Assessment of carbon rating in Kinnaird College for women Lahore, Pakistan
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ABSTRACT

Urbanization and climate change is an inextricably interlinked therefore an unplanned development causing the extreme weather patterns. In most World conferences & meetings, low carbon and planned cities are the scorching topic of the year 2009 as cities included a range of sectors i.e. academic institutions. The academic institution design implies various opportunities to reduce carbon emission from buildings and from the consumption matter during academic hours. The energy performance of a building depends on its design and quality of construction. As the locally available national building codes has no standard assessment procedure for the estimation energy consumption therefore a UK based methodology was adopted for the estimation of Carbon Footprint of an educational building. The assessment of Greenhouse gas emission mainly CO₂ through energy consumption is a first step towards energy management and quantifiable carbon emission reduction. Kinnaird College for Women (KC) was selected for assessment of carbon rating. The energy consumption from each department was calculated based on number of factors like Ventilation Rate, Environment Impact Rating and Environment Impact Rating Bands were assigned according to their specific amount of carbon emission. The carbon dioxide emission increases as energy consumption of each department increase. In addition, university routes buses and personal vehicles of staff & faculty were also included as carbon-contributing factor. GIS database was prepared for the assessment of carbon emission of the institution with its graphical representation.

Keywords: CO₂ emission, educational institution, green buildings, carbon rating, green building design.

1. Introduction

Greenhouse gases are essential features for the survival of well being on earth (IEA, 2009). However, human activities pose a serious threat on environment by creating greenhouse gases especially carbon dioxide (CO₂) which ultimately disrupt the climatic patterns and responsible for rise in global mean temperature (UN, 1995). Recently environmentalists focus on the growing concern of energy consumption and carbon emissions from buildings (Walker et al., 2007). Rising concerns about energy cost forces the planners and policy makers to integrated energy efficient and low cost technologies into planning, construction and use of building in a more sustainable way (Stoy et al., 2009). Large building stocks have momentous energy utilization therefore high energy performance achieved through implementing good energy management practices (BRECSU, 2000). The planning, construction and use of the building is the best way for the reduction of energy cost and utilization, an organization minimizes greenhouse gases especially carbon dioxide emission.
related to global warming and its negative environmental consequences (BRECSU, 1997). In this research, an educational institution of Lahore i.e. Kinnaird College for Women (KC) were chosen for carbon rating. For quantifiable carbon emission reduction, carbon footprint may be the first important step to reduce its economic cost as well as the impact on climate change (Stern, 2006). For this assessment, the campus carbon footprint was divided into the areas of ventilation rate, electricity, heating, cooling, refrigerants and transportation. A linear relationship is observed among energy usage and carbon emissions. Atmospheric carbon dioxide produced from extraction, processing, delivery and usage on site or by each kWh of energy supplied to building (BRECSU, 2000).

It is unanimously agreed by international community and Intergovernmental Panel on Climate Change (IPCC, 2007b) that cities generates greenhouse gases through energy consumption and production patterns. New academic building designs can offer several opportunities to reduce energy utilization through energy entrenched in construction material, building design, equipment and appliances, and building use. Therefore, National Building Codes of the concerned authorities, building energy codes of ENERCON and NESPAK were reviewed which provide set of rules and detailed guideline, procedures and suggestions, concerning design of different types of buildings (Ullah, 2010). For example a new building design in the context of low carbon dwelling, at a site with proper physical orientation and size of windows effect the amount of electricity required for air conditioning and lighting. Renovation of existing buildings also gives significant opportunities to reduce energy usage (Pachauri et al., 2007). These codes are formulated for the provision of lowest necessities for construction of buildings and energy-efficient designs (ENERCON, 2010).

Viet (2008) investigated the mutual relationship between green building rating systems and sustainable urban development principles. He described the attempts of push green buildings to the top rating level may not perhaps increase the sustainability outcomes in the urban context. Kenefick and Tate (2005) suggested that lime is used as a sustainable and green building product. They assessed the sustainability of limestone as a natural product through its examination and the carbon-balancing factor. Hydrated lime's ability to absorb carbon dioxide from the air & converting it back to limestone is well known (Gooch et al., 1988). According to the United Nations population projection 2006, it is estimated that urban dweller expected to 4.9 billion people in 2030. It is predicted that urban population in 2005 is 3.2 billion which is nearly four times as in 1950 (UN, 2006). Asian Development Bank (ADB, 2009) reported that Asian cities face a major challenge of rapid development in urbanization coupled with gradual increase in personal motorization and demand for mobility. This research included the data collection from the Faculty members having their personal vehicles as a mode of Transport for the estimation of carbon emission. A blueprint of questionnaire was designed for data collection. The carbon dioxide emission data from both educational institution and from the faculty member’s personal vehicles were calculated and had been analyzed by using Geographic Information System (GIS) techniques. The GIS program was used for the mapping of emission sources. Ali et al., (2005) was prepared CO₂ emission inventory by considering the total amount of fuels used in provinces with respect to sources, then this inventory was linked to the GIS mapping of provinces.

2. Materials and method

The aim of the present study was the assessment of carbon emission from the building through energy consumption and from the vehicles of the university faculty members whereas GIS application was used for the preparation of thematic mapping.
2.1 Study area

The site for this study was Kinnaird College for Women which chosen as a case study for the assessment of carbon emissions through the electricity consumption for space cooling, ventilation, lighting etc in different departments and compare carbon emission from campus building and faculty member’s personal vehicles.

2.2 Methodology

This study was based on fieldwork and it is a quantitative type of research. It includes the collection of both primary & secondary data. Therefore, descriptive method was used to carry out the study which was based on surveys, direct observation and questionnaire. Questionnaire included on the vehicle information such as types of vehicle, manufacturer, model, type of fuel used and the daily distance (Km) traveled from origin to destination and then return. Emissions from the university owned route buses, which provided services for students and staff, was also included.

2.3 Preliminary data collection

The preliminary data was collected for the examination of energy consumption in each institute which is concerned about mechanical, operational and architectural. Primary data collected through detailed survey including total covered area of each department, its orientation, area of doors & windows and the number of fans, lights and other appliances. The secondary data include maps of the university and electricity bill. Climatic data was collected from metrological department in order to understand a relation between actual climate conditions and energy usage.

2.4 Geographic Information System (GIS)

The Geographic Information System was use for the mapping of all departments according to their carbon emission. Global Positioning System (GPS) was used as a tool for accurate determination of geographical location and all departments displayed according to the respective values of solar gain, internal gain, mean internal temperature, energy consumption, energy cost and carbon dioxide emissions.

2.5 Standard Assessment Procedure (SAP)

Energy performance of educational institutions was calculated by adopting Standard Assessment Procedure (SAP, 2005) UK based methodology. The number of factors are involved that can contribute to the energy efficiency. The framework for calculation of energy performance is developed in excel’s worksheet.

2.5.1 Institute Dimension

The dimension referred to inner boundary of the building, the compass was used for determination of the dimension of the entire building.

2.5.2 Ventilation Rate
The Ventilation Air Change Rate is the rate at which outer air enters or leaves a building. Mechanical systems has 0.5 air change rate per hour (ach/h) with infiltration which is based on SAP calculation. Annual energy used by fans and applicable gain is calculated by using Specific Fan Power (SFP). Ventilation rate is determined as m³/hour whereas the chimney has 40m³/hour, for open flues is 20m³/hour, for exhaust fan it is 10m³/hour and flueless gas fire has 40m³/hour.

2.5.3 Heat Transmission

Building area depends upon the buildings internal dimensions with surfaces bounding. The total area of openings refers to doors and windows area with frames. Net roof area was measured after subtracting the area of windows or roof lights placed in the roof. U-values differ according to the characteristics or type of the element which is mentioned as Reference values in SAP 2009 (SAP 2010). The U-value of windows, floors and roofs have 2W/m²K, 0.25W/m²K and 0.16W/m²K respectively where as for external walls and doors it is 0.35W/m²K and 2W/m²K.

<table>
<thead>
<tr>
<th>Construction</th>
<th>Heat Capacity K (kJ/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground floors, Suspended concrete floor</td>
<td>75</td>
</tr>
<tr>
<td>External walls - masonry</td>
<td>17</td>
</tr>
<tr>
<td>Roofs</td>
<td>9</td>
</tr>
</tbody>
</table>

2.5.4 Thermal Bridging

The thermal bridging (Ψ) was taken into account, at junctions amidst around openings and elements. These junctions are useful in attaining the linear thermal transmittance value, which can be multiplied in accordance with length of specific junction and then included in transmission heat transfer coefficient.

2.5.5 Internal Gains

Internal gains were predicted through floor area which depends on the number of contributing factor such as lightening, appliances, cooking and metabolic gains from student of each department. Average annual energy consumption for lighting without the usage of low-energy lighting is: where TFA= Total Floor Area

\[ E_B = 59.73 \times (\text{TFA} \times N)^{0.4714} \]

Permanent lighting outlets with low-energy lamps were used in calculation with correction factor \( C_1 \):

\[ C_1 = 1 - 0.50 \times \frac{L_{LE}}{L} \]

L denotes fixed lighting outlets whereas LLE is fixed low energy outlets.

\[ G_L = \frac{\sum 0.9 \times A_w \times g_L \times FF \times Z_L}{\text{TFA}} \]

<table>
<thead>
<tr>
<th>Type of glazing</th>
<th>Light transmittance (g_L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single glazed</td>
<td>0.90</td>
</tr>
<tr>
<td>Double glazed (air or argon filled)</td>
<td>0.80</td>
</tr>
<tr>
<td>Triple glazed (air or argon filled)</td>
<td>0.70</td>
</tr>
</tbody>
</table>
Table 3: Frame Factors for Windows and Glazed Doors

<table>
<thead>
<tr>
<th>Frame type</th>
<th>Frame factor (FF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>0.7</td>
</tr>
<tr>
<td>Metal</td>
<td>0.8</td>
</tr>
<tr>
<td>PVC</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Table 4: Light Access Factors

<table>
<thead>
<tr>
<th>Overshading</th>
<th>Light access factor ($Z_L$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy</td>
<td>0.5</td>
</tr>
<tr>
<td>More than average</td>
<td>0.67</td>
</tr>
<tr>
<td>Average or unknown</td>
<td>0.83</td>
</tr>
<tr>
<td>Very little</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Kilo watt hour (kWh) is lighting energy utilized per month (Jan = 1 to Dec = 12)

\[
E_{L,m} = E_L \times \left[1 + 0.5 \times \cos \left(2\pi \left(\frac{m - 0.2}{12}\right)\right)\right] \times \frac{n_m}{365}
\]

\[
G_{L,m} = 0.40 \times E_{L,m} \times 0.85 \times 1000 / (24 \times n_m)
\]

Annual energy usage by electrical appliances in kWh is

\[
E_A = 207.8 \times (TFA \times N)^{0.4714}
\]

Kilo watt hour (kWh) is appliances energy usage per month m (Jan = 1 to Dec = 12)

\[
E_{A,m} = E_A \times \left[1 + 0.157 \times \cos \left(2\pi \left(\frac{m - 1.78}{12}\right)\right)\right] \times \frac{n_m}{365}
\]

Internal heat gains from appliance are being calculated through formula:

\[
G_{A,m} = 0.67 \times E_{A,m} \times 1000 / (24 \times n_m)
\]

Lower internal heat gains are calculated by following formula:

\[
G_C = 23 + 5 \times N
\]

Table 5: Internal Heat Gains (in Watts)

<table>
<thead>
<tr>
<th>Source</th>
<th>Typical Gains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metabolic</td>
<td>60 \times N</td>
</tr>
<tr>
<td>Losses</td>
<td>40 \times N</td>
</tr>
<tr>
<td>Pumps and fans</td>
<td>SFP \times 0.12 \times V</td>
</tr>
</tbody>
</table>

2.5.6 Solar gains and utilization factor

Solar gains ought to be calculated for each orientated side separately and for rooflights, and then totaled for use in the calculation. Where $A_w$ is the area of window

\[
Solar \ gain = 0.9 \times A_w \times S \times g^x \times FF \times Z
\]

Table 6: Solar Flux (W/m$^2$)

<table>
<thead>
<tr>
<th>Season</th>
<th>Horizontal</th>
<th>Vertical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>North</td>
</tr>
<tr>
<td>Winter</td>
<td>75</td>
<td>29</td>
</tr>
<tr>
<td>Summer</td>
<td>187</td>
<td>75</td>
</tr>
</tbody>
</table>
Table 7: Solar Energy Transmittance Factor

<table>
<thead>
<tr>
<th>Type of glazing</th>
<th>Solar Energy Transmittance Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single glazed</td>
<td>0.85</td>
</tr>
<tr>
<td>Double glazed (air or argon filled)</td>
<td>0.76</td>
</tr>
<tr>
<td>Triple glazed (air or argon filled)</td>
<td>0.68</td>
</tr>
</tbody>
</table>

Table 8: Solar Access Factor

<table>
<thead>
<tr>
<th>Over-shading</th>
<th>Winter solar access factor</th>
<th>Summer solar access factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>More than average</td>
<td>0.54</td>
<td>0.7</td>
</tr>
<tr>
<td>Average or unknown</td>
<td>0.77</td>
<td>0.9</td>
</tr>
<tr>
<td>Very little</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

2.5.7 Mean Internal Temperature

Requirements for heating or cooling of a department depend on its mean internal temperature. Average temperature of staff room area and rest of the department is separately obtained, afterward; take the mean internal temperature of the whole academic block.

2.5.8 Space Heating Requirements

Internal and external temperatures are used to calculate the necessary energy needed for the system for each month and heat transfer coefficient set aside for solar and internal gains. The cumulative energy for the whole year is named as department’ Space Heating requirement. Considering the efficiency of space heating system, an amount of necessary energy required to provide the fuel or electrical energy is then calculated. TMP = Thermal Mass Parameter, kJ/m²K (Cₘ for building/total floor area)

Utilization Factor for Heating

\[ t = \frac{\text{TMP}}{(3.6 \times \text{HLP})}, \quad a = 1 + \frac{t}{15} \]

\[ L = H (T_i - T_e), \quad \gamma = \frac{G}{L} \]

\[ \eta = \begin{cases} 1 - \frac{\gamma a}{\gamma a + 1} & \text{if } \gamma > 0 \text{ and } \gamma \neq 1 \\ \frac{a}{a+1} & \text{if } \gamma = 1 \\ 1 & \text{if } \gamma \leq 0 \end{cases} \]

\[ T_i = \text{Internal temperature} \]

\[ T_e = \text{External temperature} \]

\[ \text{HLP} = \text{Heat Loss Parameter} \]

\[ \eta = \text{Utilization factor} \]

2.5.9 Climatic Data

Climatic data of Lahore was collected from the metrological department and all calculations were based on this data.

2.5.10 Space Cooling Requirement

The space-cooling requirement was included as space cooling requirement when it has fixed air conditioning system. The cooling requirement was obtained by using formula

\[ \text{Space Cooling Requirement} = \text{Rating} \times \text{Time} \times \text{Days} \]
2.5.11 Fabric Energy Efficiency

Fabric Energy Efficiency is defined as the space heating and cooling requirements per square meter of floor area. All the data items are collected according to the actual condition of the department.

2.5.12 Total Energy Use and Fuel Cost

Electricity cost was calculated by using the electricity tariff of LESCO (Lahore Electric Supply Company). Electricity cost was calculated by using the electricity tariff of LESCO (Lahore Electric Supply Company). Electricity tariff of LESCO have variable charges, up to 50 units they charge 1.79 Rs/kWh, for 1-100 units the value of charges is 4.20 Rs/kWh, 6.34 Rs/kWh for units 101-300 units, for 301-700 units the charges are 10.24 Rs/kWh and above 700 units then 12.77 Rs/kWh variables charges applied. Electricity for lighting, fans and appliances obtained by using this formula

\[ \text{Electricity used} = \text{Rating} \times \text{Time} \times \text{Days} \]

2.5.13 Energy Cost Rating

Standard Assessment Procedure are formulated in such a way that energy cost factor can be attained at zero when SAP is 100 and Energy Cost Deflator = 0.47.

2.5.14 Carbon Dioxide Emissions

Carbon Dioxide (CO₂) emissions attributable to a department are those for space cooling, lighting and mechanical ventilation through fans (SAP, 2010). The Environmental Impact Rating is associated to the yearly Carbon Dioxide emissions by

\[ \text{CF} = \frac{\text{CO}_2 \text{ emissions}}{(\text{TFA} + 45)} \]

- if CF ≥ 28.3 EI rating = 200 – 95 \( \times \) \( \log_{10}(\text{CF}) \)
- if CF < 28.3 EI rating = 100 – 1.34 \( \times \) CF

Total floor area of the department is needed while calculating its CO₂ emission. Environment Impact rating scale is prepared in order to obtain EI 100, when carbon emission is zero.

3. Results and Discussion

The educational institutions consist of large stock of buildings which are using momentous percentage of energy especially for space cooling, lighting and ventilation (Sapril and Muhammad, 2010). Kinnaird College for Women was selected as a case study for the assessment of carbon emission from different departments through the energy consumption. This institution consists of two (2) Academic Block, three (3) Hostels, Auditorium, Amphitheater, Mira Phailbus Center and Canteen. GIS was used for the accurate determination of the departments of KC in figure 1. The examined educational building includes a variety of morphological and architectural characteristics i.e. orientation, ventilation system etc (Mooij, 1985). A good oriented building is with its longitudinal axis east west or with the window-walls facing north and south has traditionally been favored, because it can maximize preheating in winter and reduce summer overheating (Kolokotroni, 1998). The east west longitudinal axis of buildings in KC with windows wall facing north
south has high effective air change rate because the windows remained open though out the summer day. The windows of a building facing wind-blowing direction also have high infiltration rate. During summer season, all buildings required natural and fan assisted ventilation to provide cooling all the day. The height and the position of the windows are helpful in applying natural ventilation during lessons in the classroom hours. The Indoor Air Quality (IAQ) is also maintained during the winter season through windows and ventilators in every buildings of the campus which acts as passive ventilators (Aggerholm, 1997).

![Map showing the location of different Departments of Kinnaird College for Women, Lahore](image)

Figure 1: Map showing the location of different Departments of Kinnaird College for Women, Lahore

Natural and mechanical means of ventilation are mainly used in all classrooms of each university in order to maintain good Indoor Air Quality (IAQ) (Richalet at al., 1994). The South Asian region has extreme climates therefore natural ventilation is always preferred over mechanical ventilation which results in high performance of the students (Seppanen et al., 1999). The Academic Block A & B in KC has east west longitudinal axis with windows of the building prevailing wind direction and have high air change rate in the classrooms. As the windows are in same direction of wind, they have high air change rate because more air will pass through the classrooms and has higher the ventilation rate. The percentage of window to wall area ratio also affect on the ventilation rate (Table 9).

Table 9: Showing Ventilation Rate in different Departments of KC

<table>
<thead>
<tr>
<th>Departments of KC</th>
<th>Passive Vents</th>
<th>Exhaust Fans</th>
<th>% of Winds to Wall Area</th>
<th>Infiltration Rate (ach)</th>
<th>Effective Air Change Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Block A &amp; B</td>
<td>0</td>
<td>222</td>
<td>4.5</td>
<td>0.93</td>
<td>0.99</td>
</tr>
<tr>
<td>Post Graduate Block</td>
<td>31</td>
<td>225</td>
<td>13.5</td>
<td>1.18</td>
<td>1.15</td>
</tr>
<tr>
<td>Hostel A</td>
<td>10</td>
<td>48</td>
<td>4.7</td>
<td>0.85</td>
<td>0.83</td>
</tr>
</tbody>
</table>

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The ventilation heat loss of building is increased significantly when air infiltration rate maximized through door around and window openings. As the number of doors and windows increased, the ventilation heat loss also increased linearly. The ventilation heat loss in all the departments is very low during the working hour of the university because it has high number of students on that time and the ventilation heat loss in all the departments is insufficient to overcome this problem. The Academic Block A and B of KC has high ventilation heat loss because these buildings have high number of doors and window which enhances the ventilation heat loss during summer and avoid overheating as shown in Table 10.

Table 10: Showing the Ventilation Heat Loss in different Departments of KC

<table>
<thead>
<tr>
<th>Departments of KC</th>
<th>Windows Area (m²)</th>
<th>Doors Area (m²)</th>
<th>Roof Area (m²)</th>
<th>Ground Floor Area (m²)</th>
<th>External Wall Area (m²)</th>
<th>Ventilation Heat Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Block A &amp; B</td>
<td>1021.41</td>
<td>1770.33</td>
<td>2770.6</td>
<td>2770.6</td>
<td>23144</td>
<td>8134.204</td>
</tr>
<tr>
<td>Post Graduate Block</td>
<td>2825.99</td>
<td>1132</td>
<td>790</td>
<td>790</td>
<td>2784.3</td>
<td>3086.54</td>
</tr>
<tr>
<td>Hostel A</td>
<td>264.78</td>
<td>216.54</td>
<td>849.8</td>
<td>849.8</td>
<td>964.8</td>
<td>1701.6</td>
</tr>
<tr>
<td>Hostel B</td>
<td>264.78</td>
<td>216.54</td>
<td>849.8</td>
<td>849.8</td>
<td>964.8</td>
<td>1701.6</td>
</tr>
<tr>
<td>Staff House</td>
<td>441.6</td>
<td>123.6</td>
<td>719.6</td>
<td>719.6</td>
<td>512.064</td>
<td>1375.53</td>
</tr>
<tr>
<td>Auditorium</td>
<td>108.81</td>
<td>65.12</td>
<td>457.2</td>
<td>457.2</td>
<td>393.3</td>
<td>676.98</td>
</tr>
<tr>
<td>Amphitheater</td>
<td>298.7</td>
<td>263.4</td>
<td>1340.1</td>
<td>1340.1</td>
<td>216</td>
<td>1518.11</td>
</tr>
<tr>
<td>Mira Phailbus Center</td>
<td>275.6</td>
<td>210.5</td>
<td>1687.2</td>
<td>1687.2</td>
<td>1472.5</td>
<td>4073.37</td>
</tr>
<tr>
<td>Canteen</td>
<td>58.67</td>
<td>34.14</td>
<td>86.6</td>
<td>86.6</td>
<td>202.99</td>
<td>96.1</td>
</tr>
</tbody>
</table>

The internal temperature of staff room and external air temperatures of the department is quite different from each other, because the staff room is air conditioned during the summer and heated during the winter. The external air temperatures of the department are relatively high, exceeding 30°C in summer season. Internal temperatures of the staff room is very stable than that of external temperature of the department. The external temperature of atmosphere is much higher than the internal temperature of the department during summer season. The first floor remains cooler than other floor (second, third or so on). This weather scenario revealed that first floor has high thermal mass integrated with solar protection which ultimately improve indoor environment than other floor areas. The mean internal temperature of staff room and department is approximately range from 21°C to 26°C through-out the year with little fluctuation and all the values are shown in Table 11.

Table 11: Showing the Total Area (m²), No. of Students, Buildings Storey, No. of Sides Sheltered and Mean Internal Temperature (°C) of Departments of KC

<table>
<thead>
<tr>
<th>Departments of KC</th>
<th>Area (m²)</th>
<th>Number of Students</th>
<th>Building Storey</th>
<th>Sides Sheltered</th>
<th>Mean Internal Temperature</th>
</tr>
</thead>
</table>

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Table 12: showing the Internal Gains, Solar Gains, Energy Requirement and Energy Cost of different Departments of KC

<table>
<thead>
<tr>
<th>Departments of KC</th>
<th>Internal Gains (Watts)</th>
<th>Solar Gains (Watts)</th>
<th>Energy Requirement (kWh/Year)</th>
<th>Energy Cost (Rs./Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Block A &amp; B</td>
<td>391780</td>
<td>312199.1</td>
<td>144187.6</td>
<td>1841276</td>
</tr>
<tr>
<td>Post Graduate Block</td>
<td>783727.17</td>
<td>148932.79</td>
<td>249156.45</td>
<td>2576594.4</td>
</tr>
<tr>
<td>Hostel A</td>
<td>63330.83</td>
<td>95241.88</td>
<td>36344.25</td>
<td>464116</td>
</tr>
<tr>
<td>Hostel B</td>
<td>72517.92</td>
<td>95241.88</td>
<td>36344.25</td>
<td>464116.1</td>
</tr>
</tbody>
</table>
The energy requirements of Post Graduate Block of KC is greater than other departments because it has large number of appliances to run and ACs are used for space cooling which increases its electricity consumption during summer season. There is a direct relation between the energy consumption and energy cost. By increasing, energy consumption of Post Graduate Block of KC there is a linear increase between two values (Table 12).

Table 13: Showing the values of Carbon Dioxide Emission, EI Rating and Rating Bands of different departments of KC

<table>
<thead>
<tr>
<th>Departments</th>
<th>SAP Rating</th>
<th>CO₂ Emission (Kg/Year)</th>
<th>Environment Impact Rating</th>
<th>Rating Bands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Block A &amp; B</td>
<td>-330.4</td>
<td>76275.24</td>
<td>86.6</td>
<td>B</td>
</tr>
<tr>
<td>Post Graduate Block</td>
<td>-360.4</td>
<td>131803.76</td>
<td>32.43</td>
<td>F</td>
</tr>
<tr>
<td>Hostel A</td>
<td>-152.3</td>
<td>19226.18</td>
<td>85.24</td>
<td>B</td>
</tr>
<tr>
<td>Hostel B</td>
<td>-280.2</td>
<td>19226.11</td>
<td>85.24</td>
<td>B</td>
</tr>
<tr>
<td>Staff House</td>
<td>-163.8</td>
<td>16390.54</td>
<td>85.21</td>
<td>B</td>
</tr>
<tr>
<td>Auditorium</td>
<td>-50</td>
<td>3836.12</td>
<td>89.6</td>
<td>B</td>
</tr>
<tr>
<td>Amphitheater</td>
<td>-53.4</td>
<td>6998.65</td>
<td>93.17</td>
<td>A</td>
</tr>
<tr>
<td>Mira Phailbus Center</td>
<td>-88.4</td>
<td>22474.97</td>
<td>91.2</td>
<td>A</td>
</tr>
<tr>
<td>Canteen</td>
<td>-195.8</td>
<td>6259.76</td>
<td>41.15</td>
<td>E</td>
</tr>
</tbody>
</table>

Grid stations often supplied electricity for lightening the educational institutions or for other energy uses. Electricity distributed by grid station have high carbon emission factor because power generation plants have lower energy conversion efficiency. As informed by Lahore Electric Supply Company (LESCO) in an interview the major source of electricity generation in most plants in the Pakistan may be either oil or gas. During last century, most of the electric generation plants were coal fired which now substituted with gas and comparatively have lower carbon emissions. As energy consumed by higher educational institutions so SAP was used for the calculation of carbon emission from these buildings. As the carbon depends on the energy requirement so as high as the energy requirement of any department its carbon emission also raise proportionally. The Post Graduate Block of KC (Table 13) has higher carbon emission from other department because it consume more energy for the operation of computers throughout the year which also coupled with AC for space cooling in summer season along with ventilation system.

The Environment Impact Rating is helpful in order to categorize the department based on its carbon emission. EI rating of all departments were calculated in percentage as the percentage increases lower would be its affect on the environment. Carbon emission of any department has a direction relation with the energy consumption. As the energy consumption decreases, its carbon emission will decrease gradually and attaining the higher percentage of EI Rating. The Amphitheater in KC has higher EI Rating than other departments because as compare to covered area they lower energy consumption and have high EI Rating showing in Figure 2.
The SAP calculation is much more conservative and less accurate so it cannot be taken into account for estimation of energy used (i.e. lighting, fans, space cooling and for appliances).

![EI Rating of Departments of KC](image)

**Figure 2:** Graph showing the EI Rating Bands in different Departments of KC

To overcome this problem the hand on calculations are much more specific as they consist of equipment being used within the buildings. It is worthy to mention that numbers of windows, doors, lights and other appliances are counted manually may fluctuate with the passage of time. Therefore, any type of change can occur i.e. removal of appliances, number of tubes lights, fans and AC may vary from the current numbers given in this thesis.

The electricity used in KC divided into four main categories comprises of lighting, fans, space cooling and other appliances. The total use of electricity on lighting, fans, space cooling and other appliances is 119376kWh/year, 159976kWh/year, 64237.3kWh/year and 307758kWh/year respectively. The appliances had 47% energy consumption which is higher than others (Figure 3).

![Electricity use (%) in all Departments of KC](image)

**Figure 3:** Graph showing percentage use of Electricity in different Departments of KC

The carbon footprint of an educational building emitted CO₂ into the environment generally based on the activities requiring for the combustion of the fossil fuels. Two types of carbon emission sources are discussed in this thesis. The first one is the static mode include buildings...
Assessment of carbon rating in Kinnaird College for women Lahore, Pakistan

Ambreen Aslam

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(on campus) and the other one is the mobile source like mean of transportation (off campus) of the faculty members of the university. On campus carbon emission occurred when faculty members and students utilized energy for different purposes and has a significant impact on environment. The off campus carbon emission takes place during their daily commuting to and far from university. Comparison took place between the carbon footprint calculated for the actual means of transportation used and from the buildings of the whole university. On campus, carbon emission is higher than off campus clearly given in Figure 4.

![Graph showing Total percentage values of CO₂ emission from KC (Kg/Year)](image)

**Figure 4:** Graph showing Total percentage values of CO₂ Emission from KC (Buildings & Vehicles)

All means of transportation can cause considerable amount of carbon emissions. The worst transportation means are cars and buses where the gaseous emissions were calculated according to the model, type of fuel and the distance travelled (HEEPI, 2005). Carbon dioxide emission from Buildings of KC has 302,491.33 Kg/year and from vehicles cars, motorbikes and buses (petrol & CNG) is 91,964.8 Kg/year, 28,196.98 Kg/year and 26,827.5 Kg/year & 95,181.1 Kg/year respectively. This calculation helps us in determining the total carbon emission from a university and its impact on the environment during its operation. GIS tool was used for the accurate determination of geographical location and map digitization of both universities. Different themes were illustrating all the departments of each university. Grouping of the buildings belonging followed, resulting in common colored representation, in order to provide the same information.

National Building Codes of the concerned authority was reviewed which revealed that only few things had discussed regarding the academic buildings in ‘Building & Zoning Regulation’. The plot outside the boundary of educational institutions must have a separate lane for pick and drop service for the students and staff members. The floor area for one car space should be 2000 square feet (185.9m²) and 40% space shall be reserved for motorcycle and car parking. Only these things regarding to the academic institutions are discussed in ‘Building and Zoning Regulation’. The ‘Land Use Rules 2009’ of LDA and ‘Building Energy Codes of Pakistan’ (ENERCON) 2009 are also inadequate and insufficient for the estimation of carbon dioxide emission by energy consumption. Therefore, there is a need to formulate a comprehensive Building Codes separately for educational institution that should be followed during planning and construction of a building as it ultimately reduces the energy consumption as well as carbon dioxide emission.
4. Conclusion

This research mainly focuses on energy consumption of educational institutions of Lahore and its results gave a clear indication that each kWh of energy used in building incurs some amount of carbon dioxide in atmosphere. The carbon assessment is a first step towards energy management and quantifiable carbon emission reduction. The energy consumption from each department depends on the number of factors like Ventilation Rate, Ventilation Heat Loss, Internal Gains, Solar Gains and Environment Impact Rating. Based on these factors Environment Impact Rating Bands were assigned according to their specific amount of carbon emission. The carbon dioxide emission increases as energy consumption of each department increases. In addition, university route buses and personal vehicles of staff and faculty were also included as carbon-contributing factor. GIS database was prepared for the assessment of carbon emission from each institution with its graphical representation. It is proposed that a computer based Standard Assessment Procedure (SAP Pak) in Pakistan perspective should be designed for better planning and decision-making in future.

5. Recommendations

There are number of different options for cutting down the present level of carbon dioxide emission from buildings through energy consumption and vehicles through a range of different strategies. These strategies should be aimed at providing sufficient services and make ensure their implementation.

1. The Building Codes and Standard of Pakistan should be reviewed in the reference of educational institutions and incorporated latest technical knowledge available on Building codes worldwide.
2. In modern construction pattern, the building orientation should be in east west longitudinal axis by maximizing windows wall facing north south in order to take optimal advantage of day-lighting, proper ventilation and reducing the cooling cost.
3. The environmental friendly material such as thermocole sheet should be exercised during construction of walls and roofs of buildings as a good insulator it cannot allow heat to pass therefore minimizes the heating/cooling cost. It is environmentally and economically viable.
4. The window glazing is another option which reduces the solar gain. Windows glazing should be tinted as it absorbs much of the solar heat radiation. The green and blue tints are more energy efficient because it reduces heat transfer and allow the visible light.
5. Retrofitting of existing building can be done by using insulation material such as wood and thermocole sheets. In addition to that sheets prepared by recycled tetrapak material may also be used as insulator.
6. The environment friendly technologies (solar energy) should be promoted in order to reduce the raising threat to the environment day by day and it is the responsibility of the government to invest on such technologies for their proper implementation.
7. Transportation, particularly, university owned route buses and faculty mode of daily commute is the most significant source of carbon dioxide emission. The university route buses must have less carbon emission as compare to the faculty and staff members’ personal vehicle that is economically and environmentally feasible.
8. Car sharing and use of public transport is another best alternative in order to reduce carbon emission from faculty member’s personal fleets.
9. The Compressed Natural Gas (CNG), Liquefied Petroleum Gas (LPG) and bio-fuel should be used instead of petrol and diesel because they emit lesser carbon content than fossil fuels and fuel efficiency can be improved through vehicle maintenance.

6. References


8. IEA. (2009), CO2 emissions from fuel combustion highlights. IEA statistics.


