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COST EFFECTIVENESS OF SUSTAINABLE ELECTRCITY CONSUMPTION IN DOMESTIC BUILDINGS.

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Abstract
Saving electricity has become a challenge in Sri Lanka due to the warmer climates prevailing throughout the years and it has become a major requirement to have fans and air conditioners occupied in most of the houses. That may effect to electrical consumption and the monthly electricity bill. However, in order to reduce electrical consumption in domestic buildings there are some methods which can be adopted in practice. This study has covered areas of cost effectiveness of solar electrical installation systems and importance of sub-metering houses along with benefits of using light-emitting diode (LED) bulbs instead of using compact fluorescent lamp (CFL) and incandescent (filament) bulbs. Data collection carried out through interviews and questioner surveys with customers and suppliers of solar electrical installations. After analysing the data gathered, even with a highly initial cost, solar electricity installations can be considered as a cost-effective method. Furthermore, specifications and details gathered on CFL, LED and filament bulbs proved LED bulbs are more cost effective than other bulbs for the same illumination level. This study also revealed that sub metering a house under the rules and regulations of Electricity Board is another cost-effective method where a house owner can adopt in their houses.

Keywords: *Energy efficiency, Electrical consumption, sustainability, Sub-metering, Solar power*

1. Introduction

Energy efficiency is considered as an important factor ensuring a safe, reliable, affordable and sustainable energy system for the future (International Energy Agency, 2018). Energy can be conserved in many ways and at many different levels of energy consumption. One of the major facts of conserving energy can be described as saving the electricity consumption. In several developing countries usually it can be identified a little margin between existing power supply and electricity demand. Along with the increasing electricity demand, new generation must be brought through renewable sources of electricity such as hydro, geothermal or wind provides electricity at a lower price (Matek & Gawell ,2008).

2. Literature Review

2.1. ELECTRICITY CONSUMPTION

The International Energy Agency (2018) statistics estimated that globally, building sector is responsible for 42 per cent of more electricity consumption than any other sector. This percentage depends greatly on the degree of electrification, the level of urbanization, the amount of building area per capita, the prevailing climate, as and as well as the national and local policies to promote efficiency.

In this situation, the Central Intelligence Agency (2018) has ranked Sri Lanka as the eighty sixth country among 218 of countries for high electricity consumption (11.72 billion kWh). Ministry of Power and Renewable Energy Sri Lanka (2017) had pointed out that Sri Lanka's national electrification ratio has grown from 99.3% in 2016 to 99.7% in October 2017 and has already reached 100% electricity accessibility which is commendable by South Asian standards. Sri Lanka is the only country in South Asia that has 100% electricity accessibility with 24 hrs uninterrupted electricity supply. They have also emphasized that it is of national importance to move into renewable energies such as solar power and their target is to generate 1000MW from 1,000,000 solar tops around the country under the "Soorya bala sangramaya programme".

2.2 LIGHTING SYSTEM

According to the recent study of Wood and Matulka (2013) concluded that, lighting accounts for five percent of a home's energy use, which translates to about 11% of the home's electricity bill. Much of this is the result of using inefficient lighting methods adopted in the households (Terry et.al, 2013).

2.1.1 Comparing LED vs CFL vs Incandescent Light Bulbs

As the technology has advanced and environmental awareness has increased, energy efficiency has become of a paramount concern. It is common knowledge that choosing the right light bulb could drastically reduce customer's power bills and positively affect the environment. House owners has the options of choosing between incandescent, compact fluorescent (CFL), and light-emitting diode (LED) light bulbs to be used. However each one of the methods will have a different effect on the overall energy efficiency of the building.

According to the Sullivan (2015), there are two key terms pertaining to light bulbs; they are watts and lumens. With incandescent bulbs, the number of watts has become synonymous with the level of brightness, even though a watt really does not tell anything more than the amount of power necessary to light the bulb. Lumens, on the other hand, indicate the actual amount of light emitted by the bulb. For example, a typical incandescent 40W light bulb draws 40 watts of power and provides about 400 lumens of brightness. A CFL requires 9-13 watts and an LED light bulb uses 6-7 watts to provide the same amount of lumens.

Furthermore, CFLs have been touted enthusiastically in the past decade, However LEDs are beginning to surpass CFLs because they require as little as half the power and last 10 times longer than a CFL. Apart from the brightness and efficiency of the method cost is a good factor of comparing incandescent, compact fluorescent (CFL), and light-emitting diode (LED) light bulbs due to the fact that house owners are desperate in terms of the cost of application.

An Indian research had suggested that the estimated payback period of replacing an incandescent lamp with CFL is 1.2 years, and that of replacing a kerosene lamp with CFL is less than a year (Bhattacharya and Cropper, 2010). Compared to CFLs, LED lamps require a higher initial investment, but their long lifespan (up to 10 times of CFL) makes up for the high investment cost. As a rule of thumb, the investment cost for LED light is usually paid off within the first year of use. Maintenance costs are negligible during the lifespan of energy efficient lamps and ballasts.

Apart from the Technical details the easiest way of comparing the advantage of the different methods of lighting can be summarized as following table 1.

Table 1-Summary of Incandescent, CFL and LED Bulbs

	Incandescent	CFL	LED
Life span	1200 hrs	8000 hrs	25,000hrs
Watts used	60W	14W	7W
Average cost per bulb	Rs.150	Rs.300	Rs.600 or less
Total purchase price of bulbs over 20 years	Rs. 3150	Rs. 900	Rs. 600
Bulbs needed for 25,000 hours	21	3	1

Cost of electricity (25,000 hours at 22.50 per kWh)	**Rs.25,375**	**Rs.7800**	**Rs. 4500**
Total estimated cost over 20 years	**Rs.31,650**	**Rs.8100**	**Rs.5100**

After considering all the facts, though the initial cost of buying LED's is higher than other bulbs, they are becoming very affordable. Since LED bulbs are so much more efficient, and contain no toxic materials, it won't be long until these bulbs replace other bulbs as the standard means of lighting homes and businesses alike. Since life span of LED bulbs are high initial cost of buying LED bulbs can be recover in a short period further considering using for LED bulbs for houses is good for environment as well when comparing incandescent and CFL bulbs.

2.3 AFFORDABILITY OF SOLAR POWER SYSTEMS

The concept of solar energy is well suited to Sri Lanka as a good harvest on solar electricity and has been recorded in many places in the island. Increased solar energy generation and usage have been reported from the areas of Anuradhapura, Jaffna, Vavuniya, Kurunegala, Trincomalee, Mannar, Galle, Matara, Hambantota, Colombo, Batticaloa and Ampara where electricity demands are high, and consumers are cost conscious in their daily routines (Daily news,2018).

2.4 IMPORTANCE OF SUB-METERING BUILDINGS

If a multi-residential building has one central or bulk meter, along with landlords, property managers, condominium corporations or building owners. They will be responsible for the building's entire utility consumption. This can result in unfair allocation of energy costs to owner. Implementing sub-metering allows measurement of individual unit consumption and allows to be billed for each own consumption. Utility costs are one of the highest expenditures for a building. By sub-metering, building owners and operators are able to better control operational costs, allowing them to focus on other priorities. Resulting savings for the building can then be diverted to the building reserve fund or to other areas that need attention. (Enercare, 2018).

3. Research methodology

In order to investigate the research problem of this study, data collection was conducted in several areas such as Colombo, Matara, Kelaniya, Ambalangoda and also carried out a survey which was conducted in three main different areas. First area was solar power system suppliers. Five solar power systems suppliers were surveyed and collected data from their shops. Second area was people who installed solar power system in their houses. Therefore, seven houses who installed solar systems were surveyed. Third area was sub-metered and not sub-metred houses. Three sub-metered houses and two not sub- metered houses were surveyed to compare the cost effectiveness of sub-metering houses. Furthermore, research articles, websites, E-books and newspaper articles were refered as well.

4. Data Analysis

4.1 DEMAND FOR SOLAR ENERGY SYSTEMS

In present times, people are more interested in solar power energy more than past years. Interviews were conducted among solar suppliers in Colombo area .in order to identify the current demand for the solar energy in Sri Lanka.

Table 2-Details of solar system suppliers

Total number of installations so far	Solar shop 01	Solar shop 02	Solar shop 03	Solar shop 04	Solar shop 05
Domestic	1500	2500	13	175	190
Government office	100	20	00	01	15
Private office	200	20	00	18	30
Hotels	250	05	00	00	05
Other	550	10	00	20	00

This table shows information about total number of solar panels installations in different solar panels suppliers. All suppliers showed one common factor which was, all of them doing domestic installation more than other categories shown in the table. When comparing to Solar Shop 01 and 02, Solar Shop 03, 04 and 05 are newer to the business but as shown in the table even these companies are showing good stats. Furthermore, this table shows demand for the solar power in private offices and it is in a good condition.

4.2 INSTALLATION OF SOLAR ELECTRICAL SYSTEMS

As above explained data concluded demand for the solar power is increasing. Therefore, following are some of gathered data about solar customers who installed solar panel in their houses.

Table 3-Details of people who installed Solar Systems

House	Total cost of installing solar panels (Rs.)	Average amount of monthly electricity bill before installing solar system (Rs.)	Average amount of monthly electricity bill after installing solar system (Rs.)
House 01	650,000/=	12721/=	30/=
House 02	560,000/=	16,470/=	428/=
House 03	900,000/=	9992/=	30/=
House 04	1000,000/=	11353/=	1757/=
House 05	850,000/=	21443/=	30/=

According to the gathered data from these houses, above mentioned house no. three and four installed solar power system as selecting net accounting option. So, after installing solar system since then, they received Rs.2000- 3000 by government for generating electricity.

This table also shows the average amount of monthly electricity bill before and after situations of installing solar panel. According to the chart it shows there are huge differences between before and

after electricity bills. In house No. 01 it shows Rs.12,691 difference in electricity bills although in House No. 2 marked Rs.16428 difference as well. However, among all houses highest difference displayed in House No: 05 and it marked as Rs. 21,413. House number one, three and five showed only Rs. 30 amount after installing solar system in their houses.

Following chart shows gap between those electricity bills before and after more evidently.

Table 4-Estimation of recovered time-period of initial cost

House	Calculations of regarding monthly electricity bill	Estimated recovered years of initial cost
House No. 01	12,721×12= 152,652 650,000/152,652=4	4-5 years
House No.02	16,470×12=197640 560,00/197,640=3	3-4 years
House No.03	9992×12=119,904 900,000/119,904 =7	7-8 years
House No.04	11,353×12= 136,236 1,000,000/ 136,236 =7	7-8 years
House No.05	21443×12= 257,316 850,000/ 257,316=3	3-4 years

XXX- Average amount of monthly electricity bill before installing solar system (Rs.)
XXXX-one year (12 months)

According to the above mentioned table 6, it proved calculating average monthly electricity bills, initial cost of installing solar system can be recovered in around 7-8 years but in house No. 3 and 4 since they installed net accounting system they can be recovered initial cost of installing solar panels in 6-7 years.by the way this table proved solar system is a cost effective energy efficiency solution and initial cost can be recovered in short period.

Table 5 -Additional details of solar systems customers

	House 06	House 07
Total cost of installing solar panels (Rs.)	1,100,000/=	1,100,000/=
Average amount of monthly electricity bill before installing solar panel (Rs.)	434/=	1972/=
Average amount of monthly electricity bill after installing solar panel (Rs.)	17180/=	15464/=
Loan instalment per month(Rs.)	17150/=	15590/=
Average amount for generation per month(Rs.)	12,048/=	---

When monthly electricity bills of the above-mentioned houses no. 06 and 07 are considered, they are quite different from other houses. It's because they have taken loans from CEB and installed solar power

system with net accounting. The average monthly electricity bill of house no.6 was 17,180 Rupees, comprising Rupees 17,150 of monthly loan instalment and Rupees 30 fixed charge. However, they received average amount of Rs. 12,048 per month for generating electricity. Therefore, to pay back the loan for the CEB, they have to pay around Rs.5000- 5500 per month throughout the payback period of five years. After 5 years, they will have to pay only Rs.30 per month (fixed charge) but they will get about Rs. 12,000 per month for the electricity generation.

Above described all conditions are applicable for the House No. 7 as well but their average amount for generation is not properly mentioned in their electricity bill. Hence, due to that reason calculation cannot be done accurately.

4.3 SUB-METERING A HOUSE

As gathered data from LECO, In Sri Lankan practices when sub-metering a house there are some rules and regulations which must consider. According to the Sri Lanka electricity Act No. 20 of 2009, To have two meters for each floors owner must physically separate both premises and wiring should be done separately.to explain the simply that each premises should be separated units. According to the tariff plan of CEB and LECO when house is sub-metered it total units divided into the two or three floors and then electricity bill will be reduced.

According to the rules and regulations of Electricity board, Domestic (D1) effective from 16th September 2017, it is proved that the total amount of electricity bills in sub metered house is less than total amount of electricity bill non-sub metered house even total consumed units are equal. Following details are from the sub metered houses.

Table 6- Details about sub-metered houses

House	July average Monthly electricity bill in two floors (Rs.)	August average Monthly electricity bill in two floors (Rs.)
House A	5589/=	7105/=
House B	727/=	706/=
House C	6814/=	8495/=

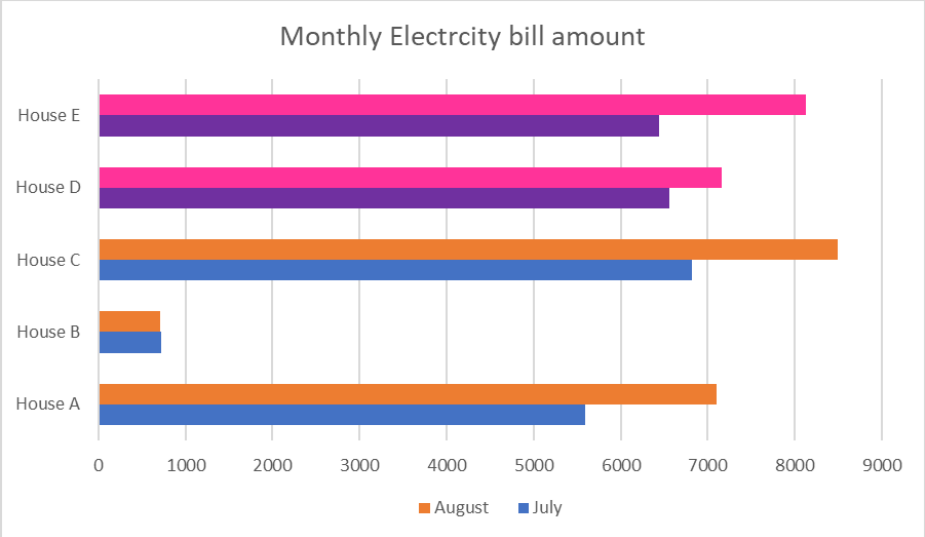
Above mentioned Houses, A, B and C are sub-metered houses. And also, House A and C rented their second floor to another family. House B rented their second floor few years ago. However, presently only one family living in that house.

Table 7 -Details about not sub-metered houses

House	July electricity bill (Rs.)	August electricity bill (Rs.)
House D	6561/=	7160/=
House E	6439/=	8132/=

This table shows details of not sub- metered houses. Only one family is living in these houses. As comparing detail of table 11 in House D and E, even when only one family is living, some monthly electricity bills of these houses are higher than A, B and C Houses and some of are quite equal. That means people who living in A, B and C Houses are getting benefits of sub-metering.

Furthermore, if A, B and C Houses are rented and owners of that houses didn't sub-meter their houses, both parties (owner and the rented) have to share the electricity bill and that can be unfair to both parties because the party who consume electricity less have to pay additional cost.



This chart shows gathered data about House A,B,C,D and E. main point of these chart is even there are two families living in House A and C their total monthly electricity bills are less than House D and E and some of bills are equal.

5. Conclusion and Findings

Electricity consumption is a common challenge any of country have to face. As a result of, the consumption of that form of energy sometimes becomes a problem because the generating capacity cannot match the demand. This study was covered areas of electricity consumptions in buildings. This study revealed considering the data gathered, the energy saving solution such as use of LED bulbs are cost effective when comparing CFL and other lighting systems. This study also revealed importance of sub-metering house and cost effectiveness of installing solar power system. Even though there is an initial amount of money to install these electricity saving methods, homeowners will often recover these costs in a short period of time due to the reduced energy expenses. This payback time can be short, taking only a few years. Saving electricity is not only for own well it is an immense contribution to the society as well. As demand for the electricity is increasing year by year it is necessary to save electricity as soon as possible.

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