Estimation of the Carbon Footprint of Student Halls of Residence in the University of Strathclyde

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Abstract: There is a rapid increase in environmental awareness, which has led to legislative and governmental policy developments addressing the reduction in carbon emissions to the atmosphere. As an example of a local level response, the University of Strathclyde has developed its Environmental Management System. This paper presents the detailed estimation of the carbon footprint of one of the University halls of residence that will assist the University in assessing its environmental impact. The procedure adopted, and the sensitivity studies undertaken, will help to inform the extension of the carbon footprint study to the whole university campus.

Key-Words: Carbon footprint, carbon emissions

1 Introduction

There have been many policy developments concerned with reducing carbon emissions following adoption of the Kyoto Protocol (e.g. the UK's Energy White Paper [1]). The building sector is a major contributor to carbon emissions, and the Higher Education sector is a significant part of it. The potential for energy savings resulting from this sector is estimated to reach over 20%, which can be expressed as 3.3 million tonnes of CO_2 reduction on an annual basis [2]. The Carbon Trust, established by the UK Department of Trade and Industry (DTI), has developed a carbon management action plan, the Higher Education Carbon Management Programme (HECMP), for organisations to create a low carbon profile. Part of this programme includes a toolkit that was developed for carbon footprint estimation. The carbon footprint analysis provides an overview of all the sources of CO_2 associated with a building without focusing solely on one particular aspect such as the energy used for heating and cooling.

The aim of study reported here was to use the HECMP toolkit for the carbon footprint evaluation of the chosen site, in order to identify the data input requirements for the software and to provide suggestions for its further effective use across the various buildings of the University of Strathclyde campus. This would help to ensure that the implementation of the University's Energy Management System (EMS) would comply with the new legislation and standards. The EMS implementation initially considers the identification of the sources contributing to the carbon release, followed by their assessment in terms of their carbon footprint and finally their management. The study was concerned with developing the procedures for undertaking a carbon footprint analysis within the University. The Higher Education sector is important, both in terms of its energy use, and in its role in educating future citizens. Many Universities have published detailed energy and environmental policies, for example [3,4,5,6].

2 Background

2.1 Carbon Footprint Definition

At the start of the study, it was necessary to define the exact meaning of a "carbon footprint". Although it is a commonly used expression, few clear definitions were found. The World Resources Institute describes it as "a representation of the effect you, or your organisation, have on the climate in terms of the total amount of greenhouse gases produced (measured in units of carbon dioxide)" [7]. A more extended explanation was attempted, providing a better understanding.

The carbon footprint of a building can be defined as the amount of CO_2 emitted into the environment. The following factors should be included in the analysis:

- all the energy requirements of the building e.g. for lighting, hot water, heating, ventilation, cooking and IT equipment;
- the daily commuting of building occupants;
- other travel undertaken by building occupants;
- suppliers' and contractors' transport e.g. transport of goods (consumables and non-consumables) and waste;
- landfilled waste, including the percentage of recycled materials.

Note that emissions associated with construction and demolition phases would normally be included in a life cycle analysis but are not included in the determination of the carbon footprint.

In some cases, the CO_2 emissions may be offset, for example by tree planting, and this should also be taken into account. The overall carbon footprint is a quantification of the net CO_2 emitted by a building which is the metric widely used to assess the contribution to global warming and climate change.

2.2 HECMP Toolkit Description

The software comprises three working sheets. In addition to these three sheets covering the emissions resulting from activities within the building as well the transport and commuting of the people using this building, the programme provides a summary sheet. The software requires annually grouped data inputs. The building sheet converts the different fuel units used in the building's energy supply into kWh. The transport sheet defines two transportation groups: business and fleet. The conversion assistant in this sheet allows the calculation of the total distance from the money spent on fuel. The commuting sheet considers more than one means of travel for a one-way commute and has as default the assumption of a 5-day 45-week commute (although this default can be customised).

In Section 3 of this paper, the graphs illustrating annual consumption, emissions and cost on an annual basis represent academic years (e.g. 2004 represents the academic year October 2003 – September 2004).

3 Carbon Footprint Estimation

The selected site is the James Goold Hall of residence (Block A). Full-time postgraduate students having a contract of 50 weeks occupy this building and it was considered feasible to obtain the transportation and commuting information of the residents. The building floor area is 1981 m^2.

The data collection was conducted partly through a questionnaire and partly from data on the University buildings and their gas and electricity consumption held by the Estates Management Department of the University. Additionally, some data, such as the fuel CO_2 factor, the typical cost per kWh, the good practice benchmark figures in kWh/m^2, the CO_2 factors for different transport types in $kgCO_2/km$ and the associated transport cost per km was provided by the software itself. The questionnaire was completed during interviews with the occupants. At the end of the survey, 55 out of 81 questionnaires were collected from the James Goold Hall, Block A. This was considered representative, and total figures were scaled from the acquired data. The questionnaire was tailored to gather information about the occupants' transport over the academic year 2004 – 2005.

With regard to power and heating requirements of the building, a comparison was made between the building's consumption, and good and typical practice benchmark values for electricity and gas consumption. The values considered as typical and good practice benchmarks for the electricity consumption were 54 and 45 kWh/m^2 respectively while for gas consumption the corresponding values were 240 and 200 kWh/m^2 [2]. The results are illustrated in Fig. 1. The red bars show values above typical practice, while the yellow ones show values above good practice. The building consumption showed a fluctuation with time, even though the data are normalised for climate severity using 20-year average degree-days for the West of Scotland. The actual energy costs and associated emissions, presented in £ and tCO_2, are shown in Fig. 2 and Fig. 3 respectively. These figures also show the potential savings that could be made if the building conformed to the good practice benchmarks – these would of course be greater if the building was further improved to best practice.

Contributions to the carbon footprint of the James Goold Hall for the academic year 2004 - 2005, shown in Fig. 4, were 42% from the emissions resulting from the energy use in the building and 58% from the transportation emissions (while the commuting emissions were found to be negligible). These percentages correspond to 144 and 199 tonnes of CO_2 respectively.

The carbon footprints for the other halls of residence were estimated by using some of the findings from the James Goold study, in particular using assumptions regarding the transportation and commuting [8]. Similar levels of potential energy, cost and CO_2 emission savings were found for the other halls of residence.

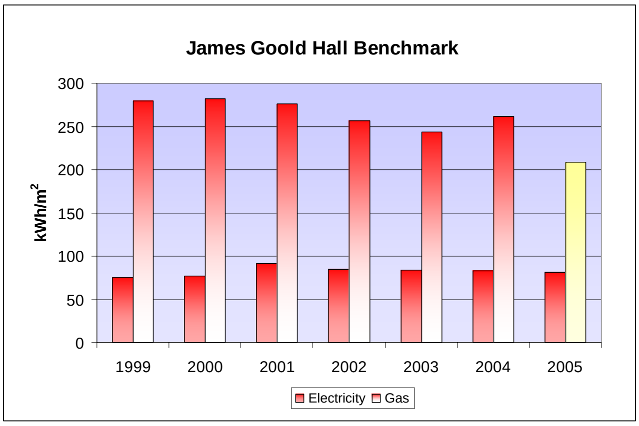

Fig. 1 Electricity and gas consumption benchmarks.

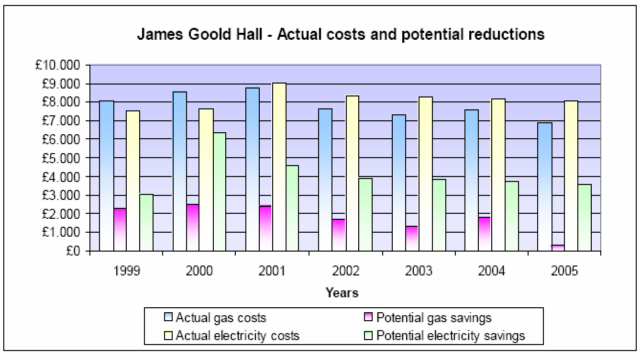

Fig. 2 Actual and potential energy savings in £.

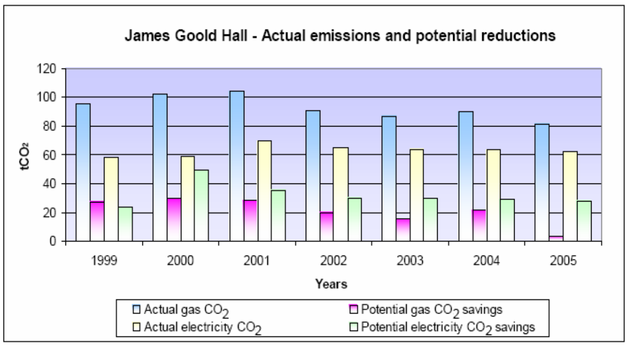

Fig. 3 Actual and potential energy savings in tCO_2.

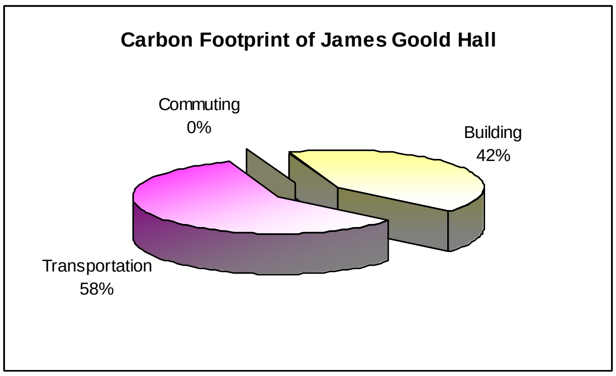

Fig. 4 Carbon footprint summary for James Goold Hall.

4 Sensitivity Analysis

Sensitivity analyses were undertaken, particularly of transport-related inputs, in order to determine the most important factors influencing the carbon footprint. This analysis is necessary to avoid unnecessary time and effort required to obtain data that do not have a significant impact on the overall assessment. One analysis undertaken focused on national (inside UK) trips made by building occupants. The reason for this was to determine the importance of this factor, as it is time consuming to acquire and analyse the data. Also, national trips are much more frequent than international ones, which are usually undertaken by plane and can rarely be replaced with another means of transportation. However, it is worth noting that the Intergovernmental Panel on Climate Change (IPCC) has estimated that the air transportation contribution is around 3.5% of the total human activities emissions and is forecast to rise up to 15% by 2050 [9]. Other studies have included sensitivity studies on car emissions related to the current and future market penetration and fuel consumption of diesel cars [10].

From the parameters studied, it was found that if buses or trains replaced the actual means of transportation used for all the national trips, there would be a 27% reduction in CO_2 emissions and 33% cost savings associated with these national trips. However, the overall carbon footprint would remain almost the same. This is caused by the fact that national trips comprise only 8% of the 58% representing the transportation emissions. Fig. 5 shows the associated reductions in cost and CO_2 related to the national trips. Future work might consider a further sensitivity analysis of the international trips, as they are responsible for a high percentage of the overall transportation emissions, at least in the halls of residence occupied by postgraduate students. As a general conclusion from this study, the level of detail for the national trips should not be considered high and as a result any mistakes occurring during the acquisition of these data will not highly affect the outcome.

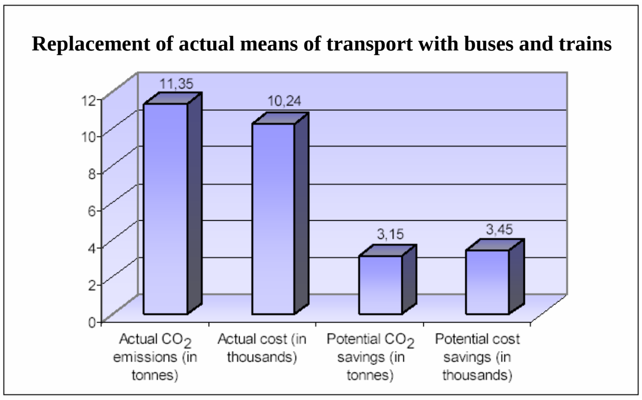

Fig. 5 Actual and potential savings in £ and tCO_2 associated with national trips.

The data availability and gathering (step 3) is described in Section 3 of this paper. Their quality was assessed and any unrealistic observations were normalised. Where there were obvious errors due to incorrect or missing meter readings, relative monthly energy consumption figures from previous and subsequent years were used to estimate the correct figure for these periods, after correction for climate severity.

The flow diagram shown in Fig. 6 is a simple high-level overview of the process, and more detailed flow diagrams were used to deal with the detail of the data acquisition etc.

5 Carbon Footprint Flow Chart

It is important to analyse the carbon footprint in a systematic way. After selecting the building to be surveyed, the parameters affecting the carbon footprint can be identified. Availability of the data plays an important role while their quality reflects the accuracy of the result, but it must be recognised that the level of required input data must be kept at a practical level.

Fig. 6 shows the process adopted for the carbon footprint estimation, generalised to be applicable to many types of buildings. However, in the case of the University of Strathclyde, it was found that the choice of buildings that could be used for the study was constrained, particularly by the need to acquire transport-related inputs during the summer months when this study was undertaken when many staff and students are on holiday. The James Goold Hall of residence (Block A) was selected as this was occupied during the summer months.

The second step on the diagram requires the set of the parameters affecting the carbon footprint. Table 1 gives the description of the factors being assessed as far as this building type is concerned.

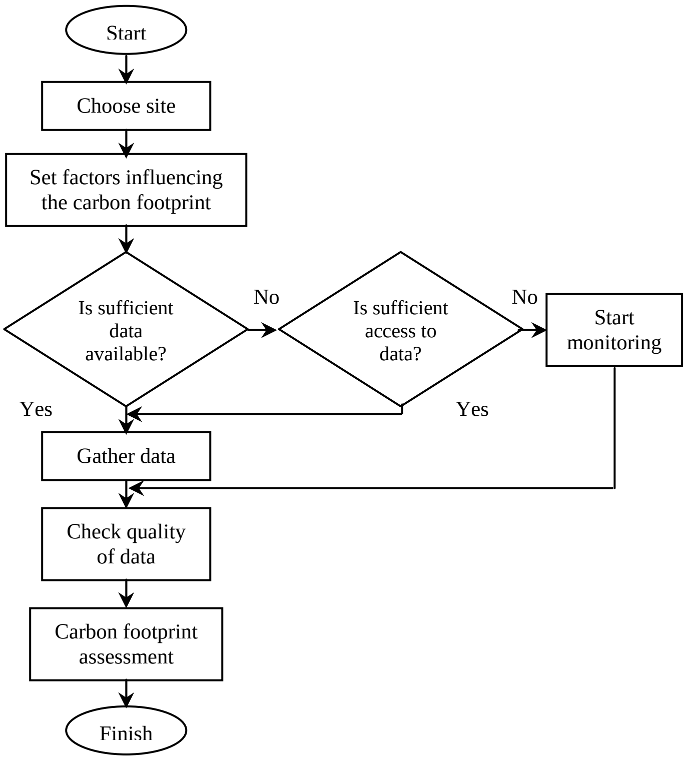

Fig. 6 Carbon footprint flow chart.

Table 1 Factors for evaluation related to carbon footprint.

Factors	Level of analysis
Energy	Emissions from energy consumption
Transport	Emissions from students' commuting Emissions from students' educational journeys Emissions from students' transportation Emissions from suppliers and contractors
Waste	Emissions from landfilled waste Emissions from waste transportation
Plantation	Offsetting CO_2 emissions

6 Conclusions

The establishment of a carbon footprint is of great importance to the management not only of the environmental pollution itself but also of the cost that may result from excessive pollutant emissions. This is likely to become a more significant factor when emission trading schemes become more firmly established. The overall evaluation of all the University buildings' carbon footprints will further assist the Estate Managers to identify and evaluate the critical factors for each building, and to help in setting priorities for carbon reduction. The monitoring of these factors on an annual basis will show whether their significance has changed. The results of the whole project should be delivered to all staff and students with feasible recommendations. The interest of the residents was obvious when the survey was conducted. Additionally, the increase of awareness of the prospective students is an important factor. It is recommended that questionnaires such as the ones used for the purpose of this study are included in the students' welcome pack and the responses submitted to the office responsible for the various halls of residence. These can provide significant information to the Estate Managers and help improve awareness.

At present, the HECMP software does not consider waste transportation and the amount of materials landfilled and recycled. However, an approximate estimation of the waste transportation was conducted and showed that CO_2 emissions in the order of 0.29 tonnes are generated annually associated with activities in James Goold Hall, leading to the conclusion that the waste transportation emissions are insignificant and can be ignored, at least in this case. The percentage for the recycled materials could not be assessed, as there are no available bins for each individual building. As a consequence, an accurate waste decomposition analysis was not feasible.

The contribution per student to the James Goold Hall carbon footprint has been estimated to be 4.24 tonnes of CO_2 during the academic year 2004 – 2005. This can be considered as a small amount. However, a small reduction in per capita emissions can result in a large contribution on the overall carbon footprint. This can be achieved through either a checklist on each room door reminding the students to turn the heating and lights off while they are away or via a responsible person informed by students for their expected days of absence (preferably for periods of over one week) from the hall of residence so that the isolation of the room from electricity and gas is possible.

Alternatively, a central Building Management System (BMS) providing monitoring on a daily basis could help the Energy Managers to detect abnormal energy use and allow early intervention. However, the investment in a BMS can be costly, and further work in the form of a detailed feasibility study is needed to accurately quantify the savings for the calculation of payback period for such an installation. Investment in the BMS may be further justified through the reduction in gas and electricity bills that should ensue from the increase in control of heating and lighting systems.

Future work can comprise a full feasibility study for the implementation of an integrated BMS that is critical to the carbon footprint reduction, as the sensitivity analysis indicated that changes in student transportation (national trips) and commuting did not affect the carbon footprint to a large degree.

References

[1] Department of Trade and Industry (DTI), Energy White Paper, Our future - creating a low carbon economy, The UK Stationery Office, 2003.

[2] The Carbon Trust, HECMP Toolkit, The Carbon Trust, 2005.

[3] University of Leicester, Energy Policy & Support Documents, 2006, available at http://www.le.ac.uk/ua/eb/energy/Policies.html.

[4] University of Cambridge, Estate Management and Building Service, 2006, available at http://www.admin.cam.ac.uk/offices/environment/guidance/.

[5] University of Oxford, Statement of Environmental Policy, 2005, available at http://www.admin.ox.ac.uk/estates/environment/statemento.shtml.

[6] University of Sheffield, Sustainability, 2006, available at http://students.shu.ac.uk/sustain/index.html.

[7] World Resources Institute (WRI), SafeClimate, http://www.safeclimate.net/calculator/, viewed in July 2006.

[8] Bezyrtzi G., Carbon Footprint of the University of Strathclyde, MSc Thesis, University of Strathclyde, 2005, available at ftp://ftp.strath.ac.uk/Esru_public/documents/MSc_2005/bezyrtzi.pdf.

[9] Intergovernmental Panel on Climate Change (IPCC) Special Report, Aviation and the Global Atmosphere, 1999.

[10] Zervas E., CO_2 benefit from the increasing percentage of diesel passenger cars: case of Ireland, Energy Policy, Vol. 34, No. 17, 2006, pp. 2848-2857.