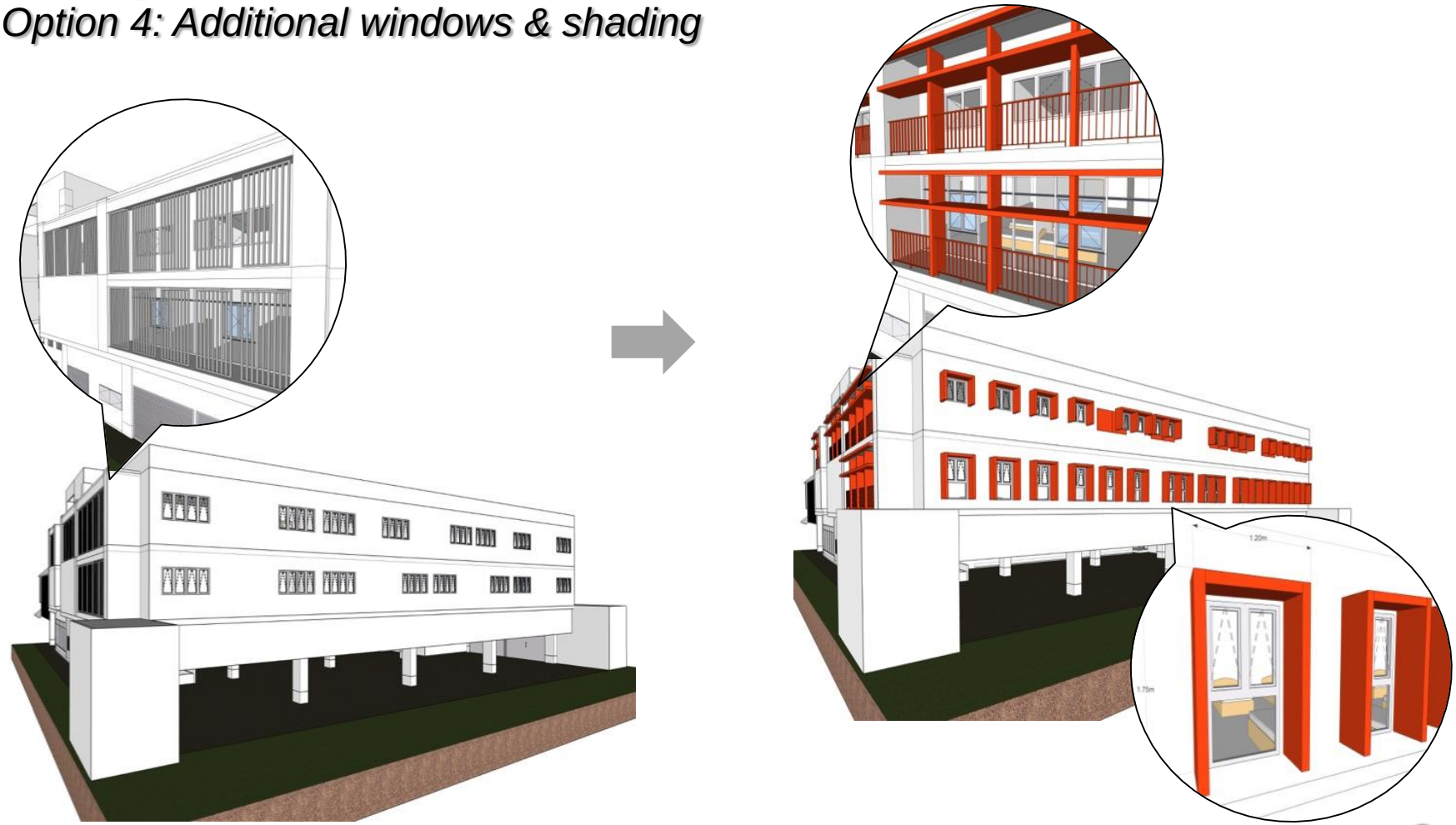
Option 4: Additional windows & shading



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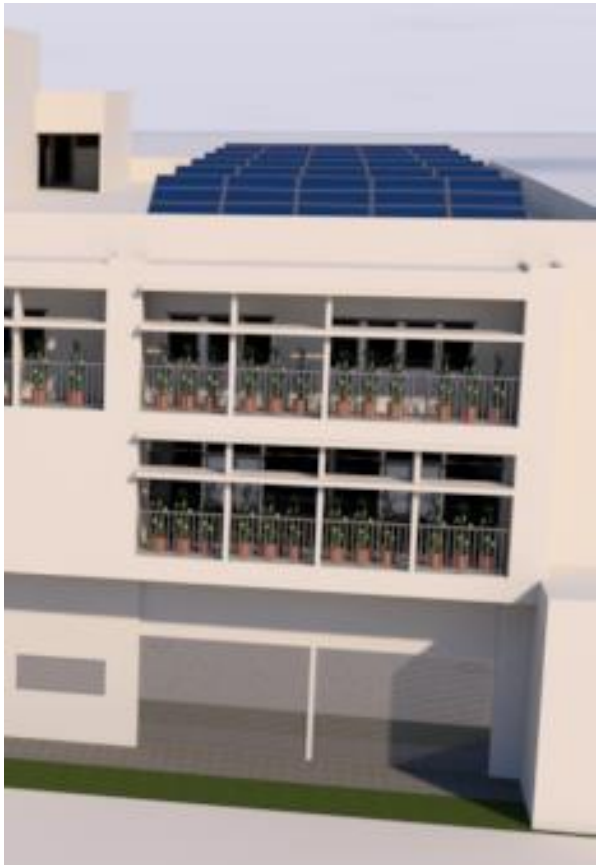
Changing of building facade



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Changing of building facade

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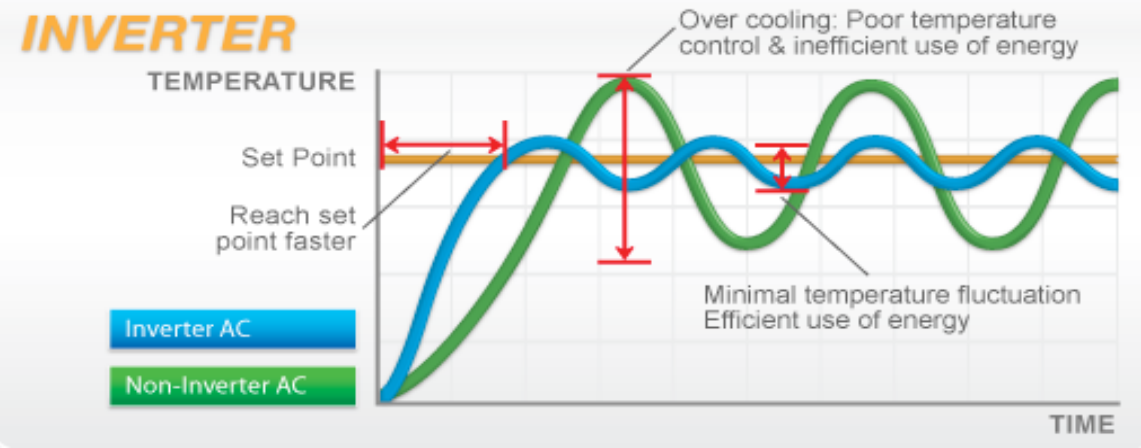
Option 5: Replace single speed split units by inverter type split units

The inverter technology works like an accelerator in a car. When compressor needs more power, it gives it more power. When it needs less power, it gives less power. With this technology**, the compressor** is always on, but draws less power or more power depending on the temperature of the incoming air and the level set in the thermostat.

Split Type Air Conditioner (single speed)

↓

Split Type Air Conditioner (inverter type)



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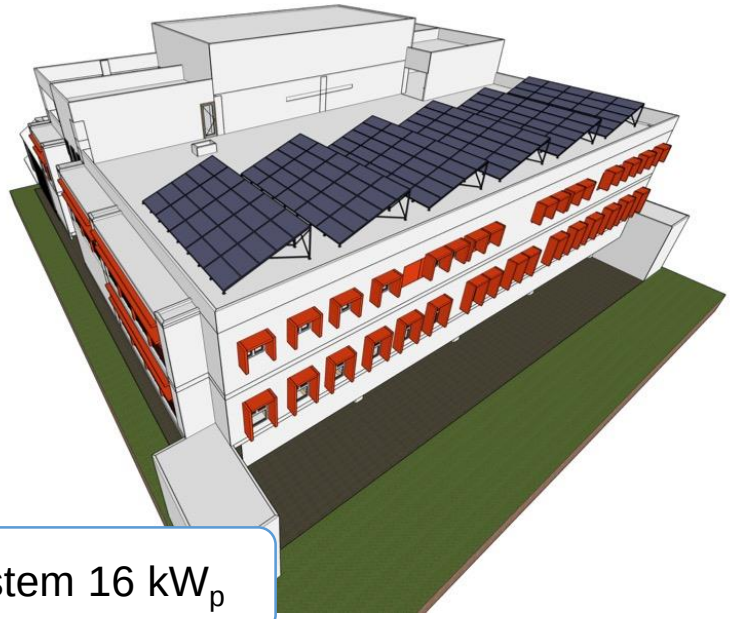
Option 6: Photovoltaic

Important remark:

- Currently no feed in available
- Maximum estimated electric power demand of building: 85 kW
  Maximum estimated power output of PV: 16 kW_P
- On week days PV energy can be consumed onsite
- But not during weekend → increased payback time



Photovoltaic system 16 kW_p

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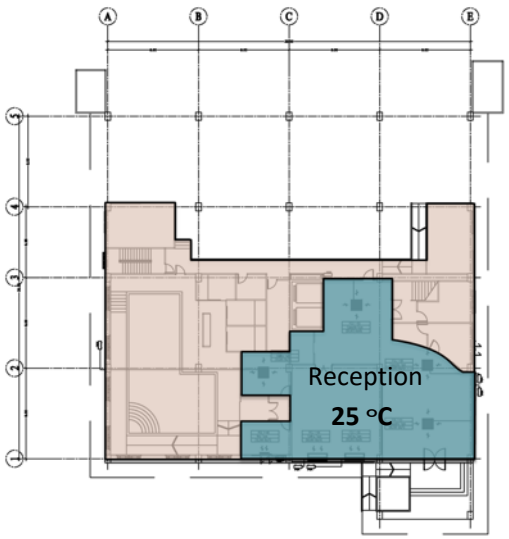
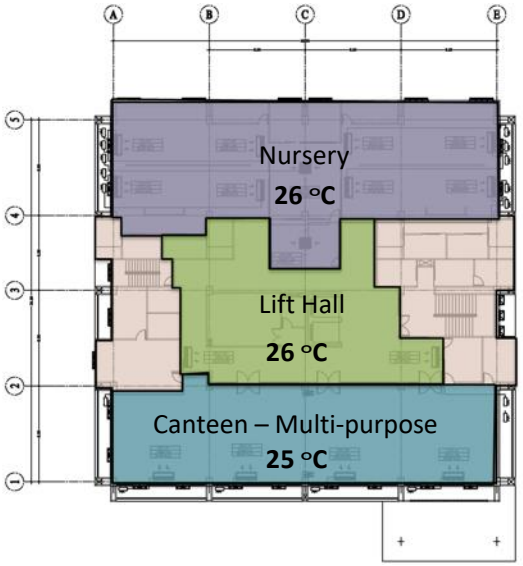
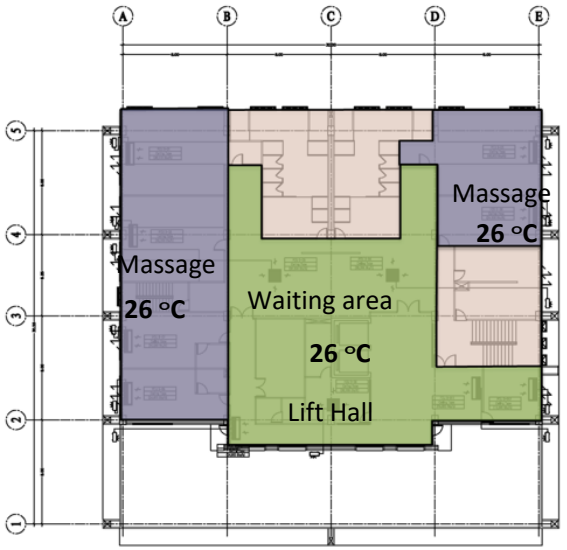
Option 7: set operative temperature at 26º in non-active rooms

Setting higher operative temperature in conditioned zones following activities in None - Active Rooms

25 ºC → 26 ºC







Cooling load baseline (option 0)

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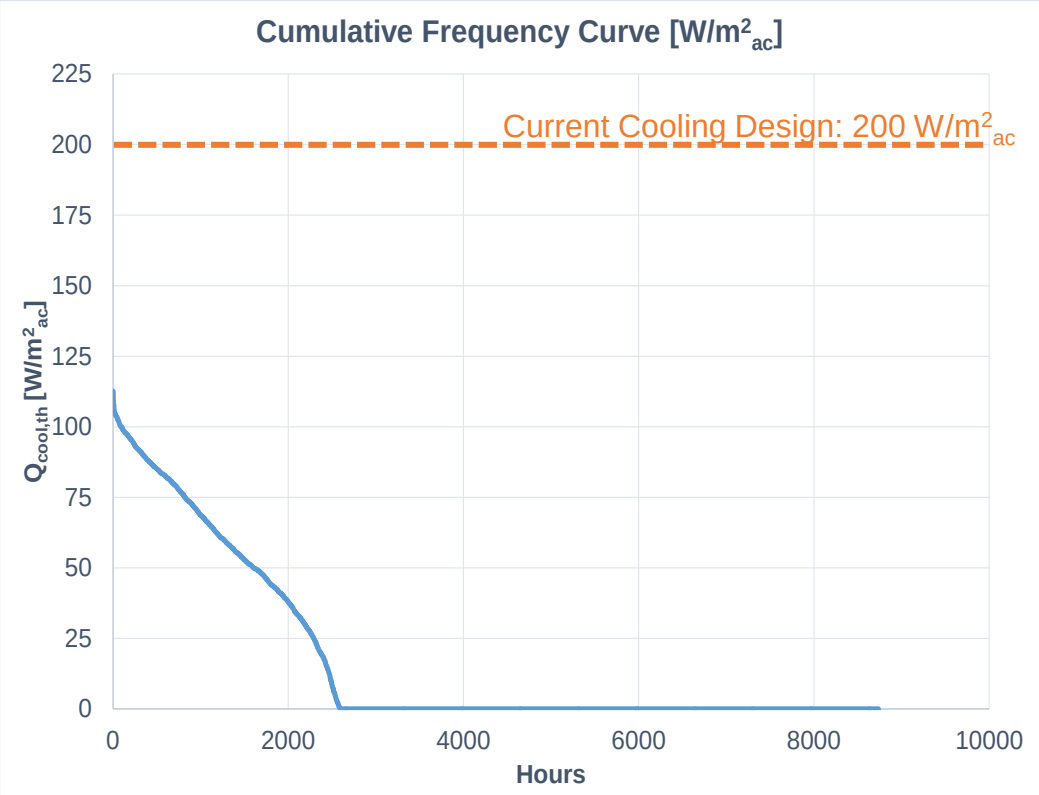
Cooling load baseline calculation



A proper cooling load calculation will help to:

- Reduce air conditioning size
- Reduce investment costs
- Improve energy efficiency
- Reduce energy costs

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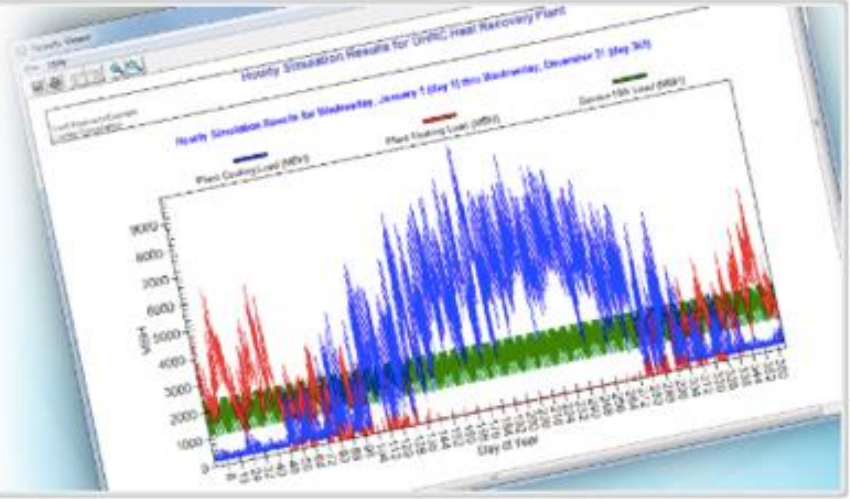
Make a cooling load calculation with an acknowledged software (e.g. carrier)!!!

HOURLY ANALYSIS PROGRAM

POWERFUL TOOLS FOR DESIGN AND ANALYSIS.

HAP is designed for consulting engineers, design/build contractors, HVAC contractors, facility engineers and other professionals involved in the design and analysis of commercial building HVAC systems. The program is a powerful tool for designing systems and sizing system components.



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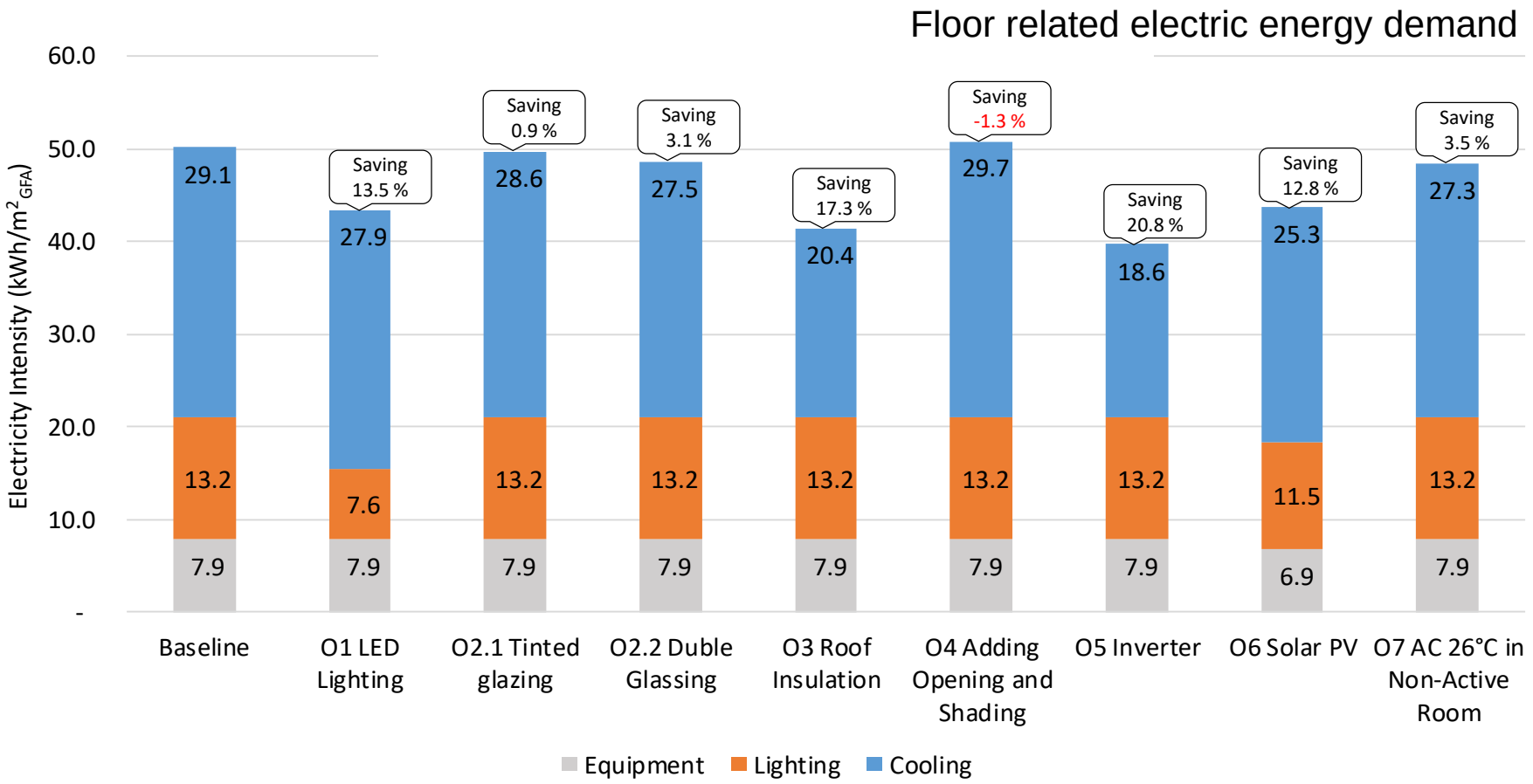
Pre-simulation and comparison of options



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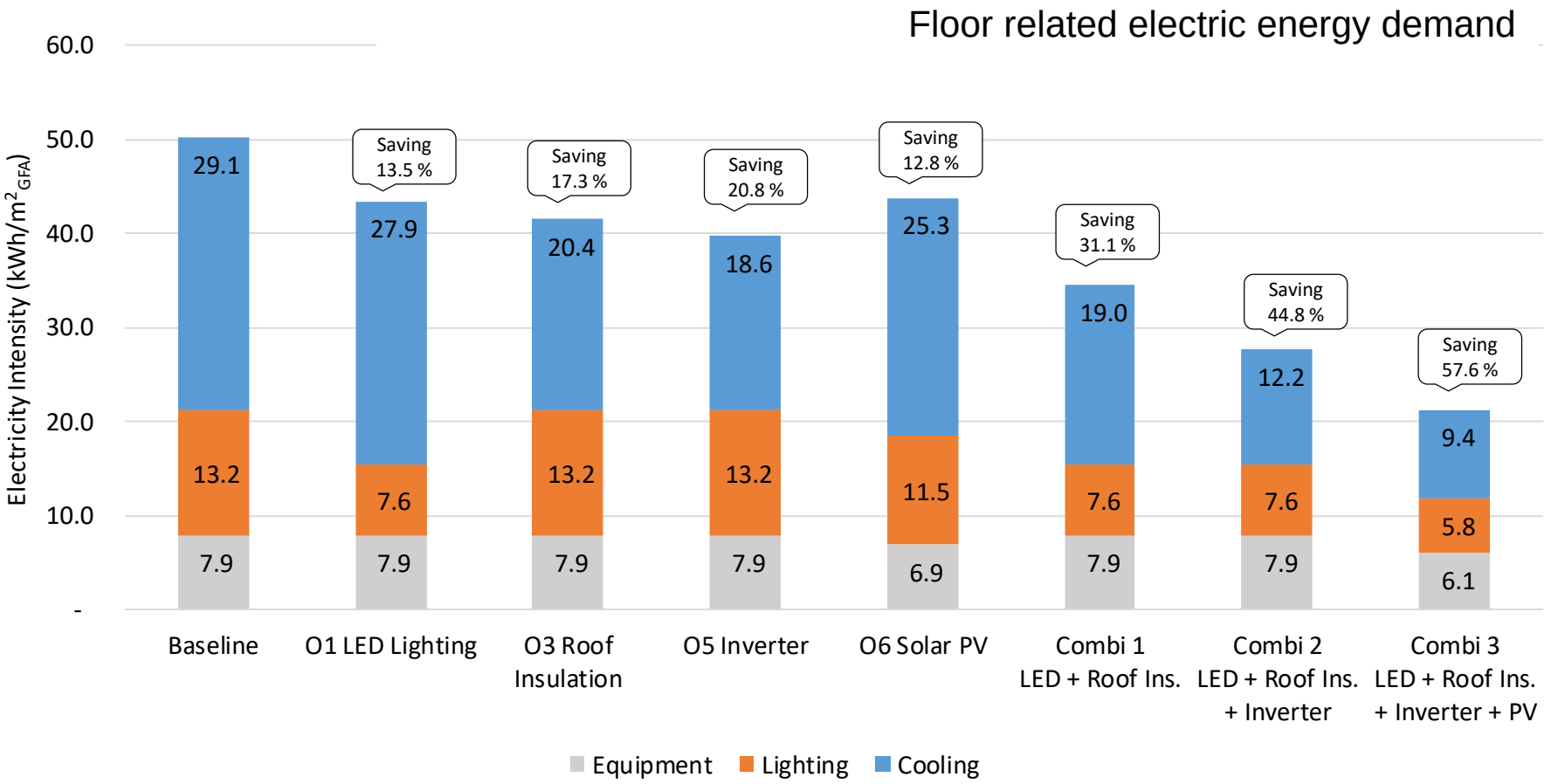
Options for further assessment



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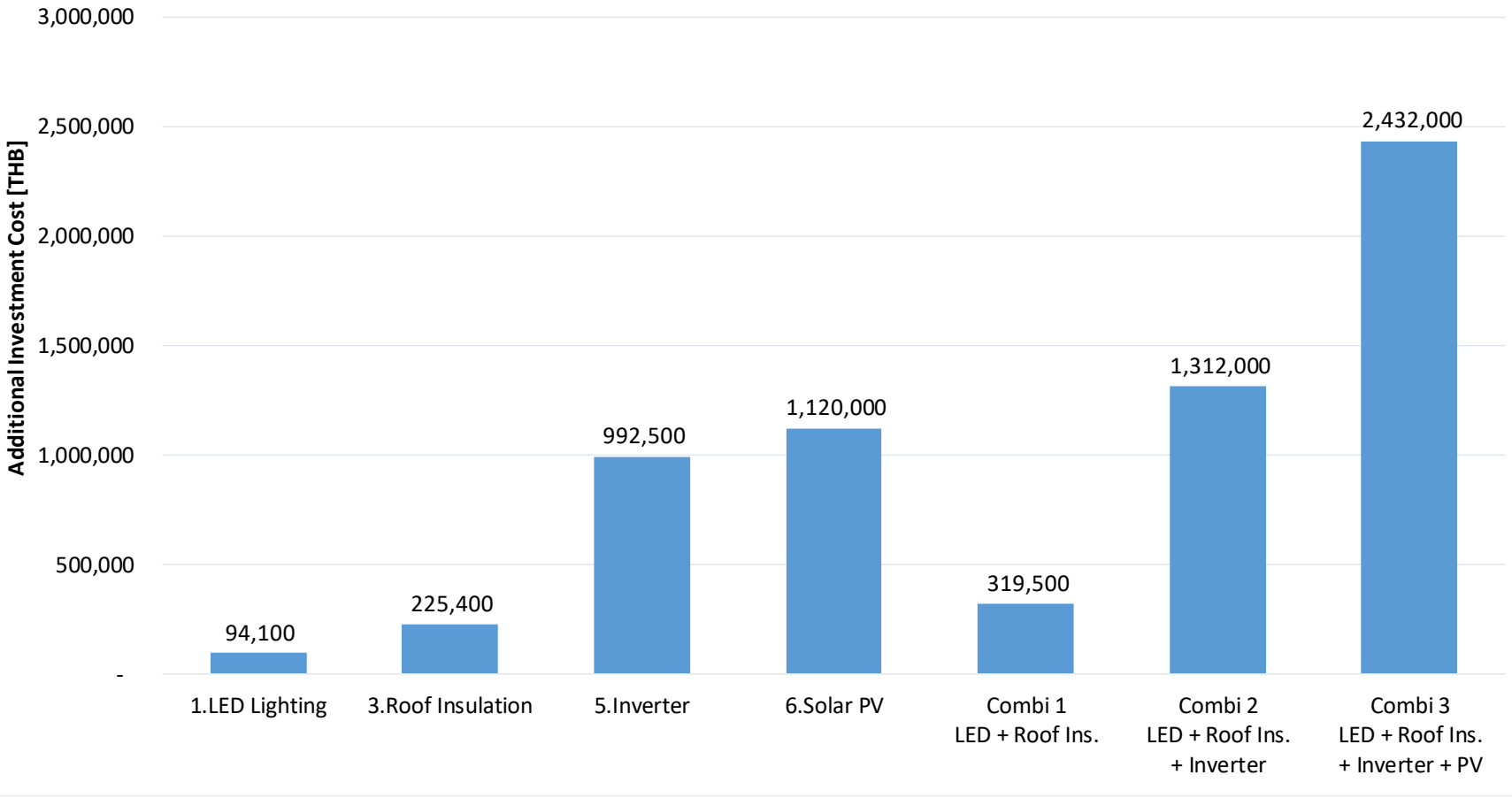
Additional investment cost in THB (Thai Baht)



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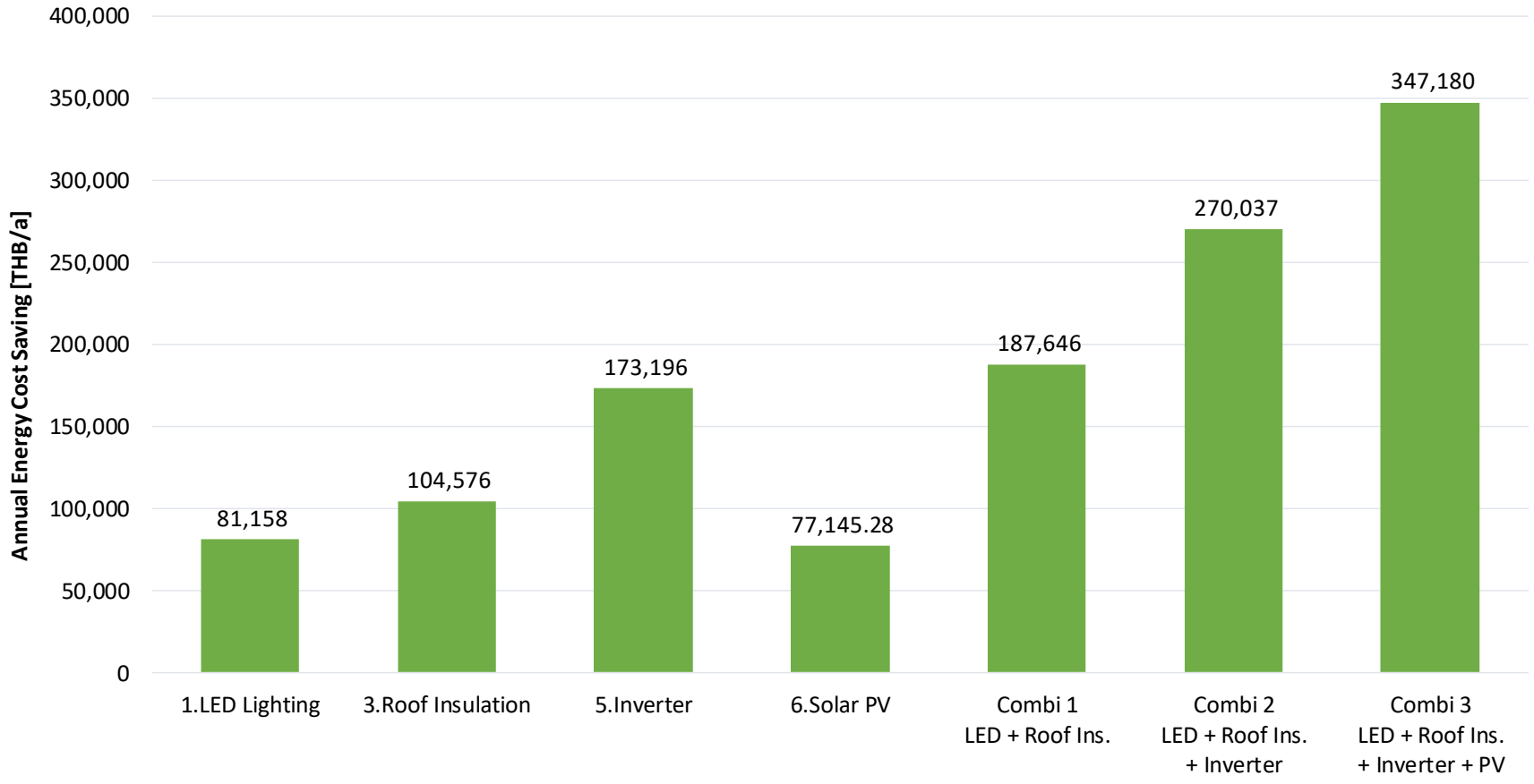
Annual energy cost savings in THB (Thai Baht)



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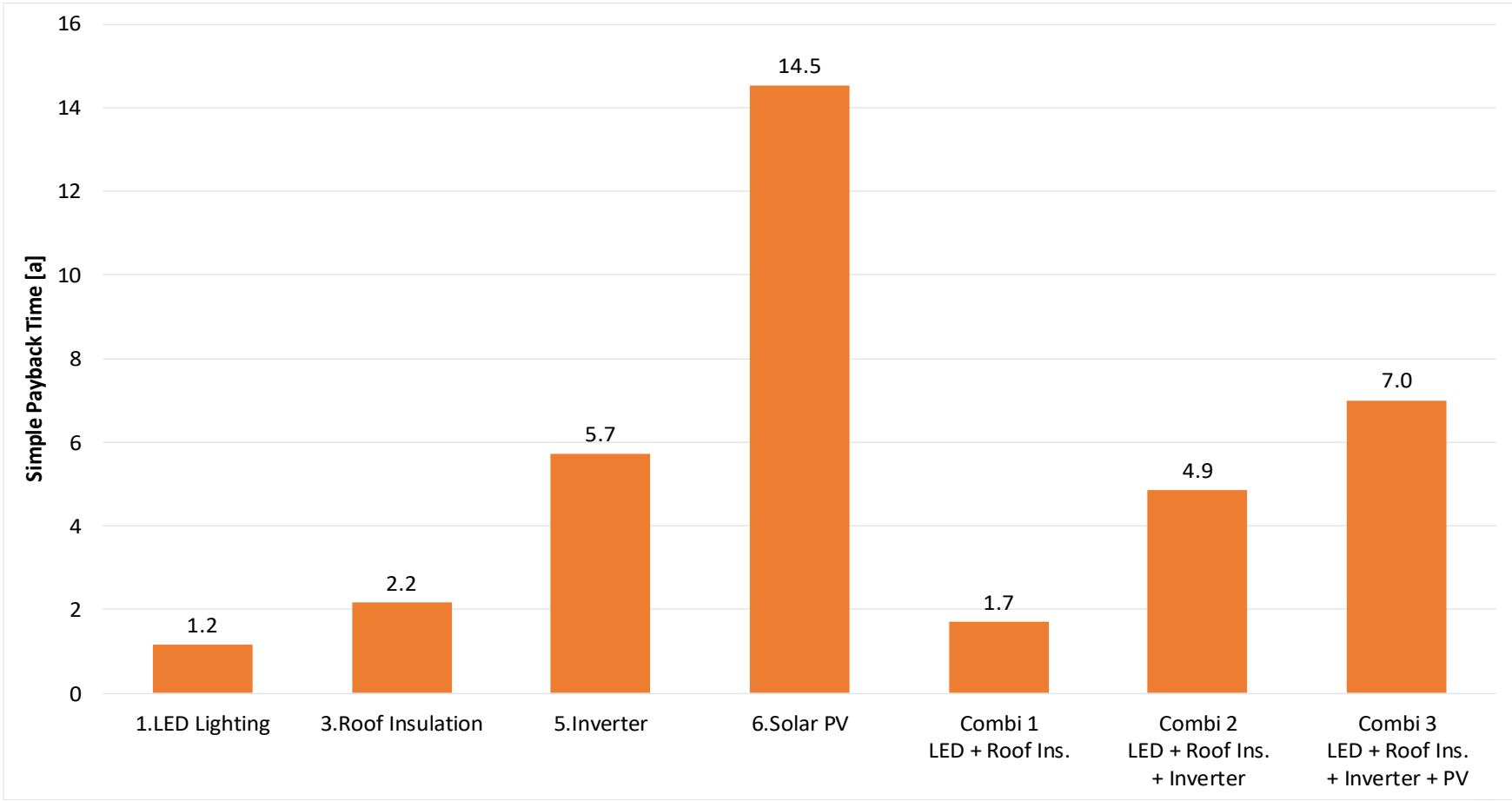
Simple payback period (in years)



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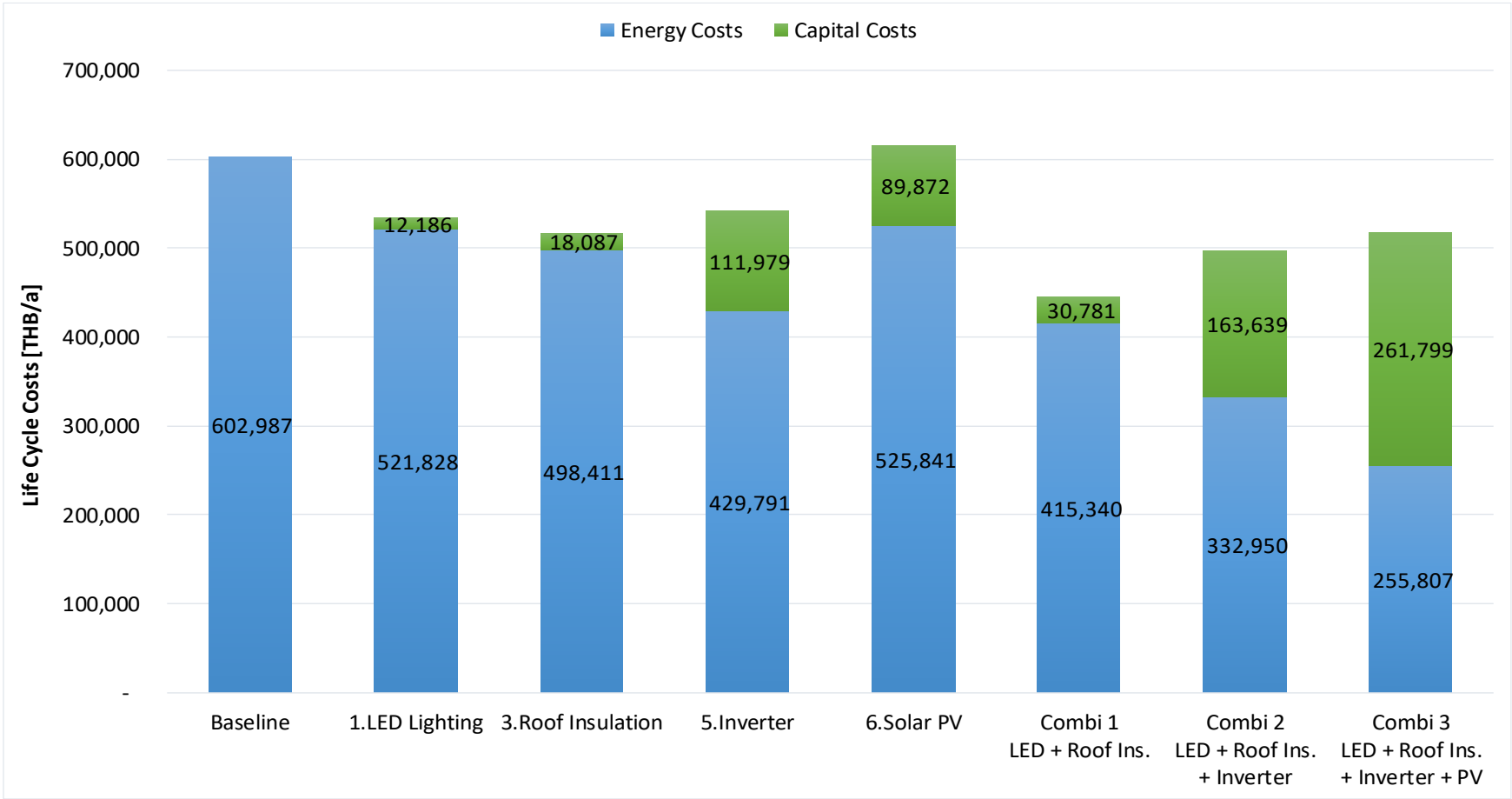
Comparison of Life Cycle Costs



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Summary (lessons learned)

- Proper cooling load calculation will reduce investment costs for air-conditioning system
- Tinted glazing and double glazing with low-e coating do not lead to significant energy saving due to efficient shading, however reduce daylight use
- LED lighting and thermal insulation lead to additional investment costs of less than 200,000 THB each and significantly reduce the energy demand
- Inverter type split units and PV lead to additional investment costs of about 1,000,000 THB each and also lead to significant energy savings with a payback time of 6 (Inverter) and 11 (PV) years
- Combination option 1 (LED + roof insulation) is the most economically effective combination option and reduces the energy demand around 30% compared to baseline
- Combination option 2 (LED + roof insulation + inverter) reduces the energy demand by up to 40%
- Combination option 3 (LED + roof insulation + inverter + solar PV) leads to the highest additional investment costs, however reduces the energy demand by up to 58% compared to baseline

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Recommendations for the implementation

- ✓ Make a proper cooling load calculation!
- ✓ Combination option 1 (LED + roof insulation) is economically the most efficient option
- ✓ Combination option 2 (LED + roof insulation + inverter) leads to the highest energy savings, without sacrificing economic aspects
- ✓ Decision has to be made depending on the available budget

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DEUTSCHE ZUSAMMENARBEIT

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"Who want success will find the way there, but those who do not want will find only excuses."

Önder Demir

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