

Project: Analysis of The Cooling Load of Building

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Course: Mechanical Engineering

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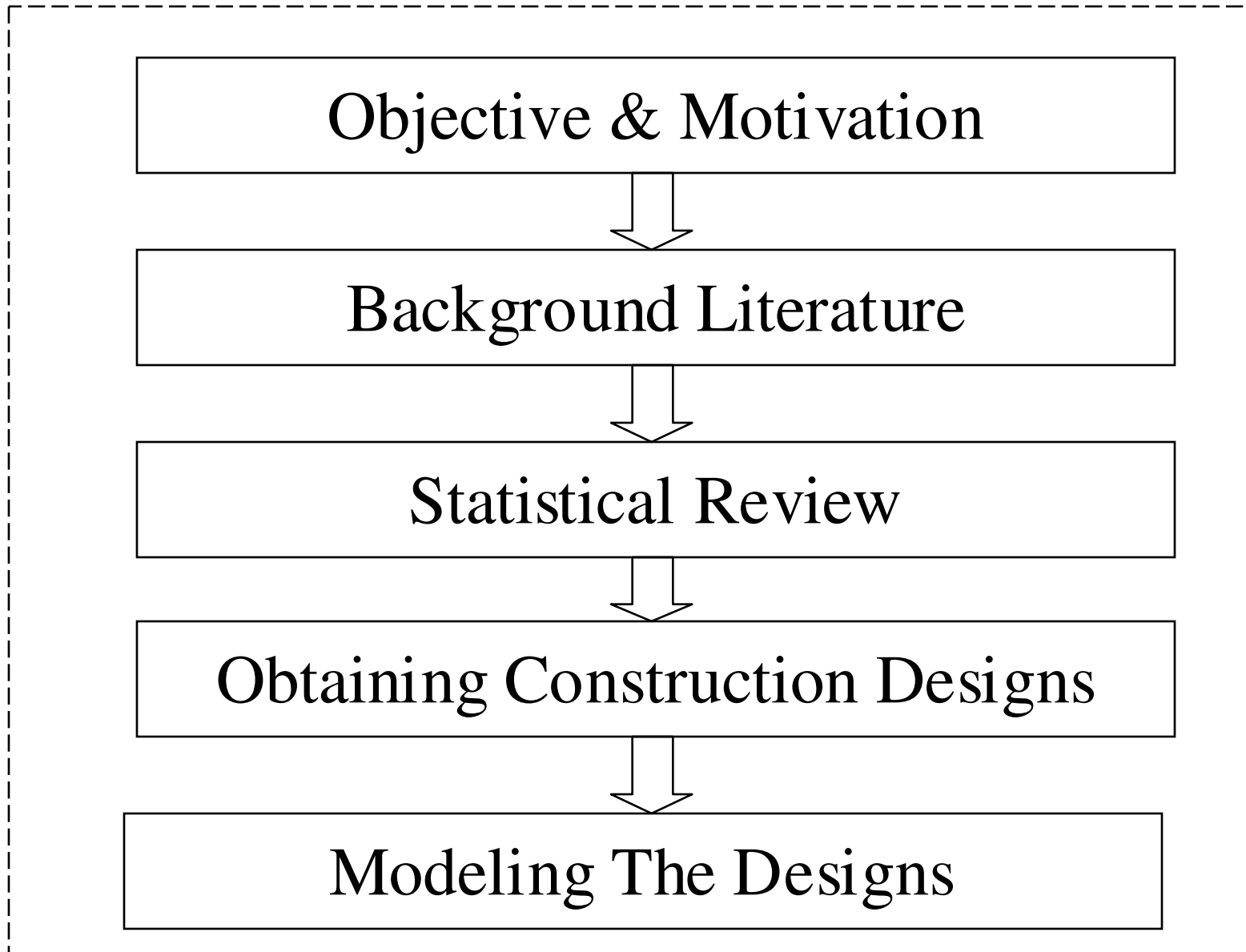
Project Moderator : Prof. Tso Chih Peng



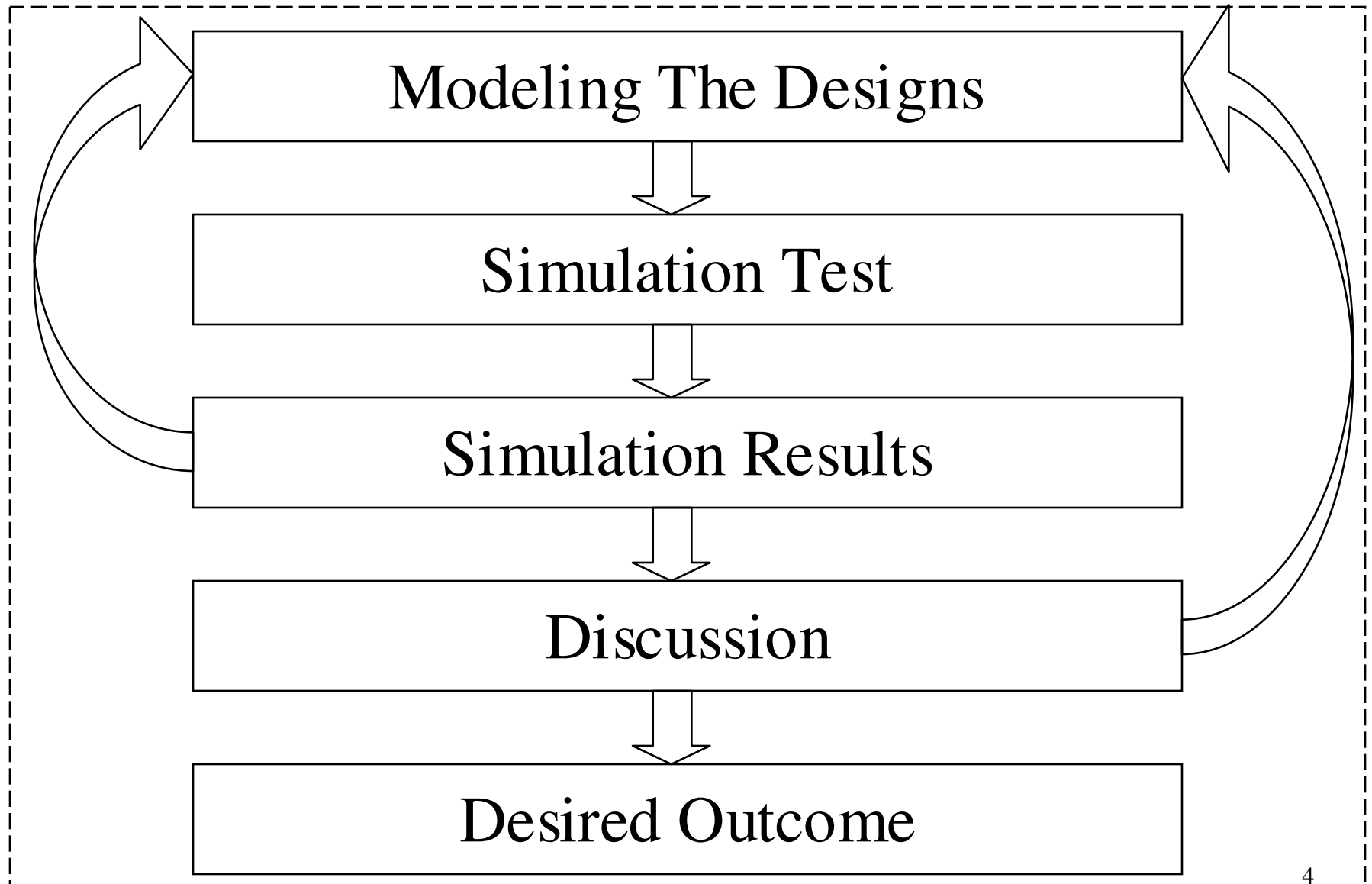
Objective

- Design an energy efficient, comfortable, and affordable building.
- To lower the cooling load of the building.
→ decrease the electricity bill.
- Reduce pollution to the environment.

Project Layout (Part 1)



Project Layout (Part 2)





Revision of FYP Part 1

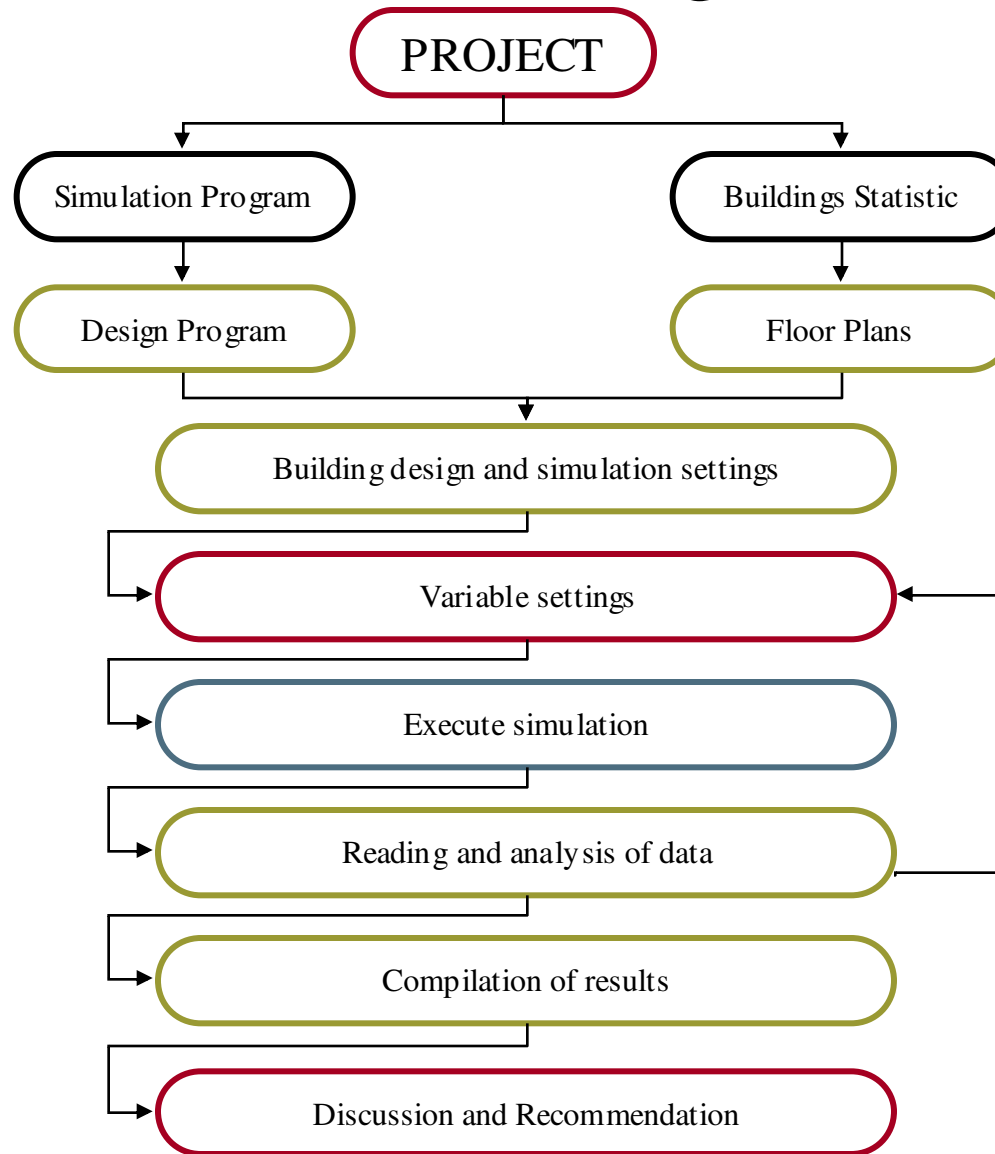
1. Software

- Building Design Software
- Building Energy Simulation Software

2. Building Models

- Building Types
- Parameter Study

Methods of Investigation

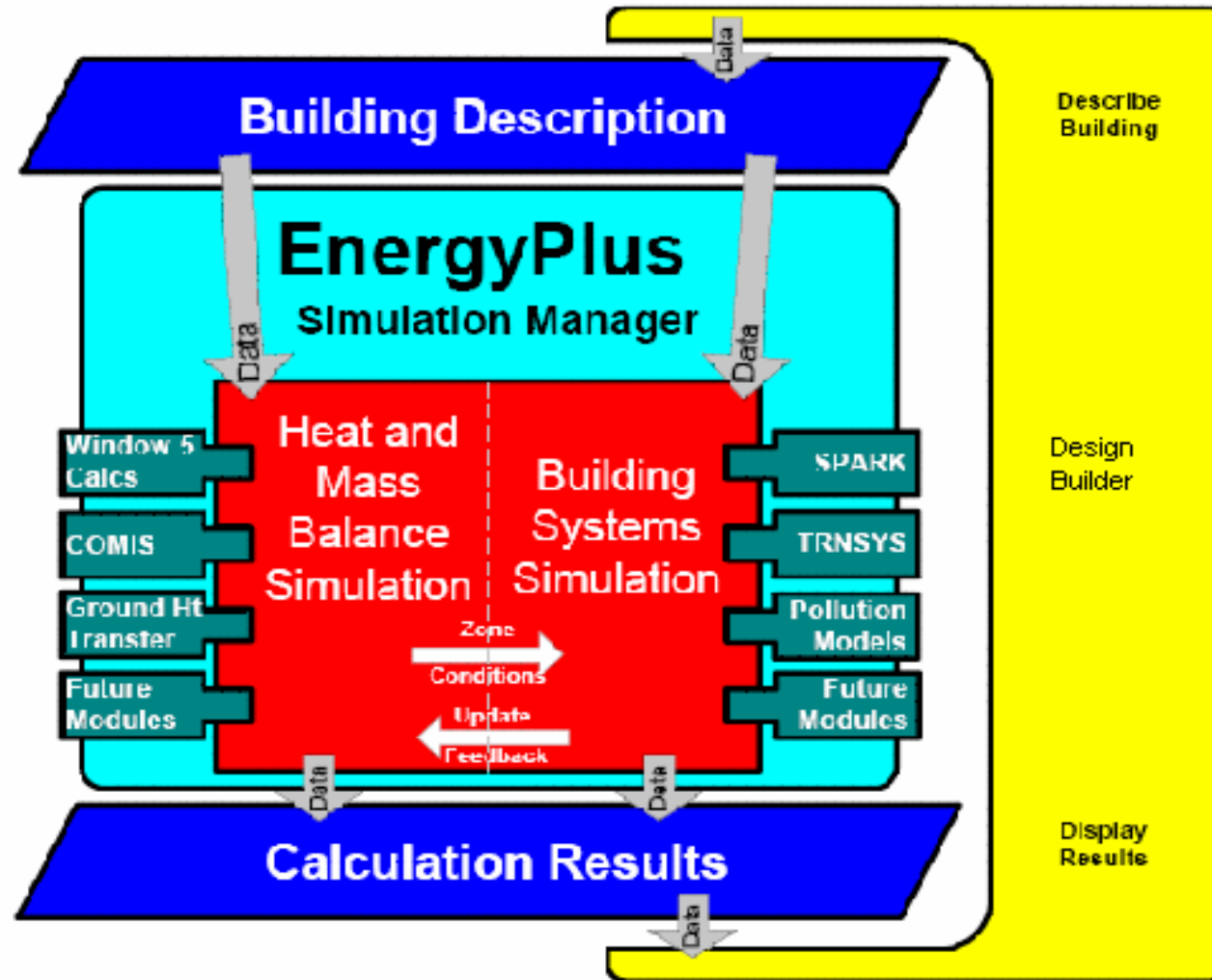




Software

- Building Design Software
 - Design Builder
- Building Energy Simulation Software
 - EnergyPlus

How EnergyPlus and Design Builder works together?





Building Models

- Building Types

- Cooltek House

- Terrace House

- Bungalow

- Traditional House

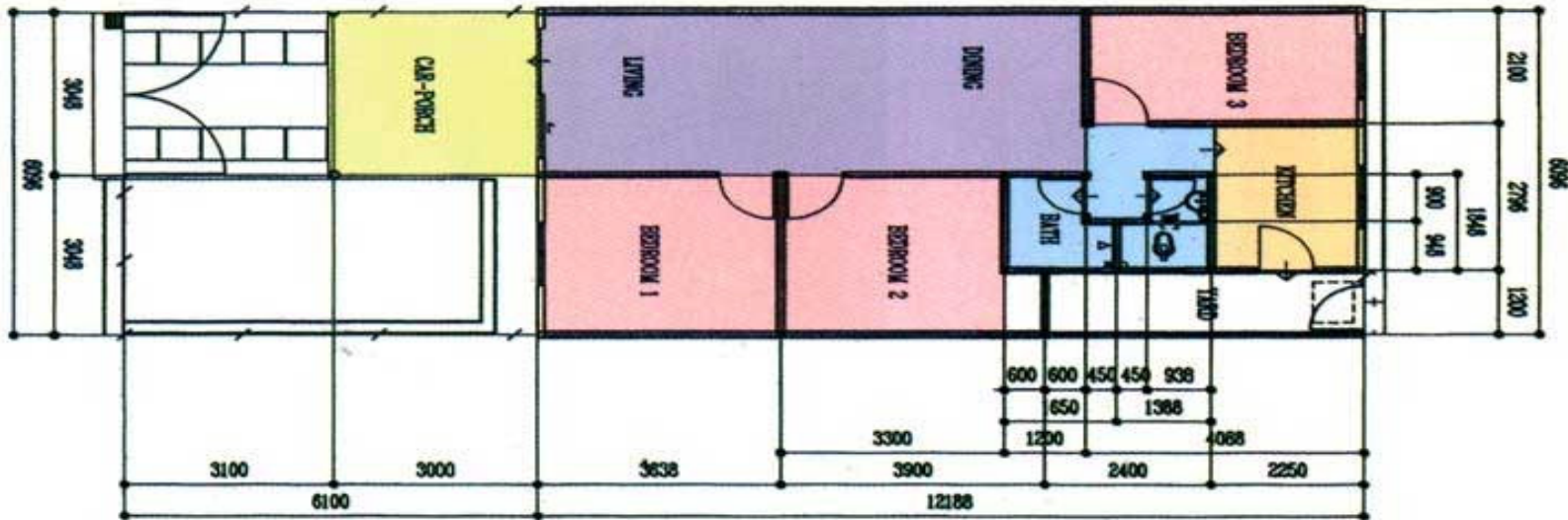
(1) Cooltek House



(1) Cooltek House visualized by
DesignBuilder

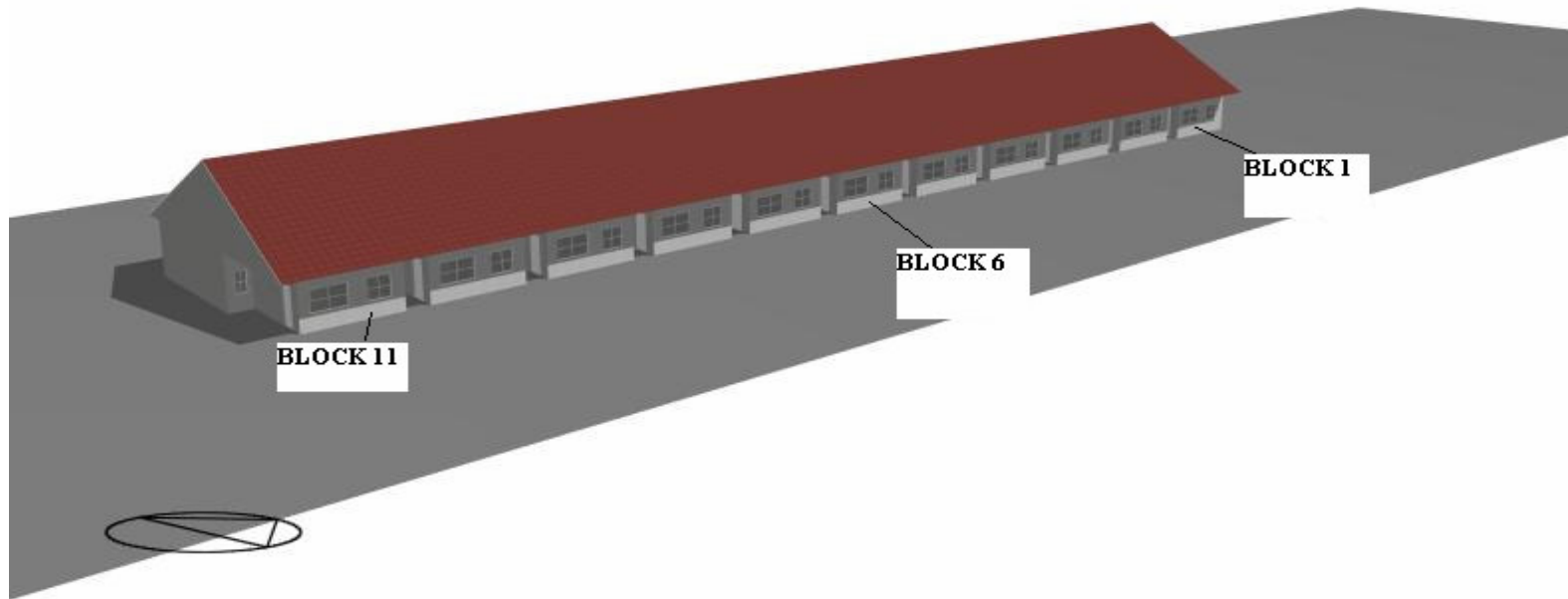


(2) Terrace House

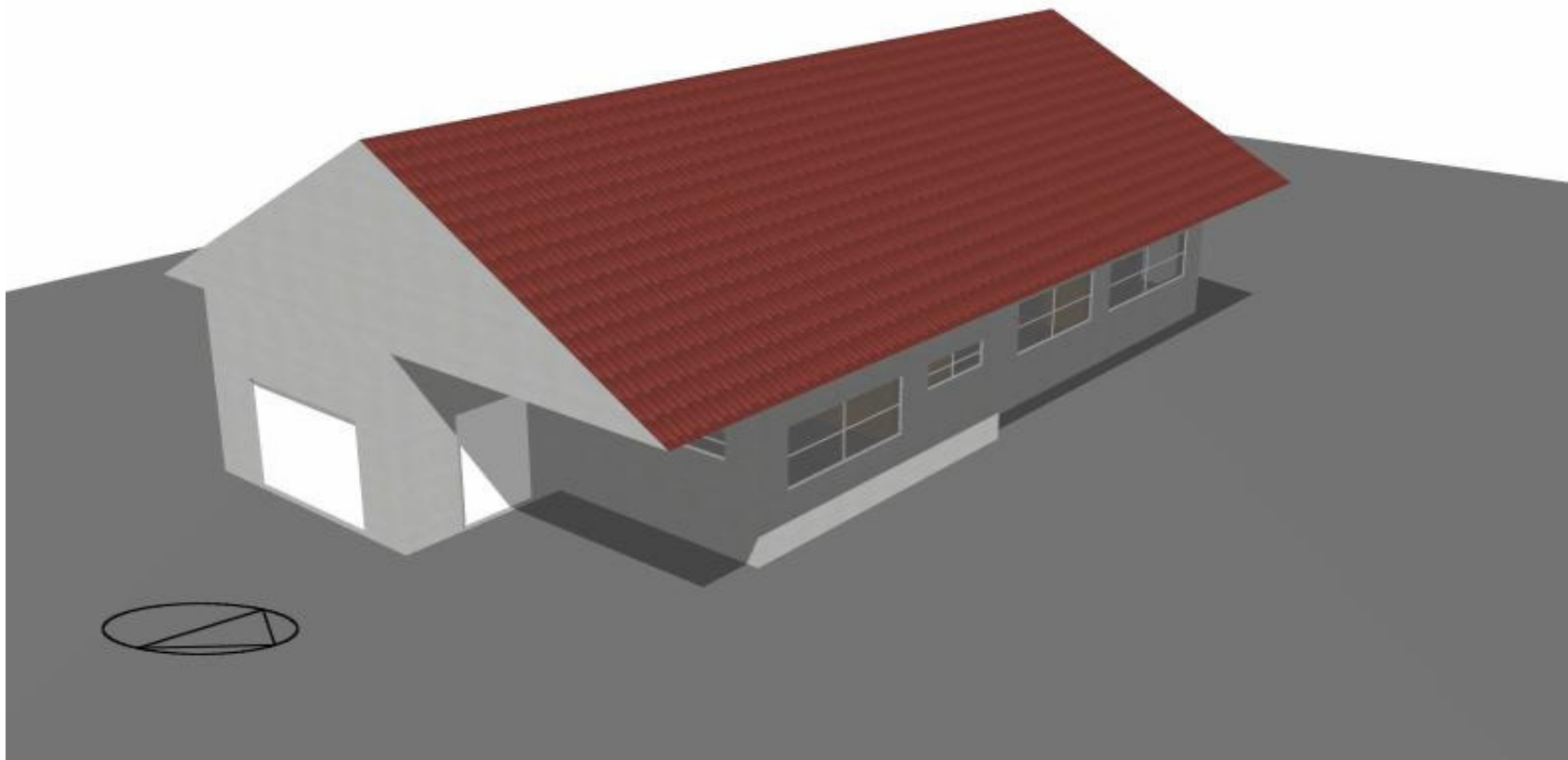


Floor Plan for terrace house.

(2) Terrace House visualized by DesignBuilder



(3) Bungalow visualized by DesignBuilder



(4) Traditional House



(4) Traditional House visualized by DesignBuilder





Parameter Study

1. HVAC

- Air Conditioning ON/OFF
- Natural Air Ventilation ON/OFF

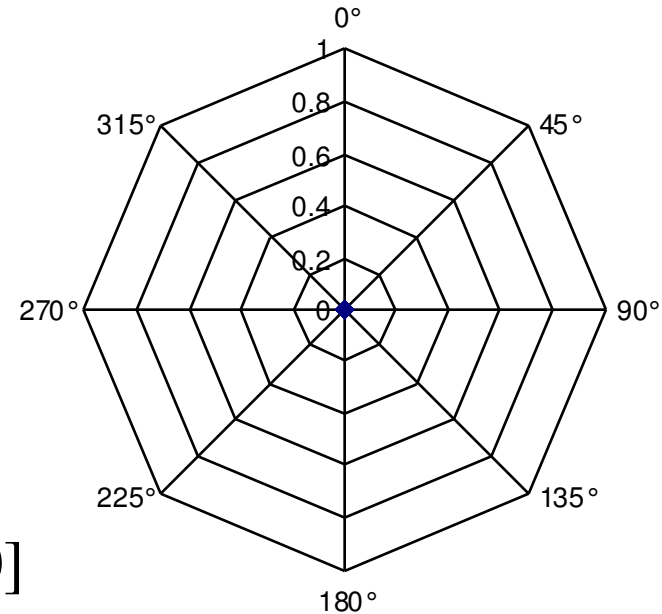
2. Windows

- Single glazing, clear, no shading
- Double glazing, clear, no shading
- Triple glazing, clear, no shading
- Double glazing, clear, Low Emisivity and Argon filled

Parameter Study (cont)

3. Orientation
 - $0^\circ, 45^\circ, 90^\circ, 135^\circ, 180^\circ, 225^\circ, 270^\circ, 315^\circ$

4. Lighting
 - Poor Efficiency
[Output($\text{W}/\text{m}^2\text{-}100\text{lux}$) = 28.00]
 - Best Practise
[Output ($\text{W}/\text{m}^2\text{-}100\text{lux}$) = 3.40]
 - Fluorescent Compact
[Output ($\text{W}/\text{m}^2\text{-}100\text{lux}$) = 4.60]





Simulation Result of Cooltek House

Parameters to study on Cooltek House includes:

- HVAC
- Windows
- Orientation
- Lighting

HVAC

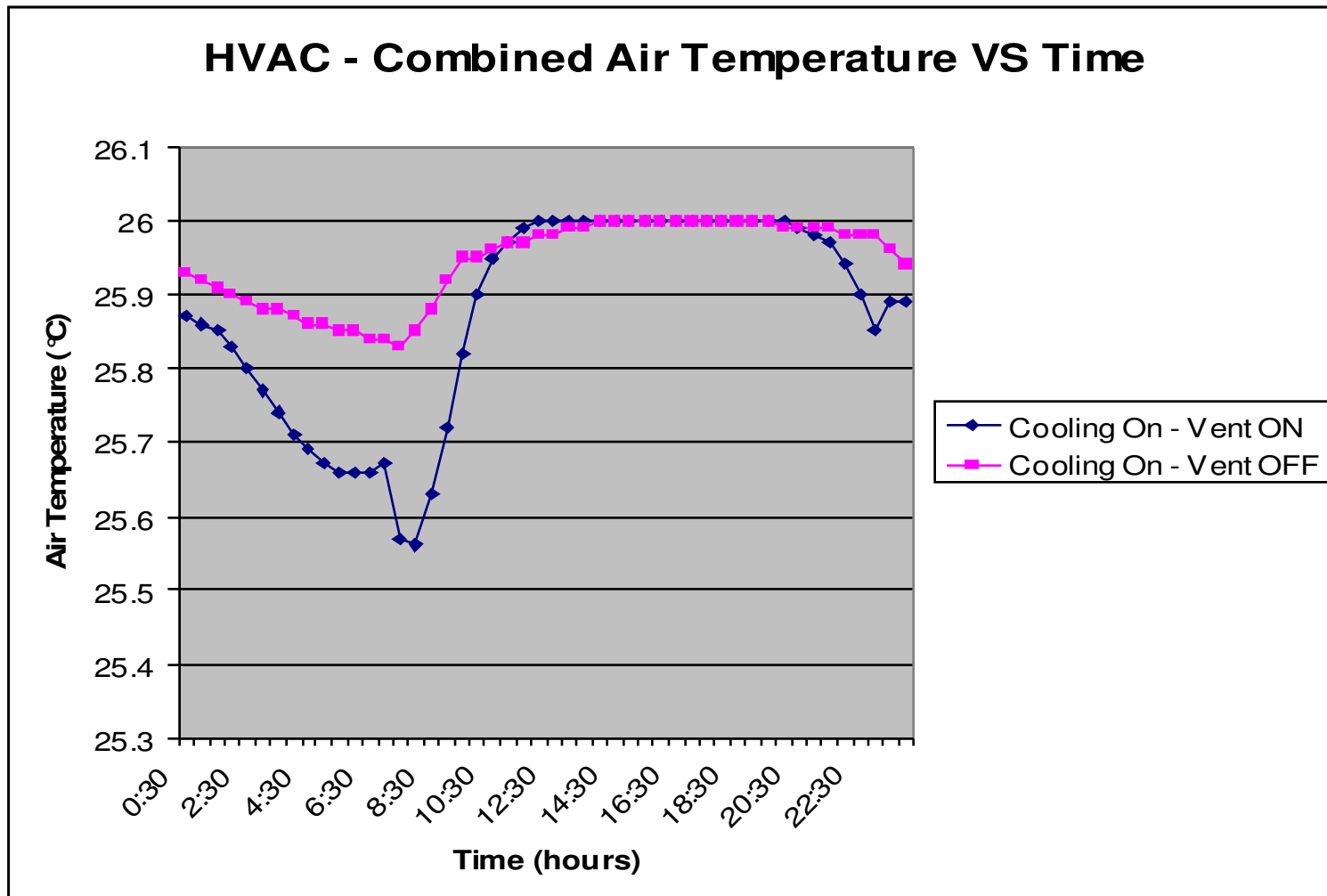


Figure 1: Comparison between Air Temperature and Time for HVAC Setting

Windows

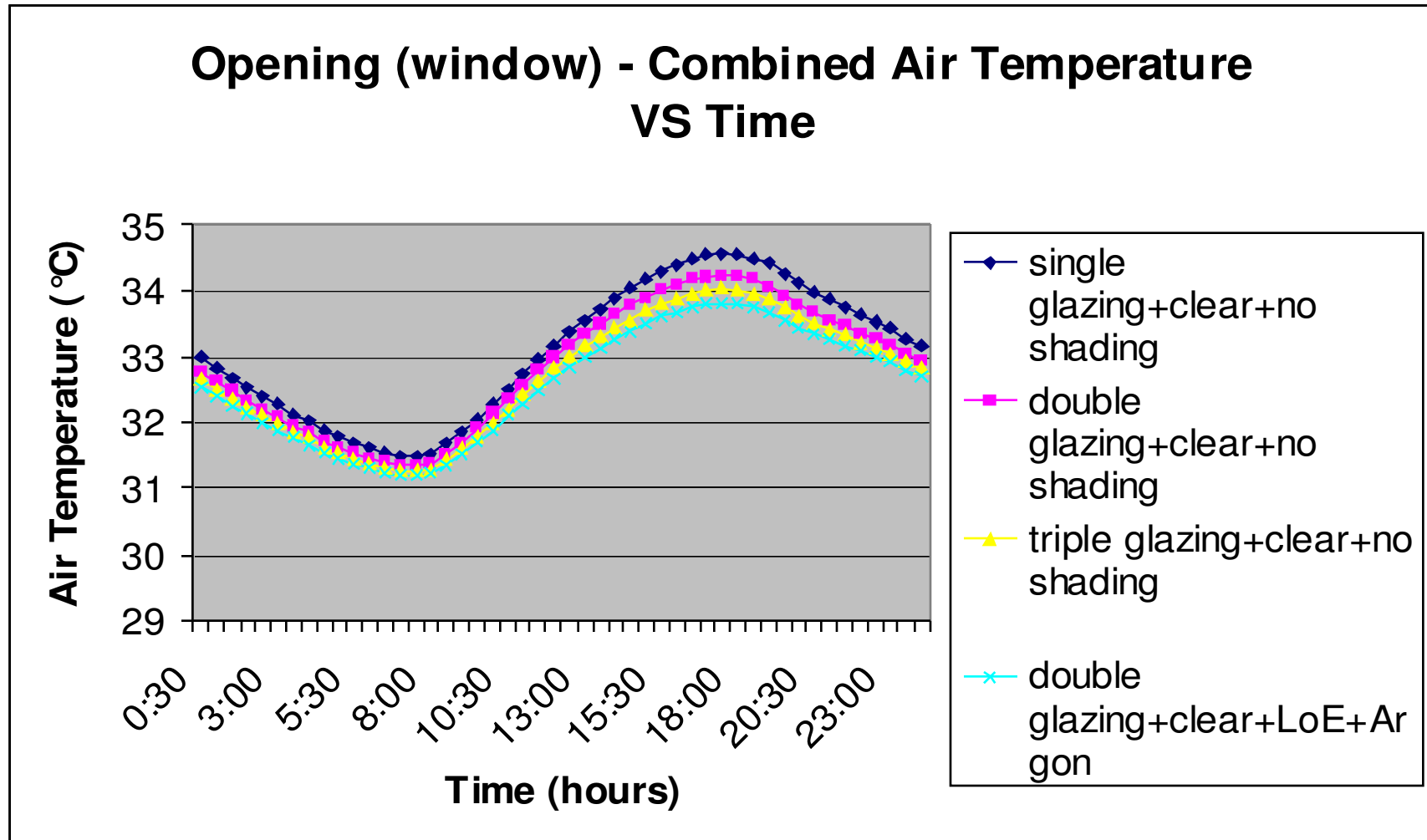


Figure 2: Comparison between Air Temperatures with Types of Windows used ₂₁

Orientation

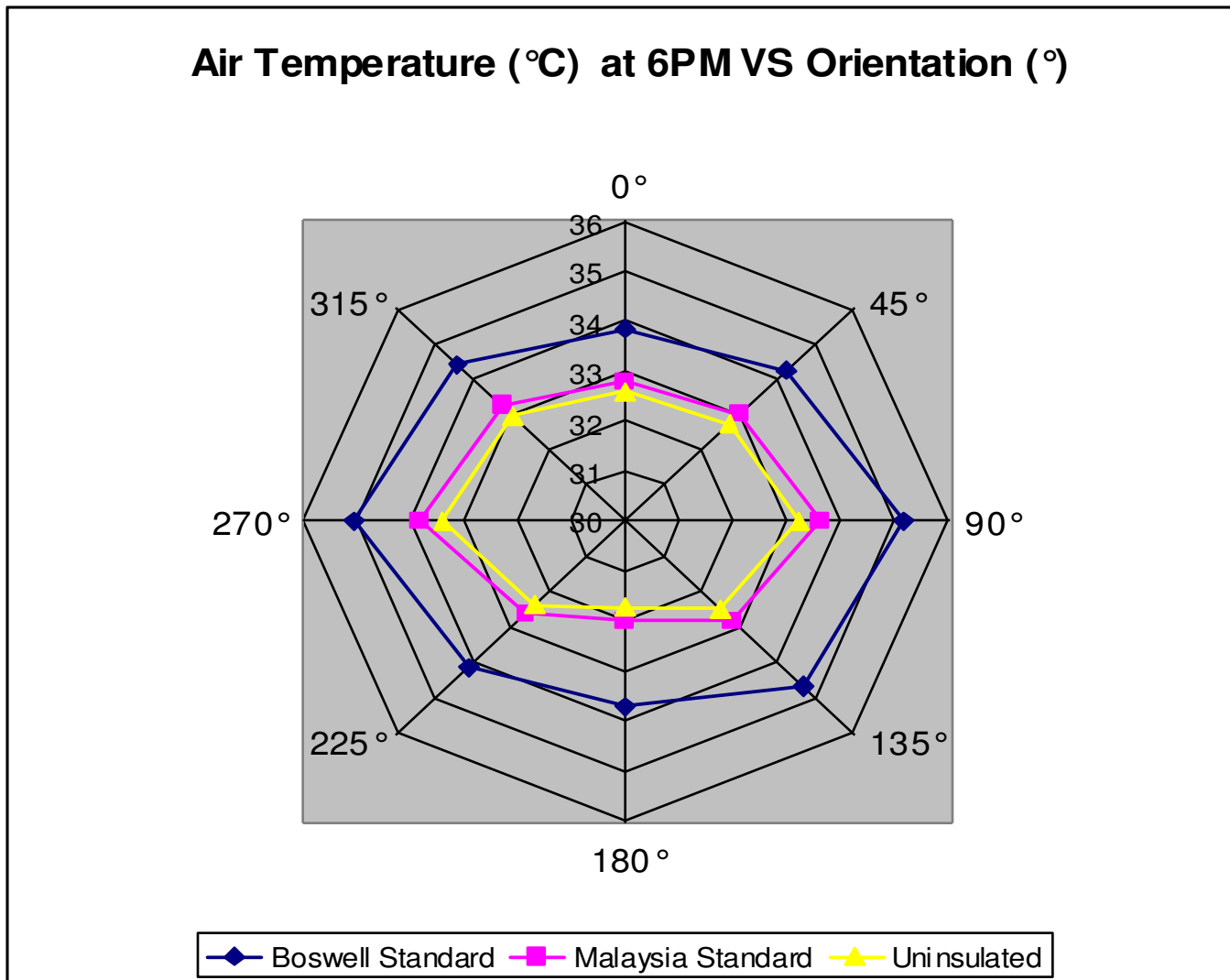


Figure 3: Comparison between Air Temperatures with Different Orientation

Orientation (cont)

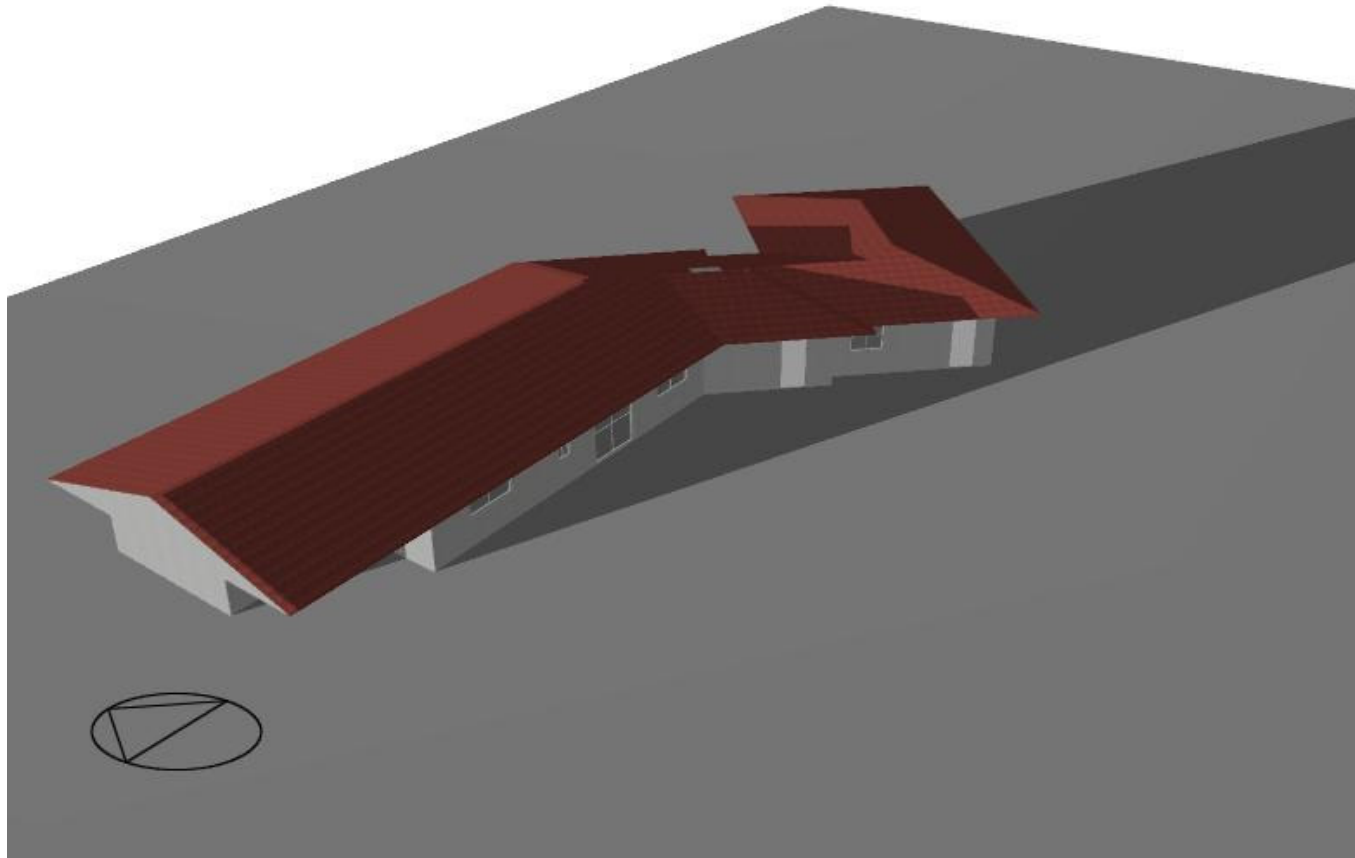


Figure showing Cooltek House visualized by DesignBuilder at 6pm afternoon.

Orientation (cont)

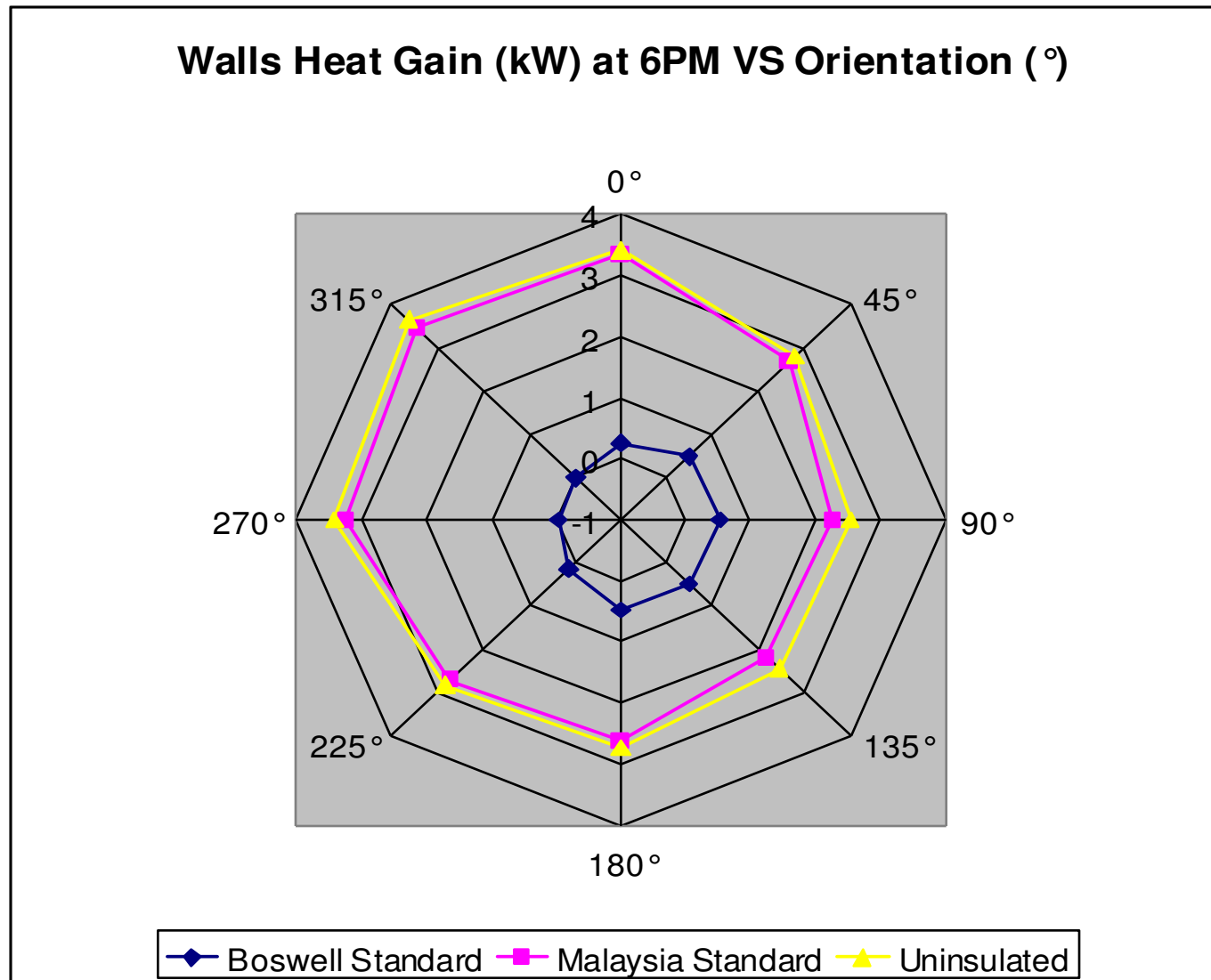


Figure 4: Comparison between Walls Heat Gain with Orientation

Orientation (cont)

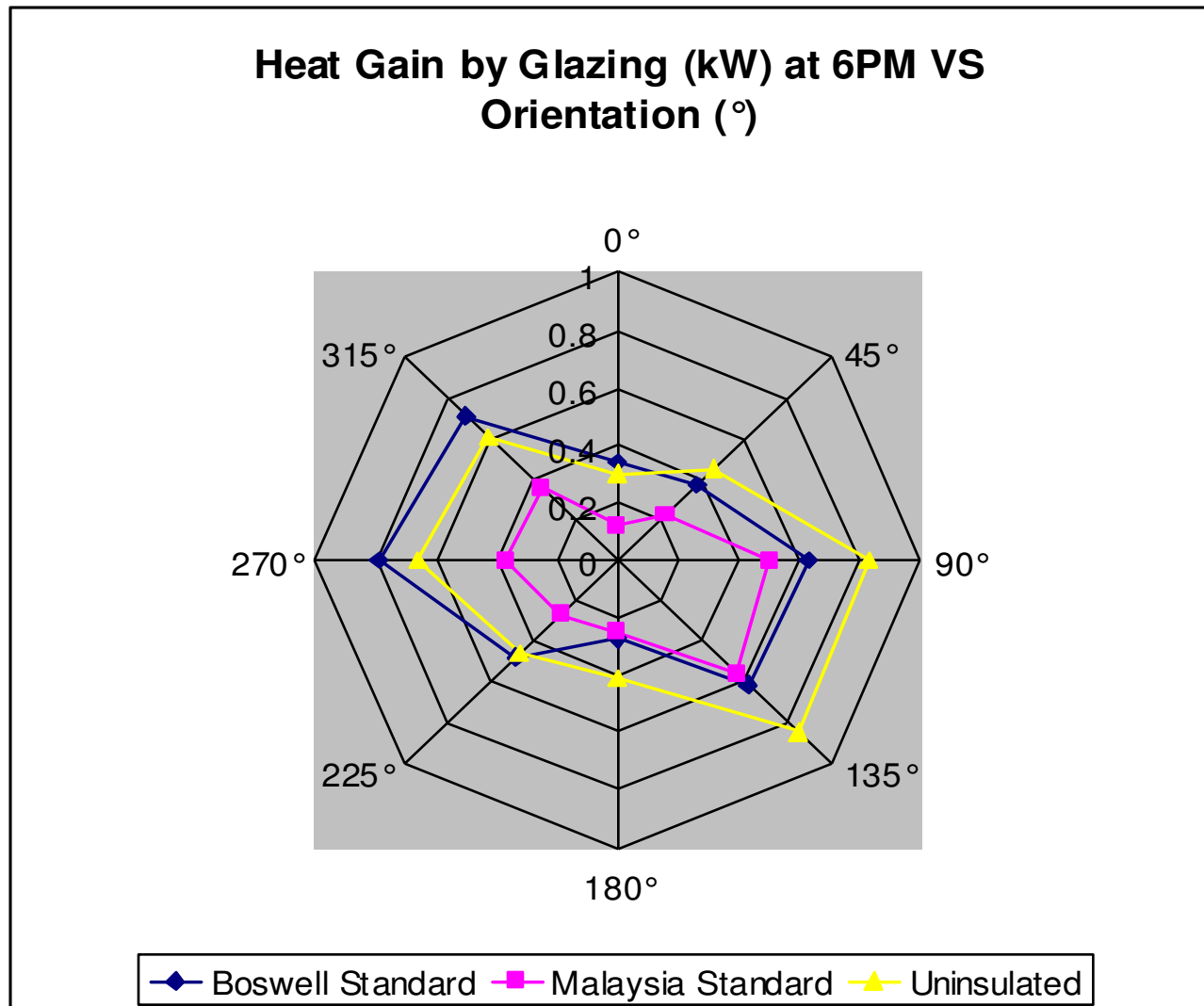


Figure 5: Comparison between Heat Gains by Glazing with Orientation

Orientation (cont)

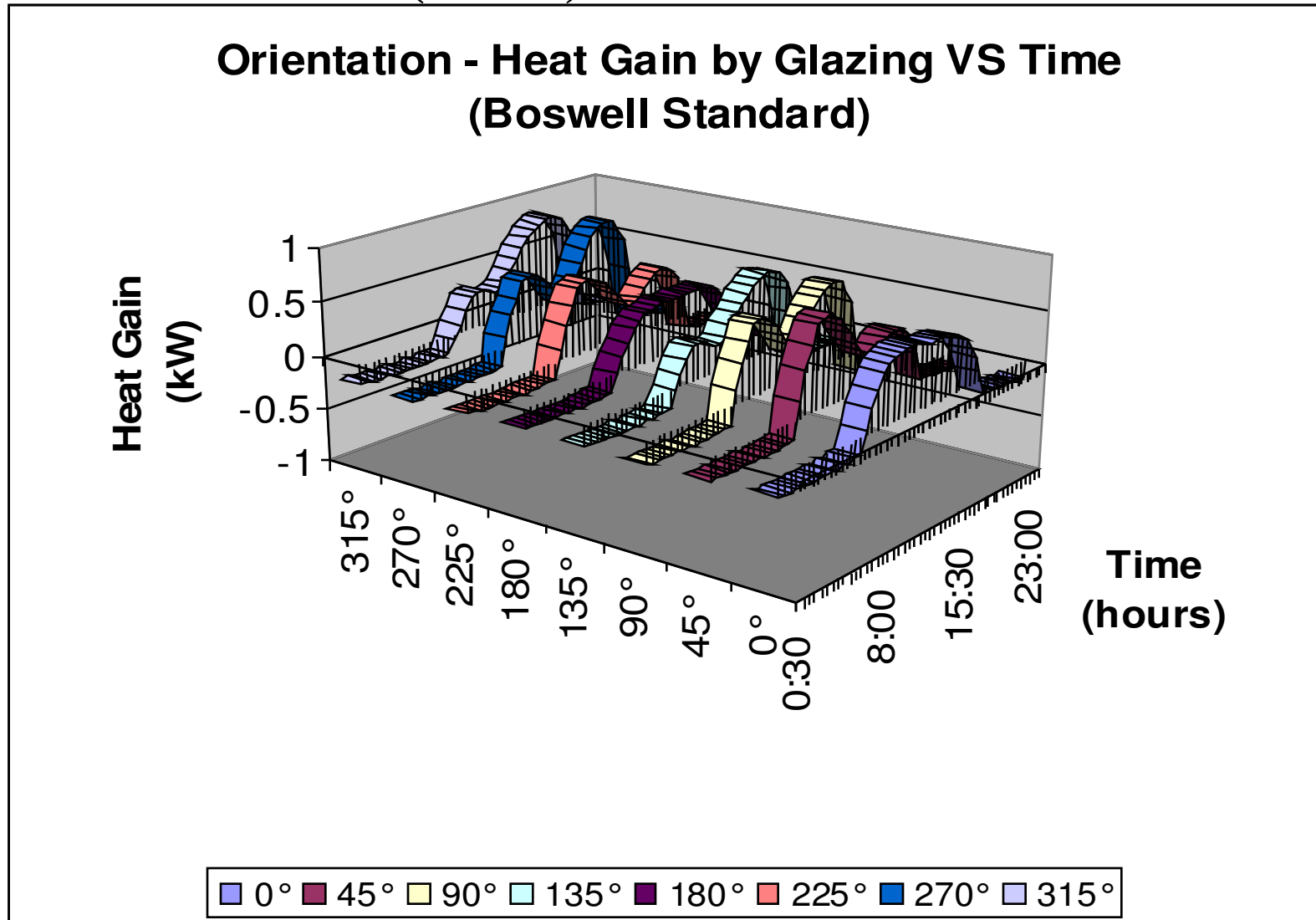


Figure 6: Comparison between Heat Gains by Glazing with Orientation for Boswell Standard

Lighting

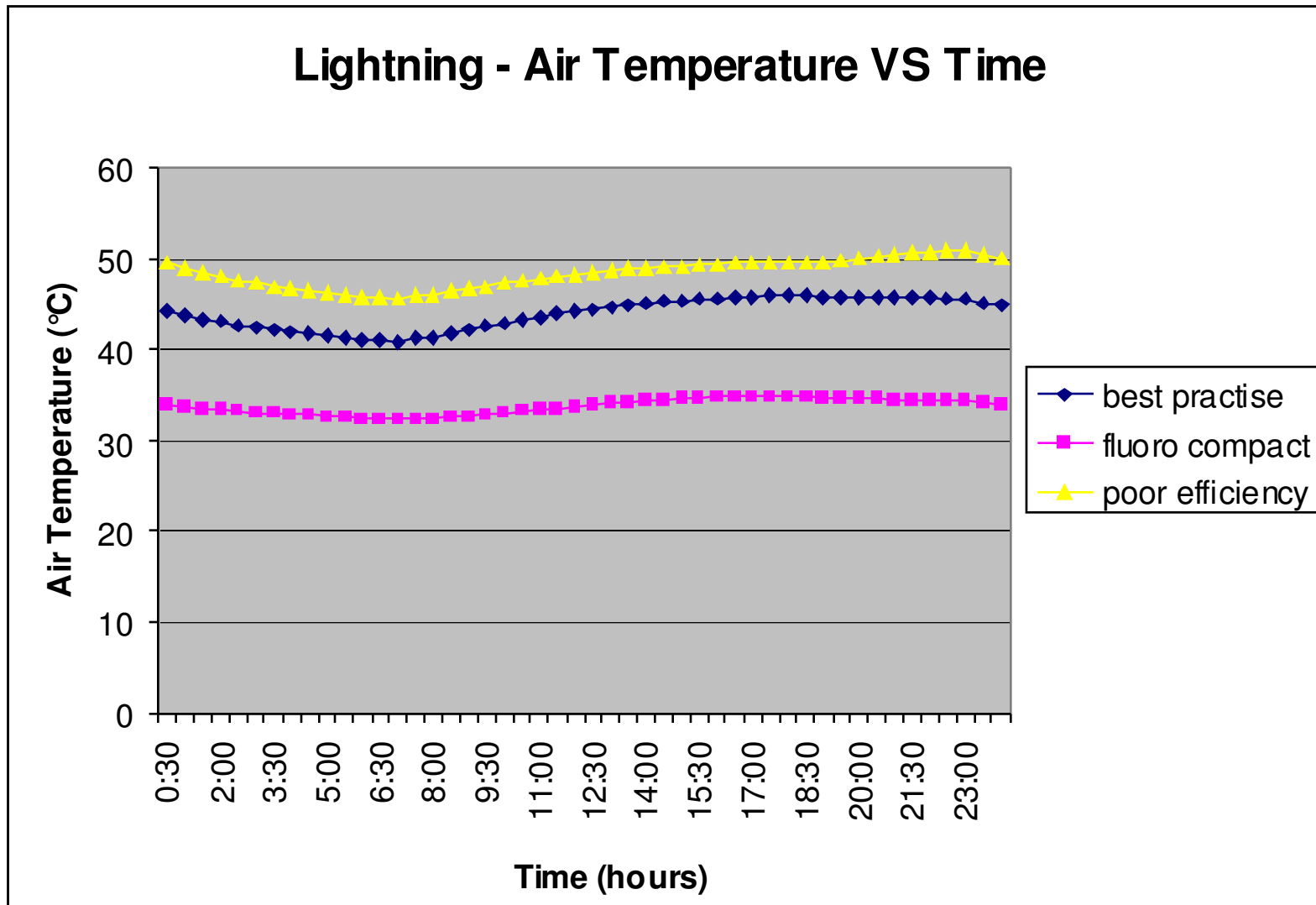


Figure 7: Comparison between Air Temperatures with Different Lighting



Simulation Results of Terrace House

- Only focus at the **Orientation** since other aspect are all the same as the Cooltek House.

Orientation

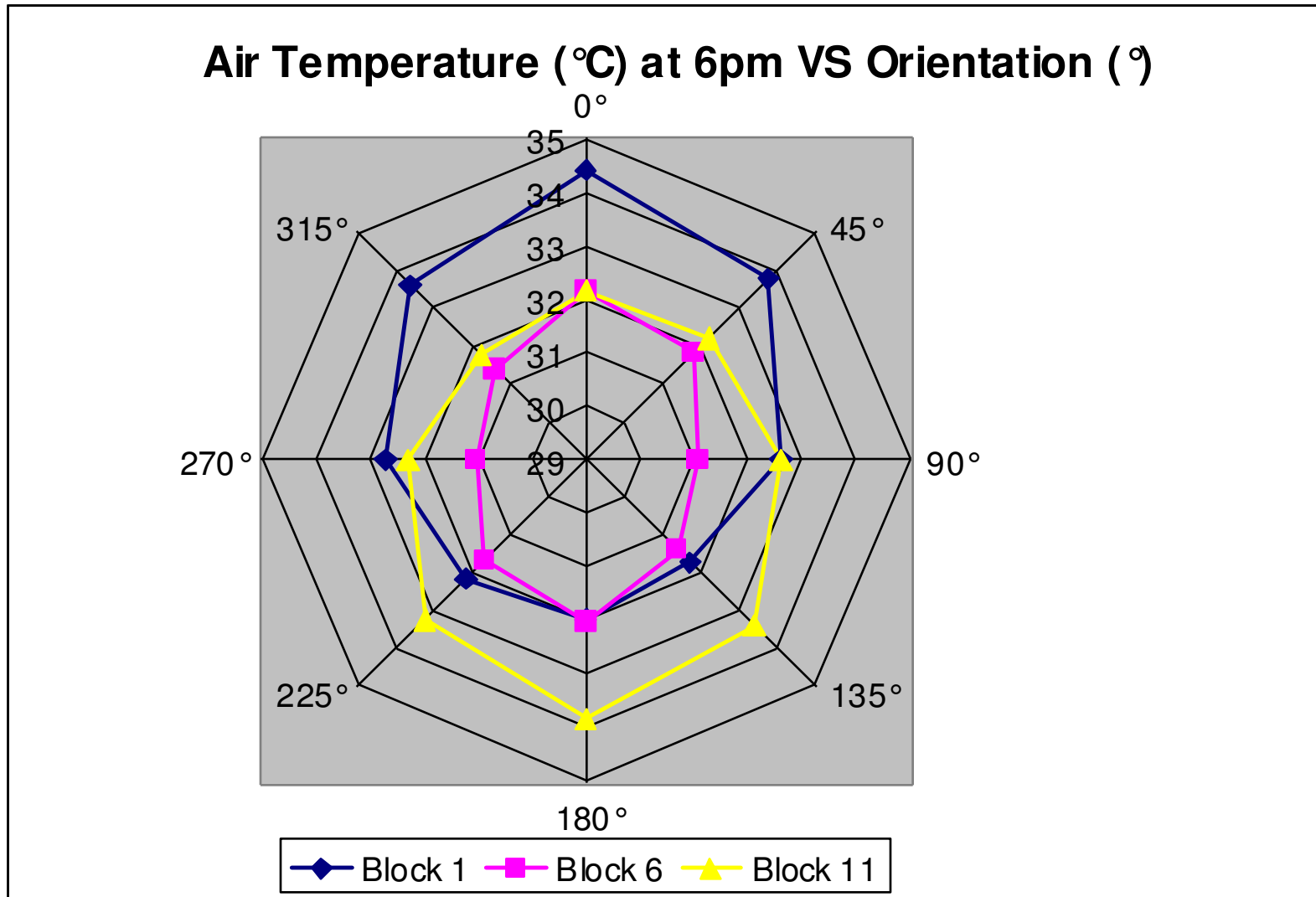


Figure 8: Comparison between Air Temperatures with Orientations for Terrace House

Orientation (cont)

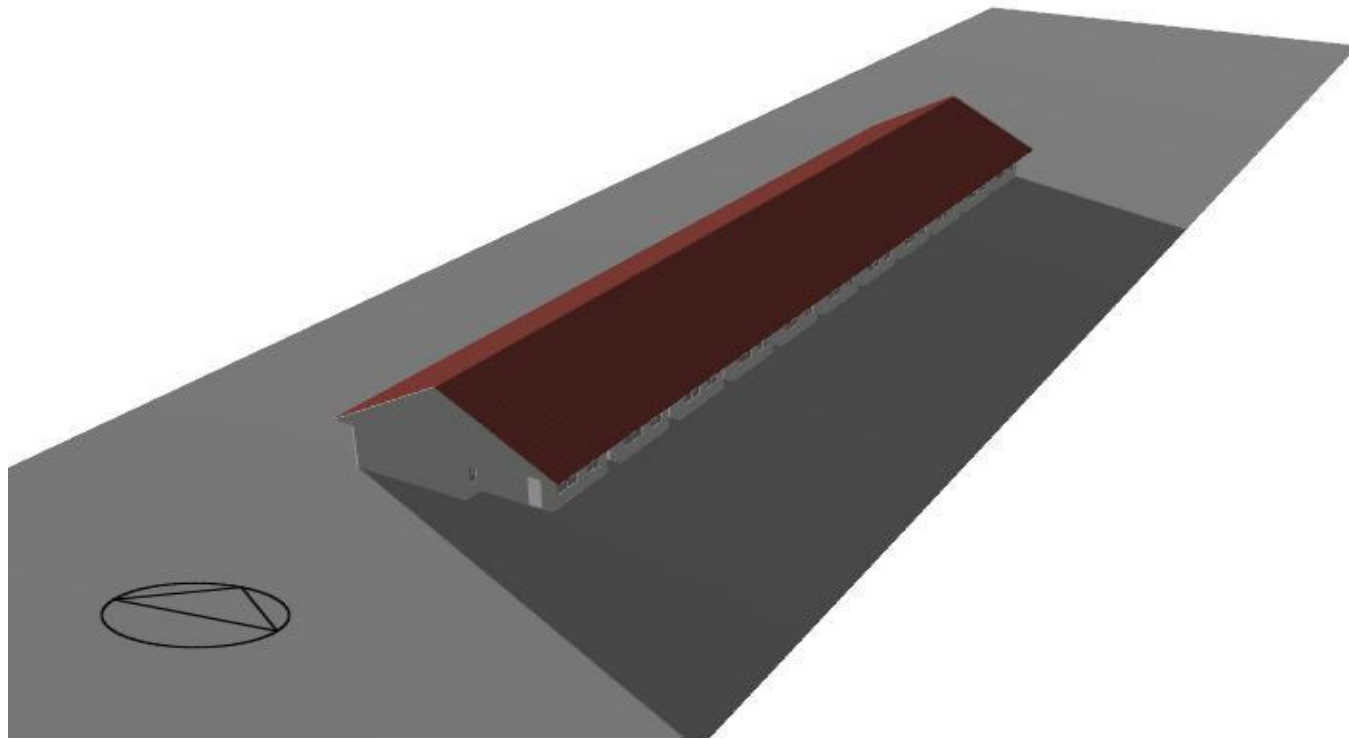


Figure showing Terrace Houses visualized by DesignBuilder at 6pm afternoon.

Orientation (cont)

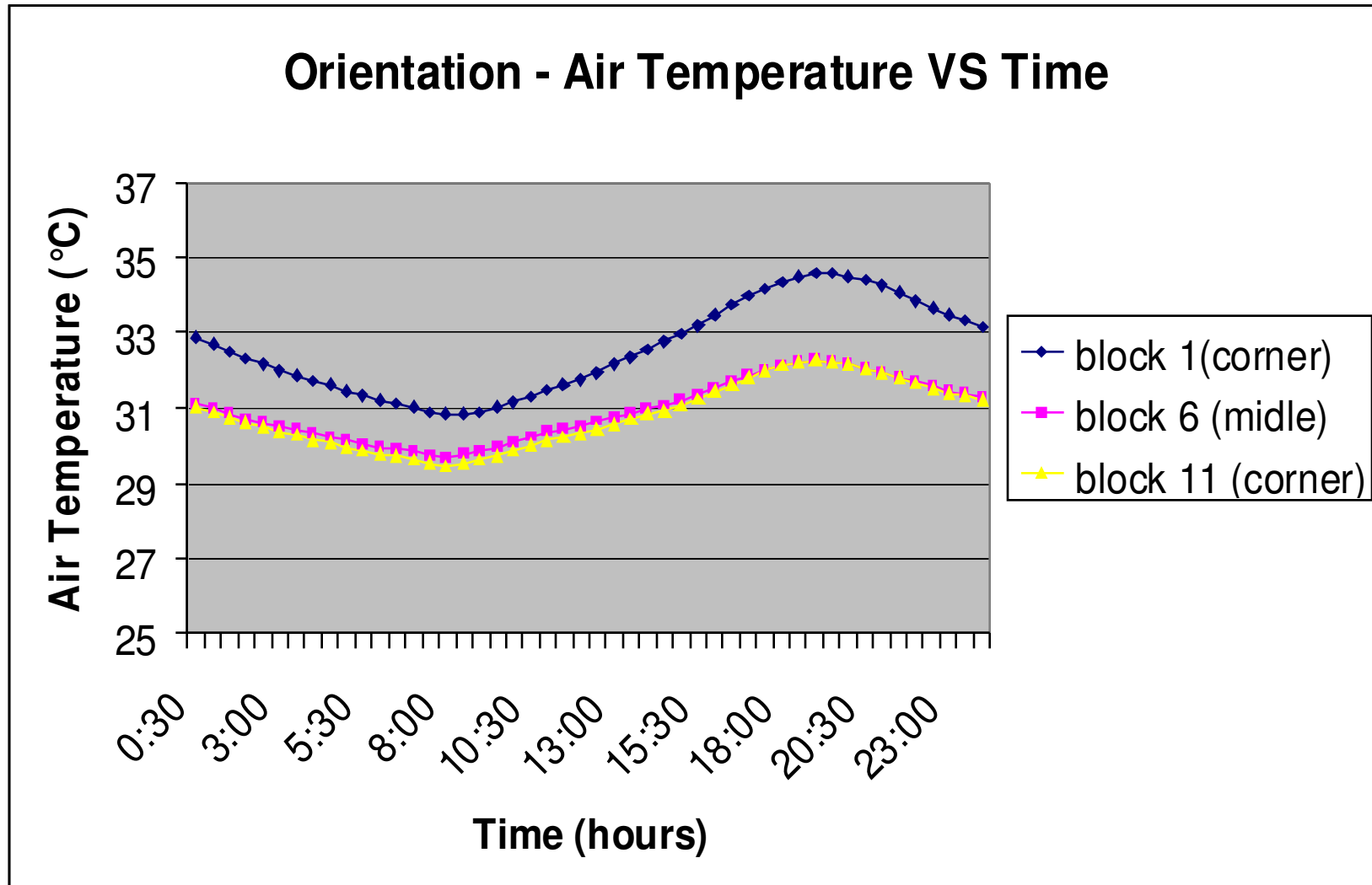


Figure 9: Comparison between Air Temperatures with Different Terrace Units

Air Temperature at 6PM VS Types of Terrace Blocks

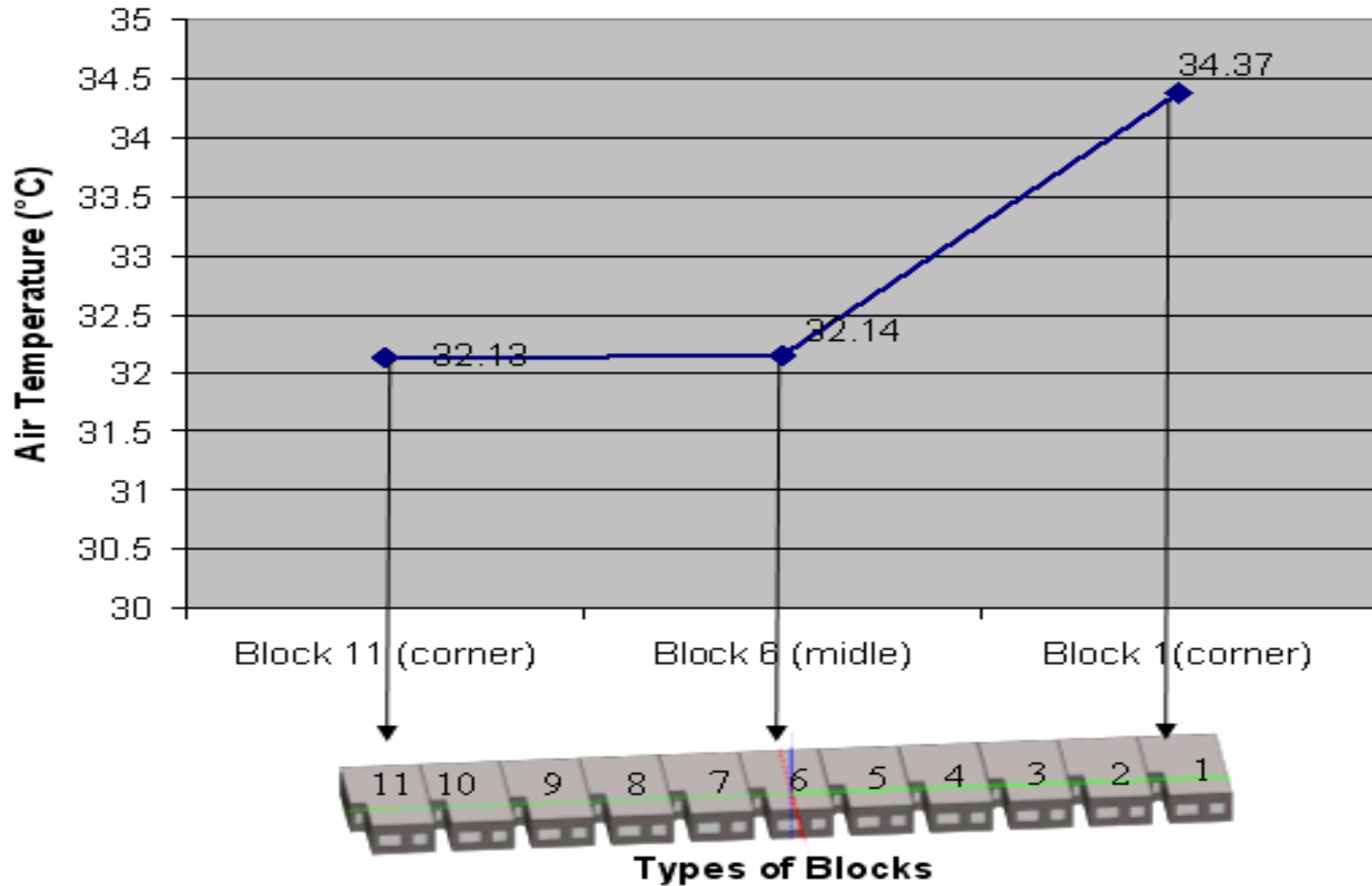


Figure 10: Comparison of Air Temperature of each Block in a row of Terrace House



Calculation of Cooling Load Requirement

- HVAC
- Windows
- Orientation
- Lighting

HVAC

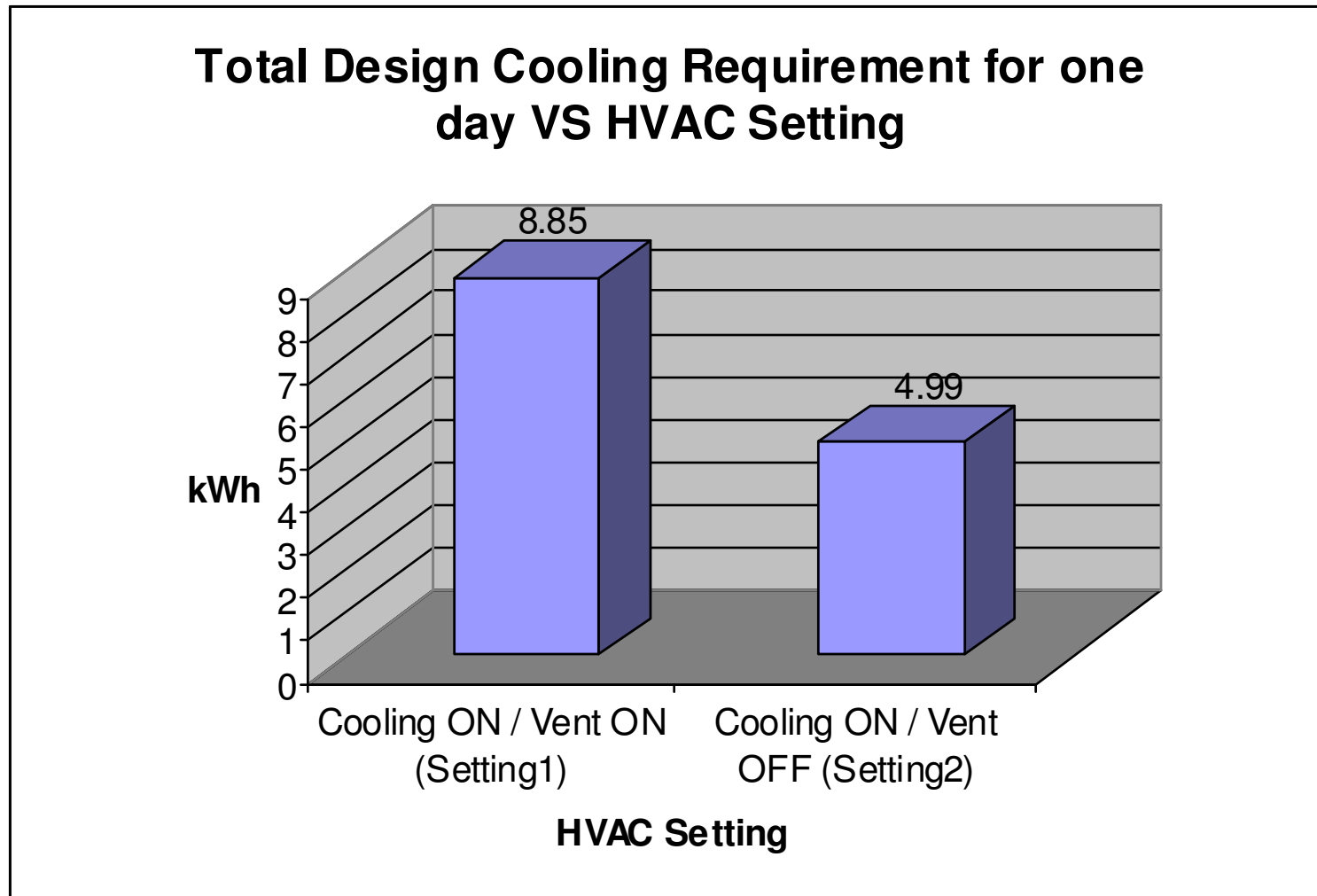


Figure 11: Total Design Cooling Requirement for HVAC



Calculation for HVAC

$$\begin{aligned} \text{Saving in energy usage} &= 8.850 \text{ kWh} - 4.990 \text{ kWh} \\ &= 3.86 \text{ kWh / day} \end{aligned}$$

$$\begin{aligned} \text{Saving in electricity bill} &= 3.86 (0.218) \\ &= \underline{\underline{\text{RM } 0.84148 \text{ / day}}} \end{aligned}$$

Windows

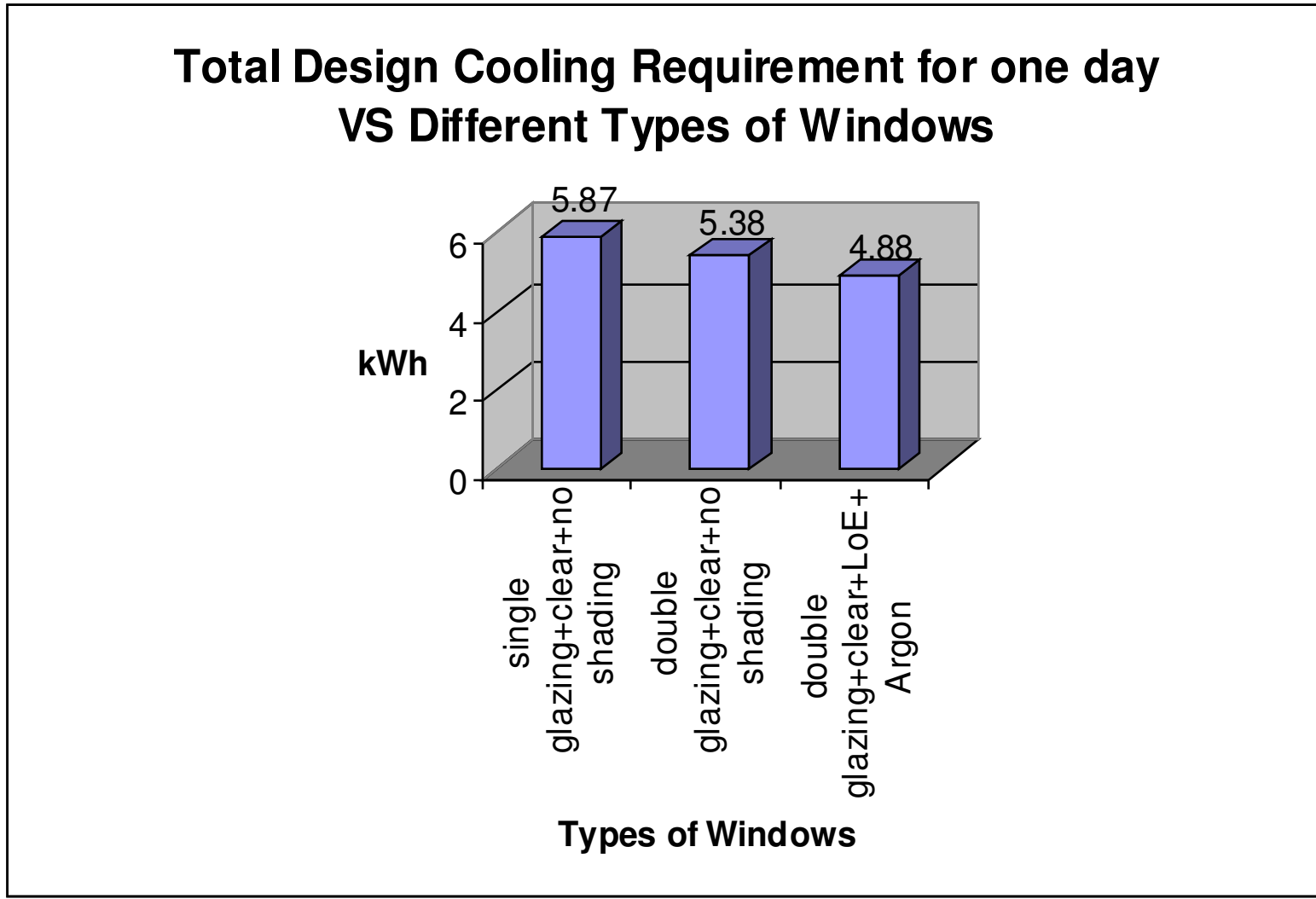


Figure 12: Total Design Cooling Requirement for Windows



Calculation for Windows

$$\begin{aligned} \text{Saving in energy usage} &= 5.870 \text{ kWh} - 4.880 \text{ kWh} \\ &= 0.990 \text{ kWh / day} \end{aligned}$$

$$\begin{aligned} \text{Saving in electricity bill} &= 0.990 (0.218) \\ &= \underline{\underline{RM 0.21582 / day}} \end{aligned}$$

Orientation

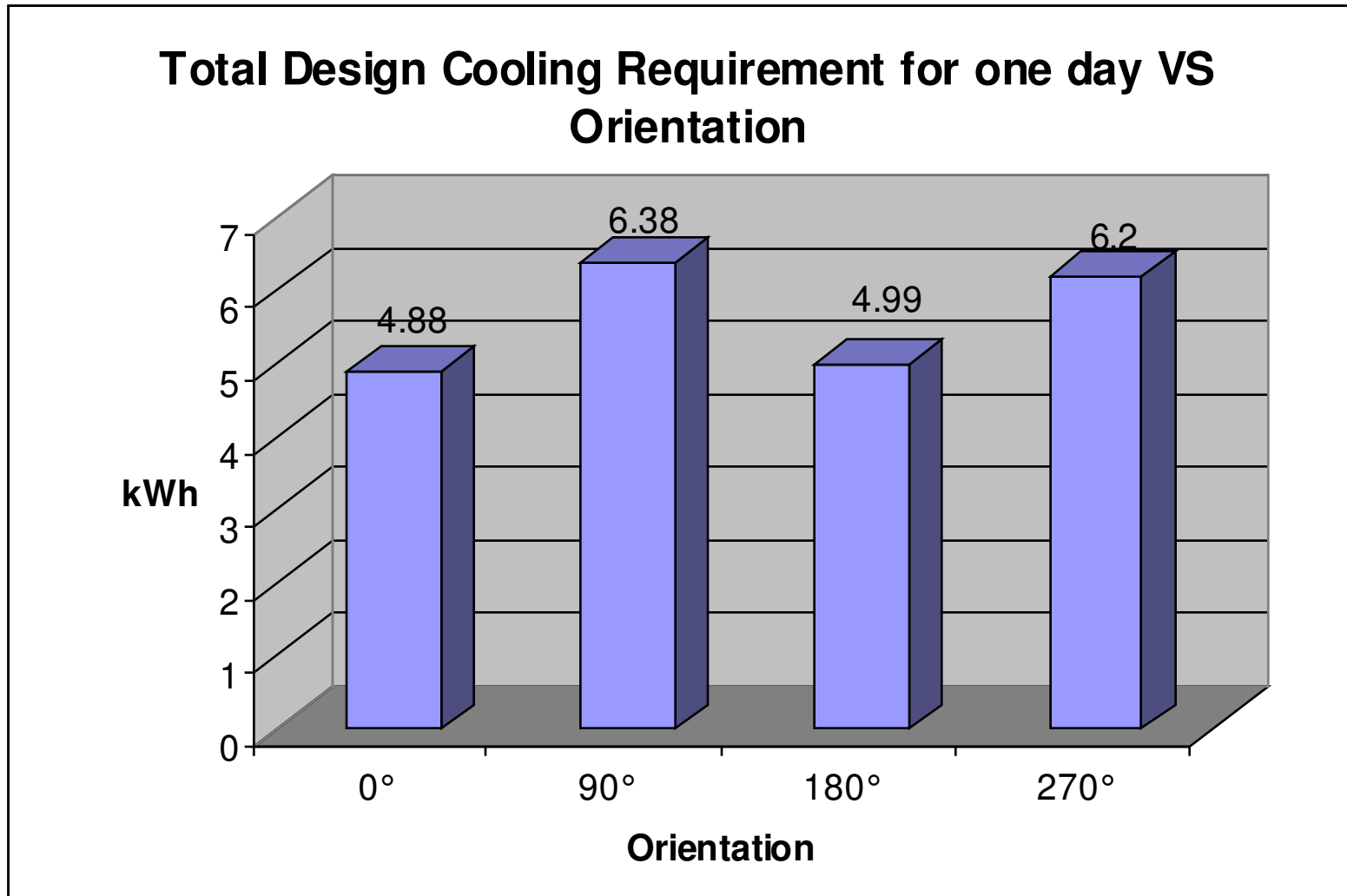


Figure 13: Total Design Cooling Requirement for Orientations



Calculation for Orientation

$$\begin{aligned} \text{Saving in energy usage} &= 6.380 \text{ kWh} - 4.880 \text{ kWh} \\ &= 1.500 \text{ kWh / day} \end{aligned}$$

$$\begin{aligned} \text{Saving in electricity bill} &= 1.500 (0.218) \\ &= \underline{\underline{\text{RM } 0.327 / \text{day}}} \end{aligned}$$

Lighting

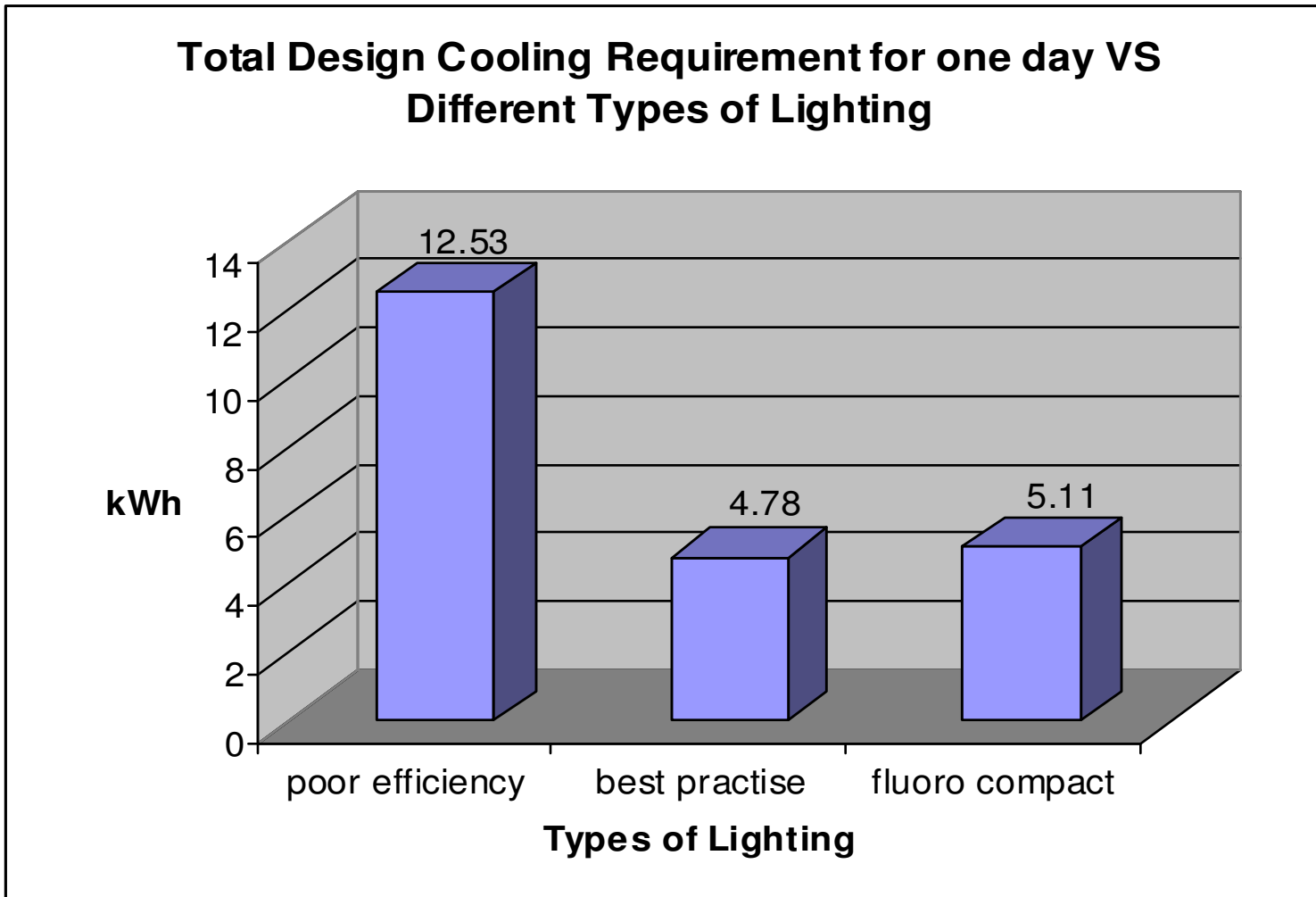


Figure 14: Total Design Cooling Requirement for Types of Lighting



Calculation for Lighting

$$\begin{aligned} \text{Saving in energy usage} &= 12.530 \text{ kWh} - 4.780 \text{ kWh} \\ &= 7.750 \text{ kWh / day} \end{aligned}$$

$$\begin{aligned} \text{Saving in electricity bill} &= 7.750 (0.218) \\ &= \underline{\underline{\text{RM 1.6895 / day}}} \end{aligned}$$



Calculation of Total Savings in Electricity Bill Per Day

Total saving in electricity bill per day

*= [Saving in HVAC + Saving in Window
+ Saving in Orientation + Saving in Lighting] / day*

= RM 0.84148 + RM 0.21582 + RM 0.327 + RM 1.6895

= RM 3.0738 / day

Calculation of Total Savings in Electricity Bill *in the long run.*

- Terrace house built using energy efficient material.
- Estimate 100units of terrace houses.

Saving for 10 years for 100 units terrace houses

= (RM3.0738 x 100) x (365 x 10)

= **RM1,121,937.00**



Total Design Cooling Requirement for One Day VS Types of Houses

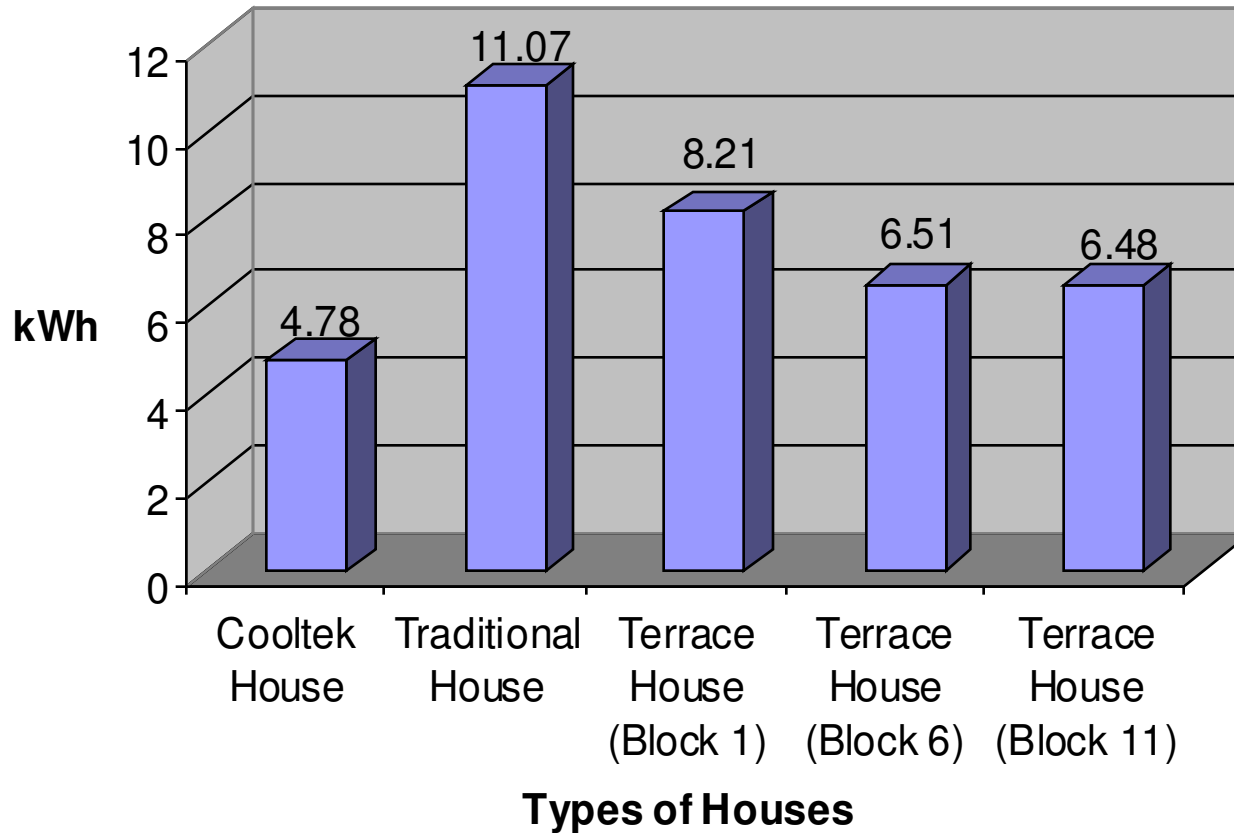


Figure 15: Total Design Cooling Requirement for Different Houses



| Types of Houses | Calculation | Electricity usage per day | Cost Factor of electricity usage compare to Cooltek house |
|--------------------------|----------------------|----------------------------------|--|
| Cooltek House | 4.78×0.218 | RM 1.04 | 1.00 |
| Traditional House | 11.07×0.218 | RM 2.41 | 2.32 |
| Terrace House (Block 1) | 8.21×0.218 | RM 1.79 | 1.72 |
| Terrace House (Block 6) | 6.51×0.218 | RM 1.42 | 1.365 |
| Terrace House (Block 11) | 6.48×0.218 | RM 1.41 | 1.356 |

Figure 16: Calculation and comparison of electricity usage for different houses

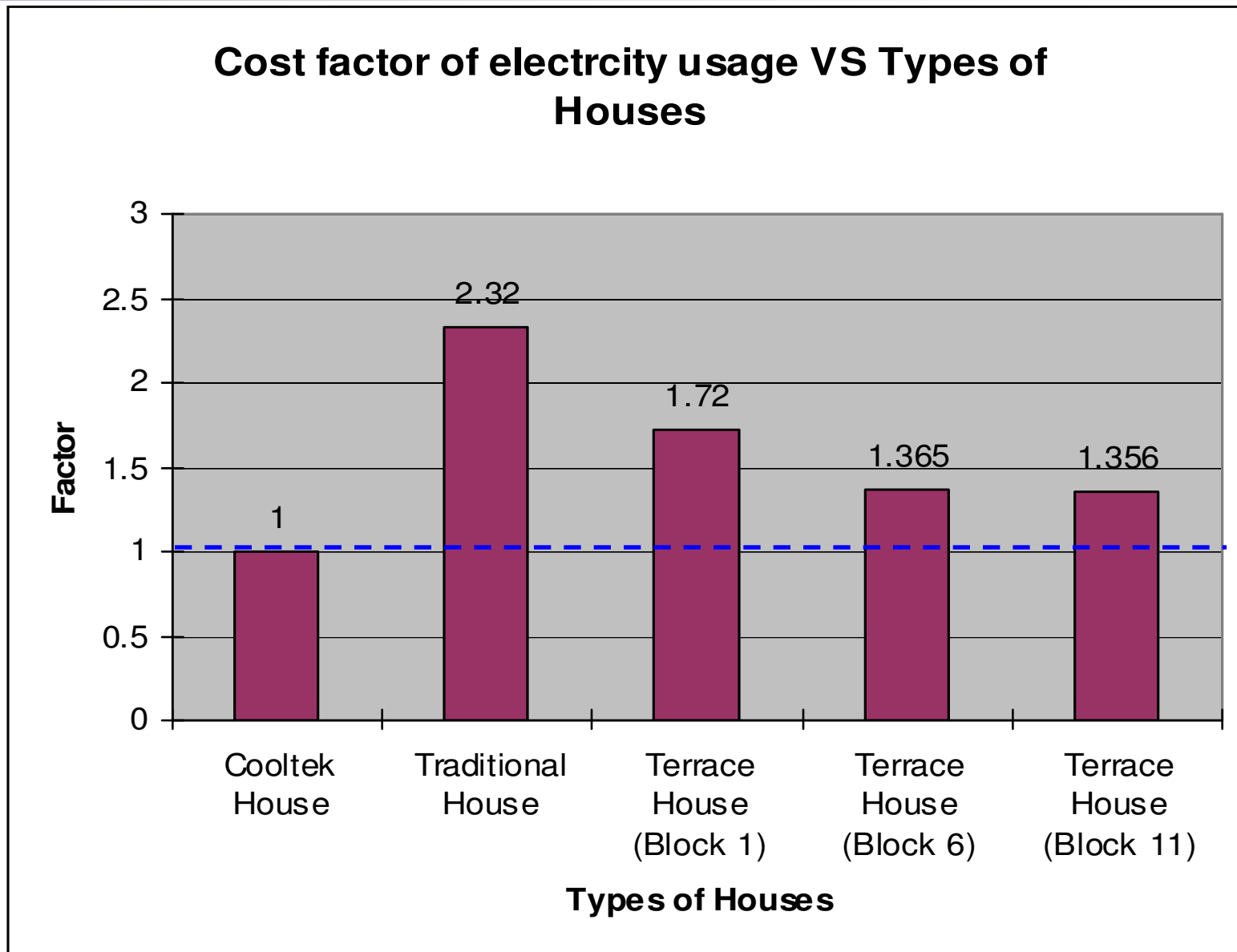


Figure 17: Cost factor of electricity usage compare to Cooltek House for different houses



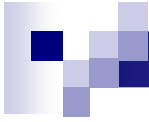
Conclusion

- Every single changes made to a certain house will effect the air temperature inside the house → cooling load.
- Little changes doesn't seems to decrease much in the energy usage of a house but it will accumulate to a large amount on the long run.
- Advantages - power plant can decrease cost by generating less energy supply to the housing area and helps to lower the Carbon Dioxide emission that leads to Global Warming.
- Disadvantages - initial cost of the material and installation.
- A 30% of cutback in energy consumption of residential region will definitely confer a large impact to the mother-earth and energy sustainability.



References

- [1] Household Glossary – Building Technical Terms Explained (2004) Carson Dunlop Report [Online] Carson, Dunlop & Associates Ltd. <http://www.carsondunlop.com/OBS/glossary.htm> [4th September, 2005]



THANK YOU

Have a nice day.....