J. Appl. Environ. Biol. Sci., 3(4)8-13, 2013
ISSN: 2090-4215
Journal of Applied Environmental and Biological Sciences
www.textroad.com

Calculating the Cost of Co2e Emitted to Generate the Required Electricity: Case Study of Lecture Rooms in the Faculty of Engineering- Universiti Putra Malaysia

M. Sadegh Shahmohammadi*, A. Noori Houshyar, Rosnah M.Y

Department of Mechanical and Manufacturing Engineering, Universiti Putra Malaysia, Selangor, Malaysia

ABSTRACT

Malaysia is endowed with abundant supplies of non-renewable energy resources, especially oil and gas. However, its current oil and gas reserves are expected to be depleted within the next few years. As of 1 January 2007, PETRONAS (Malaysia's national oil company) reported that oil and gas reserves in Malaysia amounted to 20.18 billion barrels equivalent. The government estimates that at the current production rates, Malaysia will be able to produce oil up to 18 years and gas for 35 years. Thus, if new oil fields are not found, Malaysia will have its oil depleted around 2030.Malaysia has actively participated and involved in key conventions regarding environment and sustainable development, such as Montreal Protocol and Kyoto Protocol. University Putra Malaysia (UPM) as one of the largest universities in Malaysia should try to make its energy consumption as efficient as possible and Faculty of Engineering may be the pioneer in this regard. As the result of this study we can see that only for generating the required electricity for the eight lecture rooms at faculty of engineering about RM 45 per day is the cost of Co2e emissions. In this study authors will calculate the cost of Co2e Emitted to Generate the Required Electricity for the Lecture Rooms in the Faculty of Engineering of Universiti Putra Malaysia.

KEY WORDS: Energy Saving, Energy Efficiency, Green House Gas Emissions, Energy Audit

1. INTRODUCTION

Energy crisis and global warming are two main topics that have attracted several researchers in recent years. As the total amount of fossil fuels in the world is decreasing and the problems caused by global warming are increasing, the importance of renewable energy sources has remarkably raised and developed new concepts like *green energy*, *green economy*, *green industry* etc.

Issues regarding Greenhouse Gas (GHG) emissions and improper wastes management which threatens biological diversity and climate change have always been linked to energy related developments such as generation, distribution and management of energy resources. Climate change refers to a secular trend that produces a long term significant change in the average climatic conditions(Owusu-Sekyere J.D. et.al, 2011).Malaysia has actively participated and involved in key conventions regarding environment and sustainable development, such as convention on biological diversity, Basel convention on the control of trans-boundary movements of hazardous wastes and their disposal, Montreal Protocol on substances that deplete the ozone layer and Kyoto Protocol to the United Nations Framework Convention on Climate Change, to name a few. Montreal Protocol and Kyoto Protocol are two key involvements.

Malaysia's development is tied to three key national policy frameworks: New Economic Policy (NEP), 1971–1990; National Development Policy (NDP), 1991–2000; and National Vision Policy (NVP), 2001–2010. The framework for providing energy development is mainly tied to National Energy Policy 1979, National Depletion Policy 1980 and Fuel Diversification Policy (Four Fuel Diversification Policy 1981 and Renewable Energy as the Fifth Fuel Policy 2000). The Four Fuel Diversification Policy 1981, identified the country's energy mix as oil, natural gas, coal and hydro power. Due to increasing oil price and environmental degradation, in 2001, the government of Malaysia introduced the Fifth Fuel Policy, adding renewable resources into the energy mix with important concerns placed on sustainability and efficiency (Hashim H., Ho W, 2011). Decisions which are based on Sustainability will help future generation in reaching to a well environment and success economic.(Nazarpour M, Sadighi M, 2011).

Since then, the government of Malaysia started placing emphasis on energy efficiency (EE) in industrial and commercial sectors as well as residential in domestic sectors, the utilization of renewable energy (RE) by promoting new RE resources such as biofuel, landfill gas, mini-hydro, solar, etc. and sustainable development of all energy resources (Chua S, Oh T, 2010 and Shafie S et.al., 2011).

Five key programmes implemented in energy development towards EE and the promotion of utilization of RE are as followings (Chua S, Oh T, 2010):

***Corresponding Author**: M. Sadegh Shahmohammadi, Department of Mechanical and Manufacturing Engineering, Universiti Putra Malaysia, Selangor, Malaysia. Email: Sadegh_shahmohammadi@yahoo.com

- Malaysian Industrial Energy Efficiency Improvement Project (MIEEIP)
- Small Renewable Energy Power Programme (SREPP)
- Malaysia Building Integrated Photovoltaic Technology Application (MBIPV) Project
- Building Energy Efficiency Programme (BEEP)
- Green Building Index (GBI)

Energy Audit is a way to recognize the energy problems and helps organizations to make their buildings energy efficient. Energy audit can be carried out in different ways and with different goals. It can be done to reduce the electricity bill, or to reduce the GHG emissions. The goal of this study is to estimate the Cost of Co2e Emitted to Generate the Required Electricity for the Lecture Rooms in the Faculty of Engineering of Universiti Putra Malaysia. Many efforts have been done to calculate the carbon footprint of different places such as the work by Ozawa-Meida L, et.al. (Ozawa-Meida L, et.al., 2011) and Master thesis of Yi J.L.J (Yi J.L.J, 2012) but the novelty and scientific contribution of this paper is to calculate the CO2e.emitted to generate the electricity used in Faculty of Engineering lecture rooms for both essential electricity and misused electricity and to calculate the cost of emissions as well.

The remainder of the paper was organized is follows: in Section 2, the applied methodology is described, section 3 is devoted to calculations and results and section for will describe the conclusions.

2. METHODOLOGY

Emissions from the use of electrical equipment or appliances are calculated directly from the grid electricity emission factor and the total kWh annual electricity use.

Generally the steps for calculating carbon dioxide equivalent (CO2e) are shown as below:-

- Step 1: determine activity/consumption data in each sector (kWh used, km travelled and cost spent).
- Step 2: derive associated GHG emission factors (kg CO2e/kWh used, kg CO2e/km travelled or kg CO2e/passenger kilometer and kg CO2e/cost spent). (L. Ozawa, 2011)
- Step 3: multiply activity/consumption data by the associated emission factor to estimate the emissions in kg CO2e for each sector and add up to determine the overall carbon footprint (L. Ozawa, 2011).

Therefore the basic formula below is used for calculating CO2e:

-CO2e = Electricity used (kWh) x Emission factor (kgCO2/ kWh)

The electricity emission factor in Malaysia is 0.509 kg CO2/kWh, which adapted from Energy Information Administration (Jenny Liew, 2012).Referring to step 1, a one weak visual observation was conducted in order to collect the raw data for further analysis. Therefore DK3, DK7 and DK8 were chosen as the sampling locations. The usage or utilization of each electrical appliance in these DKs were monitored and recorded.

Table 1 shows the averages of data gathered from observation:

Table 1.The averages of data gathered from observation

Class Occupancy Rate/day	5 Hours
Number of On Lightings/h	12
Air Conditioner in use time	11 Hours
Projector In use time	8 Hours
Computer In use time	8 Hours

As the normal working hours of the DKs is from 9 a.m. to 9 p.m., so the ratio of using the class and appliances will be as shown is Table 2.

Table 2.In use time percentage

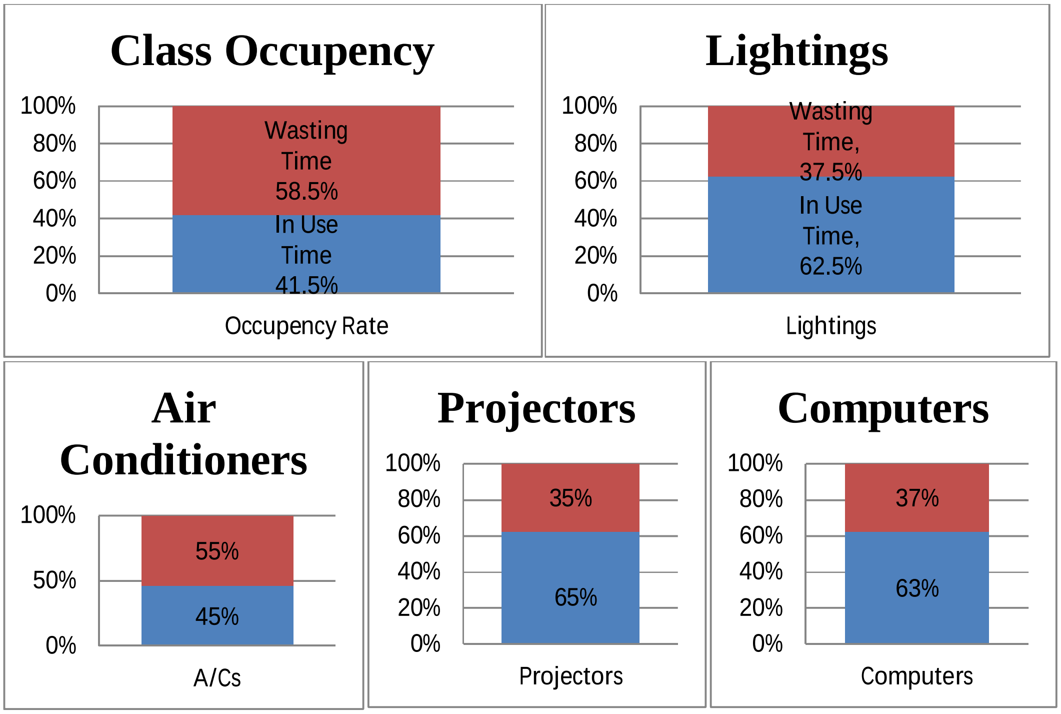
Average Class Occupancy Rate	42%
Average No. of On Lightings/h	67%
Air Conditioner in use time	92%
Projector In use time	67%
Computer In use time	67%

As the result of Table 1 and Table 2 we can calculate the wasting time percentage as shown in Table 3 and Figure 1.

Table 3.Wasting Time Percentage

Appliance	Wasting time Percentage (%)
Lightings	37.5
Air Conditioners	54
Projector	37.5
Computer	37.5

Figure 1: In use time and Wasting Time Comparison Charts



3. RESULTS

Considering the tables and charts above, we can see that in the low peak period (1pm until 2pm and 5 pm to 9 pm) although there are no people in classes but some of the electrical appliances were not switched off. So this simple aspect can cause the increase of electrical consumption directly.

Back to the further analysis and calculation for total CO2e in DKs, the amount of electrical energy (EC) consumed by an appliance can be determined by using the following formula:

EC = Nax Pr x Du (1)

Where Na = the number of appliances of a particular type,

Pr = the average power rating of a unit in watt,

Du= the duration of usage of a unit in hours.

For simplifying the calculation steps, the Pr value for each electrical appliance can be referred on table 4, but for air-conditioners we will use the date from industry and consider 11 KW input power for each class.

Table 4.the duration of usages for appliances and average power (Saidur R, 2006)

Appliances	Weekdays		Weekends		Total hours in a year	Average power (W)
	Daily average usage (h)	Yearly usage (h)	Daily average usage (h)	Yearly usage (h)		
Fluorescent light	5.67	1479.87	5.45	566.28	2046.15	30
TV	5.70	1487.7	8.15	846.04	2333.74	80
Fan	11.55	3014.55	12.04	1252.16	4066.71	60
Iron	0.53	138.33	0.46	47.84	186.17	1200
Refrigerator-freezer	8.11	2141.04	8.11	771.56	2919.34	196
Rice cooker	0.72	187.92	0.73	75.4	263.32	905
Washing machine	1.04	270.14	1.04	107.64	377.77	1005
Bulb	3.45	899.15	3.38	351	1250.15	70
Hi-fi	2.45	638.15	1.93	200.72	838.86	20
Blender/mixer	0.26	66.56	0.19	19.76	86.32	300
Vacuum cleaner	0.24	61.34	0.27	28.08	89.45	1200
Toaster	0.16	40.46	0.14	14.56	55.05	800
Kettle	0.48	125.28	0.44	45.76	171.04	2125
Hand phone charger	3.51	916.11	3.31	344.24	1260.35	30
Hair dryer	0.09	22.19	0.05	5.2	27.34	1125
Air-conditioner	5.05	1318.05	4.75	493.48	1811.53	1385
Personal computer	1.97	514.17	1.82	188.76	702.93	100
Microwave oven	0.18	45.68	0.17	17.16	62.85	1125
Water heater	0.16	40.46	1.23	127.4	167.86	2000
Electric Gate	0.34	88.49	0.34	32.74	121.33	800
Electric water filter	11.90	3139.24	12.93	1240.93	4380.15	150
VCD/VCR/DVD player	3.11	821.04	3.15	295.56	1120.59	250

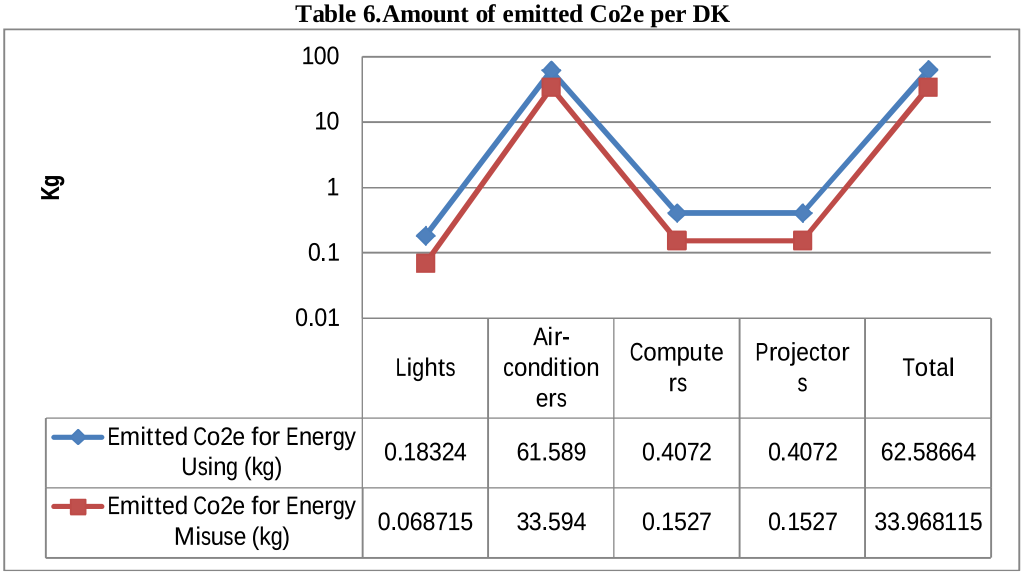
Using the abovementioned formula and data in table 4, table 5 shows the energy using and energy wasting from each appliance.

Table 5.Energy Using and Energy Wasting from Each Appliance

Appliance	Energy Consumption (kWh)	Energy Wasting (kWh)
Lights	0.36	0.135
Air-conditioners	121	66
Computers	0.8	0.3
Projectors	0.8	0.3
Total	**122.96**	**66.735**

The amount of CO2e can be calculated by multiplying electrical consumption value with emission factor (0.509kgCO_2/kWh). Table 6 indicates the amount of Co2e in each DK while the chart is drawn in logarithmic scale.

Table 6.Amount of emitted Co2e per DK



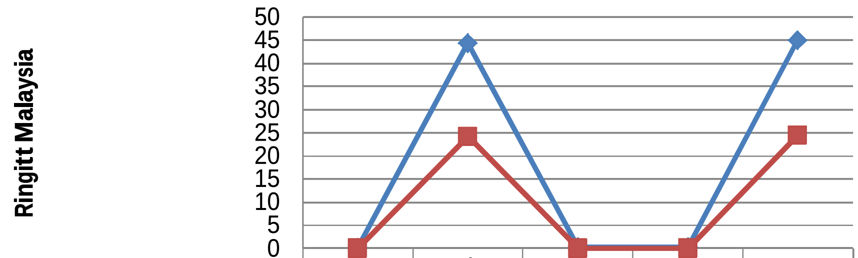
As shown above about 62.5 kg Co2e is emitted for generating the electricity of each DK from which about 54% (34 kg Co2e) is being emitted for wasting energy.

According to (Epstin et.al. 2011) the cost of every one ton of Co2e for country is USD 30 (RM 90). So the estimated cost of effects from 8 DKs in UPM Faculty of Engineering can be calculated as follows:

Estimated Total Cost of Co2 Emission=Emitted Co2e amount to generate the power for each class*Number of classes*Cost of Co2 emission per ton (2)

Using equation 2 we will have the following results:

Table 7.Estimated Daily Cost of Co2 Emission in all 8 Dks



	Lights	Air conditioners	Computers	Projectors	Total
Cost of Emitted Co2e in Energy Using (RM)	0.1319328	44.34408	0.293184	0.293184	45.0623808
Cost of Emitted Co2e in Energy Wasting (RM)	0.0494748	24.18768	0.109944	0.109944	24.4570428

Table 7 shows the total cost of Co2e emitted to generate the required electricity for all DKs is about RM 45/day from which about RM 25/day is paid by the country not for benefiting from electricity but also for wasting electricity. The biggest share is for Air-conditioning system. This point must be considered that this amount is only for CO2e emissions and does not include other factors and costs for electricity that make the total cost of electricity to be much higher.

4. CONCLUSION

Considering Malaysia has actively participated and involved in key conventions regarding environment and sustainable development, such as convention on biological diversity, Basel convention on the control of trans-boundary movements of hazardous wastes and their disposal, Montreal Protocol on substances that deplete the ozone layer and Kyoto Protocol to the United Nations Framework Convention on Climate Change, University Putra Malaysia (UPM) as one of the largest universities in Malaysia should try to make its energy consumption as efficient as possible and Faculty of Engineering may be the pioneer in this regard. Since the air-conditioning system has the biggest share in energy use, so it might be the first thing to be improved. It can be seen that only in 8 DKs there is about RM 25 per day cost of Co2e emissions that even does not benefit the students and all of it, is being wasted because of poor energy efficiency programs in UPM.Furthermore, the cost of electricity which is being wasted is not considered in this paper and clearly is more than cost of Co2e emissions.

REFERENCES

Chua S, Oh T.H, "Review on Malaysia's national energy developments: Key policies, agencies, programmes and international involvements," Renewable and Sustainable Energy Reviews,vol. 14,pp. 2916–2925, 2010

Epstein Paul R. Epstein,Jonathan J. Buonocore, Kevin Eckerle, Michael Hendryx,Benjamin M. Stout III, Richard Heinberg,Richard W. Clapp,Beverly May, Nancy L. Reinhart,Melissa M. Ahern, Samir K. Doshi, and Leslie Glustrom, "Full cost accounting for the life cycle of coal"**,** ANNALS OF THE NEW YORK ACADEMY OF SCIENCES, Ann. N.Y. Acad. Sci. 1219, 73–98 New York Academy of Sciences, 2011

Hashim H, W. S. Ho, “Renewable energy policies and initiatives for a sustainable energy future in Malaysia”, Renewable and Sustainable Energy Reviews, vol. 15, pp. 4780– 4787, 2011.

Yi J.L.J.,“Assessment of CO_2 Emission And Development Of The Carbon Footprint Calculator For UPM Students”, Master Thesis, Universiti Putra Malaysia, 2012.

Islam M. R, R, Saidur, N. A. Rahim, and K. H. Solangi, “RENEWABLE ENERGY RESEARCH IN MALAYSIA”, Engineering e-Transaction (ISSN 1823-6379), Vol. 4, No. 2, pp. 69-72, December 2009.

Ozawa-Meida L., Brockway P., Letten K., Davies J., Fleming P.,“Measuring carbon performance in a UK University through a consumption-based carbon footprint: De Montfort University case study”, Journal of Cleaner Production pp. 1-14, 2011.

Saidur R, Masjuki H.H., Jamaluddin M.Y., Ahmed S.“Energy and associated greenhouse gas emissions from household appliances in Malaysia”, Energy Policy,vol. 35, pp. 1648–1657, 2007.

Shafie S, T.M.I. Mahlia, H.H. Masjuki, A. Andriyana, “Current energy usage and sustainable energy in Malaysia: A review”, Renewable and Sustainable Energy Reviews vol. 15, pp. 4370– 4377, 2011.

Owusu-Sekyere J.D.,Andoh J., and Nyarko K., “Climate Change and Crop Production in the Mfantseman Area of Ghana”, J. Appl. Environ. Biol. Sci., no.1, vol.7, pp. 134-141, 2011.

Nazarpour M, Sadighi M, “Relationship between Rural Sustainable Development and Indigenous Knowledge”, J. Appl. Environ. Biol. Sci., No. 1, vol. 8, pp. 172-176, 2011.