YANGON UNIVERSITY OF ECONOMICS

DEPARTMENT OF ECONOMICS

MASTER OF ECONOMICS

A STUDY ON SOLAR ENERGY UTILIZATION OF RURAL HOUSEHOLDS IN AYEYARWADDY REGION

(Case Study In Bogale Township, Ayeyarwaddy Region)

YU YU THU

NOVEMBER, 2023

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A thesis submitted as a partial fulfillment towards the requirement of the degree of Master of Economics, MEcon (Economics)

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This is to certify that this thesis is entitled " A Study on Solar Energy Utilization of Rural Households in Ayeyarwaddy Region (Case Study in Bogale Township)" summited as a partial fulfillment towards the requirement for the degree of Master of Economics, has been accepted by the Board of Examiners.

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ABSTRACT

This study is to explore the utilization of solar energy and to analyze the impact of using solar energy in rural household, Bogale Township, Ayeyarwaddy Region which are not available electricity. A total of 150 respondents who start using solar energy during 2022-2023 was interviewed by using questionnaires to examine the current utilization of solar energy and its effect on socio-economics of household. It was found that the using solar home system has great impact on household quality of life, living standard and household income generating activities. Using on solar home system by the rural community is great support on the wellbeing life of rural community; especially on schooling children, reducing on family expense for lighting purpose, access to use model electrical equipment, extending extra working hours, information dissemination and receiving and general knowledge improving which related with health and fire prevention. Examining factors such as adoption rates, socio-economic impact, and challenges faced by residents, the research aims to provide insights into the effectiveness and potential improvements in promoting solar energy in this specific context.

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I would like to acknowledge the officers and staffs of Department of Rural Development in Bogale Township, Ayeyarwaddy Region for providing the necessary data and information. Furthermore, my sincere thanks to the respondents people and village administrators and teachers who helped and collected my survey from the Phoe Nyo village and Manage Gyi village. I am also special thanks to all my respondents for their contribution, patience to answer my questions and who gave their valuable input and present condition on utilization of solar home system at village level.

Finally, I would like to express my special gratitude and thanks to my parents, my brothers and sisters who were always supporting and encouraging me with their best wishes and all of the people who contributed in various ways, sharing knowledge, experiences and giving input within this study.

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LIST OFABBREVIATIONS

AC	- Alternative Current
ADB	- Asian Development Bank
ASEAN	- Association of Southeast Asian Nations
CPV	- Concentrated Photovoltaic
CSP	- Concentrated Solar Power
DC	- Direct Current
DRD	- Department of Rural Development
EPA	- Environmental Protection Agency
EPC	- Electric Power Corporation
ESE	- Electricity Supply Enterprise
GNESD	- Global Network on Energy for Sustainable Development
GW	- Gigawatt
GWh	- Gigawatt hours
ICT	- Information and Communication Technology
IDA	- International Development Association
km^2	- kilometer square
kV	- kilovolt
kW	- kilowatt
kWh	- kilowatt hour
LED	- Light Emitting Diode
LV	- Low Voltage
MLFRD	- Ministry of Livestock, Fisheries and Rural Development
MOEE	- Ministry of Electricity and Energy
MOEP	- Ministry of Electrical Power
MV	- Medium Voltage
MW	- Megawatt
NEP	- National Electrification Project
RE	- Rural Electrification

SHS	- Solar Home System
Solar PV	- Solar Photovoltaic
UN	- United Nations
UNCED	- United Nations Conference on Environmental Development
UNDP	- United Nations Development Program
WBG	- World Bank Group
WSSD	- World Summit on Sustainable Development

CHAPTER I
INTRODUCTION

1.1 Rationale of the Study

Energy is one of the most important and basic sources of sustainable development for human being. There are three types of energy sources, one is non-renewable energy and the rest is renewable energy, clean energy. Human being is using various types of energy sources as fossil fuel, coal, biodiesel, gas, water, wind, sunlight, energy from wastes and nuclear powers for various multiple purposes. Among the all types of energy sources, major energy source is still fossil fuel, its reverse is declining and it emits greenhouse gases and effect on climate changes, natural disaster and global warming. Under change perspective, the renewable energy especially on solar energy is becoming popular because it contributes to global climate change and carbon trading prospect.

Electricity is a form of energy. Any types of energy can be changed into electricity which tools or machines. Electricity is one of the basic needs for development of a country and promoting living standards. Electricity is an essential part of our human society.

Energy utilization in Myanmar mainly depends upon traditional energy such as Fuel wood, Charcoal and Biomass.Electricity is not available to many communities in Myanmar because the large capital investment required for the traditional electrical infrastructure has in area.

Solar energy is one of the unlimited natural resources for mankind. Solar energy derived from the sun can be used anywhere by any forms, reasonable price and especially is not affected the natural environment. The energy supply and utilization is relatedly linked between social economic development of a country. Rural electrification from solar energy in particular helps the development of country in various ways.

Solar energy is widely perceived broader in various sectors such as household uses, businesses, agriculture, irrigation, health and education. Solar energy as a renewable energy is considered as an important alternative options for rural because far away from national grids and isolated. Solar energy can offer electricity for free, no maintenance, no air pollution and collected prices. This study mainly focuses on use of solar energy and its impact on the rural areas which are not available electricity.

This study among with its predominantly rural landscape, presents a unique context for studying solar energy utilization among households. As the demand for energy continues to rise, exploring sustainable alternatives becomes imperative. Rural households often face challenges in accessing conventional energy sources. Investigating solar energy adoption can shed light on bridging this gap and improving energy equity. Solar energy aligns with global efforts towards sustainability. Understanding its utilization in Ayeyarwaddy Region can provide insights into reducing environmental impact and fostering eco-friendly practices.

Solar energy can contribute to economic empowerment by reducing reliance on costly and non-renewable energy sources. Examining its economic implications for rural households is crucial for informed policy decisions. Assessing the factors influencing the adoption of solar technology in rural settings can inform strategies to promote its acceptance, facilitating a transition towards cleaner energy. This study aims to explore how solar energy utilization correlates with overall community development in the Ayeyarwaddy Region, considering factors such as improved healthcare, education, and local economic activities.

This study problem in Bogale Township's distinct socio-economic and geographical characteristics warrant a focused study on solar energy adoption. By tailoring our study to this specific locale, to provide insights that can be directly applied to similar regions facing comparable challenges. Many rural households in Bogale Township encounter difficulties in accessing conventional energy sources. Investigating the role of solar energy can offer practical solutions to enhance energy accessibility, addressing a critical need within the community.

Ayeyarwaddy Region is susceptible to climate-related challenges. Analyzing how solar energy contributes to the resilience of households in Bogale Township against climate change impacts forms a key aspect of this study. Understanding the community's perception and involvement in solar energy initiatives is crucial. This

study aims to unravel the social dynamics influencing the acceptance and sustainability of solar technologies within Bogale Township. This study can inform local and regional policies aimed at promoting renewable energy adoption. To the specific context of Bogale Township ensures relevance and effectiveness in addressing energy challenges.

This case study seeks to unravel the intricate relationship between rural households in Bogale Township and solar energy utilization, contributing valuable insights to both local development strategies and broader renewable energy initiatives in the Ayeyarwaddy Region.

1.2 Objective of the Study

The objectives of this paper are:

(i) to access the current situation of solar home system utilization in rural area in Bogale Township, Ayeyarwady Region.

(ii) to identify challenges and opportunities for soalr energy adoption and the impact of using solar energy in rural areas.

1.3 Method of Study

In this study, utilization of the solar home system in Bogale Township, Ayeyarwady Region was selected to conduct survey. Primary data were collected from Bogale Township, Ayeyarwady Region by using questionnaire survey method. A total of 150 households respondents was selected as samples from two villages of Bogale Township, Ayeyarwady Region. The selected respondents are interviewed and collected the primary data and it was summarized by quantitative method and analyzed by using descriptive method to present the survey result.

Secondary data are collected from the department of rural development in Bogale Township. Information on renewable energy, non-renewable energy, solar energy and some data are collected from journals, articles, news and internet website.

1.4 Scope and Limitations of the Study

This study focused on two village tracts of two villages were selected of total village tracts 76 village tracts and 575 villages in Bogale Township such as Phoe Nyo Village, Mangae Gyi Village. The scope of the period of 2014 to 2020, which are not available to use electricity in rural villages in Bogale Township, Ayeyarwady Region.

1.5 Organization of the Study

This study is organized into five chapters. Chapter I presents an introduction, objective of the study, scope and limitation of the study. Chapter II is described about Literature Review. Chapter III is highlight the current situation of solar energy using in Myanmar. Chapter IV is presented about the survey data on utilization of the solar home system by rural households, Bogale Township, Ayeyarwady Region. Chapter V is presented about finding and conculsion.

CHAPTER II
LITERATURE REVIEW

2.1 Sources of Energy

Energy is the power that is used for transportation, for heat and light in homes and for the manufacture of all kinds of products. There are three sources of energy: renewable, non-renewable energy and alternative energy. Renewable energy sources (RES) supply 14% of the total world energy demand. RES includes biomass, hydropower, geothermal, solar, wind and marine energies. The renewable are the primary, domestic and clean or inexhaustible energy resources. Large-scale hydropower supplies 20 percent of global electricity. Wind power in costal and other windy regions is promising source of energy. Renewable sources of energy can be used respectively. These resources include solar energy, wind, geothermal energy, biomass and hydropower. RESs are also called alternative energy sources. Sustainable development requires methods and tools to measure and compare the environmental impacts of human activities for various products. At present, consumption of fossil fuels is dramatically increasing along with improvements in the quality of life, industrialization of developing nations and increase of the world population. It has long been recognized that this excessive fossil fuel consumption not only leads to an increase in the rate of diminishing fossil fuel reserves, but it also has a significant adverse impact on the environment, resulting in increased health risks and the threat of global climate change. Changes towards environmental improvements are becoming more politically acceptable globally, especially in developed countries. Society is slowly moving towards seeking more sustainable production methods, waste minimization, reduced air pollution from vehicles, distributed energy generation, conservation of native forests, and reduction of greenhouse gas emissions. Excessive use of fossil fuels has caused global warming by carbon dioxide; therefore, renewable promotion of clean energy is eagerly required.

(i) Renewable Sources of Energy

Renewable energy resources will play an important role in the world's future. The energy resources have been split into three categories: fossil fuels, renewable resources and nuclear resources. Renewable energy sources are those resources which can be used to produce energy again and again, e.g. solar energy, wind energy, biomass energy, geothermal energy, etc. and are also often called alternative sources of energy. Renewable energy sources that meet domestic energy requirements have the potential to provide energy services with zero or almost zero emissions of both air pollutants and greenhouse gases. Renewable energy system development will make it possible to resolve the presently most crucial tasks like improving energy supply reliability and organic fuel economy; the standard of living and level of employment of the local population; ensuring sustainable development of the remote regions in the desert and mountain zones; implementation of the obligations of the countries with regard to fulfilling the international agreements relating to environmental protection. Development and implementations of renewable energy project in rural areas can create job opportunities and thus minimizing migration towards urban areas.

(ii) Non-renewable Sources of Energy

Most of the energy that we use comes from fossil fuel, such as coal, natural gas and petroleum. Nuclear energy (Uranium) is another non-renewable source, but it is not a kind of fossil fuel. Uranium is converted to a fuel and used in nuclear power plants. These natural resources are used up, they are gone forever. The process of gathering such fuel can be harmful to the biomass from which they come. Fossil fuel is put through a process called combustion in order to produce energy. Combustion releases pollution, such as carbon monoxide, and sulfur dioxide, which may contribute to acid rain and global warming.

(iii) Alternative Sources of Energy

Alternative sources of energy are any energy source that is an alternative to fossil fuel. These alternatives are intended to address concerns about such fossil fuel. The nature of what constitutes an alternative energy source has changed considerably over time, as have controversies regarding energy use. Today, because of the energy choices and differing goals of their advocates, defining some energy types as alternative is highly controversial. In a general sense, alternative energy as it is

currently conceived is that which is produced or recovered without the undesirable consequences inherent in fossil fuel use, particularly high carbon dioxide emissions (greenhouse gas), an important factor in global warming. Alternative energy includes bio-fuel, bio-alcohols, biodiesel, green diesel, vegetable oil, biogas and syngas.

2.2 Historical Background of Solar Energy and Solar Home System (SHS)

(i) Historical Background of Solar Energy

Solar energy has been used to the benefit of humanity for centuries; we have records from 700 BC of people using mirrors to concentrate energy from the sun using magnifying glasses in order to make fires bigger. However, the history of the modern solar cell begins in 1876, when scientist William Grylls Adams discovered that Selenium, when exposed to sunlight, produces electricity. The first instance of an attempt to harness this electricity comes in 1883, when American inventor Charles Fritts developed the first design for a photovoltaic cell using Selenium wafers. Though Fritts is credited with this design, the cell was never successfully built.

In 1905, Albert Einstein has been discovered his own knowledge to what would become the advent of solar technology, through that one could liberate electrons on a metal surface by exposing them to light. This discovery was followed by another in 1918 by Polish scientist Jan Czochralski had discovered how to grow single-crystal silicon. With this discovery, the scientific world had discovered everything necessary to develop modern solar technology.

Solar photovoltaic (PV) cells were invented by American researchers David Chapin, Calvin Fuller, and Gerald Pearson of Bell Labs in the United States in 1954, and they have been used in space satellites for electricity generation since the late 1950s. They were the first to construct a device that could turn sunlight into usable electricity. In the late 1950's and early 1960's, solar technology was deployed in space, installed on satellites in both U.S. and Soviet space programs. By the late 1960's, solar power was standard in interstellar satellites. In the early 1970's, technological developments from American Dr. Elliot Berman significantly lowered solar costs, bringing the price down from $100 per watt to around $20 per watt. In 1977, the US embraced the development of solar energy by creating the Solar Energy Research Institute. Other countries worldwide followed suit in the creation of their own solar-dedicated institutions. In 1978 the first iteration of a Feed-In-Tariff was

implemented when President Jimmy Carter signed the National Energy Act (NEA) to encourage energy efficiency and the continued development of renewables.

In 1977, the US embraced the development of solar energy by creating the Solar Energy Research Institute. Other countries worldwide followed suit in the creation of their own solar-dedicated institutions. In 1978 the first iteration of a Feed-In-Tariff was implemented when President Jimmy Carter signed the National Energy Act (NEA) to encourage energy efficiency and the continued development of renewables.

In that period, developers were built increasingly large solar energy plants, establishing solar as more than energy source. In the 1990's, the first grid-supported solar PV system was completed in Kerman, CA, as the world's first instance of "distributed generation," and Germany began setting capacity goals. Solar was becoming mains. At the 21st century, we saw continued developments in solar efficiency capabilities and governmental dedication to the growth of the industry. Governments began instituting significant financial incentives to encourage more widespread adoption of solar energy. In 2005, the U.S. passed the Energy Policy Act, introducing for the first time a 30% investment tax credit (ITC) for residential and commercial solar energy systems. This policy was extended for one year in 2006 under the Tax Relief and Health Care Act, for eight years in 2008 under the Emergency Economic Stabilization Act, and for multiple years on a declining scale system in 2015 under the Omnibus Appropriations Act, allowing a reduced iteration of this credit to apply to commercial solar energy systems indefinitely. Since the late 2000's solar has taken off to become a national phenomenon and a credible and reliable energy source. Earlier this year, the U.S. installed its millionth solar installation; a feat that took over 50 years to accomplish, and is expected to be doubled in just two more years. Solar has taken ahold of the country and the world.

(ii) Solar Home System

The direct conversion of sunlight into electricity is called photovoltaic solar energy conversion. An essential component of Photovoltaic (PV) system is the solar cell, in which the photovoltaic effect takes place. When light falls on the semiconductors of the cell, it produces a small electric current. Photovoltaic modules, or panels, consist of a number of cells connected together to provide voltages and currents high enough for practical use.

The most common in rural electrification program is the use of solar PV as stand-alone systems in households, social institutions, or places of productive or business activities. Generally, the system is referred to as 'Solar Home System' (SHS). The SHS providing load is low (below 100W), but can be sufficient for powering of lights, radios, television sets, and to refrigerate medicines at rural clinics. Even though SHS seems to be expensive at first glance, it is cost-effective in providing electricity at small scales in areas without access to grid electricity or any other renewable energy source. Its application can furthermore be reasonable where demand is characterized by very low levels or the procurement cost of fuel is very high (blunck 2000: 376, suding et. al 2004: 72). However, with rising fuel prices SHS technologies may become more cost-efficient than off-grid alternatives based on fossil fuels. SHS operate at 12 volts direct current (DC) and use efficient fluorescent or Light emitting Diode (LED) lamps and appliances to make best use of the provided power. A typical 100WP SHS can provide enough power to operate four small fluorescent lamps, and a small 15-inch television for up to five hours. However, the range of other appliances is often limited (Cabraal, 1996 as cited in Abdulla Hraun, 2015).

(iii) Solar Home System (SHS) Electrification Approach

Solar home system is highly relevant for decentralized rural electricity supply in developing countries in general. For decentralized rural electrification purposes in developing countries, the SHS is the dominant practical application of PV technology. SHSs are the most important technology for decentralized electricity generation from a renewable energy source.

2.2.1 Advantages and Disadvantage of Solar Energy

Solar energy is the conversion of the energy from the sun to usable electricity. The most common source of solar power utilizes photovoltaic cells to convert sunlight into electricity. Photovoltaic utilize a semi-conductor to absorb the radiation from the sun, when the semi-conductor absorbs this radiation it emits electrons, which are harnessed as electricity. Everything has its advantages and disadvantages, its pluses and minuses. So, naturally, there must be a number of solar energy advantages and solar energy disadvantages too. It's been a while since a list of solar energy advantages and disadvantages are following:

(i) Advantages of Solar Energy

Using solar energy has many advantages and these include following;

1. Solar energy is a resource that is not only sustainable for energy consumption; it is indefinitely renewable (at least until the sun runs out in billions of years).
2. Solar power is pollution free and causes no greenhouse gases to be emitted after installation.
3. Reduced dependence on foreign oil and fossil fuels.
4. Solar energy can be used for diverse purposes. Solar power can be used to generate electricity; it is also used in relatively simple technology to heat water (solar water heaters).
5. Low maintenance costs, solar energy systems generally don't require a lot of maintenance. Most reliable solar panel manufacturers give 20-25 years warranty. Also, as there are no moving parts, there is no wear and tear. The inverter is usually the only part that needs to change after 5-10 years because it is continuously working to convert solar energy into electricity (solar PV) and heat (solar thermal).
6. Solar energy creates absolutely no pollution. Solar cells are totally silent and non-polluting.
7. Solar energy can be used in remote areas where it is too expensive to extend the electricity power grid. Solar power panels and products are easy to install. Wires, cords and power sources are not needed at all, making this an easy prospect to employ.
8. Increase of regional/ national energy supply and faster rate of rural electrification in developing countries.

(ii) Disadvantages of Solar Energy

Disadvantages of solar energy are included;

1. No solar power at night so there is a need for a large battery bank and it is expensive.
2. Solar energy is not constant. Solar energy is an intermittent technology as it is dependent on sunlight, that it panels can generate some energy when conditions are cloudy but not at night.
3. Solar panels are not being massed produced due to lack of material and technology to lower the cost enough to be more affordable.

4. Cost, the initial cost of purchasing and installing a solar system is slightly high. This includes paying for solar panels, inverter, batteries, wires and for the installation.
5. Weather dependent, although solar energy can still be collected during cloudy and rainy days, the efficiency of the solar system drops. Solar panels are dependent on sunlight to effectively gather solar energy. Therefore, a few cloudy, rainy days can have a noticeable effect on the energy system.
6. Uses a lot of space, the more electricity wants to produce, the more solar panels will need to use. Solar panels require a lot of space and some roofs are not big enough to fit the number of solar.
7. The efficiency of solar panels is low comparative to other sources of energy. To achieve equivalent output large equipment is required.

2.2.2 Barriers of Solar Energy Development

Since the beginning of the 21st century, renewable energy has been a significant area of research amongst scientists. However, despite scientists coming up with practical and convincing technologies on renewable energy, the process of getting people to switch from their use of non-renewable energy sources has been quite slow and uncertain especially in the developing nation. A range of barriers that constrains the deployment of solar energy technologies for electricity generation and thermal purposes. These barriers can be classified as technological, policy, management and economic.

(i) Technological Barriers

The technological barriers are complex. The highlighted varying product quality and quality standards in different countries, as well as consumer concerns about complexity, durability, efficiency and safety. These negative perceptions about solar technologies can create major barriers. In addition, a lack of knowledge about solar technologies leads to planners not recommending photovoltaic for new buildings, or to improper use and poor maintenance by adopters. In some countries and regions, climatic conditions and architectural constraints make solar less suitable than in others.

(ii) Policy Barriers

This is a limitation that is difficult to address through policy measures. Within the policy category, the identified a lack of stability of incentives for the adoption of photovoltaic, examples are inconsistencies between policy measures and socioeconomic factors, or the sudden removal of existing subsidies. While most countries have policy measures to support renewable energies, the market loses trust when policy decisions are reversed, such as the recent retrospective reduction of feed-in tariffs in Italy and Spain. Failure to involve all the relevant stakeholders in energy policy planning and regulatory issues, such as difficulties acquiring building permits and lengthy decision processes, constituted further barriers to adoption.

(iii) Management Barriers

Management barriers included inappropriate differentiation between rural and urban, or low income and high-income business strategies, where solar is an alternative power supply. The also referenced poor after-sales service; ineffective marketing and education campaigns; lack of collaboration between the building and PV industries; lack of national infrastructure; and lack of policy backing.

(iv) Economic Barriers

Initial capital, transaction costs, economic status, and availability of incentives and subsidies are important factors that determine the rate of renewable energy technological adoption. Initial capital cost of renewable energy is relatively high when compared to conventional sources of energy, which in turn raises the cost of renewable energy generation. In many developing countries lack adequate renewable energy technologies and therefore, rely on imports from industrialized nations. Initial investment costs are, therefore, high and discouraging to potential investors because imported technologies from technologically innovative and highly developed countries are more expensive compared to technologies made locally. Inadequate or lack of credit facilities is also a significant barrier to renewable energy development. In some countries such as China, from the perspective of promoting renewable energy development, in the long run, China's existing economy regulatory policies in terms of tariff and subsidy incentives are relatively weak.

2.2.3 Rural Electrification and Role of Solar Home System

Rural electrification means providing easy access to affordable electricity in rural area. Majority of population in developing countries lives in rural areas, and rural electrification is perceived as the key driver for socio-economic transformation. Electrification of rural areas is important for several reasons, where the most important are enhancing of education level, health, quality of life and economic growth. For a long period of time many people claimed that rural electrification did not contribute to development at all. Energy is one of the most important basic ingredients required to alleviate poverty and to bring about socio-economic development of a country.

Widespread electrification of rural areas started during 1930s, mainly in the United States and the more economically advanced European countries, United State Agency for Development (USAID) designed a model of rural electrification in the early 1970s and the model was replicated in developing countries. By recent estimates, more than 1.2 billion people globally live without electricity access, and more than 3 billion are reliant on biomass to meet their household cooking needs (IEA and WB 2017). The problem is heavily concentrated in rural areas, where only 73 percent of people globally have access to electricity, compared to 96 percent in urban areas (IEA and WB 2017).

Lack of electricity access is one component of energy poverty; the other is reliance on polluting fuels, such as firewood, dung, agricultural waste, or kerosene, to meet household energy needs (IEA 2011). The consequences of energy poverty are wide-ranging and include air quality and climate human health, productivity, forecast degradation and education. Extending electricity access to rural areas is an important part of ending energy poverty, and there is an increasingly diverse set of technologies available for rural electrification. These include extension of the national grid as well as mini-grids and stand-alone systems. Most common technologies for rural electrification are diesel generators, solar photovoltaic (solar home system) and small wind generators.

Electrification is a powerful instrument for raising rural productivity and improving rural household's quality of life. Rural households that obtain an electricity connection use it initially for lighting, which allows for evening reading and study, especially for school going children. Distribution companies often have a disincentive to serve sparsely populated rural areas, where prices are set low and poorer

households exhibit low levels of electricity demand. To achieve universal electrification, many governments have turned to off-grid solutions utilizing photovoltaic (PV) based, solar home systems (SHSs) to completed grid-based electrification, particularly in geographically inaccessible area.

SHS have replaced kerosene lighting, have significantly improved the health and educational outcomes of rural households and reduced lighting expenses, leading to higher levels of disposable income. The availability of high-quality lighting during evening hours makes it possible to cook after dark, freeing up women's time for income-generating activities earlier in the day.

2.3 The Importance of Rural Electrification

Rural electrification means providing easy access to affordable electricity in rural area. Majority of population in developing countries lives in rural areas, and rural electrification is perceived as the key driver for socio-economic transformation. Electrification of rural areas is important for several reasons, whereof the most important are enhancing of education level, health, quality of life and economic growth. However, for a long period of time many people claimed that rural electrification did not contribute to development at all. Energy is one of the most important basic ingredients required to alleviate poverty and to bring about socio-economic development of a country.

Widespread electrification of rural areas started during 1930s, mainly in the United States and the more economically advanced European countries (Foley, G.1990 as cited in Abdulla Harun, 2015). United State Agency for International Development (USAID) designed a model of rural electrification in the early 1970s and the model was replicated in developing countries. Nowadays, rural electricity dissemination can be achieved by either centralized supply or decentralized approaches. The centralized approach refers to connecting villages and remote areas to a national grid, which is often owned and operated by a public utility. Rural electrification through centralized approach involves high capital costs. In contrast, decentralized approaches for rural electrification, access to power is not provided by a national grid, but instead generated locally near the place of consumption. Decentralized power supply may be two types: Mini-grids and Stand-alone systems. The most common energy sources for mini-grids are diesel-wind hybrid systems. Stand-alone systems generate electricity right next to the place of consumption, and

are almost exclusively used for small-scale energy demand on household. Most common technologies for rural electrification are diesel generators, solar energy (Solar Home System) and small wind generators.

A study undertaken by the World Bank for 11 countries reveals that rural electrification results great benefits such as improvements of health facilities, better health from cleaner environment as households reduce use of polluting fuels for cooking, lighting, and heating, improved knowledge through increase access to television and better nutrition from improved knowledge and storage facilities from refrigerator.

2.3.1 Solar Energy as a Source of Sustainable Rural Electrification

Renewable energy sources such as solar energy, wind or hydropower are available on an indefinitely sustainable basis, whereas fossil resources (oil, coal, gas) are in finite quantities. A study by the World Bank in 2005 reveals that assuming availability of the respective renewable energy source Renewable Energy Technologies (RET) are the least cost option for off-grid stand-alone electrification in rural areas. In 2001, the 9th session of the Commission on Sustainable Development (CSD) gave special attention to energy. It concludes that "Energy is the central in achieving the goal of sustainable development (Global Network on Energy for Sustainable Development ,GNESD, 2007). According to Global Network on Energy for Sustainable Development (GNESD, 2007), without adequate supplies of affordable energy, it is difficult to improve health, education, and reduction of poverty.

2.3.2 SHS Electrification as a Driving Force for Socio-economic Development

Economic development depends on energy. In general, energy is not considered as a basic human need. In the past, rural energy, in particular, was not widely accepted as a basic need like water and food in the development circles. Nonetheless, energy, particularly electricity is required for meeting basic needs such as health, agriculture, education, information and other infrastructural services and shows a clear correlation with per capita income and human development index.

Although rural electrification does not necessarily reduce poverty, its relationship to poverty reduction cannot be denied. Nowadays, solar electricity is a way of the development providing electricity solutions for households, agriculture,

healthcare, education, telecommunication, rural streets and market places, as well as government and private institutions. It is benefiting rural life creating income-generating scope and activities. This is also saving environment by replacing fuel lamps and facilitating energy access for the remote localities.

Solar electricity plays a modest role in supporting economically productive and education-related activities, but "connective" applications such as television, radio and cellular telephone charging often receive a higher priority. Solar electrification is closer tied to increased television use, the expansion of markets, more rural-urban communication, and other processes that increase rural-urban connectively than to poverty alleviation, sustainable development or the appropriate technology movement.

Solar cells the most frequently used from solar technology can be used for a wide variety of applications such as solar power plants, in the rooftops of buildings, on street lights, etc. Quality of life is simply life goals of socio-economic development that can be achieved through better education, health, access to information, indoor lighting, among others. Significant impacts of solar PV systems include better quality of light, indoor smoke and fire hazards from kerosene lanterns are reduced. Furthermore solar PV electrification contributes to improve quality of life in off-grid rural communities through the direct effect of the technology on household wellbeing and enterprise income.

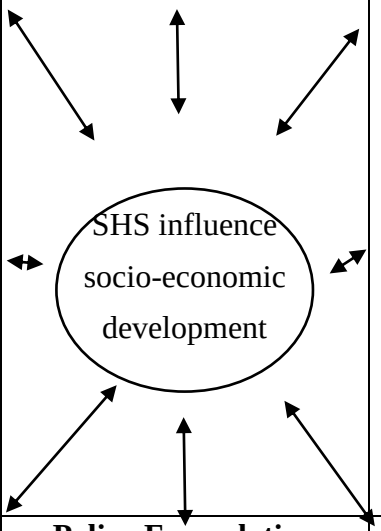
The prime role solar energy is transforming the lives of people in the rural area. Solar electrification can improve the quality of life of rural households through positive impacts that cannot easily be expressed in monetary terms. Installing solar power in homes helps families with a variety of tasks. By using a SHS children's can study for a longer period and they also can watch television and recharge their cell phone handsets. Solar energy alone cannot strategies for education, health, agriculture, access to information and infrastructure for socio-economic improvements. (Abdulla Harun, 2015)

2.4 SHS and Socio-economic Development Framework

Figure (2.1) is a framework of SHS and socio-economic development. It is an illustration of the multi-sectored linkages of SHS influence on quality of life in off-grid rural communities. It indicates social and economic benefits that may be achieved to rural beneficiaries by using SHS. The framework focuses on specific area

of education, health, agriculture information and environment linkages with several sectors through solar electrification in rural area. It is based on a combination of models and finding from relevant literature. (Abdulla Harun, 2015)

Figure (2.1) SHS and Socio-Economic Benefits

Education Benefits	**Health Benefits**	**Agriculture Benefits**
-Extended period of studying after sunset due to quality lighting -Access to educational program in TV, Radio and Mobile -Lighting helps to adult education at night school.	-Fresh household indoor air -Local storage of vaccines in solar powered refrigerators -Extended period of night health services -Solar lighting for safe child delivery	-Dry of food crops -Improved solar PV powers small-scale food processing equipment -Solar irrigation
Environmental Benefits -Reduction indoor smoke from oil-based lanterns -Reduction in per capita CO_2 emissions		**Enterprise Benefits** -Income from extended period of lighting in micro-enterprise -External lighting contributes to night trading -Local employment opportunity -Savings on kerosene
Social Benefits	**Policy Formulation**	**Information**
-Social gathering for watching TV, Radio and Other electrical devices -Availability of light at dark -Availability of lighting for women's safety and reduce stealing	-Availability of evidence based data for policy review -Availability of data for funding and global partnership	-Access to information through TV, Radio, Mobile and Laptop -Access to telephone, Internet etc.,

Source: Abdulla Harun (2015), The Role of Solar Home system (SHS) in Socio-economic development of rural Bangladesh

(i) SHS Promotes Education

Education plays an important factor for eradication of poverty. Any effort that contributes to promote education is welcome everywhere. Solar lighting provides higher quality illumination than kerosene lanterns, extended study time as well as better comfort and safety. In solar light children enjoy better facilities for education. It can improve educational lighting in remote rural schools permit children to extend their studies in the evening. For many children, especially girls in rural areas the lack of electricity translates into a missed opportunity to attend school because they are overloaded with menial tasks such as fetching water and fuel during daylight hours (Allderdice and Rogers, 2000). Furthermore, solar PV lighting enables access to radio, television and internet, which increase education opportunities and allows distance learning (DFID, 2002; UNDP, 2004). Children in electricity less rural areas spend significant portion of their time in household's activities during day time. They do not have light to study at night. A few hours of electricity to study at night students can result in major improvements in their performance (United Nations, The Energy Challenge for Achieving the Millennium Development Goals, 2005). If rural electrification policies, programme and plans integrate SHS as an alternative source for the supply of electricity services for remote rural communities, children will get access to lighting in the evening to extend their studies.

(ii) SHS Facilities Health Benefits

Public health is a critical sector in off-grid communities. Solar energy can have a significant impact on livelihoods in rural areas. The replacement of kerosene lanterns with SHS reduces indoor air pollution, which effects the health and wellbeing of rural families. World Bank has classed indoor air pollution in developing countries among the four most critical global environment problems. Indoor air smoke contributes to respiratory infections that account for up to 20 percent of the 11 million deaths of children each year (DFID cited by UNDP, 2004). Solar energy helps to improve health by reducing acute respiratory infection and conjunctivitis, commonly caused by indoor pollution. But there is lack of quantitative data on the likely proportion of reduction of indoor air smoke from kerosene lantern by using solar light. Solar electric water pumps can provide clean water, reducing the effort need for collection. Solar electricity can make possible the refrigeration of vaccines and operation of medical equipment in rural health clinics. A healthy life is a key indicator

in the capability approach to poverty. Women in labor need clean light to have safe child delivery at anytime. In a rural clinic where there is no electricity, women deliver under very uncomfortable conditions due to the lack essential equipment, medical facilities and poor visibility after sunset. So, it is necessary to reemphasize the need for pragmatic policies to set up environmental health-friendly technologies like SHS to operate remote rural health centers efficiently.

(iii) SHS Promotes Agriculture and Rural Enterprises

Agriculture plays a vital role for food security and economic development. Securing access to water plays a strategic role in ensuring agricultural production (FAO, 2005). In this regard, solar PV water pumping can supply water for dry land irrigation. Addressing energy issues related to agriculture and off-farm activities can help to increase prospects for income generation in rural households/ enterprises by providing energy for irrigation, food processing, food preservation and many types of manual production during evening hours. Power shortage and low voltages affect irrigation for the electricity operated pumps causing lower production of crops. Besides diesel operated pumps require increasing price for petroleum.

Considering the energy crisis of the country and products across the global, it is important to explore alternative energy sources for irrigation to ensure both food and energy security. SHS helps micro-enterprises to generate additional income by extending their working hours after dusk (Grameen Communications, 1999; Allderdice and Rogers, 2000; DFID 2002). With solar power people can operate rice-grinding mill in rural areas. Small rural stores can also expand their inventory by adding items that can preserved using solar powered refrigerators (Allderdice and Rogers, 2000, Etcheverry, 2003). Introduction of SHS in the rural areas creates an opportunity for the villages to open up small businesses like mobile phone charging shops, computer training centers, TV and mobile shops).

(iv) SHS creates Information and Communication Technology

Solar electricity provides alternative power to meet the information and communication needs in off-grid rural and peri-urban communities. By powering radios, televisions or computers with SHS, rural households are able to access health, education, business, agricultural and environmental information to better their standard of living. People in the rural household get information through TV and

radio news and programs or mobile message. Solar system in creating a substantial effect in the telecommunication sector in the off-grid areas. Rural people can charge their mobile phones using the SHS. They can communicate to any one easily. Mobile phones are powered by solar chargers in off-grid areas. Mobile phone is one of the important preconditions for socio-economic development in rural area. SHS create facilities for getting news and information. (Khan,S.2006 as cited in Abdulla Harun, 2015)

2.5 Reviews on Previous Studies

Literature review on previous studies regarding to utilize solar energy in rural households, found that various points of view by scholars such as the rural electrification using renewable energy sources in Myanmar, the role of Solar Home System in socio-economic development, solar technology, difficulty, effectiveness and effect of solar energy system.

Kyi Tha Min (2015) illustrated that the utilization of solar energy in rural area, explored the Solar Energy Utilization of Rural Households in Pathein Township, Ayeyarwaddy Region. The significant point of this paper was highlighted major disadvantages of using solar PV as initial costs. This study focus on the government should be reduced tariff on the solar productions and energy consumption in Myanmar.

Thida Hlaing (2016) was presented "A Study on Utilization of Solar Energy by household in rural area of Myanmar: Case study on four selected villages in Sagaing Region" found that the major disadvantage of Solar PV system is also high initial installation costs for rural communities. Reduced tariff on solar PV import by government can be more improved household quality of life, living standard, health and education sector for rural community through utilization of Solar Home System. The promotion of off-grid and grid-connected renewable sources of energy, energy efficiency and household energy options can enable Myanmar to rapidly increase its standards of living and improve community welfare.

Zar Zar Win (2017) has make "Utilization of Solar Energy in Rural Area; Case Study: Kyaung Kone Township in Ayeyarwady Region" the limited power supply and high initial cost are the major disadvantage of using Solar system. And, legal and regulatory rules and adequate legal framework will need for private power producers.

Abdulla Harun (2015), the scholar aimed to measure the impacts of Solar Home System (SHS) and the Study of the Role of Solar Home System in socio-economic development of rural Bangladesh. The study mainly focused on this paper of SHS's importance and benefit and it impacts on socio-economic development in rural Bangladesh.

CHAPTER III
UTILIZATION OF SOLAR ENERGY IN MYANMAR

3.1 Overview of the Energy Sector

Myanmar has abundant renewable energy resources, notably solar, hydropower and biomass but also potential for wind, and other resources of renewable energy. Among these resources, hydropower has been developed and utilized on a commercial scale. Other renewable energy resources remain under research and in development or pilot stages. A few pilot solar power installations are also operational in Myanmar. Solar energy is being provided by Minister of Industry (MOI) in a few off-grid villages to generate electricity for street lighting, home lighting and for community infrastructure such as schools, healthcare centers and monasteries. As of 2013, MOI has installed solar home system in 152 villages, solar mini-grid in one village and it has distributed solar lanterns in 543 villages across the country.

During 2010-2013, the MOI was given the responsibility of promoting off-grid energy access. In response to MOI's request, ADB initiated pilot (Phase-I) off-grid renewable energy activities using grant funds: Empowering the poor through increasing access to energy. This phase will focus on piloting a limited number of off-grid clean energy installations in 20 villages in Chin State in the eastern part of the country and Mandalay region in the central part of the country, and developing a geospatial least cost energy access plan for Mandalay region. These activities are ongoing with MOI as the executing agency (EA) and to be completed by 2014.

In September 2013, the President of Myanmar's office took the decision to move the Department of Rural Development from the Ministry of Border Areas to the Ministry of Livestock, Fisheries and Rural Development (MLFRD) and make this reconfigured Ministry the lead on rural infrastructure provision, including energy access. In addition to being the executing agency for both the World Bank's and ADB's community-driven development (CDD) projects, which involves support for rural energy provision, MLFRD is embarking on an ambitious energy access program and has submitted a supplementary budget request for 2014 to the parliament.

In April 2016, the government restricted its organization and reduced the number of ministries from 36 to 21. This included the merging of the Ministry of Energy and Ministry of Electric Power into the new MOEE, which is responsible for

oil and gas and electricity operations. Other ministries related to the energy sector include;

(i) Ministry of Agriculture, Livestock, and Irrigation with responsibility for off-grid rural electrification,

(ii) Ministry of Natural Resources and Environmental Conservation with responsibility for coal mining and

(iii) Ministry of Industry with responsibility for energy efficiency.

In April 2019, Myanmar's total electricity consumption reached a record high of 3609 MW, an increase of more than 250 MW compared with the same period in 2018. At present, Myanmar's power generation is about 3800 MW. It's electricity demand is growing at a rate of 19% a year. The Ministry of Electricity and Energy (MOEE) plans to produce another 3000 MW over the next three years, as the annual power consumption will reach 300–500 MW.

According to Myanmar Energy Statistics reports by Myanmar's Ministry of Electricity and Energy (2019), much of the current energy demand in Myanmar is largely filled by hydropower (36 %) followed by liquefied natural gas (LNG) (36%), and coal (3%). While Myanmar enriches solar energy resources, one can see a substantial opportunity for energy growth in Myanmar. Solar energy can improve the security of the energy supply as well as it can ease off the peak of electricity consumption. The conversion of solar energy into electricity can promote Myanmar's sustainable socio-economic development.

Despite large potential benefits that solar energy could offer to the nation, there is still a large gap in the development of solar energy utilization in Myanmar in terms of capital and technology. While Myanmar government should be collaborating with many international organizations, it also needs strong public support from its residents to accelerate the solar energy developing process.

Myanmar has quite challenging renewable energy targets – to increase the supply of renewable energy in electricity production to 8% by 2021, and to 12% by 2025 (Pode et al., 2016). Recent reports by the ASEAN Post (2019), Myanmar Ministry of Electricity and Energy (MOEE) have great emphasize on energizing the future of the country's renewable energy industry.

3.2 National Energy Policy

To ensure development of the energy and electricity sectors, the NEMC prepared the National Energy Policy paper which was approved by the President in January 2014. The paper summarized the national energy sector policies as follows:

(i) To implement short-term and long-term comprehensive energy development plans based on systematically investigated data on the potential energy resources that are feasible and can be practically exploited, considering minimum impact on natural environment and social environment.

(ii) To institute laws and rules and regulations to promote private sector participation and privatize state energy organizations in line with State Economic Reform Policy.

(iii) To compile systematic statistics on domestic demand and supply of various different kinds of energy resources of Myanmar.

(iv) To implement programs through which local population could proportionally enjoy the benefit of energy reserve discovered in the areas.

(v) To implement programs on a wider scale, utilizing renewable energy resources such as wind, solar, hydropower, geothermal, and bioenergy for the sustainable energy development in Myanmar.

(vi) To promote energy efficiency and energy conservation.

(vii) To establish a research, development, design, and dissemination institution to keep abreast with international practices in energy resources exploration and development works, and to produce international quality products and conduct energy resources exploration works in accordance with international standards.

(vii) To formulate appropriate policy for energy product pricing, meeting economic security of energy producers and energy consumers.

Government plans as set out in the National Energy Policy paper include sector restructuring, investment planning, pricing and fuel subsidy review, renewable energy and energy efficiency development, promotion of private sector, increased international trade, and a national electrification program to achieve 100% electrification by 2030. These plans are at various stages of development and implementation with

(i) A new electricity law approved in 2014 allowing for corporatization, private sector participation, and establishment of an independent electricity regulatory commission;

(ii) Energy sector and power subsector plans to be completed identifying required investments; and

(iii) Commencement of a national electrification program.

3.3 Solar Energy in Myanmar

Around year 2000, Solar Technology started introducing as Photovoltaic System and Solar Hot Water System in Myanmar. Myanmar has abundant renewable energy resources, notable solar, hydropower and biomass but also potential for wind and other sources of renewable energy. Among these resources, hydropower has been developed and utilized on a commercial scale. Other renewable energy resources remain under research and in development or pilot stages. Ministry of industry have been provided few number of off-grid villages to generate electricity for street lighting, home lighting, and community infrastructure as schools, healthcare centers and monasteries. Myanmar has played two way of using solar energy in renewable energy sector. First, solar PV electrification in rural area which are not be able to use grid electricity and another way is solar power plant which are derived to national grid and specific area as an alternative source of energy.

Beginning in 2012, the Department of Rural Development has used donor funds and Union budget to develop a nascent solar initiative that provides free Solar Home System (SHS) to households mainly in rural areas. In 2010, the Asian Development Bank (ADB) initiated the regional technical assistance project Promoting Renewable Energy, Clean Fuels and Energy Efficiency in the Greater Mekong Sub-region (GMS), to assist the five countries- Cambodia, the Lao People's Democratic Republic, Myanmar, Thailand and Vietnam- in improving their energy supply and security in an environmentally friendly and collaborative manner.

Myanmar has traditionally focused on hydropower and gas power generation. The government, in the Myanmar Energy Market Plan introduced in 2016, has planned to increase the share of coal and solar in the energy mix. Coal will be increased from 1.6% of total energy production in 2015 to 29.5% in 2030 and solar from 0% in 2015 to 5% to 2030. In September 2016, UNDP support $400 million on National Electrification Plan project. The objective of the National Electrification

Project is to help increase access to electricity in Myanmar. There are four components to the project, the first component being grid extension. This component will support the distribution utilities to extend distribution networks and connect communities and households to the national power grid, including through the provision of goods and materials for the expansion of existing medium voltage (MV) substations and construction of new MV substations. The second component is the off-grid electrification. About 5.5 million households are estimated to remain without access to national grid by 2021. Of these, 1.3 million are in the remote Chin, Kachin, Kayin, Shan, Rakhine, Taninthayi and Sagaing States and Regions. The third component is the technical assistance and project management. This component provides support to MOEP and MLFRD to: (i) strengthen institutional capacity to implement the national electrification plan; (ii) improve the policy and regulatory framework related to electrification and renewable energy. Finally, the fourth component is the Contingent emergency response (CER). In 2014, government signed two major solar power deals with foreign investors United State of America-based, The American Chamber of Commerce (ACO) Investment Group will invest USD 480 million to build two 150MW solar plants near Mandalay, both of which are due to enter operation in 2016. Thailand's Green Earth Power will spend USD 350 million on a 220 MW plant in Magway Region's Minbu in partnership with the Phillippine firm Basic Energy.

3.3.1 Solar Energy Potential in Myanmar

Myanmar has good solar resource potential, with 60% of the land area suitable for PV development, having Global Horizontal Irradiation (GHI) levels of between 1600 and 2000 kWh/m2/yr, and average Direct Normal Irradiation (DNI) levels of about 1400 kWh/m2/yr. Myanmar's mountainous terrain and protected areas, more than a third of the land area is unsuitable for solar PV installations. Myanmar's maximum technical solar power potential is estimated at 40 TWh/yr. Solar energy in Myanmar is at an early development stage. No large-scale solar plants have yet been installed in the country.

(i) Solar Radiation Data in Myanmar

MEPE (Myanmar Electrical Power Enterprise) experimental measurements indicate that irradiation intensity of more than 5 kWh/m2/day was observed during the

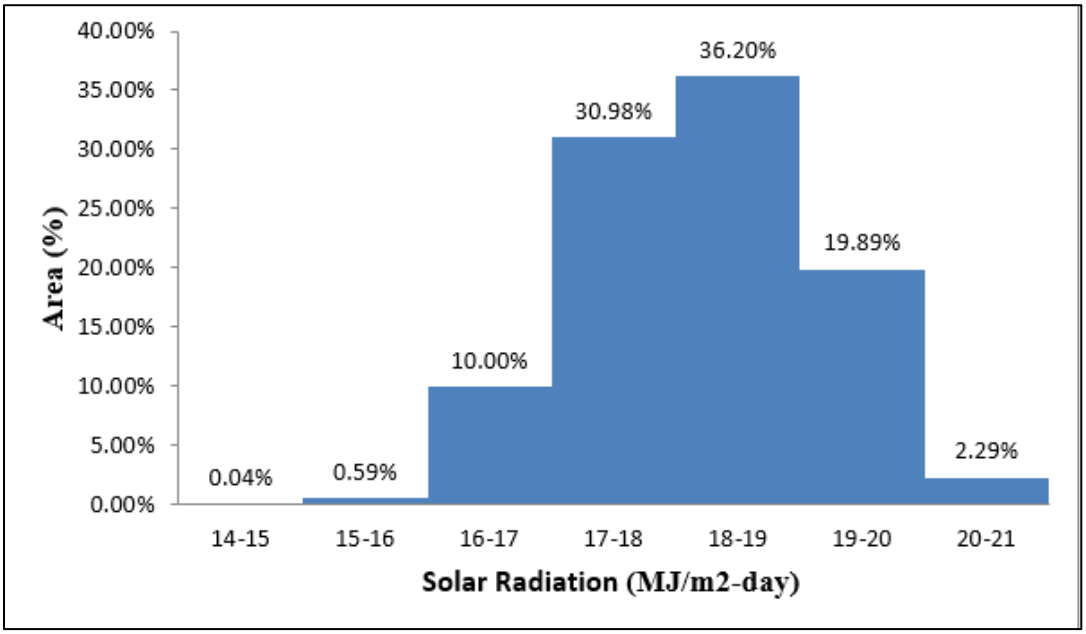
dry reason. Since the reliability of these systems is paramount, the sizing method used is based on radiation data for the worst month of the year rather than on the average daily irradiation over the year. Based on the yearly solar radiation map, solar energy potential of Myanmar was investigated. Geographical distribution of solar radiation was analyzed and the result is shown in table. It was found that 36% of the total area of the country receives annual solar radiation in the range of 18-19 MJ/m2-day, while there are only a few percent of the area with less solar radiation (<15MJ/m2-day).This indicates that most parts of Myanmar relatively high solar radiation.

Table (3.1) Assessment of Solar Radiation in Myanmar

Solar radiation(<15MJ/m2-day)	Area(%)
14-15	0.04
15-16	0.59
16-17	10.00
17-18	30.98
18-19	36.89
19-20	19.89
20-21	2.29

Source: MOEP, Assessment of Solar Energy Potentials for the Union of Myanmar, (2013)

Figure (3.1) Assessment of Solar Radiation in Myanmar



Source: MOEP, Assessment of Solar Energy Potentials for the Union of Myanmar, (2013)

3.3.2 Limitation of Solar Energy in Myanmar

The solar electric power can be improved the quality of life for people living in isolated areas. The most important thing is to keep the power system simple and dependable. Here, power and light supplied with solar system are now available for studying, working and for just playing around in rural areas. As Myanmar is situated in the southeastern part of the Asian Continent, it enjoys abundant sunshine all year around, especially in the Central Myanmar Dry Zone Area; Potential available Solar Energy of Myanmar is around 51973.8 Tera Watt-hour per year. Use of solar energy is also in the very initial stages. Due to the expensive initial cost the solar energy is presently in the research and development phase.

3.3.3 Solar Home System

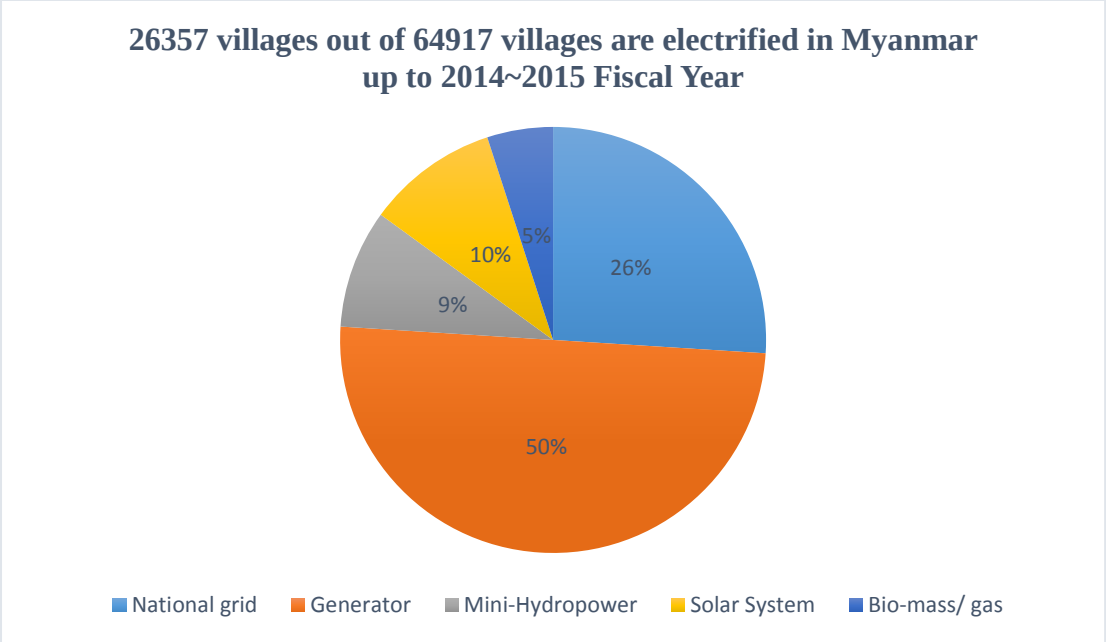
Solar Home System (SHS) are stand-alone photovoltaic system that offer a cost-effective mode of supplying amenity power for lighting and appliances to remote off-grid households. In rural areas, that are not connected to the grid, SHS can be used to meet a household's energy demand fulfilling basic electric needs. Globally, SHS provide power to hundreds of thousands of households in remote locations where electrification by the grid is not feasible. SHS usually operate at a rated voltage of 12 V direct current (DC) and provide power for low power DC appliances such as lights, radios and small TVs for about three to five hours a day. They use appliances such as cables, switches, mounts and structural parts and power conditioners/ inverters, which change 12/24 V powers to 240 VAC power for larger appliances. SHS are best used with efficient appliances to limit the size of the array. SHS typically includes one or more PV modules consisting of solar cells, a charge controller which distributes power and protects the batteries and appliances from damage and at least one battery to store energy for use when the sun is not shining.

3.4 Rural Electrification Status in Myanmar

Myanmar has one of the lowest electrification rates in Asia, with more than 60% of the population without access to a modern form of electricity, denying people the ability to work, weakening health and safety, education and limiting the opportunity to rise out of poverty. Energy poverty constrains socio-economic development. Electricity is not only critical to human well-being, it is the undercurrent of a thriving economy. In partnership with the World Bank, the

Government of Myanmar developed a National Electrification Plan that aims to achieve universal energy access by 2030 through grid extension and decentralized rural electrification via mini-grids and solar home systems. According to World Bank, the government will connect 2 million households from 2015 to 2020 and an additional 5.2 million households from 2021 to 2030. In current, 84% of households in rural Myanmar have no electrification up to 2013 and 2014 (on/ off grid) including 23034 villages out of 64917 villages in Myanmar. Currently, rural electrification 26357 villages out of 64917 villages are electrified in Myanmar up to 2014-2015. Among them 26 percent of the rural area can access National Grid (6918 villages), 50 percent from Generator (13088 villages), 9 percent from Mini- Hydropower (2426), 10 percent from Solar System (2693) and 5 percent from Bio-Mass/ Gas (1232 villages).

Figure (3.2) Current Situation of Rural Electrification



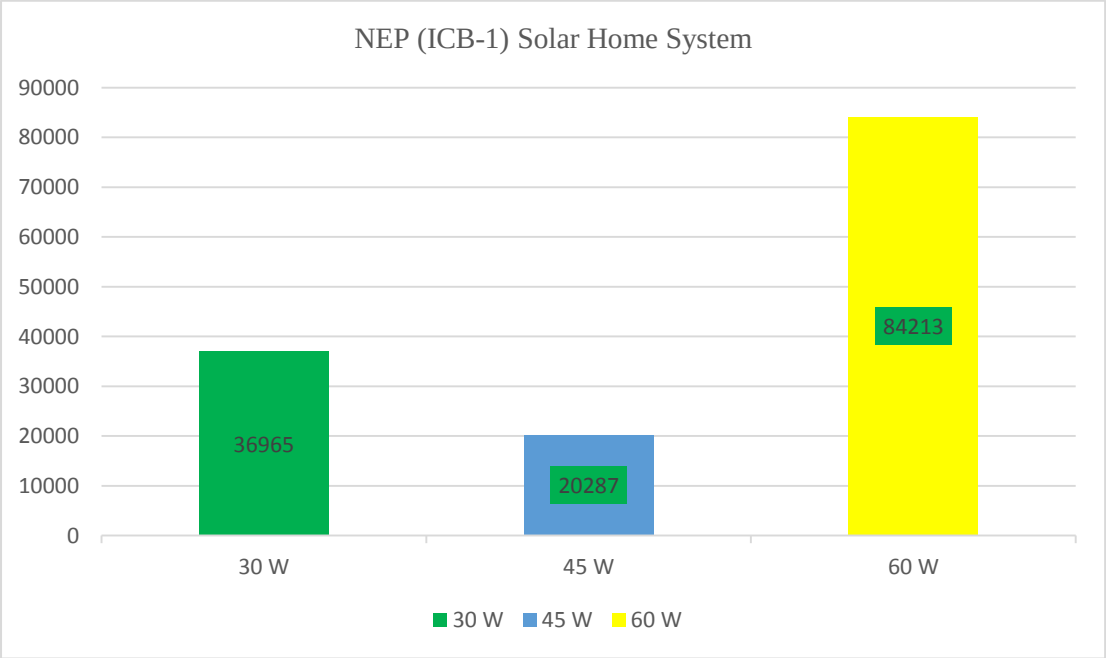
Source: Department of Rural Development, Ministry of Livestock, Fisheries and Rural Development (2015)

3.5 Regional Wide Electrification with Using Solar Home System in Myanmar

Under the National Electrification Project, DRD is undertaking Off-grid rural electrification in villages which are situated beyond 10 miles from Grid-line starting from 2016-2017 fiscal year.

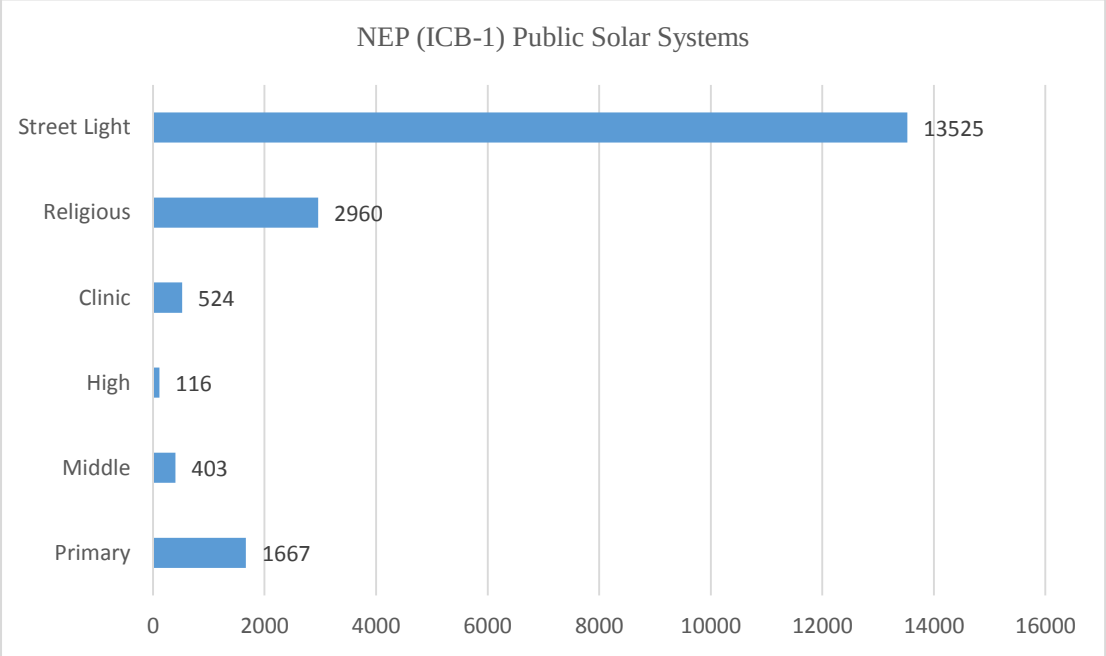
In fiscal year (2016-2017), government has been implemented Solar Home System for NEP (ICB-1) that who were implemented in 4 states and 3 Regions: Kayin, Chin, Shan, Rakhine States and Saging, Tanintharyi, Ayeyarwaddy Regions. Solar Home System has been used in household of 30 W for (36,965), 45 W for (20,287) and 60 W for (84,213) has been implemented in as 95 townships and 2708 villages. NEP also has provided Public Facilities to villages for are 1667 systems in Primary schools, 403 systems in Middle schools, 116 systems in High schools, 524 systems in Clinic, 2960 systems in Religious buildings and 13,525 systems in Street Lights with the 100% government's subsidy. All total systems of 160,660 were implemented in NEP ICB-1.

Figure (3.3) National Electrification Project (Off-Grid) Solar Home System 2016-2017



Source: Ministry of Agriculture, Livestock & Irrigation Department of Rural Development

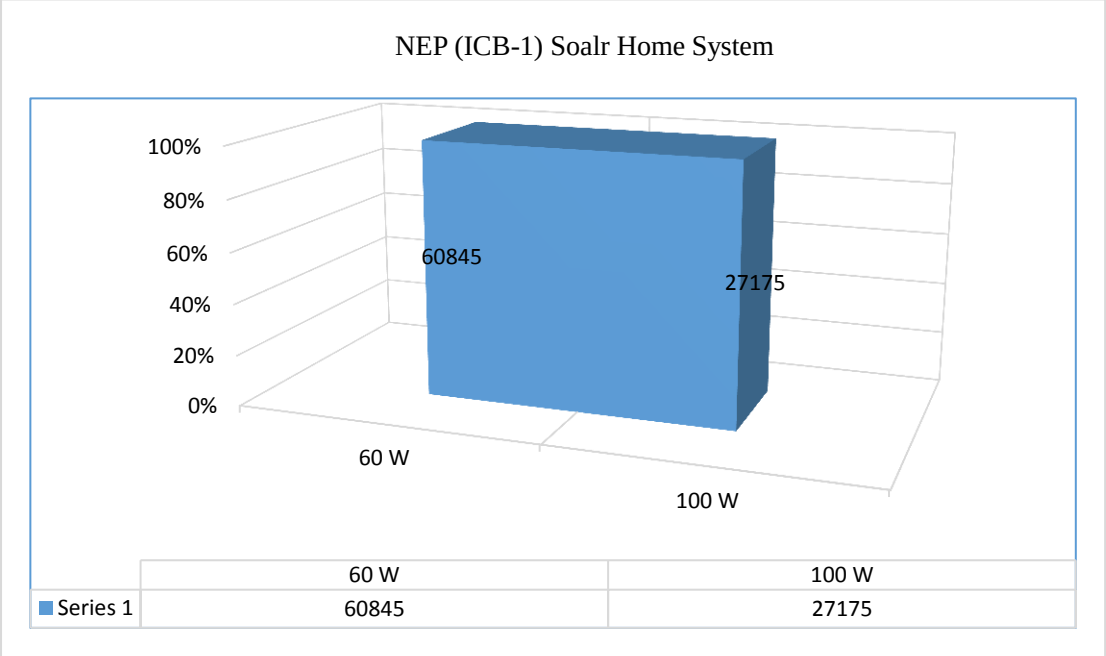
Figure (3.4) National Electrification Project (Off-Grid) Public Solar System 2016-2017



Source: Ministry of Agriculture, Livestock & Irrigation Department of Rural Development

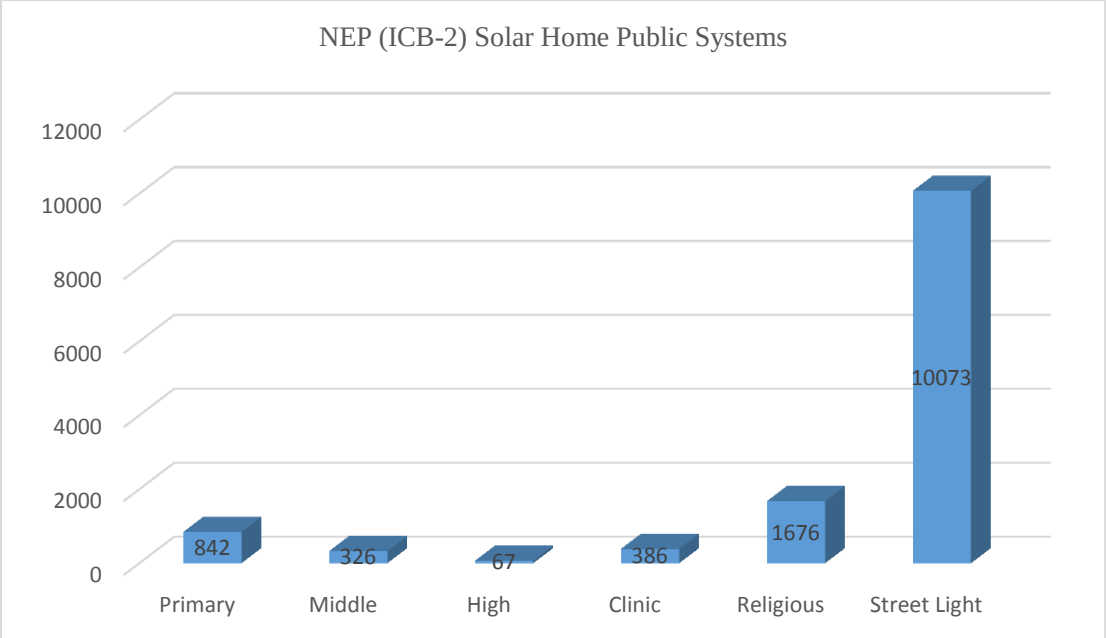
In fiscal year 2017-2018, government has been implemented Solar Home System for NEP (ICB-2) that who were implemented in 5 States and 7 Regions: Kayin, Chin, Shan, Rakhine, Mon States and Saging, Tanintharyi, Ayeyarwaddy, Bago, Mandalay, Magway and Naypyitaw Regions. Solar Home System has been used in household of 60 W for (60,845) and 100 W for (27,175) has been implemented in as 131 townships and 1,684 villages. NEP also has provided Public Facilities to villages for are 842 systems in Primary schools, 326 systems in Middle schools, 67 systems in High schools, 386 systems in Clinic, 1,676 systems in Street Lights with the 100% government's subsidy. All total systems of 101,390 systems have been implemented in NEP ICB-2.

Figure (3.5) National Electrification Project (Off-Grid) Solar Home System 2017-2018



Source: Ministry of Agriculture, Livestock & Irrigation Department of Rural Development

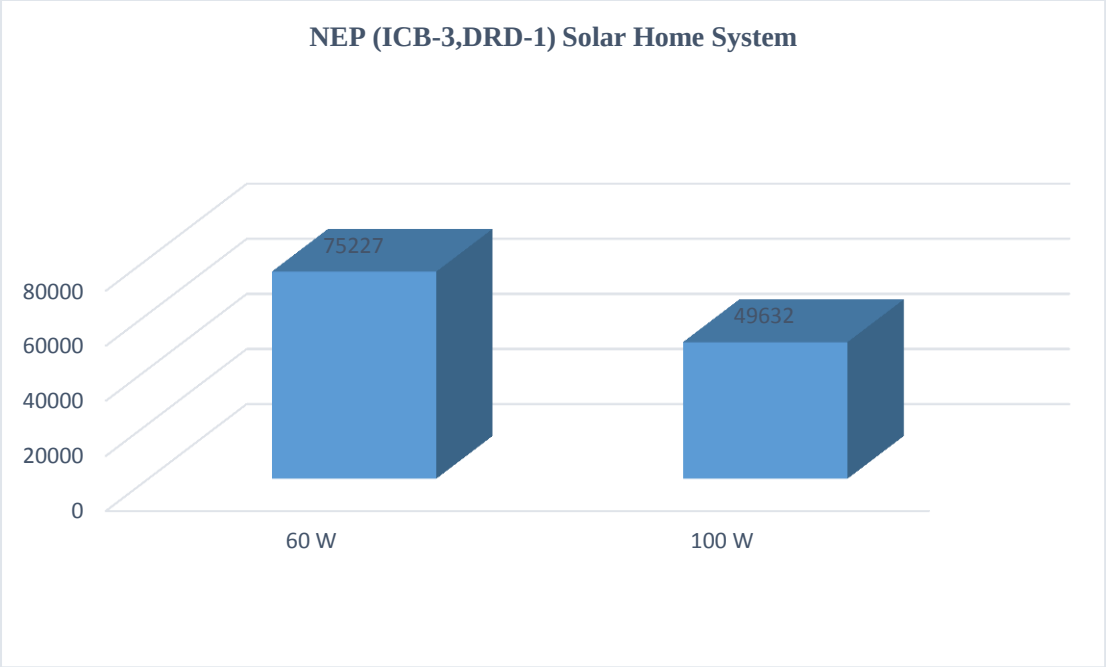
Figure (3.6) National Electrification Project (Off-Grid) Public Solar System 2017-2018



Source: Ministry of Agriculture, Livestock, Irrigation Department of Rural Development

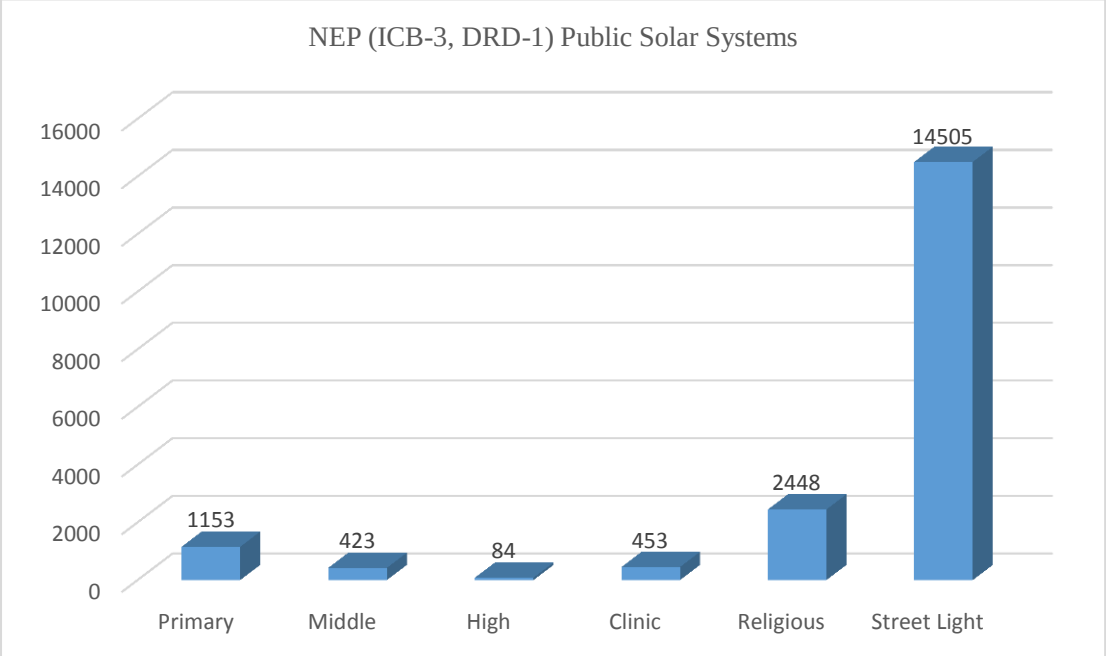
In fiscal year 2018-2019, government has been implemented Solar Home System for NEP (ICB-3, DRD-1) that who were implemented in 5 States and 8 Regions: Kayin, Chin, Shan, Rakhine, Kachin States and Saging, Tanintharyi, Ayeyarwaddy, Bago, Mandalay, Magway, Yangon and Naypyitaw Regions. Solar home system has been used in household of 60 W for (75,227) and 100 W for (49,632) has been implemented in as 167 townships and 3274 villages. NEP also has been provided Public Facilities to villages for are 1153 system in Primary schools, 423 systems in Middle schools, 84 systems in High schools, 453 systems in Clinic, 448 systems in Religious buildings and 14505 systems in Street Light with the 100% government's subsidy. All total systems of 143925 had been implemented in NEP ICB-3, DRD-1.

Figure (3.7) National Electrification Project (Off-Grid) Solar Home System 2018-2019



Source: Ministry of Agriculture, Livestock & Irrigation Department of Rural Development

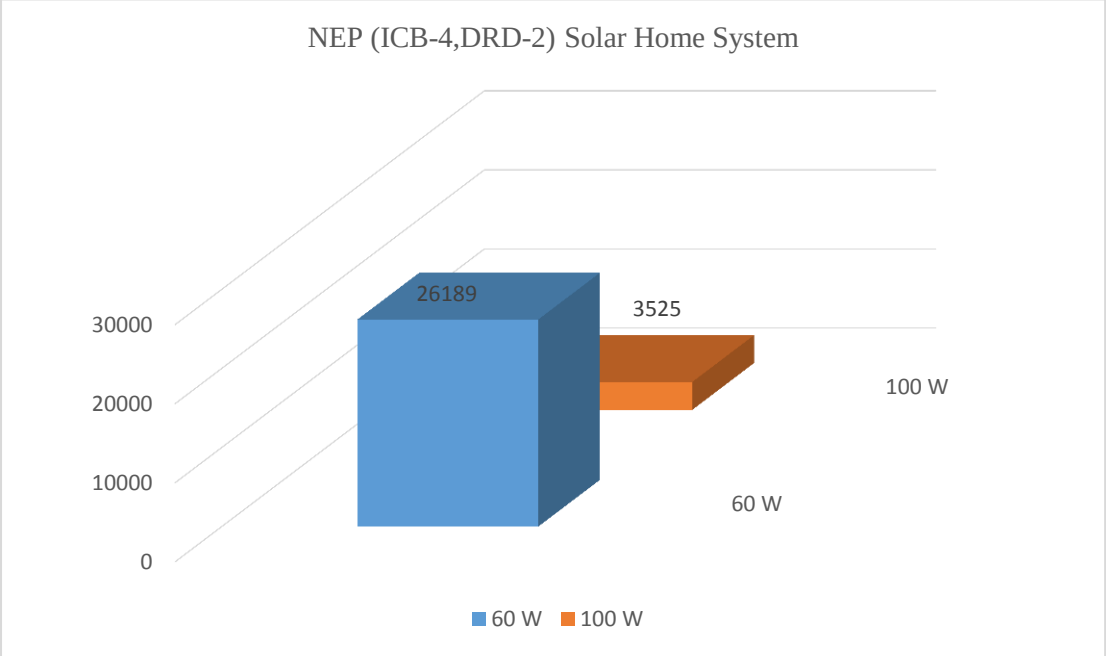
Figure (3.8) National Electrification Project (Off-grid) Public Solar Systems 2018-2019



Source: Ministry of Agriculture, Livestock, Irrigation Department of Rural Development

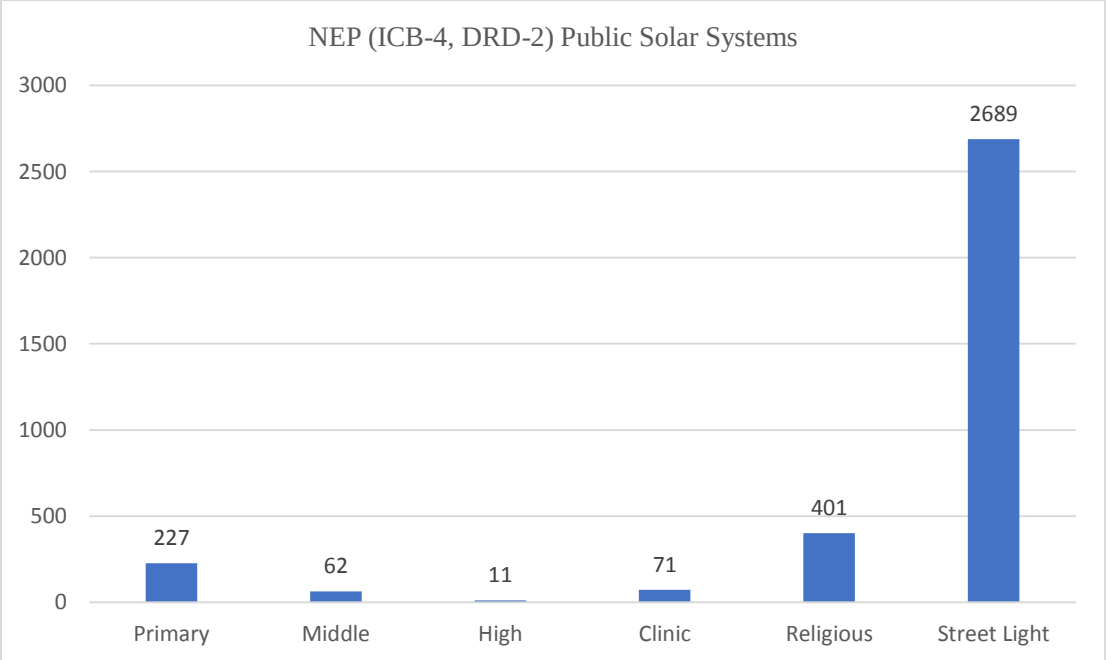
In fiscal year 2019-2020, government has been implemented Solar Home System for NEP (ICB-4, DRD-2) that who were implemented in 2 States and 3 Regions; Kayin, Shan States and Sagaing, Tanintharyi, Ayeyarwaddy Regions. Solar home system has been used in household of 60 W for (26,189) and 100 W for (3,525) were implemented in as 50 townships and (694) villages. NEP also had been provided Public Facilities to villages for are 227 systems in Primary schools, 62 systems in Middle schools, 11 systems in High schools, 71 systems in Clinic,401 systems in Religious buildings and 2689 systems in Street Lights with the 100% government's subsidy. All total systems of 33,175 had been implemented in NEP ICB-4, DRD-2.

Figure (3.9) National Electrification Project (Off-Grid) Solar Home System 2019-2020



Source: Ministry of Agriculture, Livestock & Irrigation Department of Rural Development

Figure (3.10) National Electrification Project (Off-Grid) Public Solar Systems 2019-2020



Source: Ministry of Agriculture, Livestock & Irrigation Department of Rural Development

CHAPTER IV
SURVEY ANALYSIS

4.1 Survey Profile

The survey area is Bogale Township, Pyapon District, Ayeyarwaddy Region. There are 76 village tracts and 575 villages in this township. Total population of Bogale Township is 71878. Among the villages in this township, two villages, Phoe Nyo and Manage Gyi, are selected as the survey area. Phoe Nyo village has 200 households and where Manage Gyi village has 150 households.

In this survey, Phoe Nyo village and Mangae Gyi village are using individual solar home system provided by government within 2015-2016. Hence, survey areas of respondents are not face difficulty of high initial cost of solar home system installation for their basic need of electricity consumption. All these solar home system were also common in the survey area, which produced enough energy to run four LED lamps, street light, mobile phone charging, mobile, radio and TV system. Utilization of this solar home system is provide the basic need of electricity consumption, but it can't provide for other electricity consumption such as larger capacity systems of solar water pumping can supply water for dry land irrigation. In this two sample villages, some respondents can use solar home system provided by government as well as individual installation by own income. It was found that most respondents have weather barriers to utilize the solar home system.

4.2 Survey Design

To analyze the impact of using solar home system in rural area, a survey is collected from 150 households from 2 villages out of 11 villages by 2 villages tracts at Bogale Township, Ayeyaywaddy Region. The sample households were chosen from the list of villages who are using solar home system which provided by Department of Rural Development, Ministry of Livestock, Fishery and Rural Development, Ayeyarwaddy Region. The survey is conducted with structured questionnaire to cover the installation and usage of solar home system for electricity areas, the impact of solar energy on rural households, effectiveness of using solar energy, household quality of life improvement and socio-economic development and some difficulties in using solar home system.

4.3 Analysis of Survey Results

The general characteristics of the respondents are present in table (4.1) as their gender, age, education level, occupation, household size and monthly household income and monthly household expenditure.

Table (4.1) Characteristics of the Respondents

No.	Factors	Number of Respondents	Percentage
1	Gender		
	Male	87	58
	Female	63	42
Total		150	100
2	Age		
	(19-40)	62	42
	(41-60)	65	43
	(over 60)	23	15
Total		150	100
3	Education Level		
	Primary School	94	63
	Middle School	43	28
	High School	9	6
	Graduated	4	3
Total		150	100
4	Household size		
	Small size (1-5)	118	79
	Medium size (6-10)	32	21
	Large size (over 10)	0	0
Total		150	100
5	Occupation		
	Agriculture	63	42
	Livestock	47	31
	General	28	19
	Others	12	8
Total		150	100

6	Monthly Household Income		
	Below 1lakh	7	5
	100,000-200,000 kyats	36	24
	200,001-300,000 kyats	57	38
	Over 3lakhs	39	26
	Irregular Income	11	7
Total		150	100
7	Monthly Household Expenditure		
	Below 1lakh	24	16
	100,000-200,000 kyats	49	33
	200,001-300,000 kyats	47	31
	Over 3lakhs	27	18
	Irregular Expenditure	3	2
Total		150	100

Source: Survey Data (September, 2023)

According to table (4.1), it is found that 87 of total respondents are male 58 percentage and 63 of the total respondents are female 42 percentage. As the tradition, culture and majority of Myanmar is male and they take the leading role of family earning, decision making and involving in social affair. They lead the installation, maintenances, communication, organizing and monitoring on solar home system with the support from female.

The majority of the respondents age group are between 41 to 60 years, 65 respondents or 43 percent. The respondents age group between 19 to 40 years are second, 62 respondents or 42 percent. The third group are between over 60 years are 23 respondents or 15 percent. The combining 127 respondents or 85 percent are less than 60 years of age groups. Depending on the age groups, their experience and awareness could be impact on questionnaire because the respondents well know about the positive nor negative impact on solar home system utilization and installation.

Then, the educational status of the respondents presented, total 94 respondents, 63 percent of total got the primary school education, 43 respondents, 28

percent of total got the middle school education, 9 respondents, 6 percent of total got the high school education and 4 respondents, 3 percent of total got the bachelor degree.

For the number of household size, 118 respondents of the total have between 1 to 5 family members which is 79 percent of the total and 32 respondents or 21 percent has 6 to 10 family members.

Occupation of the most respondents, the agriculture sector or farmers are 63 respondents, 42 percent of total respondents. 47 respondents, 31 percent engaging livestock sector and 28 respondents, 19 percent are general workers. 12 respondents, 8 percent are working various sectors.

And then, the average family income per months of respondents are presented. According to the survey data, household income of the respondents is mainly come from agriculture related sectors. On this account, 7 respondents, 5 percent earned less than 100,000 per month and 36 respondents, 24 percent earned between 100,000 to 200,000 per month, 57 respondents, 38 percent earned between 200,001 to 300,000 per month and 39 respondents, 26 percent have over 300,000 per month. It was also found that another 11 respondents, 7 percent have irregular income per month.

The average family expenditure per months of respondents are presented. According to the survey data, 24 respondents, 16 percent are used under 100,000 expenditure per month, 49 respondents, 33 percent are used between 100,000 to 200,000 expenditure per month, 47 respondents, 31 percent are used between 200,001 to 300,000 expenditure per month and 27 respondents, 18 percent are used above 300,000 expenditure per month. It was found that irregular expenditure per month is voted by 3 respondents, 2 percent.

Table (4.2) Monthly Cost of Energy before using Solar Home System

Description	Number of Respondents	Percentage
Less than 5000 kyats	11	7
5,001-10,000 kyats	35	23
10,001-15,000 kyats	33	22
15,001-20,000 kyats	21	14
More than 20,000 kyats	50	34
Total	150	100

Source: Survey data (September, 2023)

Table (4.2) shows the family expenditure on using various energy system per month before using of solar home system. At overall level, most of the families are expending 50 respondents, 34 percent are used more than 20,000 Kyats per month of total respondents. The expenditure on using energy between 5,001 and 10,000 Kyats per month are also 35 respondents, 23 percent of total respondents and between 10,001 and 15,000 Kyats per month for energy utilizing after using solar energy are 33 respondents, 22 percent of total respondents. 21 respondents, 14 percent are using between 15,001 and 20,000 Kyats per month of total respondents and 11 respondents, 7 percent are using less than 5,000 Kyats of total respondents respectively.

Table (4.3) Monthly Cost of Energy after using Solar Home System

Description	Number of Respondents	Percentage
Less than 5000 kyats	59	40
5,001-10,000 kyats	15	10
10,001-15,000 kyats	10	6
15,001-20,000 kyats	4	3
More than 20,000 kyats	9	6
Lack of cost	53	35
Total	150	100

Source: Survey data (September, 2023)

Table (4.3) shows the family expenditure per month on energy utilizing after using solar home system. In the overall level, most of families are using expenditure on energy utilizing the highest percent 40 percent after using solar energy and also 10 percent of total respondent's families are using expenditure between 5,001 and 10,000 Kyats per month. Expending between 10,001 and 15,000 Kyats for energy utilizing is 6 percent of total respondents and between 15,001 and 20,000 Kyats for energy utilizing is 3 percent of total respondents and above 20,000 Kyats for energy utilizing is 6 percent of total respondents. There was no one at the expenditure of 53 respondents, 35 percent of total respondents that after using solar home system.

Table (4.4) Type of Installation

Supported by	Number of Respondents	Percentage
Own Installation	65	43
Support by government	85	57
Support by non government	0	0
Total	150	100

Source: Survey data (September, 2023)

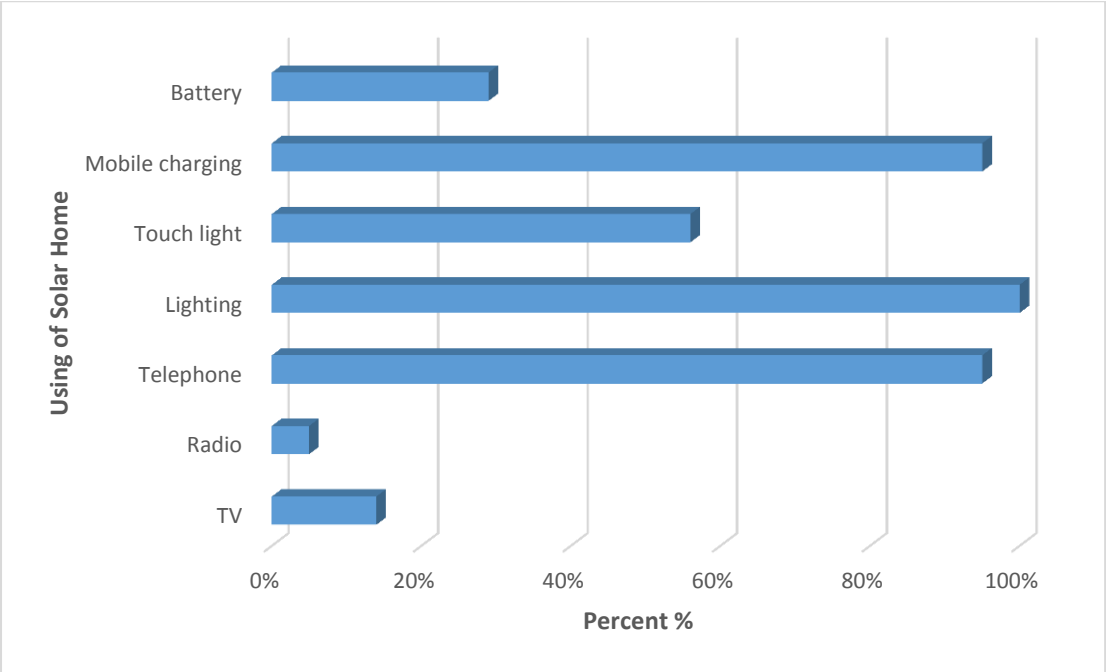
Table (4.4) illustrates that type of support on solar home system installation. The most of families who installed solar panel for household lighting purpose are government organization supported for using and solar energy at village level. Some are used for solar energy installation by family own income.

Table (4.5) Using of Solar Home System

Using of Solar home	Number of Respondents	Percentage
TV	21	14
Radio	8	5
Telephone	143	95
Lighting	150	100
Touch Light	84	56
Mobile charging	143	95
Battery	44	29

Source: Survey data (September, 2023)

Figure (4.1) Using of Solar Home System



Source: Survey data (September, 2023)

Table (4.5) shows that the household using of solar home. According to the survey data, used for lighting is the largest 100 percent. 143 respondents, 95 percent of total respondents are used for telephone and mobile charging and 84 respondents, 56 percent of total respondents are used for touch light with home solar. It was also found that the using of home solar for battery and TV by 29 percent and 14 percent of total respondents respectively. By least percent, home solar used for radio is 5 percent of total respondents. Therefore, it can be seen significantly that lighting, telephone and mobile charging is more important for the households.

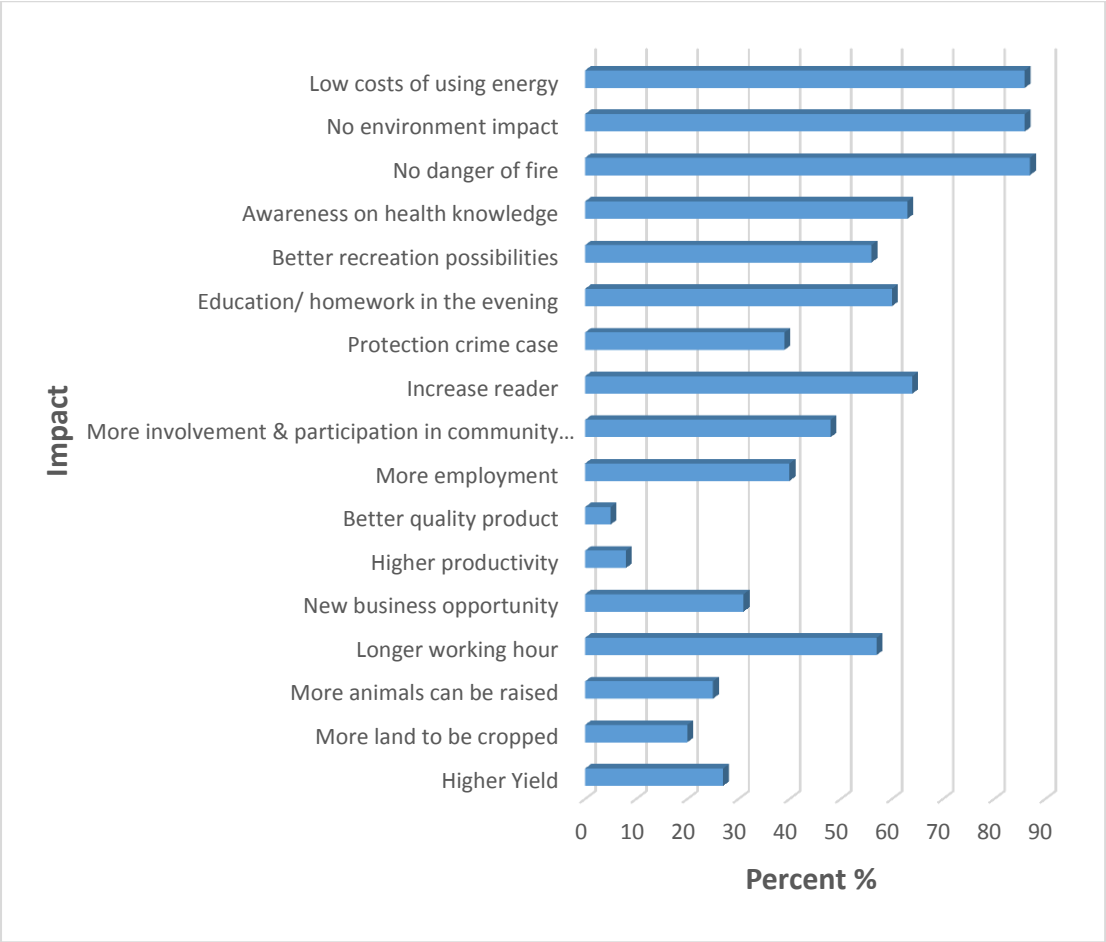
4.3.1 Impact of Using Solar Home System

Table (4.6) Impact of Using Home Solar

Impact	Number of Respondents	Percentage
Higher Yield	40	27
More land to be cropped	30	20
More animals can be raised	37	25
Longer working hour	85	57
New business opportunity	46	31
Higher productivity	12	8
Better quality product	7	5
More employment	60	40
More involvement & participation in community development activities	72	48
Increase reader	96	64
Protection crime case	58	39
Education/ homework in the evening	90	60
Better recreation possibilities	84	56
Awareness on health knowledge	94	63
No danger of fire	130	87
No environment impact	129	86
Low costs of using energy	129	86

Source: Survey data (September, 2023)

Figure (4.2) Impact of Using Home Solar



Source: Survey data (September, 2023)

Table (4.5) shows the impact of using solar home system. According to the survey data, no danger fire, no environment impact and low costs of using energy are the largest percent of 87 percent, 86 percent and also 86 percent of total respondents respectively. Increase reader is voted by 96 respondents, 64 percent of total respondents and 90 respondents, 60 percent of total respondents are voted on education and homework in the evening. Awareness on health knowledge, longer working hour and better recreation possibilities are voted by 63 percent, 57 percent and 56 percent of total respondents. More involvement and participation in community development activities, more employment and protection crime case which have 48 percent, 40 percent and 39 percent of total respondents respectively. New business opportunity, higher yield, more animals can be raised and more land to be cropped which have 31 percent, 27 percent, 25 percent and 20 percent of total respondents respectively. It was found that at least higher productivity and better quality product which have 8 percent and 5 percent of total respondents.

Table (4.7) Attended or Not Attended Training or Seminar Concerned with Solar Technology

Attending	Number of Respondents	Percentage
Yes	18	12
No	132	88
Total	150	100

Source: Survey data (September, 2023)

Table (4.6) shows the respondents are attended or not attended the training and seminar about solar technology. 132 respondents, 88 percent of total respondents are not attending some training or seminar concerned with solar technology and 18 respondents, 12 percent of total respondents are attended some training about solar technology.

Table (4.8) Satisfaction on Using Solar Energy

Satisfaction	Number of Respondents	Percentage
Yes	150	100
No	0	0
Total	150	100

Source: Survey data (September, 2023)

Table (4.7) presents that satisfaction on using solar energy. According to the survey data, all of the respondents who answered very satisfaction are 150 respondents, 100 percent of total respondents.

Table (4.9) Difficulty on Using Solar Home System

Difficulty	Number of Respondents	Percentage
Yes	125	83
No	25	17
Total	150	100

Source: Survey data (September, 2023)

Table (4.8) shows the difficulty on using solar home system. According to the survey data, 125 respondents, 83 percent have difficulty on using solar home system and 25 respondents, 17 percent do not have difficulty on using solar home system.

Table (4.10) Causes of Difficulty on Using Solar Home System

Causes of Difficulty	Number of Respondents	Percentage
Lack of technical knowledge	20	13
Weather condition	91	61
Rare of Spare part	69	46
Low quality	15	10
High cost for initial installation fees	14	9

Source: Survey data (September, 2023)

Table (4.9) shows the causes of difficulty on using solar home system. According to the survey data, 91 respondents, 61 percent of total respondents have caused weather condition during the rainy season. Lack of technical knowledge and low quality have caused 13 percent and 10 percent of total respondents respectively. The last one is high cost for initial installation fees have 14 respondent, 9 percent of total respondents.

Table (4.11) Impact of Using Solar Home System by Sector (Respondents Opinion)

Sector	Number of Respondents	Percentage
Agriculture	53	35
Livestock	48	32
Small Family Business	62	41
Commercial Business	30	20
Household Quality of Life	136	91
Education	106	71
Health	105	70
Social Services & Rural Development	106	71

Source: Survey data (September, 2023)

Table (4.10) shows that the respondents opinion on the impact of using solar home system by sector. From the survey data, 136 respondents, 91 percent of total respondents are assumed that the using of solar home system is strongly impacting on household quality of life. 106 respondents, 71 percent of total respondents are voted

on education sector and also impacted on social services and rural development. 105 respondents, 70 percent of total respondents are answered health service sector. And then, it was found that the respondents opinion which is the impact of using solar home system on agriculture, livestock, small family business and commercial business by 35 percent, 32 percent, 41 percent and 20 percent respectively.

4.3.2 Socio-Economic Improvement after Using Solar Energy

Solar energy is one of the driven sources to improve socio-economics development of the rural community.

Table (4.12) Areas of business Improvement by Using Solar Home System

Areas of business	Number of Respondents	Percentage
Retails Shop	19	13
Tailoring	2	1
Agriculture	12	8
Livestock	27	18
None	116	77

Source: Survey data (September, 2023)

Table (4.11) illustrates the area of local business sectors improvement by using solar home system. According to the survey result, 18 percent of total respondents answered livestock business is significantly improved after using solar lighting. 13 percent of total respondents replied that the retail shops, 8 percent and 1 percent of total respondents said that agriculture and Tailoring respectively. It was found that the rest number of total respondents 116, 77 percent are using solar energy for lighting purpose only.

Table (4.13) Solar Home System Support on Social Sector

Social Sector	Number of Respondents	Percentage
School	150	100
Library	75	50
Religious Space	150	100
Public Health Services	75	50
Educational Services	75	50

Source: Survey data (September, 2023)

Table (4.12) illustrates the areas of solar using at public spaces and services. Total 100 percent of the respondents answered that solar lighting is using at school and religious space, 50 percent said that it is using at library, public health services and educational services areas.

Table (4.14) Solar Home System Supported on Village Development

Support on village development	Number of Respondents	Percentage
Fully Agree	145	97
Agree	0	0
Mutual	5	3
Not Agree	0	0
Full not at all	0	0
Total	150	100

Source: Survey data (September, 2023)

Table (4.13) shows the perception of the village on solar energy supports on village development as social and business areas. Base on survey result, 97 percent of total respondents fully agreed that solar energy supports on village development process and 3 percent of total respondents are in mutual.

CHAPTER V
CONCLUSION

5.1 Findings

The study is mainly focusing on the utilization of the solar home system and its impact on the rural community through questionnaire survey. The survey was conducted in two villages of Bogale Township, Ayeyarwady Region in September 2023 and the sample size was 150 respondents of households those mostly who are currently using solar home system by government subsidy and their own income.

The survey questionnaire covered on the characteristics of the respondents, gender, age, education, family size, occupations, family income, expenditure of using before and after using solar energy. In this study, the question concerning the using of solar home system were asked based on three categories; such as application in household, business and social sector.

The study included the general questions concerned with attending or not attending training or seminar concerning Solar Technology, satisfaction, difficulty, effectiveness and impact of solar home system by respondents opinion.

It was found that agriculture farming is the main household occupation in the survey villages. Among them, a significantly part of household occupation is growing paddy and some are doing livestock and employees. Household income of the survey villages mainly income from agriculture, agriculture related work and small business. In survey villages, estimated present average monthly total income of the households are above 300,000 Kyats. It can be seen that the income gap was separated who are more reliable to use solar home system by their own income which are not only government subsidy.

Before installation of solar energy system, candle was the most prevalent source of household lighting in survey area though both candle and kerosene were also used in few cases. The result of energy sources used for lighting expenditure before solar system installation. Normally, candle was purchased from local village market and average monthly expenditure was above 20000 Kyats. As the price of candle increase, the expenditure increase day by day. Expenditure for using energy before solar energy installation was too high for survey villages but cost declines after using solar energy which effects on household saving and investment. Extra money it can be also used for other sectors of their needs and wants such as education, health and other recreation possibilities.

Solar electricity provides alternative power to meet the information and communication needs in off-grid rural area. By powering radios, televisions and mobile phone with solar energy, rural households are able to access health, education, and business, agricultural and environmental to better their standard of living. All of households used lighting and mobile phone chargers to charge mobile phones in villages which are main intention of using solar energy system. Especially, using street lighting which is necessity for safety at night. Households use solar electricity for watching TV, listening radio and using mobile phone was seen in 14 percent, 5 percent and 95 percent recently of total respondents. It was strongly concerned with the family income level and using solar energy system by government subsidy or own income.

After using of solar energy system, household create more new business and job opportunities. Lighting is the major benefit which will be attractive to create a new business. Among business, retail shops are the most created in survey villages and then various types of works are created and improved too. Working hours are extending in evening and night which has a great effect on household income, saving, investment and other income generating activities. As a summary, all of the businesses have improved more after using of solar system.

It was also found that using solar system for basic social sector, are rural public health services, school, library and education services, street light and lighting for villages monastery and pagoda. Most of the solar system used for basic social sector was provided by villager's donation. Using of solar system for health and education sector greatly effects on household quality of life and living standard.

It can be assumed that using solar energy increase readers, longer working hours, education and homework in the evening. It was also found that low costs of using it by largest percent which is a great effect on household saving and investment. In a consequences, new business opportunity and higher productively are happening in them. Solar system provides people in the rural household facilities to get better recreation possibilities and awareness on health knowledge though using TV, radio and mobile phone. Those of effects are strongly related to each other and lighting is key point of using solar energy system and also the major benefit. No danger of fire and no environmental effects are the other advantages of using solar energy system.

Most of the respondents did not attend the training and seminar about solar energy system but some attended. Those training and seminar are held in village monastery, user's home and schools when they install solar energy system. And then, they received clear instruction how to use solar system in various productive ways.

In this study, it was found that all of the respondents are satisfied with using solar home system. Some respondents faced to some difficulties in using solar home system. Most of difficulties are misunderstanding on technology weather affecting on it. Those included in disadvantages of solar system. It was found that other difficulty is un-quality equipment and scare spare parts. It can be strongly concerned with the low awareness of solar technology and user education level.

It can be assumed that using solar energy system is great affected on rural home business, health benefit, education, access to information and communication, having nighttime safety. It indicates social and economic benefits that may be achieved to rural beneficiaries by using solar home system.

According to the survey data, using solar energy system for some sectors has greatly improved in these survey villages such as household quality of life, education, small family business and some commercial business. Health sector which is strongly depending on using inventory relative with public health services can be more improved. Livestock and agriculture is still the main income generating activities in rural area. Utilization of solar electricity for agriculture purpose is very limited. Most of the households are not able to use solar equipment for agriculture and livestock sectors because of high initial cost of solar system. Lighting is the key point for all sectors in rural areas and effect of using solar energy system is based on cost of the solar technology and equipment.

Today, solar energy system is a way of sustainable renewable energy in the world. Solar electricity is relentlessly active to involve in many innovative application. Right incentives, policy alignment, development of local technological capabilities, political and institutional support is very much essential for sustainable and effective use of solar energy system.

5.2 Suggestions

Technical knowledge, low quality, rare spare parts and high initial installation cost is the major disadvantage of using solar system for end users. The absent of legal and regulatory for solar energy sector is one of the barrier for public producers can operate it needed. According to the objectives and goals of National Electrification Plan of the government for 100 percent electrify at year 2030 but most of the rural areas and some urban areas are under line of estimated plan. Myanmar is a developing country, progress of rural electrification has been very slow. Solar energy is one of the best ways to provide electricity for those living in rural communities. Myanmar needs to develop rural electrification plans and policies for those remote areas where there is no access to national grid electricity supply. The advantages of off-grid renewable energy in these areas are taken into account by the policies and rural development programs. Due to high initial investment costs of renewable energy systems, the rural electrification utilizing renewable energy sources must be supported financially by government subsidies to rural community for solar home system installation and purchasing. For rural electrification development, Department of Rural Development takes a leading role on planning and implementation but need to more actives on community engaging, facilitating, promoting and mobilizing among the rural community to apply and install standalone solar system.

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Questionnaire Survey of the Solar Energy Utilization of Rural Households in Two Villages of Bogale Township, Ayeyarwaddy Region

I am studying Master of Economic at Yangon University of Economics. I have designed the following questionnaire for **"A Study on the Solar Energy Utilization of Rural Households (Case Study; Bogale Township, Ayeyarwaddy Region)".** I am conducting a study on rural energy access and use and would like to include your opinion.

The participation in this survey depends on your wish. The information given by you will be strictly confidential. I hope that you will participate in this survey and make it success by providing correct answers to all the questions. I would highly appreciate if you participate to answer the following questionnaire. Your opinion is of great value to us and we thank you in advance for your cooperation.

Part (1) Respondent Profile

1	Name	
2	Age	
3	Education	
4	Sex	○ Male ○ Female
5	Family Member	
6	Job/ Position	
7	Family Income for average per month	○ Less than 100,000 ○ Between 100,000 and 200,000 ○ Between 200,000 and 300,000 ○ Above 300,0000
8	Family Expenditure for average per month	○ Less than 100,000 ○ Between 100,000 and 200,000 ○ Between 200,000 and 300,000 ○ Above 300,0000

9	Monthly Cost of Energy Using Before Solar Home System	○ Less than 5000 ○ Between 5000 and 10,000 ○ Between 10,000 and 15,000 ○ Between 15,000 and 20,000 ○ Above 20,000
10	Monthly Cost of Energy Using After Solar Home System	○ Less than 5000 ○ Between 5000 and 10,000 ○ Between 10,000 and 15,000 ○ Between 15,000 and 20,000 ○ Above 20,000

Part (2) Solar Panel is Source of Electricity

1	Project Name	
2	Initial Year for installation	
3	Project Implemented By	○ Own Installation ○ Supported by Government ○ Supported by Non-Government ○ Others
4	Usage of Energy System	○ Solar Energy ○ Others
5	Power Consumption System	○ Central Distribution System ○ Solar Home System ○ Others

6	Please describe if the households has electrical appliances that use solar energy	○ TV ○ Radio ○ Computer ○ Telephone ○ Electrical light/bulb ○ Refrigerator ○ Street lamp ○ Flashlight ○ Phone Charger ○ Battery pot ○ Other electrical equipment
7	Describe the types of rural home businesses and small businesses that are more developed, if any, that start up using solar energy	○ Retail Store ○ Restaurant ○ Liquor store ○ Battery shop ○ Telephone shop (store) ○ Repair workshop ○ Craft workshop ○ Transportation business (battery bike/cycle) ○ If there are others, please specify
8	Describe the types of local social services and infrastructure that use solar electricity	○ School ○ Library ○ Religious building ○ Village administration office ○ Rural dispensary ○ Public telephone shop ○ Health Service (child immunization) ○ Education Service (Night School) ○ If there are others, please specify

Part (3) Impact areas by using of Solar Home System

1	High yield per acre	○ Yes ○ No
2	Expanded yield acre	○ Yes ○ No
3	New product introduces at the market place	○ Yes ○ No
4	Increase additional working hours	○ Yes ○ No
5	Create working opportunity	○ Yes ○ No
6	Increasing productivity of goods	○ Yes ○ No
7	Pay attention on social affair and village development activity	○ Yes ○ No
8	Increase the number of reading practices	○ Yes ○ No
9	Preventive criminal cases	○ Yes ○ No
10	Improvement of children on studying and general knowledge	○ Yes ○ No
11	Improving on information sharing and dissemination	○ Yes ○ No
12	Improvement on basic health knowledge	○ Yes ○ No
13	Knowledge improving on fire controlling and disaster prevention awareness	○ Yes ○ No
14	Reducing energy costs	○ Yes ○ No
15	Others comment	○ Yes ○ No

Part (4) General Questions

1	Attended training/educational lectures on solar energy technology	○ Yes ○ No
2	The installation organization/ company provides detailed instructions to the users on the usage tips and do's and don'ts	○ Yes ○ No
3	Customer satisfaction with the availability of solar energy	○ Yes ○ No
4	Difficulties encountered in using solar energy for electricity	○ Yes ○ No
5	Reasons for difficulties weak	○ Understanding of technology ○ Weather ○ Shortage of spare parts ○ Material quality is low ○ High initial installation costs
6	Do you think solar power technology is effective in local development projects?	○ Fully agree ○ Agree ○ Mutual ○ Not agree ○ Fully not at all
7	The following aspects of using solar energy are significantly affected 1. Agriculture 2.Livestock 3.Rural home businesses 4.Small businesses 5.Social activities and regional development 6.Quality of life of households 7.Education 8.Health	 ○ Yes ○ No ○ Yes ○ No ○ Yes ○ No ○ Yes ○ No ○ Yes ○ No ○ Yes ○ No ○ Yes ○ No ○ Yes ○ No

Thank you