Available online at http://www.journalijdr.com

International Journal of DEVELOPMENT RESEARCH

ISSN: 2230-9926

International Journal of Development Research
Vol. 5, Issue, 01, pp. 3020-3024, January, 2015

Full Length Research Article

ENERGY MANAGEMENT AND ANALYSIS FOR REPLACING FOSSIL FUELS WITH SOLAR CELLS IN AN SME: A CASE STUDY OF BLUE APPLE PRINTING

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ARTICLE INFO

Article History:
Received 25th October, 2014
Received in revised form
28th November, 2014
Accepted 31st December, 2014
Published online 26th January, 2015

Key words:
Energy management,
Solar energy,
Comparative UK and Kurdistan

ABSTRACT

The role of energy management has greatly expanded in industrial companies who are collaborating with energy service providers to implement energy management practices to improve efficiency. The effort to introduce energy management in small and medium scale enterprises (SME) is limited due to the lack of initiation, expertise and financial constraints. In manufacturing, energy cost is usually only a small portion of the total production cost, and therefore, energy cost receives relatively little attention. Another problem is the lack of knowledge regarding the underlying principles involved in energy management. There is an urgent need to educate SMEs on energy management concepts and practices. This paper aims to provide a guideline for entrepreneurs in implementing energy management. It reviews the methodology of energy management that was introduced in a German bakery with a clear and consistent path toward introducing energy management. The methodology, tools used, results and difficulties encountered during the study are discussed. In this study a methodology has been developed to compare a micro-business model in the UK and Kurdistan-Iraq. The comparison clarifies that even though Kurdistan is abundant in oil and gas, its climatic conditions favour the implementation of solar cells that can replace the existing use of non-renewable fossil fuel sources. Our study suggests that solar can replace a reasonable amount of the energy needed in the UK and a much higher proportion in Kurdistan, Iraq. Using 20% efficient solar cells, 28% and 83% of the energy requirements of the microbusiness in the UK and Kurdistan-Iraq can be replaced respectively. These percentages are encouraging giving confidence that solar is a viable alternative in the future as solar cell efficiencies continue to improve.

INTRODUCATION

There is a worldwide energy crisis due to lack of supply in numerous parts of the world, the damaging effect on the environment and increasing price volatility. The Middle East represents only 5% of the world's population but houses 66% of world's oil and 43% of world gas reserves (Tsui, 2011). Although Middle Eastern countries are rich, this windfall wealth is unevenly distributed and does not lead to a widespread economic development (Ross, 2001).The USA accounts for only 5% of the world's population and is responsible for about 25% of the world energy consumption (Ewing and Rong, 2008), and related greenhouse gas emissions (Wilkinson *et al*., 2007). The world demand for oil and gas is increasing significantly each year due to rising demands from the developing countries such as India and China where industrialization and the demand for consumer products is escalating at an unprecedented pace (Pachauri andJiang, 2008). This means that the consumption of non-renewable energy is still rising. If energy derived from fossil fuel sources can be replaced by solar energy then environmental damage can be reduced and energy can be generated at source without the need for an extensive infrastructure development for transporting oil, gas and electricity (Armaroli and Balzani, 2007). In this paper, the feasibility of replacing fossil fuels sources of electricity with solar energy from the sun has been investigated. Energy analysis has been carried for a micro-business in the UK,

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which could be duplicated in Northern Iraq. Analysis of the available solar energy for such a business in both the U.K and Northern Iraq has been carried out together with an estimate of the reductions in harmful carbon emissions. The energy utilized by all the tools and components used in business operation have also been analyzed to determine the maximum usage points in the business (Eltawil *et al.*, 2009). This unit represents a microbusiness and in terms of numbers of these businesses their impact on the environment is much greater combined than the large companies which are fewer in number.

Methodology and approach

A list of the equipment using electricity was compiled and the power ratings noted. Over a period of two months the time that each machine was used was recorded (Zhang*et al.*, 2013). The data obtained was analysed using EXEL in order to determine trends and explore various features. Using known and projected solar cell efficiencies the possibilities of replacing all or a proportion of fossil fuel sources was investigated. A comparison between UK and Iraq was then made. The relationship between electricity usage and CO_2 was developed and calculations regarding the amount of CO_2 that can be prevented from entering into the atmosphere completed. The amount of electricity used from a non-renewable source was measured in a Blue Apple Printing, which was chosen as a business unit to investigate the system. This can be applied to any other micro-business. Start with first step, which was to evaluate and understand the equipment, and units that consumed electricity. The electricity used was taken from the main electricity meter. The electricity input was distributed into different components, machines and devices used in the business operation. An analysis of the usage of each equipment and device within the business was done by measuring the utilization time for each machine. The average and peak energy consumption of this business was examined.

The energy used by each machine and other units such as the bulbs, appliance, music centre, Large format printer, photocopier 1 & 2, document center, guillotine, heat press, laminator was measured. The timer was started as soon as the job printed. A stopwatch was used to measure the time. The timer was kept on until printing or the job complete. The time used was then noted. Several factors keep the machines for longer period of time such as technical problems. The same procedure was repeated for all other machines. The analysis of each machine utilised is shown that the busiest machine used were Photocopier 1, Document Centre and large format printer indicating they a relatively large amount of electricity consumption. The measurement methodology was the same for all equipment. The timer was turned off as soon as the operation was completed. The total time was recorded along with the power rating of the machine used for the job. TOther items which used electricity included: bulbs (100W and 60W), kettle for coffee and tea, music centre, heater and computer. The music centre, lighting and computer were on for the whole opening business amounting to 8 hours a day for six days a week. The amount of electricity consumed is calculated using the formula for each machine.

$$Energyconsumed(Joules) = powerrating(Watts) \times time(seconds)$$

i.e.

$$E = P \times t$$

RESULTS AND DISCUSSION

Analysis of Electricity Consumption

The electricity used by the machines in printing is given table 1. This was used to determine localized inactive and active electricity used for each of the equipment utilised in a printing shop.

Table 1. Inactive and Active electricity used and cost for each machine

Machine	Inactive Electricity Used (kWh)	Active Electricity used (kWh)	Total Electricity used (kWh)	Cost (£)
Large format printer	6.09	14.09	20.18	3.027
Photocopier 1	0	16.81	16.81	2.5215
Photocopier 2	0	9.29	9.29	1.3935
Document Centre	13.22	17.91	31.13	4.6695
Guillotine	0	12.61	12.61	1.8915
Heat Press	92.75	11.86	104.61	15.6915
Laminator	0	5.13	5.13	0.7695
Total	112.06	87.70	199.76	29.964

From the table the costs were £30 (machine) plus other usage of £45 equals £75 total average monthly electricity used in November 2012.

Thus this gives £75 / 30(days) = £2.50 per day.

The cost of electricity has been calculated using the formula

$$C = E \times UP$$

where E is the energy in kWh, P is the power in Watts, C is the cost in £ and UP is the unit price of £0.20. Hence, the daily cost has been calculated to be £2.50.

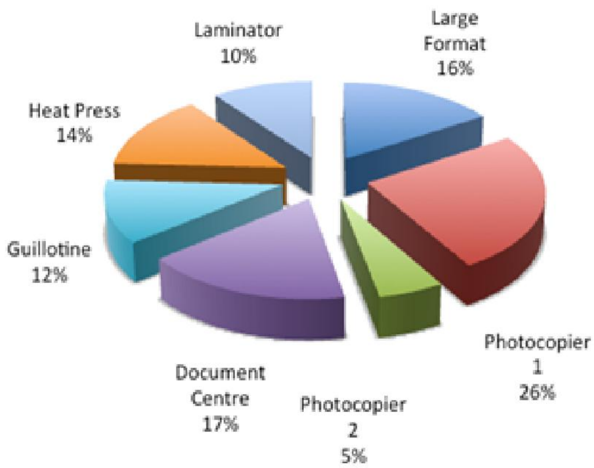

Figure 1. Overall usage time of machines used in Blue Apple Printing in November 2012

The electricity used and the associated costs are shown in table 2.

Table 2. Actual monthly and annual energy utilization and costs

Month	Units Used (kWh)	Cost (£)	Days Open
Jan	355	69.14	26
Feb	367	71.42	25
Mar	532	97.59	27
Apr	574	109.78	25
May	461	89.26	27
Jun	426	83.11	26
Jul	427	83.29	26
Aug	404	79.21	27
Sep	460	88.71	25
Oct	543	104.32	27
Nov	416	80.61	26
Dec	372	73.15	20
Total	5337	1029.59	307

The firm opened 307 days in 2012 using 5337 kWh of electrical energy, hence assumed that the calculated monthly electricity cost was £767.5 and the actual electric bill was £1029.59. The difference between the theoretical and actual value was £1029.59– £767.5 = £262.09 annually. Hence, the daily difference between the theoretical and the actual electrical energy used was about £0.85 per day. As a percentage of the daily rate the amount can be calculated as

$$\%\,difference = \frac{0.85}{2.5} \times 100 = 34\%$$

The main reasons for the difference between actual and calculated values will be discussed later.

The efficiency of solar cells has been increasing as new materials and architectures have been developed. One of the major objectives of this study is to investigate the feasibility of replacing electricity generated from non-renewable fossil fuels with solar energy (Green, 1987). A number of factors need to be considered and effect how much electricity is generated from solar panels on the roof. These include the size, number of panels, their power rating, position on the roof, and hours of daylight. Standard production solar panels based on silicon solar cells generate 1000W/m^2 with an efficiency of about 20%; hence a 1m^2 panel produces about 200W in good sunlight conditions and less in cloudy dull conditions. The efficiencies of commercial solar cells are expected to rise since research has already produced higher efficiency solar cells. In the past few years the adaption of solar panels widely has increased significantly due for several reasons, including China producing much more affordable solar panels, improvements in efficiency, development of technology, and government subsidies.

Factors such as efficiency, cost and reliability have meant that there has been a rapid rise in adoption of solar energy to replace non-renewable fossil fuel source (Solangi *et al*., 2011). Table 2 shows the monthly units used, cost of electricity incurred and the number of days the business is open. The sum, mean, minimum and maximum have been calculated. Figure 2 shows the number of units of electricity consumed over the months in 2012. To smooth out variations a two-point moving average was used to obtain a trend line. It appears from the data that the electricity utilisation reaches a peak in Easter months, and peaks again in the September. This may be due to business getting ready for marketing campaigns for the summer and for Christmas.

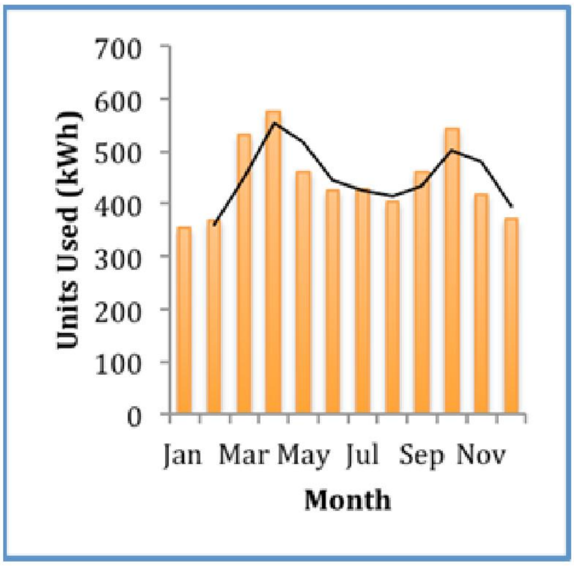

Figure 2. Units of electricity consumed during months in 2012

The relationship between the number of days open, units of electricity consumed and cost was explored by normalizing the data using the mean values see table 4 and figure 2.

Table 3. Normalized energy utilization, customers and days open

Month	Normalised Units	Normalised Cost	Normalised days
Jan	0.79991	0.8058	1.0164
Feb	0.8262	0.8324	0.9773
Mar	1.1976	1.1374	1.0555
Apr	1.2922	1.2794	0.9773
May	1.0378	1.0403	1.0555
Jun	0.9590	0.9686	1.0164
Jul	0.9612	0.9707	1.0164
Aug	0.9095	0.9231	1.0555
Sep	1.0378	1.0339	0.9773
Oct	1.2224	1.2158	1.0555
Nov	0.9365	0.9395	1.0164
Dec	0.8374	0.8525	0.7819

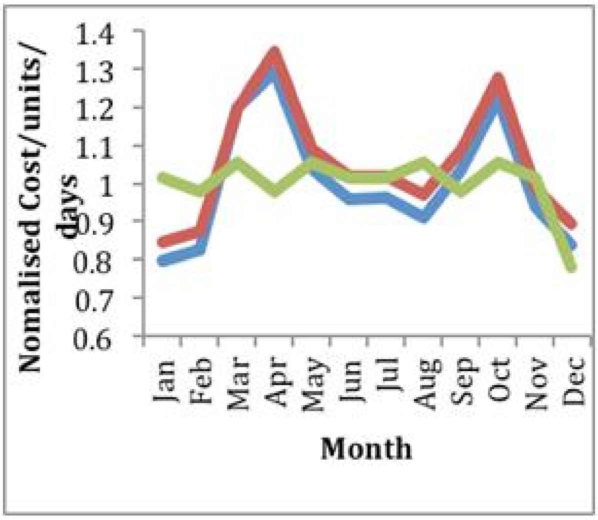

Figure 3. Normalized values of days business is open (blue line), electricity used (red line) and cost (green)

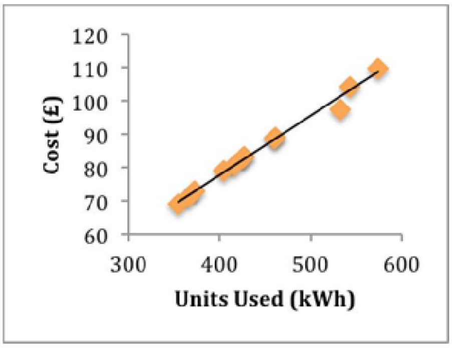

Figure 4. Linear relationship between cost and electrical units consumed

Figure 4 indicated that there is a positive correlation between the cost and the amount of unit used, the nature of the printing job when the customer visits the shop. These factors result in variations in the time and tools required to print a specific type of printing job, according to customer requirements.

Feasibility of replacing fossil fuels with silicon solar panels

By replacing non-renewable source with solar panels we can prevent it from being released into the atmosphere to prevent global warming and other environmental disasters. With millions of small businesses worldwide this will have a significant long-term impact. Solar cells rely on sunlight for their mode operation it is thus useful to compare UK with Kurdistan, Iraq.

Table 4. Units of electricity consumed and the carbon dioxide generated

Month	Units consumed (kWh)	UK Carbon dioxide produced (kg)
Jan	355	152.65
Feb	367	157.81
Mar	532	228.76
Apr	574	246.82
May	461	198.23
Jun	426	183.18
Jul	427	183.61
Aug	404	173.72
Sep	460	197.80
Oct	543	233.49
Nov	416	178.88
Dec	372	159.96
Total	5337	2294.91

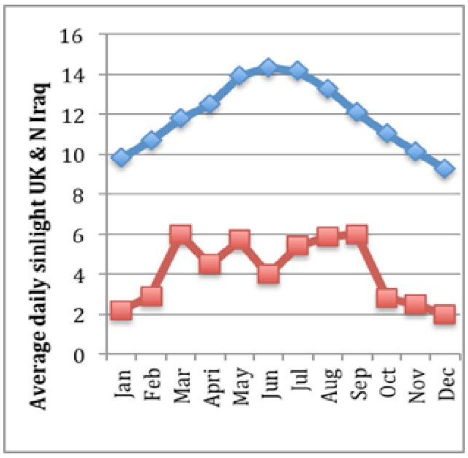

Figure 5. Shows a comparison between average daily sunshine in Kurdistan-Iraq (Blue) compared to UK (Read) in 2012

The annual consumption of electricity was 5337 kWh, which can be equated to the amount of CO_2 released into the atmosphere, which equates to 2294.91.46kg. In 2012 the daylight hours are shown in Figure 5. In the UK in the winter the average amount of sunlight per day is about 2 hours equating to about 60 hours per month whereas in the spring, autumn and summer it is about 5 hours, which is about 150 hours per month [14]. When this is compared to Northern Iraq the figures are 10 hours and 14 hours respectively per day. Hence, it not surprising that the weather conditions in Northern Iraq are more conducive to solar cell technology than the UK.

The expected electricity generated using solar panels can be calculated as follows:

$$Electricity = A \times 1000 \times \xi \times t$$

A is the area of solar panels, ξ is the efficiency and t is the

hours of sunlight to give the electricity generated in kWh per day.

Considering the Blue Apple Printing and we can calculate the amount of electricity that can be generated daily in UK and Iraq. The physical dimensions of the roof are 6 x 2 = 12 m^2 and about 50% of it is available for installation of silicon solar cells. Hence, an area of 6m^2 is thus available for solar cell installation. The amount of electricity generated in a typical day UK is

Electricity (UK) = 6 x 1000 x 0.2 x 4 = 4,800 Wh/day = 4.8 kWh/day

The efficiency was assumed to be about 20% with daylight of 4 hours typical an average in the UK in 2012 and the amount of electricity generated per day would be 4.8 kWh/day. Compared with Northern Iraq the calculation involves longer hours of daily sunlight and the intensity of sun is also much higher hence repeating the calculation gives

Electricity (N. Iraq) = 6 x 1000 x 0.2 x 12 = 14,400 Wh/day = 14.4 kWh/day

In Northern Iraq the amount of electricity generated for an equivalent business unit using the same solar cells 14.4 kWh/day electricity can be compared to the UK value of 4.8 kWh//day due to better weather conditions and therefore use of solar energy is much more attractive. This represents a factor of 3 times more electricity generated in Northern Iraq compared to the UK making it more attractive as an environmentally friendly technology solution for energy production.

Table 5. Comparison between the UK and Northern Iraq for 20% efficient solar cells and corresponding amount of reduction in CO_2

Silicon Solar cell efficiency (%)	UK (kWh)	N. Iraq (kWh)
20	4.8	14.4
Annual (307 days)		
20	1474	4421
Annual CO_2 reduction (kg)		
20	634	3227

Clearly calculations for the replacement of fossil fuels with solar cells show that the carbon emissions will be decreased thus reducing damage to the atmosphere. The benefits in Iraq would be much greater due to more sunlight and a about 5 times the reduction in CO_2 emissions can be achieved in Northern Iraq compared to UK. This type of analysing and conclusions drawn are also applicable to other regions in the Middle East. For the UK we calculate the percentage of electricity generated from 20% efficient solar cells compared to replace fossil fuels to be as follows:

$$\%E(replaced) = \frac{E(solar)}{E(fossil)} \times 100$$

$$= \frac{1474}{\mathbf{5337}} \times 100 = 28\%$$

However, for the same business in Northern Iraq with 20% efficient silicon solar cells and longer day light hours we can calculate the percentage of electricity needs that can be replaced with solar cells.

Table 6. Comparison of the percentage of current electricity requirements that can be replaced with solar energy using with silicon solar cells

Solar cell	Percentage of the energy requirements replaced with solar in the UK	Percentage of the energy requirements replaced with solar in Northern Iraq
Silicon solar cells (20%)	28	83

The calculations above using the solar panel with efficiency of 20% can replace only 28% of the total electricity required to run Blue Apple Printing in the U.K. The replacement of fossil fuels with solar cells will also reduce the carbon emission into the atmosphere and reduce damage to the environment. However, in Northern Iraq due to longer daily and annual daylight hours we can replace 83% of the energy needs with silicon solar cells.

Conclusions

A comparison between a micro-business in the UK and Northern Iraq for energy utilization has been carried out. Northern Iraq is abundant in oil and gas however its conditions are highly favourable for implementing solar energy compared to UK. A proportion of fossil fuel sources can be replaced with silicon solar cells. For existing solar cells we can replace 28% and 83% of the energy requirements of the microbusiness in the UK and Northern Iraq respectively. The impact of fossil fuels on the environment in terms of carbon emissions could be reduced dramatically when summed over all micro-businesses globally. Some of the differences in the actual electrical consumption of the micro-business and those calculated can be accounted for by using a lower unit price tariff comparable to available commercial rates and also by the accuracy of the time measurements of the operating hours which were made during the case study.

REFERENCES

Tsui, K. K. 2011. "More oil, less democracy: Evidence from worldwide crude oil discoveries*," *The Economic Journal,* vol. 121, pp. 89-115.

Ross, M. L. 2001. "Does oil hinder democracy?," *World politics,* vol. 53, pp. 325-361.

Ewing, R. and F. Rong, 2008. "The impact of urban form on US residential energy use," *Housing Policy Debate,* vol. 19, pp. 1-30.

Wilkinson, P., K. R. Smith, M. Joffe, and A. Haines, 2007. "A global perspective on energy: health effects and injustices," *The Lancet,* vol. 370, pp. 965-978.

Pachauri,S. and L. Jiang, 2008. "The household energy transition in India and China," *Energy policy,* vol. 36, pp. 4022-4035.

Armaroli,N. and V. Balzani, 2007. "The future of energy supply: challenges and opportunities," *Angewandte Chemie International Edition,* vol. 46, pp. 52-66.

Eltawil, M. A., Z. Zhengming, and L. Yuan, 2009. "A review of renewable energy technologies integrated with desalination systems," *Renewable and Sustainable Energy Reviews,* vol. 13, pp. 2245-2262.

Zhang, D., N. Shah, and L. G. Papageorgiou, 2013. "Efficient energy consumption and operation management in a smart building with microgrid," *Energy Conversion and Management,* vol. 74, pp. 209-222, 10//.

Green, M. A. 1987. "High efficiency silicon solar cells," in *Seventh EC Photovoltaic Solar Energy Conference*, pp. 681-687.

Solangi, K. H., M. R. Islam, R. Saidur, N. A. Rahim, and H. Fayaz, 2011. "A review on global solar energy policy," *Renewable and Sustainable Energy Reviews,* vol. 15, pp. 2149-2163, 2011.

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