PROFITABILITY ASSESSMENT OF SOLAR PV INSTALLATIONS IN SRI LANKAN RESIDENTIAL BUILDINGS

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ABSTRACT

The study focused on developing a cost recovery model to evaluate the profitability of installing solar panels in buildings in Sri Lanka to address the growing demand on the electricity supplied from the national grid. The study aimed to make the buildings in Sri Lanka zero carbon buildings. A cost-benefit analysis model was developed using Microsoft Excel to assess the profitability of solar power panels. The model was applied for a sample consisting of 8 domestic (small to large) consumers, to identify the type of domestic consumers most suitable for installing solar panels. Using the standard electricity tariffs enforced by the Ceylon Electricity Board, the average annual costs of electricity consumed by eight consumers were computed along with their Net Present Values (NPV) for a period of 25 years based on the interest rates offered by banks in Sri Lanka, to identify the discounted annual cash flows and evaluate the recovery period of high initial costs of solar power panel installations. The model shows that when solar panels are installed in buildings with high power consumption their high initial installation costs could be recovered in a relatively short period of time. Therefore, the installation of solar penal in such buildings would be profitable.

Keywords: *Cost Benefit Analysis; Net Present Value (NPV); Zero Carbon Buildings; Zero Carbon Economy.*

1. INTRODUCTION

Large scale hydro and thermal power plants are the main sources of electricity generation in Sri Lanka (Ceylon Electricity Board, 2018). The commercial and residential sectors in the country consume a significant amount of electricity generated. Of the total electricity consumption of the country, 24% is consumed by the commercial sector while as much as 40% is consumed by the domestic sector (Arachchige, 2004).

In the past two decades, Sri Lanka has used various sources to generate energy (Ceylon Electricity Board, 2018) mostly hydro power sources. Thus, the power generation in Sri Lanka is highly dependent on the annual rain fall rate which is quite unpredictable. The annual rainfall of the period from 1961 to 1990 has decreased by about 144 millimetres (about seven per cent) from the annual rainfall of the period from 1931 to 1960. The annual rainfalls recorded at the meteorological stations in Baticaloa, Kurunegala, and Rathnapura have shown high variations (Chandrapala, 1997). Because of the decreasing annual rainfall and the unpredictability of the rainfall pattern, the demand on carbon fuel based electricity generation has increased significantly in the recent times (Ceylon Electricity Board, 2018). Sri Lanka annually imports 2 MMT of crude oil, 4 MMT of refined petroleum products and 2.25 MMT of coal, which altogether cost approximately 5 billion USD which is 25% of the total expenditure on imports and almost 50% of the total income received from exports. These imports mainly intended for use by the transport sector meet 44% of the energy requirements of the country (Rodrigo, 2015).

In 2013, a year which had good rainfall, 50% of the electricity generated was from hydro power, 9.85% from Non-Conventional Renewables (NCR) (mini-hydro, wind, biomass and solar) and the balance from thermal plants. There was less rainfall in 2014, and as a result, the contribution from hydro power sources dropped to 29.4%. Since the contribution from NCR sources remained unchanged, the balance of over 60% was generated

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by using oil or coal plants owned by the Ceylon Electricity Board (CEB) and supplemented by private power plants that used oil (Gunawardana, 2016). According to Ceylon Electricity Board (2018), carbon based energy sources provide 27.95 GWh (81.04%) of electrical energy and hydro and other clean energy sources provide a minimum of 6.54 GWh (18.96%). There is a increasing tendency to use carbon based sources for energy generation, which release high amounts of CO_2 to the environment, a significant negative deviation from the current global trend of adopting de-carbonized economic concepts (European Commission, 2011). Wiseman and Edwards (2012) have focused on an economy using low carbon power sources to ensure minimal emissions of Green House Gases (GHGs) to the environment and eliminate global warming. Several alternatives have been identified during the last decades to achieve a zero carbon economy, thus paving way for renewable energy capacity to grow worldwide at annual rates in the range of 10–60 per cent and for promoting technologies involving wind, tidal, solar and biomass.

Therefore, during the last few decades in Sri Lanka, there has been a growing concern on the need to adhere to 'zero carbon energy economy' especially in the building sector. In this context, it will be necessary to reduce the dependence on carbon based energy sources. Therefore, the focus should be on implementing the 'zero carbon energy economy' concept along with the development of new clean energy sources such as wind, tidal, solar and biomass. Consumers such as offices and residences who have high electricity consumption need to seriously consider switching over to clean energy sources.

Sri Lanka being a tropical country has good potential for utilizing solar energy for electricity generation which will be even sufficient to meet the entire electricity demand of the country. Solar radiance in the country fluctuates between 5.5 and 6.5 kWh/m^2/day on clear sky days (NREL, 2018).

However, since the initial/installation cost of solar PV Panels is high, a financial analysis will be necessary to determine the viability of having solar panels as a clean energy source for electricity generation. Therefore, the need arises for a market focused financial investment model to assess the costs and benefits of solar Photovoltaic (PV) cells.

Before using solar PV technology, it is necessary to identify the category of consumers who are best suited to make use of this technology. According to Sustainable Energy Authority of Sri Lanka (2010), domestic sector in Sri Lanka consumes 40% of the total energy consumption of the country while commercial and industrial sectors consume 24% and 34% respectively. Thus, the domestic sector was considered as the most significant sector to this study. The cost-recovery model to be developed can evaluate the profitability and the recovery period of the high initial/ installation cost of solar PV which is a net zero carbon alternative to the conventional power supply fed from hydro-power and diesel powered energy sources.

The study focused on developing a Microsoft–Excel Spread Sheet giving a profitability index to identify the most suitable type of domestic consumers (from among those who have low, mid and high electricity consumption) who can use solar panels for their energy needs. Finally, an analytical approach was developed to determine the recovery period (within a period of 25 years which is the life time of solar PV panels) of the high initial investments made on solar panels. The study further recommends that policies be formulated to enable the move towards globally led low carbon society that would considerably reduce greenhouse gas emissions.

2. LITERATURE REVIEW

2.1. CONCEPT OF ZERO CARBON ECONOMY

As the probability and risks of climate change continue to grow, there is a very urgent need for a swift transition towards a strong zero-carbon economy (Nader, 2009). Global GHG emissions are highly dependent on climatic conditions. According to Watson (1997), in the next century, the global economy is expected to turn into a fossil fuel-intensive economy. Low-carbon economy (LCE), low fossil- fuel economy (LFFE), or de-carbonized economy is an economy based on low carbon power sources that have minimal emissions of GHGs into the biosphere. This specifically refers to GHG emissions of carbon dioxide. Thus, in order to avoid catastrophic climate changes, steps need to be taken to embrace the concept of zero-carbon economy (Low Carbon Innovation, 2010; IRENA, 2012).

2.2. LOW-CARBON ECONOMY (LCE)

Moves towards zero carbon energy have come into place as a result of the paradigm shift in the global economic policies such as the strategies proposed for moving towards a holistic low-carbon economy with low carbon emissions (Rogelj, 2012). In industrialized countries like Australia, USA, Canada, Finland, France, Germany, Sweden, Norway and the UK, low-carbon energy concepts, renewable energy policies, and energy efficiency strategies are incorporated into national policies to achieve rapid reductions in unwanted emissions. These concepts, policies and strategies have emerged mainly due to the tendency that exists to transfer private capital to a low carbon society through GHG emission reductions. However, efficiency improvements, lifestyle changes, technological developments, policy designs, and demand reductions also need attention in this regard (Rogelj, 2012).

In developing an economic policy accommodating the concepts of low carbon economy, a certain degree of emphasis has to be on 'business models' that will facilitate behavioural changes. As a result, proposals for low-carbon economy should have an element of social innovation in a wide scale to change public behaviour towards a low-carbon society. Nishioka and Ishikawa (2012) highlight the potential that 'green growth' policies have for economic recovery through a low carbon society approach.

2.3. POLICIES ON ZERO CARBON ENERGY ECONOMY

Renewable sources including solar help to achieve the goal of bringing atmospheric carbon dioxide equivalent (CO_{2e}) to 350 ppm or below, and to rapidly bring down CO_{2e} emissions to zero along with carbon sequestration. As a result of the global trends that exist towards low carbon transition, low carbon roadmaps have come into the picture, with more energy effective strategies to promote renewable energy sources such as solar PV, wind, water (hydro, wave, tidal) and geothermal. For a more successful approach for a global energy system with 100% renewable energy, fossil fuel subsidies have to be removed and carbon taxes introduced. Nishioka and Ishikawa (2012) have further stated that taxes and tariffs can be incentives for behavioural changes of the public required for low-carbon development. Moreover, the increasing investments made in low carbon technology innovations have promoted the de-carbonizing of the energy supply to meet emission reduction goals.

The focus of the Governments of Australia, Germany, Denmark, Wales and the UK and the European Commission is on reducing GHG emissions during 2020-2050. To encourage zero carbon emissions, market based mechanisms such as rejecting 'transition fuels' (e.g. gas) and 'transition technologies' (e.g. more efficient petrol cars), higher prices on carbon, increased investments, incentives for innovation, commercialization and governance improvements of renewable energy have been adopted while promoting energy efficient technologies, systems and grid connectivity. In addition, cost-effective expansion of renewable energy sources and efficiency improvements have been proposed to foster their usage. With the current level of energy demand, the need has arisen for higher efficiency in power systems, electrification, decarburization through renewables and biomass. The integration of renewables and low-carbon energy sources is considered as secondary. In the coming years, the focus will be on the erection of wind turbines or solar plants in every town with more than 1000 high energy consuming people, reduction of deforestation and logging and the cessation of coal power plants (Nishioka and Ishikawa, 2012).

2.4. SOLAR POWER AS AN ALTERNATIVE TO CARBON BASED ENERGY SOURCES

According to Irena (2012), solar PV is the fastest growing renewable energy technology and is expected to play a major role in the future in the global electricity generation mix.

High Cost of Solar Photovoltaic Technologies

Solar PV technologies can be used anywhere provided the required solar exposure is available. The technology offers a number of significant benefits such as zero fuel costs and relatively lower operation and maintenance (O&M) costs (Green Match, 2017). IRENA (2012) states that unlike conventional power plants that use coal, nuclear, oil and gas, solar power as an alternative source of power can control carbon emissions. Even though solar panels can be expensive in the short run, once installed in contrast to conventional electricity supplies they will have no operational costs (Green Match, 2017). The maintenance cost of the system can be perceived as an additional cost, but in reality, the maintenance of solar panels includes only removing dust and/or washing (Borenstein, 2008). Moreover, according to Borenstein (2008), to encourage consumers to help in meeting the high initial cost of PV panel installations, the Energy Policy Act has been enacted in USA, establishing a new commercial federal tax incentive scheme for residential investments on renewable energies.

2.5. SOLAR POWER GENERATION IN SRI LANKA

Under Soorya Bala Sangramaya program of the Government of Sri Lanka, it is expected to add to the energy grid by 2020, 220 MW of clean power, which is about 10% of the country's current daily electrical consumption, and by 2025, 1,000 MW (Ministry of Power and Renewable Energy, 2016). Twenty per cent % of this energy is expected from solar power. However, currently, the installation of a solar panel with a capacity of 1 kWh will cost around LKR 200,000. Investing this amount of money upfront will be economically feasible only to those who consume 200 kWh or more. A guaranteed tariff for consumers who supply energy to the national grid using solar PV through what is called net accounting has also been proposed. Thus, the consumer will be paid if the solar PV power he generates is greater than what he consumes from the national grid creating a win-win environment for the two parties concerned.

At present, because of the multi-tier tariff system in force, those users who consume up to 30 units of electricity during a month pay LKR 7.85 per unit while those who use more than 180 units have to pay LKR 45 per unit (Gunawardana, 2016). Solar energy consumers will be paid during the first seven years LKR 22 per unit (1 kWh) for the excess solar power they generate and LKR 15.50 from the eighth year onwards (Gunawardana, 2016).

2.6. COMPONENTS OF A SOLAR PV SYSTEM

A solar PV system will have a breaker panel with circuit breakers that will interrupt the supply to appliances if they draw high currents that can cause fire hazards (Lowder, 2016).

2.7. ECONOMIC EVALUATION OF THE OPTIONS AVAILABLE

A cost benefit analysis will evaluate the benefits and costs of different options available. Among the common economic evaluation models such as Life-Cycle Cost Analysis (LCCA), Net Savings (or Net Benefits), Payback Period, Net Present Value(NPV), Savings-to-Investment Ratio (or Savings Benefit-to-Cost Ratio), and Internal Rate of Return (IRR) available to assess the benefits of different options, the Net Present Value (NPV) method was used to calculate the recovery period of the two options: conventional electricity supply and solar PV installation.

2.8. COST BENEFIT ANALYSIS USING NET PRESENT VALUE (NPV)

Net present values for different discount rates can be obtained by using the concept of time value of money . The concept involves the calculation of the future value of the present money component/ amount that is spent/invested today, against a discounted amount of cash flows coming in after a given time period (Storesletten, 2003).

$$NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \dots + \frac{C_T}{(1+r)^T}$$

$-\,C_0 = Initial\ Investment$
$C = Cash\ Flow$
$r = Discount\ Rate$
$T = Time$

$$NPV = -C_0 + \sum_{i=1}^{T} \frac{C_i}{(1+r)^i} \qquad \text{Eq. (01)}$$

Cash outflows such as the initial investment are denoted with negative figures in order to identify the profitability of a project/ investment. Thus, net present values have to be positive (the sum of discounted cash flows), for a project to be profitable (Storesletten, 2003). In this study, the present value of investment for each solar panel option was calculated for 25 years using a formula generated with Microsoft Excel and provided in electronic format for the benefit of future users.

3. METHODOLOGY

Because of the high initial costs of solar panel installations, it was necessary to first identify based on their power consumptions the buildings in which it will be profitable to have solar panel installations.

As among the different types of electricity consumers, the highest percentage of the total electricity consumption is identified by domestic consumers (40% of the total consumption) (Ministry of Power and Renewable Energy, 2016), a random sample of eight domestic users with low, medium and high electricity consumption were selected for the study. Their average electricity consumption and the related cost were computed by averaging the corresponding figures given in their monthly electricity bills spanning a period of 12 months, to develop a financial model for profitability analysis. Table 1 presents the standard CEB billing rates that were used to derive the value of the mean annual bill for each case for the years 2016-2017.

Table 1: The Standard CEB Billing Rates (Available from :http://www.ceb.lk:accessed on 18/05/2018)

RANGE	Monthly consumption(kWh)	Unit Charge(Rs./kWh)	Fixed Charge(Rs./Month)
0-60	0-30	`2.50	30.00
	31-60	4.85	60.00
61->180	0-60	7.85	N/A
	61-90	10.00	90.00
	91-120	27.75	480.00
	121-180	32.00	480.00
	>180	45.00	540.00

Table 2 presents the monthly electrical consumption of the samples and their average monthly costs and average annual costs (for year 2014-2017).

Table 2: Monthly Electrical Consumption of a Random Sample of Eight Domestic Users

Months	Monthly electrical consumption and cost of the consumers															
	1		2		3		4		5		6		7		8	
	kWh	Rs.	kWh	Rs.	kWh	Rs.	kWh	Rs.	kWh	Rs.	kWh	Rs.	kWh	Rs.	kWh	Rs.
1	53	184	81	677	71	568	69	561	84	2,690	108	2,260	225	5534	487	17324
2	51	179	73	570	72	591	73	570	80	1,070	113	2,379	253	5984	425	14534
3	62	491	61	221	68	551	73	570	117	2,594	98	2,022	185	3734	472	3734
4	73	570	64	515	65	534	72	582	106	2,253	108	2,327	234	5534	539	19664
5	54	191	73	570	55	189	81	677	110	2,534	108	2,327	323	9944	215	5084
6	52	184	87	737	55	196	180	3,449	108	2,260	113	2,379	305	9134	458	16019
7	48	160	68	555	65	521	78	647	113	2,379	87	1,747	268	3960	567	20924
8	50	170	78	647	51	182	69	561	98	2,022	88	1,851	302	8999	477	16874
9	54	191	180	3449	63	501	78	647	108	2,327	128	2,736	235	5984	540	19709
10	54	191	72	582	62	226	64	515	108	2,327	101	1,277	317	9674	496	14220
11	53	184	72	582	63	591	78	647	113	2,379	118	1,935	256	6929	543	16335
12	62	491	78	647	51	315	73	570	87	1,747	175	3,516	206	4679	489	17414.00
YEB (Rs)	**3,187.12**		**9,751.20**		**4,964.25**		**9,479.25**		**26,582.50**		**26,757.00**		**80,0089.00**		**181,835.00**	
Avg. kWh	**55.50**		**82.25**		**61.75**		**82.33**		**102.67**		**112.08**		**259.08**		**173.75**	
AMC(Rs)	**265.59**		**812.60**		**413.69**		**789.94**		**2,215.21**		**2,229.75**		**6674.08**		**15,152.00**	

YEB(Rs) -Total annual electricity bill; Avg. kWh- Average monthly consumption; AMC (Rs) –Average monthly electricity bill

A cost recovery analysis model was developed to evaluate the profitability and the time taken to recover the initial/installation cost of the solar power panels using Microsoft Excel. The values derived were then used for the cost recovery analysis calculations pertaining to annual electricity consumption. Table 3 presents the average prices of the essential components of solar-PV panels: solar panels, charger controller, and inverter.

Table 3: Average Selling Prices of the Essential Components of Solar-PV Panels, of Seven Randomly Selected Suppliers

		Supplier prices											
		Solar panel				Charger controller (MPPT*)				Inverter			
Supplier		kWh	Brand	$	Rs.	A	Brand	$	Rs.	V	kWh	$	Rs.
	1	100	Brand S1	107	16,589	70	Brand CC1	153	23,705	230	Brand In1	259	40,156
	2	320	Brand S2	95	14,729	60	Brand CC2	269	41,826	220	Brand In2	440	68,219
	3	100	Brand S3	57	8,837	40	Brand CC3	113	17,520	220	Brand In3	155	24,025
	4	250	Brand S4	89	13,799	60	Brand CC4	261	40,311	220	Brand In4	199	30,853
	5	300	Brand S5	108	16,744	30	Brand CC5	262	40,500	220	Brand In5	91	14,186
	6	325	Brand S6	130	20,155	30	Brand CC6	156	23,415	220	Brand In6	202	31,319
	7	300	Brand S7	150	23,256	40	Brand CC7	95	14,729	220	Brand In7	50	7,752
Avg.					**16,301**				**28,858**				**30,830**

Since the average lifetime of a conventional solar panel is 25 years, the assessment done was for a period of 25 years. The average monthly electricity bill was computed using the electricity bills of twelve consecutive months. The value obtained was used to compute its net present values of each year for a period of 25 years for cost recovery analysis using Microsoft Excel. The average monthly consumption from the conventional system was then used to identify the number of panels required, the total cost of the panels, and the initial cost of the solar panels including the costs of batteries, charger controller and converter.

The consumption (kWh) was discounted for 25 years. Each value was separately discounted at 8%, 10%, 12% and 14% based the average deposit rates offered in Sri Lanka during the period 2011 - 2017. Table 4 presents the Key economic indicators for the Deposit rates during 20111 to 2017(CBR Sri Lanka-KEI.pdf- PART-1)

Table 4: Key Economic Indicators - Deposit Rates - (CBR Sri Lanka-KEI.pdf- PART-1)

Deposit rates	2011	2012	2013	2014	2015	2016	2017(a)
Commercial Bank Average Weighted Deposit Rate (AWDR)	7.24	10.10	9.37	6.20	6.20	8.17	9.07
Commercial Banks Average Weighted Fixed Deposit Rate (AWFDR)	8.95	13.21	11.78	7.33	7.57	10.46	11.48
NSB Saving Account Rate	5.00	5.00	5.00	5.00	5.00	4.25	4.00
NSB 12 month Fixed Deposit Rate	8.50	12.50	9.50	6.50	7.25	11.00	11.00

Based on the figures given above, the discount rate was taken as ranging from 8% - 14%, and these rates were used to identify the recovery period of solar power panel installations. If the present value for a particular year is negative for the rates considered (8%, 10%, 12& 14%), the investment in solar panel for that year will not be beneficial considering the internal rate of return.

4. DATA ANALYSIS AND FINDINGS

Table 5 presents a sample of the MS Excel model developed based on the findings of the cost-benefit analysis of the data obtained from the eight samples. Accordingly, the initial Recovery period for the initial cost of Solar-PV Panels was identified for each of the case.

Table 5: Recovery period of the initial cost of Solar-PV Panels

(Sample Case 08: Average monthly consumption: 173.75 Wh)

Avg. monthly consumption (Wh)	**173.75**				
Cost of the solar panel (Rs)	**16,301.00**				
Number of panels	**2**				
Total cost of the panels (Rs)	**32,602.00**				
Cost of batteries (Rs)	**10,000.00**				
Cost of charger controller (Rs)	**13129.00**				
Cost of charger converter (Rs)	**28716.00**				
Cost of installation (Rs)	**0.00**				
Total cost (Solar)	**114,447.00**				
1	114,447.00	105,969.44	104042.73	95,372.50	81747.86
2	114,447.00	98,119.86	94,584.30	91,236.45	88,063.25
3	114,447.00	90,851.72	85,985.73	81,461.11	77,248.47
Total cost for a conventional system					
	Total initial cost of a conventional system based on the yearly electricity bill (discounted for cumulative savings)				
	Discount rates				
No. of years	**-**	**8%**	**10%**	**12%**	**14%**
1	34,278.48	31,739.33	31,162.25	28,565.40	30,068.84
2	68,556.96	90,515.88	87,820.90	83,218.59	82,821.20
3	102,835.44	172,149.96	165,082.69	156,414.82	152,232.19
4	137,113.92	272,932.79	258,733.34	243,553.20	233,414.64
5	171,392.40	389,579.58	365,154.54	340,805.85	322,430.48
6	205,670.88	519,187.12	481,250.39	445,005.12	416,131.37
7	239,949.36	659,195.26	604,382.35	553,546.02	512,024.09
8	274,227.84	807,352.03	732,311.66	664,302.05	608,157.14
9	308,506.32	961,682.00	863,148.45	775,552.52	703,025.28
10	342,784.80	1120457.70	995,306.83	885,920.05	795,489.36
11	377,063.28	1,282,173.67	1142321.36	994,316.73	884,709.08
12	411,341.76	1,445,523.14	1,273,387.52	1099,897.92	970,086.81
13	445,620.24	1,609,376.78	1,402,467.83	1,202,022.58	1,051,220.61
14	479,898.72	1,772,763.59	1,528,840.16	1,300,219.36	1,127,865.23
15	514,177.20	1,934,853.69	1,651,930.10	1,394,157.61	1,199,899.65
16	548,455.68	2,094,942.68	1,771,290.03	1,483,622.62	1,267,300.27
17	582,734.20	2,252,437.63	1,886,580.88	1,568,494.55	1,330,118.84
18	617,012.60	2,406,844.44	1,997,556.03	1,648,730.62	1,388,464.25
19	651,291.10	2,557,756.45	2,104,047.33	1,733,424.25	1,442,487.79
20	685,569.60	2,704,844.18	2,196,688.74	1,813,023.53	1,480,871.31
21	719,848.10	2,847,846.14	2,293,962.22	1,887,647.85	1,526,816.38
22	754,126.60	2,986,560.56	2,386,603.63	1,957,449.51	1,569,038.26
23	788,405.00	3,120,837.99	2,474,651.26	2,015,624.31	1,607,758.48
24	822,683.50	3,250,574.63	2,558,174.69	2,065,849.75	1,643,200.33
25	856,962.00	3,375,706.43	2,637,268.85	2,116,259.09	1,675,585.06

With no discount, the investment in solar panels will be profitable only after the 3rd year (with the cumulative savings as added to the capital for each year). For discount rates of 8% 10% 12%, and 14%, the investment (with cumulative savings) will be profitable after the 3rd year which means that the investment will bring in positive cash flows only after the 3rd year.

Table 6 presents the recovery period calculated over internal rate of return for 25 years. (MEB-Monthly Electricity Bill (Rs.), YEB-Yearly Electricity Bill (Rs.).

Table 6: Recovery Period over Internal Rate of Return (8%, 10%, 12%, 14%) for 25 Years

Case	Average monthly consumption-(Avg) kWh	Monthly electricity bill (MEB)(LKR)	Annual electricity bill (Avg.)YEB (LKR)	Recovery Period (within 25 years) (Years)				
				No discount	8%	10%	12%	14%
1	55.50	265.59	3187.12	Not recovered	10.0	10.0	10.0	9.0
2	61.80	413.69	4964.28	Not recovered	8.0	8.0	8.0	8.0
3	82.25	812.60	9,751.20	Not recovered	16.0	15.0	15.0	14.0
4	82.30	812.60	9,751.20	Not recovered	16.0	15.0	15.0	14.0
5	102.7	2,215.21	26,582.52	8.0	7.0	4.0	4.0	4.0
6	112.1	2,229.75	26,757.00	8.0	4.0	4.0	4.0	4.0
7	149.2	3,063.33	36,759.96	6.0	3.0	3.0	3.0	3.0
8	173.8	2,856.54	34,278.48	7.0	3.0	3.0	3.0	3.0

The model developed was adopted to identify the period of recovery within a period of 25 years, which is the expected life span of solar PV panels, of the investments made in solar panels by the consumers.

The results show that even though the difficulty in recovering the initial cost is considered as a major constraint for moving towards a green energy economy, residential buildings with high electricity consumption have a higher potential for recovering the high initial cost of installation within a relatively short period of time. Therefore, residential buildings with high electricity consumption are recommended for installing solar PV panels because of the profitability.

5. CONCLUSIONS AND RECOMMENDATIONS

The study proves that in comparison to other users, domestic users with high electricity consumption are capable of recovering within a short period, the relatively high initial costs of solar PV installations. Therefore, for households with high electricity consumption in a country like Sri Lanka which has a tropical climate with the solar radiation on clear sky days fluctuating from 5.5 to 6.5 kWh/m^2/day, solar PV panels can be highly recommended. The study further recommends investments in solar PV panels as they are quite profitable due to their low operational and maintenance costs, a result of not requiring fuel for their operations.

Furthermore, in order to be a partner in the global pursuit of low carbon economies producing minimal amounts of GHG emissions, it is recommended that the Government provides tariff reductions and tax incentives for solar PV investors especially to those who are engaged in supplying solar PV systems for domestic consumers with mid and low electricity consumptions who will need a long time to recover the high initial cost of such systems.

Accordingly, a policy decision on low-carbon energy concepts, renewable energy, and energy efficiency strategies focussing on a sustainable energy based economy which would be environmentally friendly and effective for 20 -50 years will have to be made. Use of renewable energy has to be encouraged, any subsidies provided for fossil fuel imports have to be removed and strategies to bring in changes in the attitudes of the general public have to be introduced, all with a view to boost a zero carbon based society. Special attention has to be given to break the market monopoly of carbon based fuel. Lifestyle changes, technological developments, GHG emission reductions and carbon emission reductions should be promoted with specific timeframes and milestones in the move towards a low carbon society with the goal of achieving 'green growth'.

Low carbon economic policies introducing reduced tariffs on the use of clean energy will encourage private parties to invest in clean energy sources such as solar PV with a business model emphasis.

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