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Performance Evaluation of Energy Conscious Building by Using Integrated Approach towards Sustainability

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Abstract

Sustainable design is a design approach put in place to promote the environmental quality and the quality of building indoor environment by reducing negative impacts on building and the natural environment. Also, it is a design philosophy that seeks to incorporate sustainable development concept in terms of initiatives and values into sustainable building envelope design. However, the problem remains as to what constitutes sustainable development concept required for sustainable envelope design. Therefore, this paper is aimed at examining the role of sustainable development concept in sustainable envelope design by investigating the impacts of sustainable envelope design on building sustainability using Integrated Performance Model. This was validated by comparing the energy efficiency performance from selected case studies of buildings with sustainable development concept and building envelope without sustainable development concept. It is expected that the incorporation of sustainable development concept in terms of initiatives and values will enhance the energy performance of building envelopment development and bring about building sustainability

1. Introduction

Construction industry has significant environmental, social and economic impacts on the society. As one of key outputs of the construction industry, buildings largely reflect these impacts during its life cycle. The positive impacts of construction activities include: providing buildings and facilities to satisfying human being's requirements, providing employment opportunities directly or indirectly (throughout her industries related to the construction industry) and contributing toward the national economy. For instance, the construction industry in Australia contributes 7.5% to the Gross domestic product (GDP) and provides more than 1 million jobs. Similarly, buildings and construction activities play a crucial role in urbanization.

The negative impacts of buildings and construction activities area so well recognized. These include the noise, dust, traffic congestion, water pollution and waste disposal during the construction stage. A large quantity of natural and human resources will be consumed. Once completed, buildings continue their impacts on the environment. According to the World Business Council for Sustainable Development, building block accounts for 40% of total energy consumption. The increasing demand of land fill presents a new challenge to all countries that have issues with limited land.

Researcher defined green building as: healthy facilities designed and built in are source-efficient manner, using ecologically based principles. It is worth noting that green building has been used as a tem interchangeable with sustainable building and high performance building. Researcher pointed out that there are four pillars of green buildings, i.e. minimization of impacts on the environment, enhancing the health conditions of occupants, there turn on investment to developers and local community, and the life cycle consideration during the planning and development process. Common elements of these definitions are: life cycle perspective, environmental sustainability, health issues and impacts on the community.

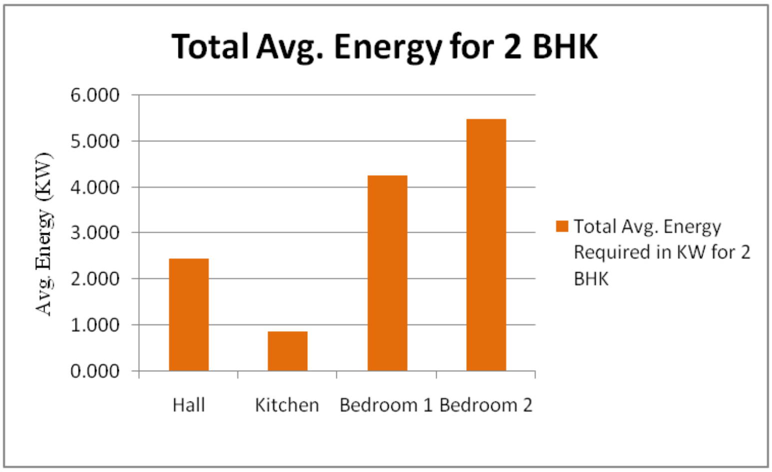
2. Embodied Energy Calculations

- **Quantity of Steel**
  Total concrete required for building = 2115 m3
  Assume 1% of reinforcement of volume of concrete = 21.15 m3
  1 Kg solid steel = 7800 kg
  Total Steel = 164970 kg
  Embodied Energy = 164970 × 20.1
  = 3315897.171 J/kg
- **Cement**
  Total Cement required = 288.595 m3
  = 8245.57 bags
  1 Bag = 50Kg
  8245.57 Bags = 412278.5Kg
  Embodied Energy Factor = 1
  Embodied Energy = 412278.5MJ/kg
- **Concrete**
  Total Concrete = 2115 m3
  1 m3 = 2406.53 Kg concrete
  5089811 kg Concrete
  Embodied energy factor = 1.11
  Energy = 5089.11 × 1.11
  = 564987.90MJ/kg
- **Bricks**
  Total No. Of bricks = 46648218
  Weight of 1 brick = 3 kg
  Total Weight = 139944654 kg
  Embodied Energy Factor = 3
  Energy = 139944654 × 3
  = 419833962MJ/kg

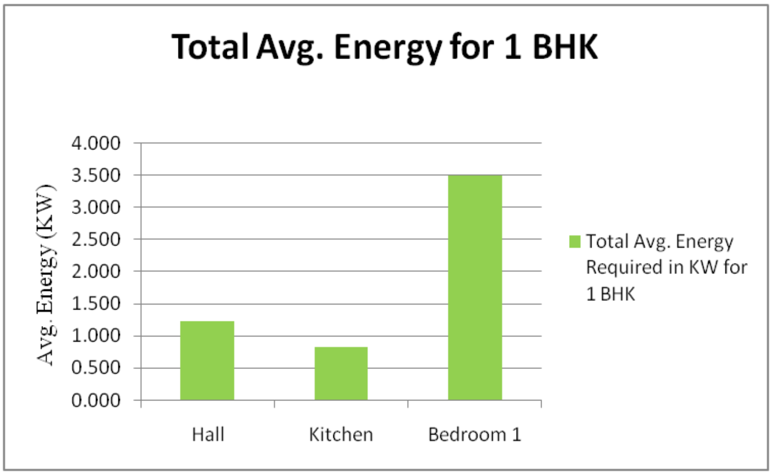
- **Aluminium**
  Total Weight of Aluminium = 9305
  Embodied Energy Factor = 155
  Energy = 9305 × 155
  = 1442275MJ/Kg
- **Aggregate**
  Total Aggregate = 1143.146 m3
  Embodied Energy Factor = 0.083
  Energy = 1143.146 × 0.083
  = 94.881MJ/Kg

3. μ Value Analysis and Embodied Energy

- Standard Outside Wall Surface Resistance (R1)
  R1 = 0.06 m2× 0C/w
- Brick Work
  Thickness of Brick = 0.15
  Thermal Conductivity = 0.9
  Thermal Resistivity (R2) = $\frac{0.15}{0.9}$ = 0.166m^2×^{o}C/w
- Plaster
  Thickness of Plaster = 0.012
  Thermal Conductivity = 0.35
  Thermal Resistivity (R_3) = $\frac{0.012}{0.35}$ = 0.03m^2×^{o}C/w
- Standard inside Wall Surface Resistance (R4)
  R4 = 0.12m2×oC/w
- Total Thermal Resistivity (RT)
  RT = R1 + R2 + R3 + R4
  = 0.06 + 0.166 + 0.03 + 0.12
  = 0.376
- Therefore Thermal Transmittance of the Wall is
  $\mu = \frac{1}{RT} = \frac{1}{0.376} = 2.65$
  μ = 2.65W/ m^2×^{o}C



Total Avg. Energy for 2 BHK

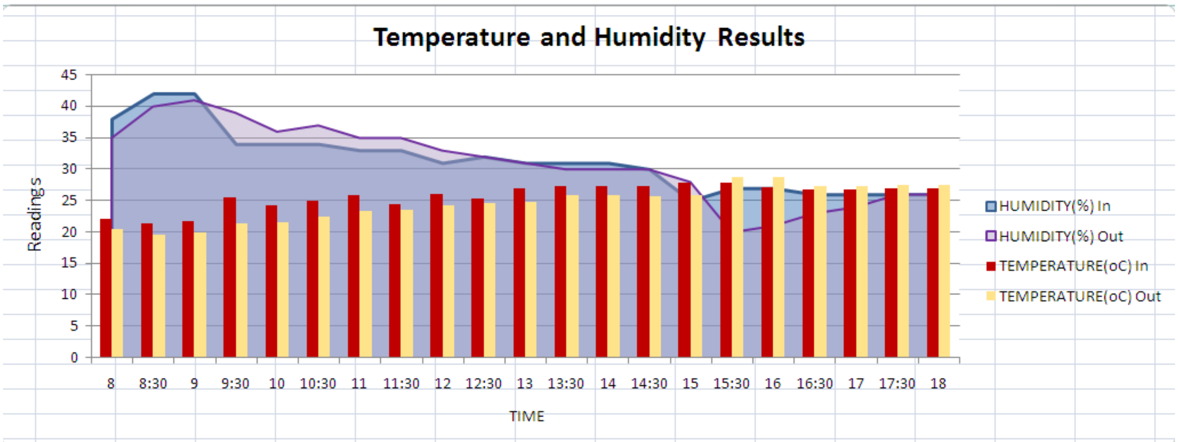


Total Avg. Energy for 1 BHK

4. Hot and Humid Readings

DATE - 18/01/2018					
TIME	PRESSURE(Hg)	TEMPERATURE(°C)		HUMIDITY (%)	
		In	Out	In	Out
2pm	28.05	28.6	28.1	31	30
2:30pm	28.02	27.5	26.9	30	30
3pm	28.02	29	27	27	29
3:30pm	28.02	28.8	27.2	29	29
4pm	28.02	28	27.4	28	26
4:30pm	28.02	27.9	27.1	30	27
5pm	28.02	27.7	27	30	27

5:30pm	28.02	27.6	26.7	29	28
6pm	28.02	27.5	26.1	36	29
DATE - 19/01/2018					
TIME	**PRESSURE(Hg)**	**TEMPERATURE(°C)**		**HUMIDITY (%)**	
		In	**Out**	**In**	**Out**
8am	28.14	22.1	20.5	38	35
8:30am	28.11	21.3	19.5	42	40
9am	28.14	21.7	19.9	42	41
9:30am	28.14	25.4	21.4	34	39
10am	28.14	24.2	21.6	34	36
10:30am	28.14	24.9	22.4	34	37
11am	28.14	25.8	23.3	33	35
11:30am	28.14	24.4	23.4	33	35
12am	28.1	26	24.2	31	33
12:30am	28.11	25.3	24.6	32	32
1pm	28.05	26.9	24.8	31	31
1:30pm	28.05	27.2	25.9	31	30
2pm	28.05	27.2	25.9	31	30
2:30pm	28.06	27.2	25.7	30	30
3pm	28.05	27.8	25.9	25	28
3:30pm	28.02	27.7	28.7	27	20
4pm	28.02	27.1	28.6	27	21
4:30pm	28.01	26.8	27.2	26	23
5pm	28.01	26.8	27.3	26	24
5:30pm	28.01	26.9	27.4	26	26
6pm	28.01	26.9	27.4	26	26



Temperature and Humidity Results

5. Automatic Weather Station

Date - (18/1/18)						
DIRECTION	**0-1**	**1 to 2**	**2 to 3**	**3 to 4**	**4 to 5**	**5 to 6**
N						
N-E						
S						
S-E		||			|	
S-W						
W		|	|			
NW			|			
E		|	|			|
Date - (19/1/18)						
N	|			|		
N-E		|		|		|
E		|	||			|
S-E		|				
S				||		
S-W			|			
W	||		|		|	
NW		||		||		

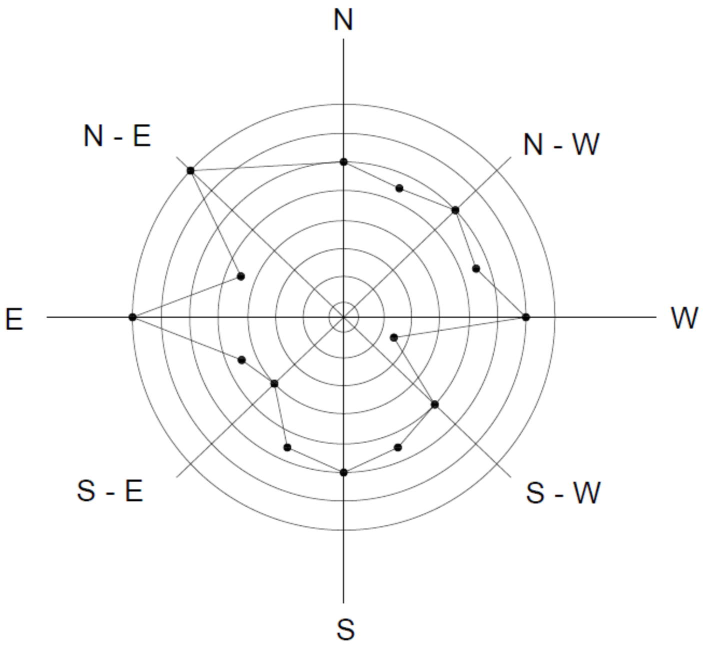


Figure No. 5.4: Windrows Diagram

6. Lux Meter Analysis for Daylight

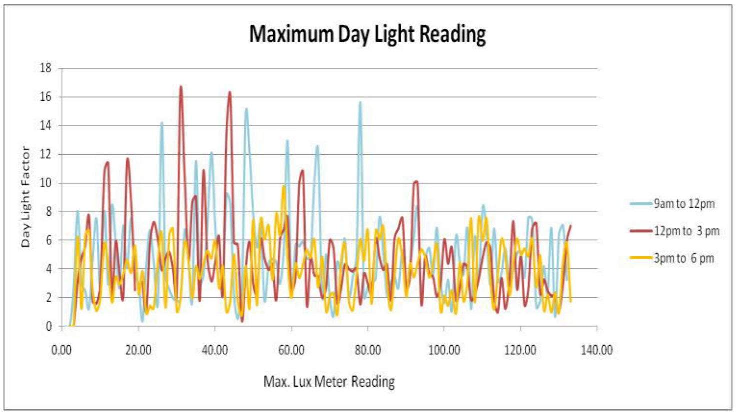


Figure No.5.5: Maximum Day Light Reading

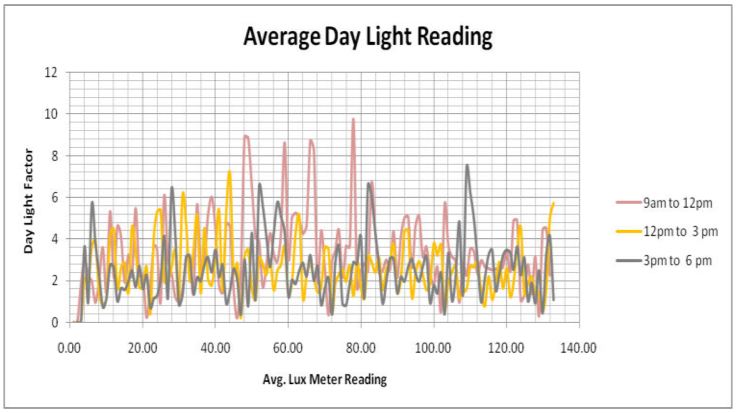
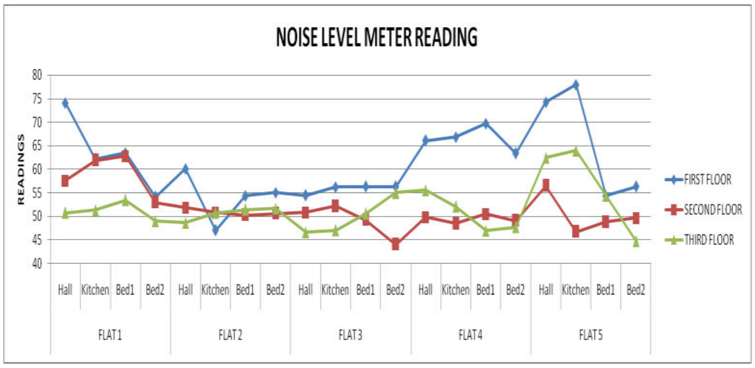


Figure No.5.6: Average Day Light Reading

7. Noise Level Meter Readings



Noise Level Meter Readings

8. Conclusion

This comparative study has investigated the most reliable and commonly used schemes in the global context (BREEAM, LEED, SBTool and CASBEE), with particular attention given to the domain of credits allocation (weighting system) and sustainable development criteria in each scheme, with the obvious similarities and differences having been identified. These tools have been highlighted in the terminal objective of implementing the principles of sustainability. As an important aspect of the sustainable construction delivery system, these assessment tools are mapping an essential road to the sustainability in the construction sector. Certain categories that are considered in both SBTool and CASBEE, such as Economic aspects and Quality of service, have been consolidated in the potential new scheme, in addition to the most important environmental categories evaluated by BREEAM and LEED. This integration aims to achieve superiority through a consideration of the most reliable criteria to reflect and diagnose environmental performance, as well as to encourage a smooth transition to sustainable practices such as renewable energy, passive design and rainwater harvesting system.

The following conclusions can be drawn from this research study.

- No one-to-one relationship exists between LEED® certification process and BIM-based sustainability analyses due to the lack of LEED® integration features in the currently available software.
- The results of sustainability analyses software can be used to directly, semi-directly or indirectly generate LEED documentation. Up to 17 LEED credits and 2 prerequisites may be documented using results generated by BIM-based sustainability software; however; only 5 credits and one prerequisite have been verified in this study so far.
- BIM-based sustainability software generates results very quickly as compared to the traditional methods. In other words, a building information model can be used as a by-product to run these analyses. This could save substantial time and resources.
- Some discrepancies were recorded between the software and manual results. This was mainly due to the inaccuracy of the building information model developed for this project. Readers are advised to always perform manual checks to avoid any mistakes in the LEED® documentation..

9. Future Scope

- Building information modelling based on life cycles assessment for LEED rating.
- Comparing Different rating system with LEED rating suggesting the measure to improve the rating.

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