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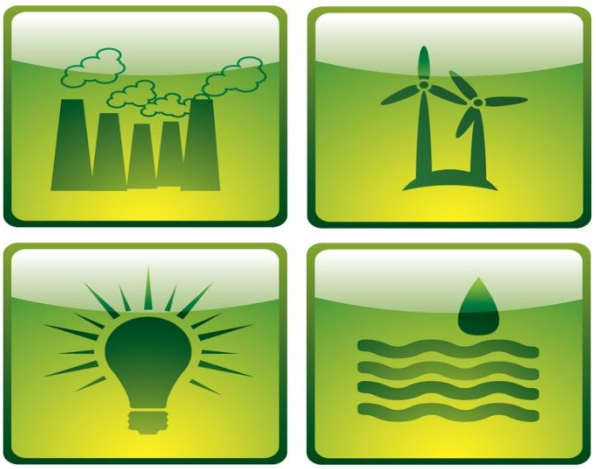

Energy Use and Carbon Footprint at The Darnall Forum and Post Office

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1.Introduction

It has been estimated that 48% of all greenhouse gas emissions, can be generated from buildings [1]. CO_2 arising from energy use in buildings associated with human activity such as, changing window opening and lighting usage, is one source of the problem [2].The spread of small pollution sources in, for example, a postal business, can generate a certain amount of pollution. Certainly, CO_2 arising from such sources should be taken into an account.

There are roughly 12,000 post offices in The UK.[3]. Some of them may lack awareness about possible energy savings and environmental concerns. As a result of that, to clarify systematic study at the Darnall Forum and Post Office in proposed. The aim of this mini project is to investigate systematically whether there is any possibility of energy saving in the operation of the Darnall Forum and Post Office. In addition, a CO_2 footprint calculation will be carried out.

2. Methodology

There are four parts to the methodology which were in this investigation as shown in figure 1.

1.Energy consumption and CO_2 emissions :This scheme will be based on the calculation tool Design Builder SBEM v 2.2 using the calculation engine SBEM v 3.5.a.0. The study has been conducted by the Building Environments Analysis Unit (BEAU), The University of Sheffield.

2. Rate of heat conduction on: this can be carried out with following The Fourier's Law equation.

3. The CO_2 footprint was calculated using LCA (Life Cycle Analysis), ISO 14064-1: 2006 (E) part 1 only CO_2 Inventory and,

4. In-depth interviews with employees, together with environmental investigation. It will assisted be by Environmental Meter model N09AQ.

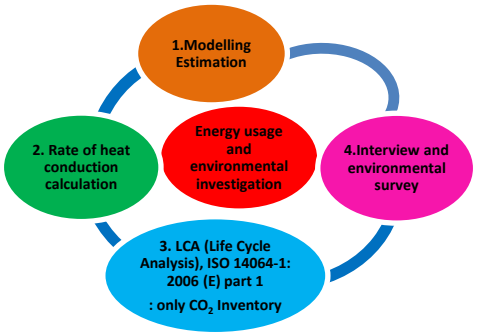

Figure 1 The systematic study at The Darnall Forum and Post Office

2.1 Energy consumption and CO_2 emissions

A building comprises both energy system and environment. Design features such as building type, dimensions (small, medium and large sizes) and location, must also be taken into account. Since these can affect energy usage, heat transfer and CO_2 emissions [4].

Therefore, this study was a survey of the special areas and surface features (i.e., area, rooms, windows, doors, and so forth) using a measuring equipment. The study collected data from electricity and gas bills in order to determine costs. In addition, the site was surveyed to assess systems related to heating, ventilation, the boiler system and all electrical equipment. The data were processed and modelled using a software programme at The Building Environments Analysis Unit (BEAU), The University of Sheffield [5].

2.2 Rate of heat conduction

A major problem, heat loss from the doors of office is considered. Therefore, this project will focus on the rate of heat conduction. Basically, heat transfer is directly related to various factors, for example: the type of system (closed/opened), area size, and the ventilation system.

According to Fourier's Law, when heat flows through a door surface, as appears in Figure 2, a higher heat decreases to a lower heat. Thus, the rate of heat conduction (q_k) depends on the area (A); differences in temperature (ΔT, °K /°C), and the distance (metre) of the heat flow (x), which is expressed as Equation 1.

The actual rate of heat flow, however, hinges on thermal conductivity (k) with units of watts per meter kelvin (W/mK). The thermal resistance (L/Ak), is namely R_k. Substituting Equation 2 into Equation 1, gives the relationship in Equation 3[6]. Temperature is taker into account and analysed by this concept.

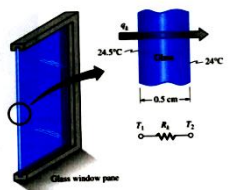

Figure 2 Heat of conduction at the door

$$q_k \propto \frac{AdT}{dx} \quad \text{----------1}$$

$$R_k = \frac{L}{Ak} \quad \text{----------2}$$

$$q_k = \frac{Ak(T\,hot - T\,cold)}{L} = \frac{\Delta T}{L/Ak} \quad \text{----------3}$$

2.3 CO_2 footprint

In regard to CO_2 footprint, there are a number of organization guidelines [7], such as the Carbon Trust [8], POST [9], ISO [10], IPCC 2006, PAS-2050 [11], WWF [12], and US.EPA (US Environmental Protection Agency). However, LCA has been used to assess CO_2 emissions and is widely accepted by the international

community. This methodology could be used to support and enhance strategic decision-making processes [13]. The LCA analysis included: 1.Top-down or environmental input –output (EIO), 2. Bottom up or Process Analysis (PA), and 3. Hybrid –EIO-LCA (Environmental Input-Output) [14]. The ISO -14064 (2006) guidance consists of three main components; 1: Specifications with GHG guidance and inventory design, 2: Identification of the project level for monitoring and reporting data, and 3: Validation and verification of GHG assertions.

A conceptual model of GHG emissions (ISO 14064) involves three types of sources: 1) direct emission 2) indirect emission, and 3) all other outsource distributions. There are examples of CO_2 footprint projects in electricity [7], schools [15], food [16] and Banks [17]. In addition, the amount of CO_2 can be related to the atmospheric condition of, for example, temperature (T) and RH (relative Humidity) [18].

This study used LCA analysis only for CO_2 part inventory by following the ISO 14064-1:2006 (E). Emission source was integrated and analysed by equation 4.The forum activities and postal business cycle involve into six main sources of area of activities and energy usage. These include; 1. employees travel, 2. paper use, 3. Electricity, 4. gas use, 5.postal delivery and 6.Transportation. (see Figure 3)

Figure 3 Postal cycle business

Total carbon dioxide = $\sum_i^n Ci$ or Total carbon dioxide = the amount of carbon that occurs (tonne/year) …….4

when C_i = carbon per each of activities, n = amount of activities

2.4 Interviews and Environmental circumstances

In the study, human behaviour influence on energy consumption is considered [1]. Thus, this study will conduct the in-depth interviewing of employees and observation energy usage at site. The specific questions will enquire for example 1. How employees could enhance energy conservation in the workplace, 2. How CO_2 might affect their health, and 3. How to effectively reduce CO_2 emissions. Moreover, the environmental criteria will inspect by using the environmental survey meter for example, RH and noise level.

3. Data Collection, Validation and Verification

The Data will be collected by an energy and environmental audit sheet. The conversion factors will be used from the government or credible organisations. It will use the most current data available. The CO_2 footprint results will be compared with the modelling estimation and SLS consulting, Inc. work. The study will verify, conclude and then provide recommendations for the Darnall Forum and Post Office.

4. Results

The results of the study are divided into four sections as follows:

4.1 Energy consumption and CO_2 emissions

There are 3 parts of this survey. The first part obtained general information such as floor area, heating and gas system, energy consumption and emissions rate (see Table 1). The second part was the recommendations and payback for the Darnall Forum and Post Office. The third part presented energy efficiency and bill& energy reduction by selected recommendation. The recommendations were consisted in 3 groups; short term (see Table 2), medium term and long term. These are provided to the Darnall office where the office can select either pay back or other possibilities.

Table 1. General information regarding the building

Total Useful Floor Area (m²)	208
Building Environment	Heating and Natural Ventilation
Main heating fuel	Natural Gas
Energy Consumption (kWh/year)	Gas : 34,643
	Electricity : 11,825
Building emission rate (kg CO_2/m²)	145.53

Table 2 Recommendation with a short payback

Recommendation	Potential CO_2 impact	Payback (years)
Consider replacing T8 lamps with retrofit T5	High	1
Some spaces have a significant risk of overheating. Consider solar control measures such as the application of reflective coating or shading devices to windows.	Medium	1.7
Introduce HF (high frequency) ballasts for fluorescent tubes: Reduced number of fittings required.	Low	2.1

4.2 Rate of heat conduction

As mentioned above. The site survey at the main entrance door appeared that the rate of heat conduction was approximately 183 W(watt). For the post office door, it found around 69 W. The heat loss at the main entrance door is higher than the post office. The cause of differences may possible be originated from the different of raw material, thickness and inefficiency of the ceiling system.

4.3 CO_2 Footprint

The CO_2 footprint was calculated from LCA analysis in 6 categories. The total emissions are approximately 30.20 tonnes per year (see Table 3 and Figure 4). The main source generated pollution from the postal delivery around 7.22 tonnes per year. The other sources are i.e. gas and electricity. The amount of CO_2 emissions are 7.14 tonnes per year and 6.75 tonnes per year respectively.

Table 3 Summary of CO_2 emissions at The Darnall Forum and Post office

Activity	Emissions (tonne /year)	% CO_2
1.employees travel	5.52	18.28
2.paper use	0.19	0.63
3.electric use	6.75	22.35
4.gas use	7.14	23.64
5.postal delivery	7.22	23.91
6.post transportation	3.38	11.19
Total	**30.20**	

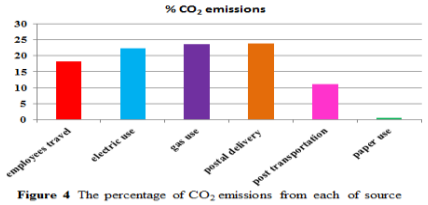

Figure 4 The percentage of CO_2 emissions from each of source

Comparatively, the result found that total energy consumption from modelling was around 11,825 kWh, however, LCA analysis founded approximately 11,844 kWh. CO_2 emissions from LCA were 30.20 tonne/year. It differs from the modelling (30.27 tonnes of all area) around 0.07 tonnes (or 2.12 % of the total CO_2

emissions of modelling). This dissimilarity may be derived from a different methodology. The modelling analysed CO_2 emissions through automatic running. The unit express in term of weight of CO_2 per area (tonne/m^2). Controversially, this study explored the results based on manual calculations by integration of individual activity. The unit is total weight per year (tonne/year). Uncertainty about conversion factors could also have affected this.

The study differs considerably from the SLS Consulting, Inc. work. The report of SLS Consulting Inc.(2008) mentioned that emission of CO_2 gas equivalent from the US postal system in 2006, was approximately 33,280,344 metric tonnes (MT). The study estimated by using the LCI modelling (Life Cycle Inventory) [19]. It was also found that the yield of CO_2 from the waste (postal paper) 1 tonne of the SLS Consultant is roughly 0.50 tonne, whilst, this study's was 0.96 tonne. Unlikely value is probable due to raw material, discarding and so forth. Because, the consultant focused on waste such as paper, board manufacturing and mail production. Some of them dispose by landfill or solid waste stream. However, this study was assessed by using the conversion factors of Department for Environment, Food, and Rural Affairs (DEFRA). It concentrated on paper and disposal by landfill.

4.4 Interviews and environmental circumstances

The result of interviews based on an employee survey. The study was completed by 90% of all employees (9 people from 10 people). The result showed that everybody concerned about energy reduction in the office. Moreover, the employees mentioned that switching off all electrical equipment (such as lights, computers, kettles and boiler) after usage will assist to save energy. In addition, reduction of car use will also improve the environment. Nevertheless, it was observed that, there was sometimes a light switched on the toilet and kitchen.

For environmental issues, the survey showed that 56 % of employee accepted that CO_2 had an effect on their health. 44% of employee thought the reverse. For CO_2 reduction, 46% of all opinions indicated that they had not considered about this topic. The remaining 54% comprehended the problem of CO_2 emissions and suggested that they will reduce CO_2 emissions by stopping deforestation and changing theirs behaviour to use less fuel.

For environmental monitoring was inspected by environmental meter model N09AQ. It found that the temperature is approximately 20.5 – 22.8 °C, even as RH (%) is approximately 30.0 - 41.7%. The noise level is around 26.4-67.3 dB.

5. Conclusions and Recommendations

This systematic study was involved 4 schemes such as: 1.energy consumption and CO_2 emissions from buildings; 2.rate of heat conduction; 3.CO_2 footprint; and 4. Interviews and environmental survey. The results showed that energy consumption was around 11,844 kWh/year. The rate of thermal conduction at the main entrance door was around 183 W., whilst, that though, the post office door was estimated to 69 W. The total CO_2 footprint was approximately 30.20 tonnes per year. The employees agree to reduce energy use in the office. However, they should be encouraged to comprehend energy and environmental study.

In conclusion, the main sources of energy loss, possibly are derived from material, thickness and inefficiency of the sealed door associated with employee behaviour. Thus, the solution of the problem should be focused on;

1) Improving the heat insulation and increasing sealed system.

2) Reduction of energy consumption. Basically, there are a lot of methods to save energy such as using efficiency lamp, thermostat to switch off heaters, automatic switch off, energy conservation technology and so forth.

3)To promote energy efficiency, the office should set up an energy and environmental monitoring system. Inspecting electricity and gas bills should be established, a monitor of energy use.

4) Establish a CO_2 capture/offset project in the work place.

5) Enhance employee performance. To build up their awareness; it is important to train employees in how to encourage energy efficiency in practice and how to reduce GHG and CO_2 emission.

Please note that the details of recommendations will be provided to The Darnell Forum and Post Office.

6. Further Works

The mini project is not a complete work of analysis, because it had a limited time. In addition, it lacked information such as CO_2 data from car exhaust pipes. Some data had to be estimated from secondary sources, for example conversion factors. The assumption of appropriated conversion factor might not be suitable for example; CO_2 from postal package and virgin paper from landfill are given the same values. However, type of paper and disposal affect to the emission values. Moreover, it lacks information in the social study section and so forth.

Thus, it will be useful information, if there were study about: 1.How energy savings relate to background knowledge, awareness and behaviour of employees in the office; 2. How to enhance a performance and capacity building of employee to use energy efficiency and to increase environmental education; 3. How to balance energy use and reduce CO_2 emissions in best practices.

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