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ENERGY POVERTY AND DEVELOPMENT OF SOLAR POWER AS A SUSTAINABLE ENERGY SOURCE: A STUDY BASED ON CUSTOMER PERSPECTIVES OF SRI LANKA

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ABSTRACT

Lack of opportunities to access energy services and products, deficiency of electricity to assist the socio-economic development, incompetency to reach quality standards in domestic energy services like cooking, space heating and cooling, use appliances and IT-related material. On the other side, sustainable development can be described as the capacity to withstand natural systems in order to deliver the resources and ecosystem services that are essential to the economy and society. Since energy crisis in Sri Lanka is getting worst, people are experiencing a deficiency of hydroelectricity and natural gas daily. Hence, Sri Lanka should look for alternative energy sources to sustain the economy. Out of many energy sources, the researcher identified solar energy as the best source to produce electricity need of the country. Therefore, this can be considered a topic worth rigorous investigation.

The existing literature reveals a deficiency in theoretical and empirical knowledge on the usage of solar power as a sustainable energy. Therefore, the researcher aims to design a sound framework to develop solar power as sustainable energy source in Sri Lanka. To do that, the researcher introduced four objectives for this research.

Having identified variables thrugh literature survey, a theoretical framework was developed indicating the relationships between variables. Theoretical framework was then operationalized associating relevant dimensions. As this research follows positivist and deductive approaches, Likert Scale will be used to formulate questionnaire to collect data quantitatively.

Key Words: Energy Poverty, Renewable Energy, Solar Power, Sustainable Energy Source

INTRODUCTION

Energy poverty can be defined as a dearth of opportunities to access sustainable energy services and products (Habitat for Humanity, 2021). Berry (2018) states that in daily life, energy provides many services for people like heating, lighting, food preparation, air conditioning, and refrigerating, etc. However, in the presence of energy poverty, many households find it difficult to obtain these services at their convenience. Moreover, some energy policies encourage authorities to raise electricity tariffs which often weakens the general public's ability to use electricity as they wish (Parry et al., 2005; Fullerton, 2008). In addition, energy poverty can be observed in all circumstances where there is a shortage of reasonably priced, trustworthy, quality, safe, and ecologically sound energy services. Low-income people often find it difficult to afford high energy costs, therefore they opt to live in houses with low energy efficiency. Though Sri Lanka is said to be one of the countries that met 100% grid electricity, many cannot afford it due to the high cost of electricity, vulnerability to energy insecurity and low reliability (Kumarawadu, 2018). It is a fact that Sri Lanka first used solar photovoltaic (PV) technology in 1970 to electrify the population in dark, however, the usage of solar power in Sri Lanka is yet in the primitive age. Up until the Sri Lankan Electricity Board established the Energy Unit in 1980, the Sri Lankan government had not ventured to promote solar photovoltaics to electrify rural domestics (Gunaratne, 1994). Despite the governments' aim to enhance the use of solar PV to reduce energy poverty, there is relatively less intent in the Sri Lankan community to use solar PV to meet the impending energy crisis in the world (Obeng et al., 2008).

PROBLEM STATEMENT

As per existing statistics, solar power can produce 32% of Sri Lanka's annual power demand that is approximately about 10,500 gigawatts, however, thus far 0.01% of that capacity has been produced, as per the Sri Lanka energy sector development plan for 2015-2025 (Perera, 2016). Being aware of the impending power crisis in the world, it is surprising to witness the the reaction of the Government of Sri Lanka (GoSL) in this regard. Hydroelectricity power crisis generally occurs when there is a shortage of rain that leads to low levels of water in the hydro dams. Having experienced that, the Public Utilities Commission of Sri Lanka (PUCSL) has taken an initiative to turn off the national grid to preserve power for essential services.

While reviewing the literature, it was realized that Sri Lanka has become a country that sufficiently reached 100% hydroelectricity a few years before. However, due to power shedding for over five years on a daily basis and high per-unit electricity cost, many people struggle to use electricity as they wish. Therefore, many use electricity with care or light only one bulb during night. Some others use kerosene oil to light up their houses as they cannot afford high electricity costs. Recently, the price of kerosene oil in Sri Lanka has increased from Rs. 87/- to Rs. 340/-, which is an increment by 391% (Nilar, 2022). Hence, the researcher is of the opinion that Sri Lanka should promote solar energy to generate electricity for the countrymen. Solar power is a technology that converts photons into electrons to produce direct current. With that motive, Sri Lanka has joined hands with the Asian Development Bank (ADB) to enhance the use of solar power to generate electricity for the whole country and to comply with the Paris Agreement on climate change. GoSL envisions 1000 megawatts of solar power generation capacity by 2025 using the rooftops of businesses and homes (Asian Development Bank, 2021). Given that, ADB has granted an approved for $50 million loan for Sri Lanka's Rooftop Solar Power Generation Project in 2017, however, the usage of solar power in Sri Lanka yet remains in its primitive age. In the year 2016, the GoSL launched a Rooftop Solar PV Programme named "Sooryabala Sangramaya" to generate solar power to export the excess energy to the grid at a tariff of Rs. 22/= per kWh during the first seven years and Rs. 15.50 per kWh during the remaining thirteen years (Sri Lanka Sustainable Energy Authority, 2021). But these are yet to come into reality.

As of 2022, the electricity tariff was increased dramatically for Domestic and Religious and Charitable Institutions as follows.

Table 1: Increased Tariff Applicable to Domestic, Religious and Charitable Institutions

Consumption per month (kWh)	Block	Energy Charge (LKR/kWh)	Fixed Charge (LKR/month)
Domestic Category			
Consumption 0 – 60	0 – 30	8.00	120.00
	31 – 60	10.00	240.00
Consumption above 60	0 – 60	16.00	N/A
	61 – 90	16.00	360.00
	91 – 180	50.00	960.00
	Above 180	75.00	1500.00
Optional times	Day (05.30 – 18.30)	70.00	1500.00
	Peak (18.30 – 22.30)	90.00	
	Off Peak (22.30 – 0530)	30.00	
Religious and Charitable Institutions			
Consumption	0 – 30	8.00	90.00
	31 – 90	15.00	120.00
	91 – 120	20.00	
	121 – 180	30.00	150.00

	Above 180	65.00	1500.00

Source: CEB (2022)

Moreover, three different rates were introduced to Industrial, General Purpose, Hotel, Government, Street Lighting and Agricultural Sector sectors and the same is given below.

Table 2: Tariff applicable for Industrial, General Purpose, Hotel, Government, Street Lighting and Agricultural Sector sectors

OTHER CONSUMER CATEGORIES			**Industrial**		**General Purpose / Hotel / Government**	
			IP 1-1	**IP 1-2**	**GP 1-1 / H 1-1 / GV 1-1**	**GP 1-2 / H 1-2 / GV 1-2**
Rate 1 Supply at 400/230V Contract demand <= 42kVA	Volume differentiated monthly consumption		***For ≤ 300 kWh/month***	***For > 300 kWh/month***	***For ≤ 180 kWh/month***	***For > 180 kWh/month***
	Energy Charge (Rs. /kWh)		20.00	20.00	25.00	32.00
	Fixed Charge (Rs. /Month)		960.00	1500.00	360.00	1500.00
Rate 2 Supply at 400/230V Contract demand > 42 kVA	Energy Charge (Rs. /kWh)	Day (05:30 – 18:30 hrs)	29.00			
		Peak (18:30 – 22:30 hrs)	34.50			
		Off Peak (22:30 – 05:30 hrs)	15.00			
	Demand Charge (Rs. /kVA)		1500.00			
	Fixed Charge (Rs. /Month)		4000.00			
Rate 3 Supply at 11 kV & above	Energy Charge (Rs. /kWh)	Day (05:30 – 18:30 hrs)	28.00			
		Peak (18:30 – 22:30 hrs)	34.00			
		Off Peak (22:30 – 05:30 hrs)	14.00			
	Demand Charge (Rs. /kVA)		1400.00			
	Fixed Charge (Rs. /Month)		4000.00			
STREET LIGHTING (Rs. /kWh)			22.00			
AGRICULTURE - Optional Time of Use Electricity Tariff						
			Energy Charge (Rs. /kWh)		**Fixed Charge (Rs. /Month)**	
Rate 1 Supply at 400/230V Contract demand <= 42 kVA	Day (05:30 – 18:30 hrs)		20.00		1500.00	
	Peak (18:30 – 22:30 hrs)		35.00			
	Off Peak (22:30 – 05:30 hrs)		15.00			

Source: CEB (2022)

Considering the current situation, Sri Lanka should venture into an alternative source of electricity generation and ideal option is solar power. Though initial investment is high, benefits receive in the longer run as people can use the electricity on free of charge basis while transmitting the excess energy to the national grid to earn additional incomes. By conducting this research, the researcher intends to promote solar energy in Sri Lanka with the mediation of the GoSL. This will provide a solution to the impending energy crisis in the country.

RESEARCH OBJECTIVES

- To examine the percentage of energy poverty in Sri Lanka to enhance the usage of solar power as renewable energy in Sri Lanka.

- To identify whether solar power is a viable and long-lasting solution to reduce energy poverty in Sri Lanka.
- To investigate what type of government mediation is required to enhance the usage of solar power in the country.
- To comprehend whether sustainable solar power development is achieved in Sri Lanka within a decade from now.

LITERATURE REVIEW

This literature survey is conducted by referring to books, journal articles, concept papers, past researches, and the internet of things. At the outset, the researcher trust that identifying relevant definitions and theories related to the study is significant.

Definitions Related to Energy Poverty

Accordingly, the researcher discovered the following definitions and theories related to energy poverty. Energy poverty can be defined as a lack of opportunities to access sustainable energy services and products (Habitat for Humanity, 2021). Reddy (2000) and Obeng et al. (2008) state that the deficiency of electricity to assist the socio-economic development of a country is termed energy poverty. Meanwhile, Berry (2018) states that energy poverty is the inability to achieve essential capabilities resulting directly or indirectly from insufficient access to affordable, reliable, and safe energy services. Phimister, Vera-Toscano, and Roberts (2015) illustrate two alternate measures of energy poverty as energy expenditure, and consumers' perceptions on heating their homes, paying utility bills, and housing conditions. Hills (2012) argues that energy-poor households are considered a category deprive of heating their homes adequately. Turai, Schmatzberger, and Broer (2021) show driving factors for energy poverty as the income of households, the energy efficiency of buildings and appliances, and energy markets; coupled with much weaker social systems. Okushima (2017) illustrates a multidimensional energy poverty index (MEPI) that comprises energy cost, income, and energy efficiency of housing from which energy poverty can be measured. Nussbaumer, Bazilian, and Modi (2012) indicate that the provision of modern energy services through effective policies is essential for sustainable development, and to enhance the living standards of people. Papada, and Kaliampakos (2016) state that income support measures are required to alleviate the energy poverty of households and to enhance

their living conditions. Bouzarovski (2017) points out that energy poverty takes place when a domestic is incompetent to secure a level and quality of domestic energy services like space cooling and heating, cooking, use appliances, and IT-related material.

Sattler (2016) states that worldwide, 1.4 billion people live in lack access to electricity, and 2.7 billion people depend on outdated biomass for cooking, this surely leads to an energy crisis. Similarly, González-Eguino (2015) indicates that in a few decades, the energy sector will have to encounter three major transformations related to climate change, security, supply, and energy poverty. Herington et al. (2017) state that across the world, about two-thirds of the population persist with traditional cooking practices. One of the theories to do away from this practice is to adopt social practice theory which helps them to think of adopting alternative, modern energy practices. Further Pellicer-Sifres, Simcock, and Boni (2021) argue that energy poverty can bring detrimental impacts on multiple aspects of people's well-being and life quality and this can be well studied using Nussbaum's normative theory of Central Capabilities. Moreover, energy poverty can directly harm health, emotions, affiliation, play, practical reason and senses, imagination, and thought process. Accordingly, it can be said that the lack of avenues to sustainable energy services to enhance people's well-being and life quality can be termed as energy poverty. Energy cost, income, and energy efficiency of housing are some of the key measures of energy poverty. Hence a multi-dimensional approach from the highest possible authority is required to motivate people to acquire solar energy to meet the energy crisis in the future.

Definitions and Theories Related to Solar Power

Warnecke & Houndonougbo (2016) point out that one of the good strategies to battle against energy poverty is solar power as which can light the darkness. Meanwhile, Gunaratne (1994) states that without a proper evaluation of the current solar PV electrification projects, governments cannot reap the full benefits of solar power to reduce energy poverty. Gillard, Snell, and Bevan (2017) show that in the face of rising energy costs, poor households are unable to afford solar power as renewable energy considering the high capital cost to avert energy poverty. Perera (2016) states that the Sri Lankan government is planning to light 100,000 homes with solar panels to convert them into power producers for the national grid. This may not be a lucrative move for many as the initial expenditure to get this installed is a

little high. Renewable Energy Sources (RES) are often produced from natural resources and they do not diminish as Non-Renewable Sources (NRES). Therefore, the world is now encountering difficulties in using NRES since they are severely declining with the upsurge of the world population and the enhancement of their basic needs. Hence, the world has to move towards RES like solar power to light up their homes/workplaces/industries.

At this point, it is important to learn how solar cells work. Often light contains small 'parcels' or 'packets' of energy named photons and when photons shine on a solar cell, they are captivated by the cell. Then cell starts releasing electrons if the photons have sufficient energy. Then these electrons go in wires and travel around an electrical circuit in the form of a direct current (DC) which travels only in one direction. If the light is more powerful, more electrons will be released to make the electrical current bigger, but the voltage of the cell will stand the same (STELR, 2021). The photovoltaic effect is the theory behind solar cell that converts light into electricity. The photovoltaic effect is a method that happens in some semiconducting materials which absorb a photon, which will then be extracted into an electrical circuit by built-in and applied electric fields. Electron energy levels are often divided into two bands: the valence band (comprises the main occupied electron energy levels) and the conduction band

(comprises the lowest unoccupied electron energy levels). The energy variance between the top of the valence band and the bottom of the conduction band is named the bandgap. No bandgap can be found in a conductor, as the valence band is not filled and that allows the free movement of electrons through the material (Duffie and Beckman, 2013).

Government Mediation

A program named "battle for solar energy" was launched by the government of Sri Lanka aiming to fulfill 10% of the country's daily electricity demand or 220 megawatts to the national grid by 2020, however, that was not achieved to date (Perera, 2016). Moreover, there is another plan to add 1,000 megawatts of solar power to the grid to meet fast-growing power needs. Sri Lanka will stop building coal-fired power plants and double the share of its electricity from renewables by 2030, according to the government's latest climate plan. Moreover, the GoSL has a plan to generate 70% of the island's electricity from renewables by 2030 by offering loans to set up rooftop solar (Lo, 2021). As the initial cost or investment to get solar power installed to

remain high, a government mediation to promote this is highly essential. Moreover, wide publicity also has to be given to make the general public aware of the need to switch from hydroelectricity to solar electricity to face the impending energy crisis in the future.

Towards the Sustainable Solar Power Development in Sri Lanka

The government of Sri Lanka is having a plan to implement solar energy schemes across industrial parks and big scale roofs and households to reduce the current electricity cost. Moreover, the GoSL has to make the people aware of the solar power buy-back scheme to get them to know the additional revenue that they can get from it (Asian Development Bank, 2021). To have sustainable solar power development, the GoSL has already established an authority named Sri Lanka Sustainable Energy Authority to drive Sri Lanka towards a new level by enhancing indigenous energy and increasing energy efficiency and energy saving within the country. One of the main aims of the Authority is to recognize, measure, and develop renewable energy resources to increase energy security to reap economic and social benefits to the country.

RESEARCH METHODOLOGY AND RESEARCH DESIGN

Philosophy – Pragmatism

Research can be divided into four philosophies; positivism, realism, interpretivism, and pragmatism (Mahesh, 2020). Sekaran & Bougie (2016) state that positivist attempt to view the world, science, and scientific research to get at the truth as they trust that there is an objective truth that exists to comprehend the world correctly so that the researchers can forecast and regulate it. Positivists often believe that there is a cause-and-effect relationship exists for everything so the scientific approach suits to study them (Pierre, 2017). Positivists believe that the reliability of observations is the key to generalizing the findings. Often they put forward deductive reasoning to test theories using a fixed, preset research design and objective measures. The main approach of positivist scholars is the experiment, which facilitates them to test cause and effect relationships through manipulation and observation. Therefore, positivists conclude that describing phenomena using emotions, feelings, and thoughts is impossible (Sekaran & Bougie, 2016).

Realism is the second research philosophy that trusts that reality should be independent of the human mind. It hypothesizes that the scientific approach is the best way to explore knowledge, hence it is divided into two; direct realism and critical realism. Direct realism is called naive realism and that trusts that "what you see is what you get" (Saunders, Lewis, and Thornhill, 2012). Those who believe in direct realism use human senses to see the world. On the other hand, Novikov and Novikov (2013) state that human beings experience the sensations and images of the real world as deceptive and not as they see.

Researchers who count on interpretivism interpret elements of the study through social constructions like language, shared meanings, consciousness, and instruments (Myers, 2008; Collins, 2010). They often criticize the philosophy of positivism and they extensively believe in quantitative analysis. This facilitates researchers to identify variances of people using multiple methods.

Mahesh (2020) states that pragmatism follows a mixed-method (quantitative and qualitative). It is also known as a problem-oriented philosophy that assists researchers to answer research questions effectively by evaluating vivid aspects of a research problem (Creswell and Creswell, 2017).

Since the researcher intends to conduct this research by incorporating both quantitative and qualitative data, the researcher adopts pragmatism philosophy in this research.

Research Approach – Deductive

The purpose of this study is to determine the ways and means of motivating customers for enhanced use of solar power as renewable energy to face the impending energy crisis, the researcher adopts a deductive approach to explore identified theories or phenomenons and tests if that theory is valid in given circumstances (Sekaran & Bougie, 2016). By employing a deductive approach, a researcher tests the variables of this research based on existing theories (Bruce, 2003). That is exactly what the researcher attempts to do in this research.

Methodological Choice – Quantitative

In this research, the researcher intends collecting data using quantitative research techniques (Sekaran & Bougie, 2016). Statistical tools like Mean,

Standard Deviation, Pearson correlation, P Value and ANOVA will be utilized in analyzing the data (Watson, 2015).

Research Strategy - Survey

In the survey method, a researcher attempts to find answers by raising questions in the form of statements to get their level of understandings and satisfaction. Later the collected data is analyzed from that particular sample of individuals (AESA, 2021). Since the main objective of this research is to determine the ways and means of motivating customers for enhanced use of solar power as renewable energy to face the impending energy crisis, the researcher adopts the survey method in this research.

Time Horizon – Cross-sectional

Research can be divided into two types based on time; longitudinal (succeeding independent samples) and cross-sectional (Bell et al., 2022). In the longitudinal study, the researcher studies a phenomenon or a population over some time (Caruana et al., 2015; Hastorf, 1997). In the cross-sectional study, the researcher takes a 'snap-shot' of the study; it refers to a phenomenon or a cross-section of the population is examined for one time (Setia, 2016). Due to time limitations, the researcher adopts cross-sectional time series in this study.

Data Collection and Analysis

In this study, the researcher adopts a questionnaire survey and interview methods to collect data. The researcher further intends to collect data from approximately 300 households by adopting a stratified sampling technique and to conduct structured interviews with almost all the solar power agents in the country. The data then will be analyzed establishing validity, reliability, and factor analysis.

THEORETICAL FRAMEWORK

This research follows a quantitative and qualitative method, therefore the deductive method is used to emphasize scientific principles or theories, explain a causal relationship between variables, gather quantitative data, employ a methodical approach, operationalize concepts to guarantee clarity of definitions (Warnakulasuriya, 2021). Moreover, the researcher will be developing research questions based on selected theories and then design a

research strategy to test their validity and reliability. Therefore, this research follows a mixed-method through a deductive approach. Accordingly, the theoretical framework of this research is formulated as follows.

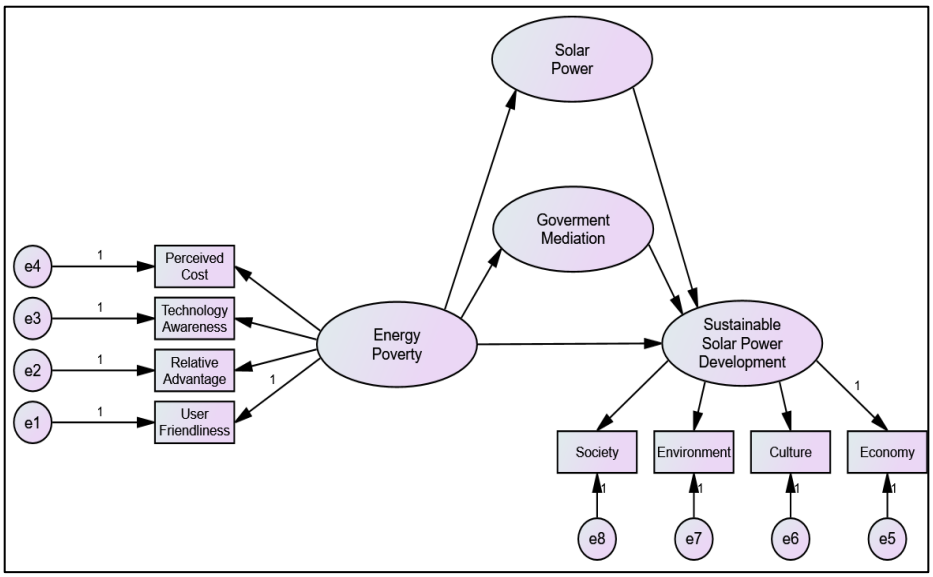

Figure 1: Conceptual Framework

Source: Constructed by the Researcher

Operationalizing the Variables

The operationalization of the variables is as follows.

Table 3: Operationalization Table

Variable	Type	Dimensions	Indicators	Measurement criteria	Literature
Energy poverty	IV	Perceived cost	• Direct price	**1 - 5 SD - SA**	Shah Alam et al. (2014)
			• Non-price cost elements		
			• Purchase intention		Kim et al. (2014)
			• Consumer behaviour		

			• Maintenance cost		
		Technology trend awareness	• On types of renewable energy		
			• On Solar technology		
			• Difficulties in operating solar energy		
			• Adoptability		
			• Long-term benefits		
		Relative advantage	• Environmental benefits		
			• Reduction of air pollution		
			• Decrease carbon footprint		
			• Cost benefits over time		
			• Increased competitive advantage		
		User-friendliness	• Clean and simple		
			• Operability		
			• Risk aversion		

			• Ease of installation		
			• Quick learning		
Solar Power	MV	Requirement	• For what purpose		
		Dimension	• Length		
			• Width		
		Power	• For domestic use		
			• For commercial use		
			• For business purposes		
		Weight	• Number of cells and weight		
		Installation	• Roof or land		
			• Purpose		
Government mediation	MV	Capacity	• Development of Solar Parks		
			• Development of Ultra Mega Solar Power Projects		
		Funding	• Full or partial		
			• Loan schemes through		

			government and private banks		
		Awareness	• Through media		
			• Workshops		
			• Social media		
Sustainable solar power development	DV	Society	• Clean and pure energy from the Sun		
			• Combat greenhouse gas emissions		
			• Reduces collective dependence on fossil fuel.		
			• Coal and natural gas plants produce air and water pollution that is harmful to human health		
		Environment	• Limit greenhouse gas emissions from fossil		
			• Reduce the demand for fossil fuels, limit greenhouse gas emissions, and		

			shrink your carbon footprint.		
			• Solution for global temperatures and climate change.		
			• Reduce water usage		
			• Reduce air pollution		
			• Reduces dependence on nonrenewable energy sources		
			• Improves humanity's health in the long-run		
		Culture	• Getting used to clean culture		
			• Preserve cultural heritage		
			• Create a new technological culture		
		Economy	• Lower utility bills		
			• Can offset electricity usage		
			• Job creation		

			• Diverse uses		
			• Powering new generation		
			• Help eliminate poverty		

Source: Researcher's work

FINDINGS AND DISCUSSION

Findings will be discussed in the following manner.

a. The level of energy poverty in Sri Lanka will be identified through literature review to make the Sri Lankan community aware on varying benefits of Solar Power.
b. The dimensions of all veriables (independent, mediate and dependent) will be measured sufficiently to discuss the advantages and disadvantages.
c. The level of government mediation that requires to promote solar power in Sri Lanka will be discussed in length.
d. The significance of developing solar power as a sustainable energy source will be discussed to identify ways to mitigate energy crisis in Sri Lanka.

SIGNIFICANCE OF THE STUDY

Solar power as a renewable energy source is extensively used by many developed nations to fulfill their energy needs. It is a known fact that hydropower is becoming a scarce resource shortly. To bridge that gap, solar power seems to be an ideal solution. However, the usage of solar power in Sri Lanka is still in its primitive age. Therefore, this research will help authorities to identify the means of enhancing the use of solar power in Sri Lanka which facilitates the users to earn an additional income while zeroing their electricity bills. Since the initial investment is high and lack of awareness of the benefits of solar power Sri Lankan community is yet reluctant in investing in solar power. For this, the mediation of the GoSL is highly necessary to promote and set up more and more solar panels in the rooftops of households and businesses. In that sense, this is a timely study to drive the country in a new direction.

LIMITATIONS OF THE STUDY

The limitations of this study are as follows.

a. The lack of previous studies highlighting the importance of adopting solar power in Sri Lanka is considered a limitation. There are many scholarly articles written on solar power and its benefits to the world, but they cannot be rightly applied to the Sri Lankan context. Hence, the collection of literature was found as a major limitation.
b. The reluctance of obtaining sensitive information from the ministry and the CEB is one of the major limitations as they do not like to highlight their inefficiencies in implementing scheduled programs to enhance solar power in Sri Lanka.
c. Since the researcher is employed, the researcher had to resort to assistance from his friends in collecting data from necessary ministries and other government and non-government agencies. However, the researcher will take his best efforts to discover the true picture of this study.

CONCLUSION

This research was undertaken to determine the ways and means of motivating customers for enhanced use of solar power as renewable energy to face the impending energy crisis. Having identified the research gap through a literature survey, the researcher constructed the conceptual framework and operationalize the same incorporating the essential dimensions. Since the researcher intends to use a structured questionnaire along with interviews and focused group discussions, the researcher adopts a quantitative method in this study. As the researcher uses existing theories in this study, intends to follow positivist and deductive approaches. The data will be analyzed through SPSS and AMOS software using all statistical techniques. The findings of this research will be helpful for sustainable energy development authorities to enhance the usage of solar power as a renewable energy source to meet the impending energy crisis in the future.

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