YANGON UNIVERSITY OF ECONOMICS
DEPARTMENT OF APPLIED ECONOMICS
MASTER OF PUBLIC ADMINISTRATION PROGRAMME

A STUDY ON THE BENEFITS OF SOLAR ELECTRICITY FOR RURAL DEVELOPMENT IN MYANMAR

(Case Study: Ye Nan Gyaung Township, Magway Region)

KHIN MAUNG THEIN
EMPA - 13 (18th BATCH)

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A thesis submitted as a partial fulfillment towards the requirement for the degree of Master of Public Administration (MPA)

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ABSTRACT

The main objective of the study is to analyze the benefits of solar electricity system implemented by Department of Rural Development in selected rural areas of Ye Nan Gyaung Township, Magway Region. The data for this study is collected by using structured questionnaire and face to face interview on randomly selected 250 households form five villages have got electricity from solar electricity system by Department of Rural Development in their villages. The respondents said that services for lighting, television, mobile phones, fans and more. Furthermore, storing the electricity in a battery will allow electricity to be used for hours into the night. This solar electricity system is reduced to half of household monthly cost for electricity and reduction a carbon dioxide emission in the region. The government implement the solar electricity system projects for rural households because some rural areas have away from nation grid can enjoy the electricity generated by solar electricity system. The government should be supported mini-grid in the country. In this way, the living standards of the people will be improved and the country will develop continuously.

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
BOT	Build Operate Transfer
DRD	Department of Rural Development
HP	Hydropower
IEA	International Energy Agency
JV	Joint Venture
kW	Kilowatt
MEPE	Myanmar Electric Power Enterprise
MOE	Ministry of Energy
MOEE	Ministry of Electricity and Energy
MOEP	Ministry of Electric Power
MOST	Ministry of Science and Technology
MW	Mega Watt
NEP	National Electrification Plan
O & M	Operation and Maintenance
ROR	Run-off-the-river
SHS	Solar Home System
SPV	Solar Photovoltaic
TWh	Terawatt-hour
UNEP	United Nation Environment Programme
VECs	Village Electrification Committees

CHAPTER I

INTRODUCTION

1.1 Rationale of the Study

Electricity plays an important role in rural socio-economic development. Inadequate electricity in rural areas is a significant obstacle to development and exacerbates the problem of poverty in developing countries. Myanmar is a developing country with a population of about 60 million. The gap in access to electricity between urban and rural areas is very large.

Most of the country's rural population does not have access to the power grid and is dependent on off-grid sources. In the past, rural households used kerosene for their household electricity and heat. diesel fuel Wood and charcoal are used.

Most rural areas in Myanmar have high potential for solar energy. Myanmar's average solar radiation is 5.08 kWh per square meter per day, making solar energy suitable for mini-grids in many areas. Solar mini-grids can only provide a limited amount of light, can only be used for phone charging etc. Suitable for limited hours per day for basic energy services for households such as phone charging and fans.

Compared to other technologies, solar mini-grids have a short development time and can be installed in a few months. Small-scale solar energy systems, called Solar Home Systems (SHS), made available to consumers through the government, are being implemented in rural electrification projects. Solar systems are versatile and can be used to generate electricity for rural households. Solar systems can be easily moved if needed.

Solar energy is a powerful source of energy and sunlight has proven to be very beneficial. Solar energy is one of the fastest growing energy technologies in the world. It is being rapidly upgraded and supplemented by solar battery storage systems. This means it converts solar energy into a more efficient and cleaner source of energy.

The advantages of solar energy are: (a) It is clean energy that fights pollution and carbon footprint. (b) Installation of solar panels will reduce electricity bills as they provide energy(c) Solar photovoltaics can generate electricity from sunlight and use solar energy for heat. (d) Solar energy systems usually do not require much maintenance.

Disadvantages of solar energy are: (a) Initial purchase costs for solar panels, batteries, wires, inverters and installation costs. (b) Solar energy depends on the weather because sunlight is produced most on a sunny day. (c) The cost of solar energy storage is expensive as large batteries have to be purchased. (d) Certain toxic materials and hazardous products are used in the manufacturing process of photovoltaic panels.

The issue of technical detail is usually incomprehensible to less educated rural farmers, but relevant information such as how many lamps and electricity systems are provided for each family should be provided. Street lights may be included, and the use of electricity installation will cost the community and individual households.

The study purposes renewable energy is providing the electricity in the rural area because how to develop and how to benefit for the village households of rural area.

1.2 Objective of the Study

The main objective of the study is to analyze the benefits of solar electricity system implemented by Department of Rural Development in selected rural areas of Ye Nan Gyaung Township, Magway Region. This solar electricity system is how to affect the rural household socioeconomic situation and how to benefits using solar electricity system by Department of Rural Development.

The sub-objectives of the study are:

1. To find out the challenges and opportunity of solar electricity system for rural development of Ye Nan Gyaung Township, Magway Region.
2. To access the benefits of electric power generated by solar electricity system have on rural households and reducing the cost of electricity to access solar energy is an environmental factor in Ye Nan Gyaung Township, Magway Region.

1.3 Method of the Study

The method of the study is descriptive method based on primary data and secondary data. Primary data is collected by conduction a survey using structured questionnaire on randomly selected 250 households of rural area in Ye Nan Gyaung Township, Magway Region. Secondary data is obtained the relevant documents from Ministry of Border Affairs, Ye Nan Gyaung Township General Administration Department, Community Organizations, International Non-governmental Organizations, Asia Development Bank, libraries and on the websites.

1.4 Scope and limitations of the Study

The scope of the study is the period from 2015 to 2020. The major limitation of this study was that this did not cover the other rural areas in Myanmar. This study was conducted to study the operation solar electricity system and their financial and social impacts besides other changes brought about by solar electricity over the last of installing them in their region.

1.5 Organization of the Study

The study is divided into five chapters. Chapter one is introduction chapter with rationale of study, objective of the study, method of the study, scope and limitations of the study and organization of the study. Chapter two is literature review on solar energy and types of solar panels and energy generation system. Chapter three demonstrates the renewable energy potential in Myanmar, renewable energy situation in Myanmar, renewable energy technologies for mini-grids, solar energy potential and application in Myanmar. Chapter four is survey analysis on benefits of solar electricity for rural development in Ye Nan Gyaung Township, Magway Region. Chapter five is conclusion with findings and suggestions.

CHAPTER II

LITERATURE REVIEW

2.1 Global Warming and Environmental Factors

Global warming is the long-term heating of the Earth's surface since the pre-industrial era (between 1850 and 1900) by human activities; Primarily by burning fossil fuels, Increases the amount of greenhouse gases in the Earth's atmosphere and increases heat waves.

Since the pre-industrial period, human activities are estimated to increase temperatures by about 1 degree Celsius (1.8 degrees Fahrenheit) per decade, rather than 0.2 degrees Celsius (0.36 degrees Fahrenheit). It is abundantly clear that the current warming trend is the result of human activity since the 1950s and is continuing at a rate unprecedented in millennia.

Global warming is perhaps the most important environmental problem in the world today. Human activities are increasing the amount of greenhouse gases in the atmosphere, changing the composition of the atmosphere and causing global warming. Climate scientists agree that human activities, such as burning fossil fuels, contribute to the problem.

More specifically, changes in near-surface air temperature can influence ecosystem functioning, and therefore plants, It will influence the biodiversity of animals and other life forms. Adaptations to seasonal climate patterns have established the current geographic range of plant and animal species. Because global warming has changed these patterns on timescales that are much shorter than those caused by natural climate change in the past, Sudden changes in climate can challenge the natural adaptive capacity of many species.

Surface warming in temperate regions is likely to lead changes in various seasonal processes for instance, earlier leaf production by trees, earlier greening of vegetation, altered timing of egg laying and hatching, and shifts in the seasonal migration patterns of birds, fishes, and other migratory animals.

Other likely impacts on the environment include the destruction of many coastal wetlands, salt marshes and mangrove swamps as a result of rising sea levels and the loss of certain rare and fragile habitats that are often home to specialist species that are unable to thrive in other environments.

Renewable energy is beneficial for reducing global warming and environmental factors.

2.2 Solar Energy

Solar energy is a huge and inexhaustible source of energy (Anish, Fabian, Jesper and Fredrik, 2017). The power from the Sun intercepted by the Earth is approximately 1.8 x 1010 Mega Watt (MW), which is thousands of times higher than the rate of energy consumption on Earth. Solar energy can sustainably supply all of the world's current and future energy needs; It is one of the most promising non-conventional energy sources and it is an environmentally friendly and clean energy source available almost all over the world.

The sun provides the basis for life on Earth and enough energy to meet all our needs. Photovoltaic is a technology that converts sunlight directly into electrical energy. No moving parts; environmental benign activity; It has many advantages such as suitable resource for remote applications. Photovoltaic systems are obviously suitable for remote areas where there is no electricity supply. In addition, Space programmers have proven the technical feasibility of the photovoltaic system due to its high efficiency and reliability.

The performance and reliability of photovoltaic systems have been demonstrated in small and medium-sized stand-alone applications as well as several megawatt grid-connected power plants. Solar photovoltaic systems with or without storage batteries; separate system; They can work in many modes such as hybrid and grid connected with many of their applications.

The input energy for solar photovoltaic systems is location; time of day It is the resulting solar radiation that depends on the year as well as the angle at which solar energy is received and other relevant environmental conditions. Solar photovoltaic

(SPV) array output also depends on solar cell operating temperature, which is affected by ambient air temperature. These limits are hourly; day by day It continues to change monthly and yearly.

The energy released by the sun that causes chemical reactions to release heat from the sun is called solar energy. It is the most powerful and massive source of energy. The total amount of solar energy on Earth's surface is far greater than the world's current and future energy needs. If properly harnessed, it has the potential to meet all future energy needs.

Therefore, solar energy is used to generate electricity these days. Solar energy is expected to become the most attractive renewable energy source. Solar energy has an inexhaustible supply, and non-renewable resources such as coal, It is non-polluting like natural gas and oil.

There is a process of generating electricity from solar energy. Photovoltaic cells are used to generate solar electricity. When light falls on these cells, they generate a small electrical voltage. Photovoltaic cells are constructed of metals and semiconductors or two semiconductors. When light strikes two metals and a semiconductor or semiconductor, an electric voltage is generated. One photovoltaic cell can produce about two watts of power.

In solar energy plants, many photovoltaic cells are used to generate solar energy. Multiple cells are connected in a panel. Solar panels generate hundreds of kilowatts of electricity. Therefore, Solar energy is converted into electricity using a number of photovoltaic cells.

The sun is a very powerful source of energy, and sunlight is by far the largest source of energy received by Earth. However, the intensity of sunlight at the Earth's surface is very low because of the large amount of radiation from the distant Sun. Moreover, Earth's atmosphere and clouds lose the intensity of sunlight. 50% visible light; About 45% of infrared radiation and small amounts of ultraviolet and other electromagnetic radiation make up the sunlight that reaches the Earth's surface. Earth receives 200,000 times of the world's total daily electric generating capacity in the form of solar energy.

Solar energy is free, but its collection; The large costs of conversion and energy storage make it difficult to use properly. Sunlight can also be converted into thermal energy or electrical energy.

Advantages of solar energy:

- Solar energy is the cleanest energy because it does not pollute, and coal, It does not emit carbon dioxide like renewable energy sources like natural gas etc.
- Solar energy is the energy that has remained on Earth for as long as the Sun has existed, and it is a renewable energy source.
- Solar energy can be stored in batteries and converted into other forms such as heat and electricity. It can be used in many ways and is very reliable.
- Solar energy is free and available to anyone who can capture sunlight with the necessary technology.

Disadvantages of solar energy:

- Solar energy production also decreases due to less solar radiation during winter and cloudy days.
- The initial and installation costs of the equipment required to harness solar energy to obtain solar energy are also high.
- The space required for the materials to harness solar energy is large.

2.2.1 The Environmental Benefit

The most important environmental benefit derived from the installation and operation of solar energy systems is the reduction of pollutant emissions. Energy used in power plants to generate electricity is a major part of the pollution cycle. The cost of environmental impacts of conventional fuels is very high and may be of the same order of magnitude as their estimated production costs (Georgopoulou, Lala and Papagiannakis, 1997).

A general conservative estimate of this value is USD 24 per ton of carbon dioxide (CO_2). Table (2.1) estimates the quantity of CO_2 in tons that will be eliminated by different sizes of PV system. It is assumed that 827 kg of CO_2 are emitted for each megawatt hour of electricity produced by burning fossil fuels (World Bank, 1999).

Table (2.1) Reduction in CO_2 Emissions by the PV System

Station Output Capacity (MW)	Annual Output (MWh)	CO_2 Emission	Annual Emission at USD 24 per Ton
1	2	1.6	39.7
10	20	16.5	396.9
50	102	84.3	2024.5
100	203	167.9	4039.1

Source: World Bank, 1999

From Table (2.1), if the station output capacity is 1 MW to reduce 1.6 CO_2 emission and the annual reduction in CO_2 emission will USD 39.7 by the PV system. If the station output capacity is 10 MW to reduce 16.5 CO_2 emission and the annual reduction in CO_2 emission will USD 396.9 by the PV system. If the station output capacity is 50 MW to reduce 84.3 CO_2 emission and the annual reduction in CO_2 emission will USD 2024.5 by the PV system. If the station output capacity is 100 MW to reduce 167.9 CO_2 emission and the annual reduction in CO_2 emission will USD 4039.1 by the PV system.

2.2.2 The Economic Benefit

Economic profit is the difference between total revenue and total opportunity cost, including its explicit and implicit components. From an economic point of view, Money must not change hands before an expense is incurred. Cost connotes sacrifices; and scarifies can be made and alternatives can be forfeited without money changing hands.

The economic benefit of generating electricity using a PV solar system can be analyzed. Each unit of electricity produced by a PV system will replace a unit of electricity produced by fossil fuels. Savings in terms of energy source (oil) can be sold in the global energy market for higher profits or saved for future generations.

To determine the economic profitability of PV solar systems, the opportunity cost of using fossil fuels to generate electricity should be taken into account. In addition, the opportunity cost should consider the indirect cost of environmental pollution.

A solar electricity system will get more economic benefit for small businesses to continue production later into the night. The local people will increase their incomes, and allows them to begin to lift themselves out of poverty.

2.3 Weather and Climate

Weather is the immediate or current state of the atmosphere, the temperature, Atmospheric pressure humidity wind speed and direction; It can be measured in terms of cloudiness and precipitation. Climate is years, Decades The state of the atmosphere over long periods of centuries or more. In general, weather and climate surface organisms that affect Earth's surface occur in the troposphere.

Climate change affects Earth's regional, A long-term change in the average weather patterns that come to define regional and global climates. These changes have far-reaching effects that are synonymous with expression. Since the mid-20th century, changes in Earth's climate have been driven by human activities, particularly the burning of fossil fuels, which have increased the amount of greenhouse gases in the Earth's atmosphere and raised the Earth's average surface

Naturally variation in solar irradiance, variations in orbital parameters of earth and volcanic activities cause climate change. Portion of incoming solar energy reflects back to space. However, part of that energy is absorbed by atmospheric gases, helping to warm the temperature (which is why the Earth is hotter than the Moon). If these natural thermoregulating properties were not available, the Earth's average surface temperature would be about 33°C lower (IPCC, 2001). The gases are known as greenhouse gases.

In recent decades, after the industrial revolution, atmospheric greenhouse gas (GHG) levels have increased greatly due to human GHG emissions and the removal of natural sinks such as deforestation and ocean pollution.

The process of increasing the greenhouse effect causes the earth's surface to warm and the atmosphere, space It changes the transfer of energy between land and oceans. This process is called global warming. In addition, solar energy or temperature, wind, ocean currents humidity model; Global climate is the driving force behind global weather patterns as it is driven by the movement of clouds and so on. This also intensify the effect of natural disasters such as storms, flooding rain, landslides, drought, land degradation and agricultural loss, species loss and epidemics.

Earth's weather and climate are driven by the sun's energy. Sunlight heats the Earth's surface and the Earth radiates energy back into space. Some of the gases in the atmosphere trap some of the released energy and retain heat. This increases the global temperature and also causes subsequent changes in weather patterns. Gases that trap heat energy are known as greenhouse gases. All greenhouse gases are positive radiative agents and are capable of disturbing the energy balance in the atmosphere.

The sun provides the basis for sufficient energy to meet solar photovoltaic technology. This technology to convert sunlight directly into electrical energy. The amount of useful solar energy incident in any particular location is highly dependent on good weather condition and climate.

2.4 Types of Solar Panels and Energy Generation System

Solar panels convert solar energy into electrical energy. A solar cell is a combination of p-type and n-type semiconductors. A p-type semiconductor is obtained by adding a trivalent impurity (boron) to silicon. Similarly, n-type semiconductor is obtained by adding a pentavalent impurity (phosphorous) to silicon. It is a p-n junction and the diffusion of charged particles creates an electric field.

The basic principle of solar cells depends on the photovoltaic effect; That is, On the solar cell's exposure to sunlight; Voltage and current are induced in the material. Sunlight emits invisible particles called photons. In a solar cell, the top layer or n-type layer; It consists of three parts: middle layer (depletion layer) and bottom or p-type layer.

Light of wavelength 350-1140 nm is captured into the depletion layer. Photons emitted from sunlight, which contain neutral atoms, penetrate the collapse layer as a free electron and hole. Free electrons move to the n-type layer and holes move down to the p-type layer.

Therefore, the wire between the top and bottom layers provides a path for electrons to move towards the hole forming a current. Each cell produces 0.5v to 1v.

When these solar cells are connected in series and parallel, the required voltage and current are obtained.

The conversion of sunlight into electricity is done through solar cells and this direct current is converted into electricity by an inverter. After powering the equipment, any excess electricity is stored in batteries that act as a backup when solar power is not available. But the demand for electricity is increasing, and when there is not enough solar energy and not enough power to provide from the battery, it becomes difficult to do the necessary work.

In an on-grid solar system, also known as a grid-top or grid-fed solar system, solar panels, inverters, Includes meter and power/utility grid. The electrical energy obtained from solar cells is direct current. It uses electricity for powering most devices. The current is obtained through an inverter that flows through an electricity meter that delivers electricity to devices.

If the solar system emits more energy than it needs, the excess electricity can be sent back to the grid and charged in the path (Fit). Electricity from the grid can be used at night or when the solar power system is not in a suitable condition.

An off-grid solar power system has battery storage instead of being connected to the grid in a stand-alone power system. Off grid solar power uses minimal electricity from the grid. It has a solar cell if needed. It comes with an inverter and battery bank and can also be used for power backup.

During the day, sunlight is converted into electricity. The excess will be stored in batteries similar to an off-grid system. If the excess power is stored, it is fed back into the grid, just like solar on the grid. In the absence of solar power and grid support can use power from batteries. Also, when there is not enough battery backup and there is no solar energy, electricity can be continuously obtained from the grid and the battery can be charged.

Since mini-grids for rural electrification are often stand-alone and typically face budget constraints, the design of the subsystems should be carried out in an integrated manner, as each subsystem should be closely related and compatible with the other systems.

In addition to project costs, system design also determines the cost of energy production and the quality of services delivered to consumers.

Determining the correct capacity of the generation system is a challenge, especially for communities that have previously had no access to electricity services. If the system is large, Project costs will be high, taxes will be high, and some capacity will not be used.

In designing the system, several considerations are important:

Alternating current or direct current: This depends on the technology used and the power consumption. PV and batteries produce direct current (DC) power, while hydro and biomass typically produce latent current (AC) power. High efficiency DC lights and other small household appliances are available, but commercial or productive applications may require AC power.

Single- or three-phase distribution grid: A single-phase grid is cheaper but can only handle small loads. Using larger equipment requires a three-phase grid. This will allow it to connect to the national grid when it reaches the distribution grid.

Batteries: If the system includes batteries, they need to be deep cycled. The capacity of the battery pack is mainly determined by the number of days the system can provide electricity without recharging the battery and without draining the battery. It depends on the expected number of consecutive days without sufficient sunlight during the rainy season.

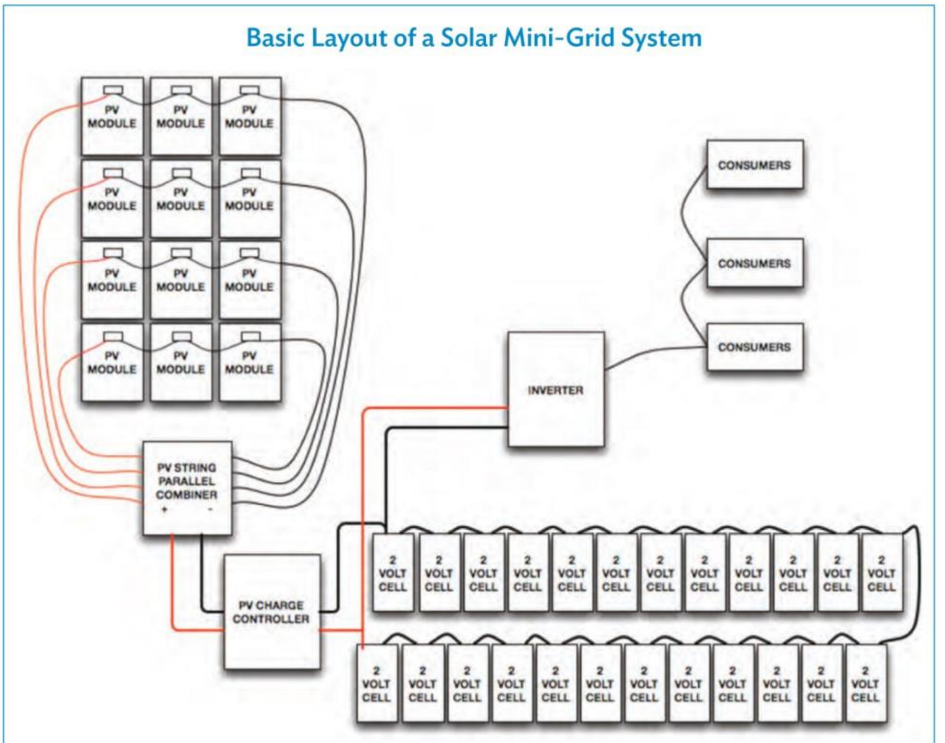
Wires and conduits: They need to be sized for minimum voltage drop (line loss). physical harm; It also needs to be firmly protected from UV rays and weather.

Circuit protection: This is required in the form of fuses and circuit breakers. It is important that all wires connected to the battery have circuit protection.

Flood protection: Many areas in Myanmar can experience severe flooding, so it should be installed at high elevations or at least exposed to flooding. This will allow the system to continue operating during a flood event or at least avoid major damage.

The basic layout of a solar mini-grid system is illustrated in Figure (2.1).

Figure (2.1) Basic Layout of Solar Mini-Grid System



PV = photovoltaic.
Source: ADB Myanmar Off-Grid Renewable Energy Demonstration Project Team (2017).

Solar energy is being introduced on a limited basis in some rural areas to generate electricity from photovoltaic cells to charge batteries and pump water for irrigation. As an initial step to demonstrate photovoltaic power systems for remote villages, some equipment has been installed under a technical cooperation program with other developing countries. Standalone PV systems are being used for rural electrification in areas that cannot be connected to the national grid, with notable initiatives in schools and universities.

The following highlights the main strengths and constraints of the use of solar for mini-grids.

Strengths

- Solar mini-grids can be installed as modular systems. They can be easily expanded over time if demand increases and the need for regenerative capacity arises.
- Compared to other technologies, solar mini-grids have a short development time and can be installed in a few months. Systems can be easily moved if needed.
- The costs of solar systems are dropping dramatically. Mini-grids aimed at providing basic energy services to households can be installed at low cost.
- Solar photovoltaic panels have a long lifespan, and high quality panels typically have a 25-year warranty on performance.
- Operation and maintenance (O&M) is relatively simple and can be handled relatively easily at the village level. There are no moving or rotating parts that require higher maintenance.

Constraints

- The solar systems generate electricity during the day and most of the villagers use the energy in the evening. This means that electricity needs to be stored before it can be used. Solar systems are very expensive and use deep cycle batteries for storage that need to be replaced every 3-5 years.
- Solar mini-grids can only provide a limited amount of power and can only be used for lighting, lighting, etc. Suitable for limited hours of the day for basic energy services for homes such as phone charging and fans. They are rice cookers, Not suitable for 24-hour services and high service such as milling.

2.5 Review on Previous Studies

Kyi Tha Min (2015), studied on solar energy utilization of rural households in Ayeyarwady Region (Case Study in Pathein Township). The study found that the use of solar PV can improve the life of the household. It was found to have a significant impact on living standards and household income-earning activities.

Thida Hlaing (2016), found that four villages use solar PV systems for some sectors such as household education; new business opportunities; increasing readership. There has been great progress in the four villages in terms of the absence of fire hazards and lower energy consumption costs. More involvement and participation in community development activities can further improve the sector. Lighting is central to all sectors in rural areas, and the impact of solar energy use is based on how much is spent on solar technology and equipment.

Khaing Zaw Nyein (2016), studied the impact of rural electrification in Myanmar with the case study of Thanlyin Township. This study found that electrification projects can have an immediate effect on the improvement of household living conditions through access to electricity, and the improvement of productive activities. However, the impact of rural electrification in relation to public service provision is low and most of the respondents are experiencing the positive and negative effects of electrification in their livelihoods.

Daung Zay (2018), found that the use of solar energy home systems by rural people can reduce the family's cost of lighting, especially for school children. access to standard electrical equipment; extension of overtime; General information distribution and reception; Promoting health and fire awareness.

Pwint Phyu Thin (2019), found that a consensus among respondents for improving health and income emerged as a result of access to electricity. Households gain more time due to the support of their daily tasks through the use of electronic devices, and spend that extra time doing other tasks. More time can be spent praying or enjoying entertainment with family members. However, the effect of access to electricity is ineffective because they are reluctant to risk their own business by taking advantage of electricity.

CHAPTER III

AN OVERVIEW OF RENEWABLE ENERGY IN MYANMAR

3.1 Renewable Energy Policy in Myanmar

A sustainable energy mix in Myanmar's current economic development requires a clear view of the role of renewable energies and their position in the country's development.

A renewable energy policy must provide equal support to both public and private options to give recipients a choice and ensure the most efficient achievement of the enormous task of rural electrification. Rural electrification is not a government-only effort, but requires a strong and collaborative partnership with the private sector. In such a way, providing sufficient electricity can fulfill the task of providing sufficient electricity at a much lower cost than grid electricity.

The renewable energy policy outlined in this document identifies targets for national renewable energy development and names the priority actions needed to achieve these targets. The last and most important step that remains is to initiate action at the national level over time. It is to establish an actor that will be monitored and developed. renewable energy projects are tackled one at a time and lack the concept of long-term sustainable development. To date, the private sector has not found clear economic conditions in terms of finance and taxation.

The renewable energy policy component now has a new range of tasks and can use this opportunity to create a compact and efficient national oversight structure. Responsibility can be seen in organizational areas:

- Build a national office responsible for national and international renewable energy development as a one-stop service unit;

- Establish a strong legal and regulatory basis for renewable energy;
- Collaborating with private entrepreneurs to carry out long-term investments;
- Prepare and update required renewable energy database for planning and evaluation;
- Organize operational project supervision, monitoring and evaluation, training and certification
- Arrange maintenance, service and quality assurance for all national renewable energy installations
- Coordinate the financial activities with electrification premiums, project financing
- Organize social, economic and environmental impact assessment

In order for Myanmar to continue to develop and maintain the conditions that will secure the health and safety of the people, the national government has implemented climate-resilient, sustainable low-carbon society and a strategic vision of prosperity and inclusion has been established. For the well-being of present and future generations.

To achieve the above-mentioned objective, Myanmar needs to direct its development activities (especially in social, infrastructure and economic sectors) in two strategic ways: (a) enhancing the adaptive capacity of vulnerable communities' sectors and (b) Create and increase opportunities to pursue a low-carbon development path by ensuring development benefits for all communities and economic sectors.

In the energy sector, Myanmar aims to achieve a conditional annual target of avoiding 144.0 million tCO_2e emissions by 2030 against that predicted under the Business as Usual (BAU) scenario, of 297.01million tCO_2e (NDC, 2021). Myanmar aims to achieve this target by: increasing the total share of renewable energy (solar and wind) to 53.5% (from 2000MW to 3070MW) by 2030, and decreasing the share of coal by 73.5% (from 7940MW to 2120MW) by 2030 (NDC, 2021).

Under its unconditional target, in the energy sector Myanmar will achieve avoiding 105.24 million tCO_2e by 2030 from the BAU. In the Agriculture sector, Myanmar has introduced a new conditional cumulative target of sequestrating 10.4 million tCO_2e over the period of 2021-2030 (NDC, 2021).

Highlighting the fact that the country is becoming increasingly urban and industrial, Myanmar has set 2030 targets for improvement of energy efficiency of the residential sector by 7.8%, the industrial sector by 6.63%, the commercial sector by 4%, and other sectors by 1.36%. Thus, the policy target for energy efficiency is a cumulative of 20% by 2030 avoiding a cumulative of 0.133 million tCO_2e as a conditional energy efficiency target (NDC, 2021). Myanmar has passive and active energy for these sub-sectors. It is requested to provide basic information and support in developing mitigation actions targeting several heating and cooling standards and technologies.

In addition to the sectoral objectives identified above; We welcome support to promote low-carbon urban models and increase the use of integrated resource management and planning methods in urban resilience policies (such as the urban context approach) for cities of all sizes. Cities are now home to 29% of the population, and thus need to be safe, resilient, environmentally viable, and carbon-efficient without sacrificing development (NDC, 2021).

The following Table (3.1) shows the fossil carbon dioxide (CO_2) emissions of Myanmar.

Table (3.1) Fossil Carbon Dioxide (CO_2) Emissions of Myanmar

Year	Fossil CO_2 Emissions (tons)	CO_2 emissions change	CO_2 emissions per capita
2015	8,461,713	0.82%	0.17
2016	8,964,066	5.94%	0.17
2017	10,507,960	17.22%	0.2
2018	15,116,431	43.86%	0.29
2019	15,814,133	4.62%	0.30
2020	16,701,776	5.61%	0.31

Source: Mulia, Nguyen & Steward (2020)

3.2 Mini-Grid in Myanmar

A total of 32 mini hydropower (with a total capacity of about 34 MW) projects have been implemented with installed capacity ranging from 50 kW to 5,000 kW to reach remote border areas in Kachin and Shan Stat. There is the potential for many more small- and medium-sized hydropower projects, each of which has a capacity of less than 10 MW, for a total potential installed capacity of approximately 250 MW (ADB, 2015).

Myanmar has a strong solar radiation level. Myanmar's maximum solar power potential is estimated capacity is about 40,000 GWh per year. In the past decade, solar energy has been introduced in some rural areas through photovoltaic cells to charge batteries and pump water for irrigation. The MoEE is conducting a preliminary investigation to construct solar power plants of a total of 1,460 MW with foreign direct investment in Minbu, Magway Region, Myingyan, and Mandalay Region. Solar PV in small grid systems was reported by the Department of Rural Development (DRD) in 2017. Either through the DRD program, where several households in a village have already installed solar home systems or self-purchased.

The most common mini-grid generation technology in Myanmar is diesel generators. According to the 2014 census, about 178,000 households (about 152,000 rural) use private water purifiers as their main source of electricity, while 1,013,149 households use diesel generators (836,000 rural). Solar mini-grids, either standalone or hybrid PV/diesel are much less common. DRD reports about 150-200 villages in 2017, Most of them received large grants as pilot projects awarded by non-governmental organizations or DRD.

There are two main business models for mini-grids in Myanmar. Some mini-grids are operated by a group of farmers selected by the Village Electrification Committee (VEC). In this model, The head of each block of 10 households in the village collects monthly customs payments. Other small grids are owned and operated by private operators. Studies have found that the tariffs charged by diesel-powered mini-grid operators are 1000-2000 Kyats per month (USD 0.9-1.82/month) and 2500-5000 Kyats (USD 2.27-4.55 per month) for connecting a light bulb. Connection to lighting and TV.

Equivalent tariffs per kWh are about USD 0.37-1.00. Tariffs of hydropower mini-grids are typically lower than tariffs at about Kyat 200–K 860 (USD 0.18–0.78) per kWh (World Bank, 2017). Biomass gas generators are widely used in the Delta region, and in addition to mini-grids, mills, irrigation pumps; Operates sawmills and oil presses. The small tariff for biofuel gas is about 400 kyats per month.

Renewable energy sources for Mini-Grid Solar Home Systems (SHS) seem to be most suitable for poor villages with about 100 or fewer houses. In comparison, mini-grids can power larger residential areas and can power refrigerators, freezers, and more. water pump Regional economic development can be driven by the reinforcement of large-scale manufacturing facilities, such as sawmills and mills or agricultural facilities such as corn huskers.

Although grid expansion and microgrid development require organizational integration, solar home systems can be installed on an individual basis. For villages with weak leadership or the inability to organize collective payment arrangements; With low demand, solar homes are an ideal solution for household electricity needs.

Even in large-scale situations where economic factors favor micro-grids as the primary energy source over solar home units, solar home units can play a valuable backup role. This is because the generators and gasoline generators commonly used in villages and rural settings only run for two to three hours a night to power the entire micro-grid. Therefore, any individual or commercial use during other times requires auxiliary provision through platforms such as solar home systems (KWR-ERIA, 2015).

Rural electrification is a major need as only 50 percent of Myanmar's population has access to electricity. In the absence of renewable electricity, rural communities use diesel generators. Off-grid mini-grids will be located at least 10 miles from the national grid.

Under the current update of the ongoing National Electrification Plan (NEP-2016-2021), the off-grid program managed by the Department of Rural Development has set targets for setting up solar home systems and mini-grids as shown in Table (3.2).

Table (3.2) Solar Home System and Mini-Grid

Financial Year	Solar Home System		Mini-Grid	
	Villages	Households	Villages	Households
2016-2017	2708	141465	10	1503
2017-2018	1684	88020	35	6868
2018-2019	3275	125009	39	9774
2019-2020	1396	59967	35	11940
2020-2021	769	39374	35	7132

Source: Department of Rural Development, 2022

3.3 Electricity Demand in Myanmar

Access to electricity remains a problem for the 30 million people in Myanmar, 58 percent of whom are not connected to the national grid. The Government of Myanmar has formulated a National Electrification Plan (NEP) composed of 5 phases, which aims to achieve 100% electrification in NEP by 2015, with a limited role as a temporary electrification solution for 0.7 million in NEP. 2% of people or off-grid population.

A major challenge in implementing the 2015 NEP Roadmap based on global standards is that grid electrification is expected to require considerable time and investment. In this case, Mini-grids can deliver electricity to off-grid areas as a “Grid 2.0” distributed solution while expanding the main grid.

The mini-grid cost per connection is on average about 40% lower than the main grid extension. Microgrids have large developmental implications because they can support demand from business users. Mini-grid generation and energy storage assets can be deployed as micro-distributed generation and energy storage systems, and distribution assets can be deployed to ensure last-mile connectivity to households and businesses in villages. Thus, mini-grids provide a bottom-up “grid 2.0” solution that can accelerate electricity availability while expanding the main grid.

However, Grid-ready microgrids are expensive and require subsidy support. In addition, The lack of a comprehensive regulatory framework and a clear transition mechanism when the grid arrives creates risks for small grid projects close to the main grid. Currently, mini-grids serving residential and local businesses are only financially viable from the perspective of private developers if investment subsidies are provided. Mini-grids are not regulated under a licensing system and have no compensation and/or transition mechanisms when the grid is reached.

Therefore, with current grant budget availability and no regulatory changes. The potential market size is expected to remain at just 230 mini-grids covering approximately 110,000 people by 2025. By 2030, there will be 590 mini-grids covering 531,000 people, or 2.3% of the off-grid population.

By 2025, only small grids are financially eligible under the Investment Support Scheme. At the current level of budget available for investment grants, approximately 230 small grids could be developed. By 2030, As equipment costs fall, beyond the investment subsidy program, small grids are expected to become financially viable in favorable locations. However, in the absence of regulatory reform. Investable areas are restricted to villages in stages 4 and 5 of the NEP, resulting in a total of 590 potential mini-grids.

Access to reliable electricity supply has been a long-standing problem in Myanmar. Of the 11 million households, 6.5 million or approximately 58 percent are not connected to the national grid. 4 million have no electricity at all, lighting, kerosene as energy sources for cooking and other domestic uses; oil and solid fuels are used. The remaining 2.5 million households have diesel generators; Access to electricity through solar home systems or other power generation devices. However, Supply from these off-grid solutions is often unreliable and expensive.

Providing reliable electricity at affordable tariffs to households and businesses without internet access is critical to Myanmar's socio-economic development. In other developing countries, gridlocked areas have largely benefited rural areas. For example, in India, rural electrification programs have revealed significant social, health and economic benefits. Rural electrification can be achieved through grid expansion and through off-grid solutions.

The Myanmar government plans to expand the electricity grid, but it will take time and require significant investment. In parallel, Advances in technology have significantly reduced costs in distributed renewable power generation and storage, opening up new possibilities for off-grid solutions. In some regions, Myanmar has a unique opportunity to jump to a decentralized power system, accelerating the cost reduction of electricity. A decentralized model of electricity supply can have advantages in terms of supply efficiency and security.

The government has set an ambitious roadmap to increase access to electricity, with a target of 100% grid power by 2030, and a 58% increase in electrification in 12 years from 42% in 2018. Moreover, the implementation capacity further constrains the power grid. Instead of relying solely on grid electricity, mainly diesel generators. Solar home systems and mini-grids are ways to provide electricity locally or regionally. (including mini-grids combining solar PV generation with storage and backup diesel generation systems).

These solutions not only support residential loads such as (1) lighting and small appliances, but also machinery for welding; Carpenter water pumps; Differentiated by their ability to support large production loads, such as machinery for processing farm crops (eg rice milling) etc. and (2) cost and reliability of power supply. Diesel generators use a diesel fuel engine to generate electricity locally.

The typical production capacity is more than 5 kW, which can provide electricity for many households, and the production capacity is large. Their main disadvantages are very high average electricity costs (average MMK 510/kWh, but can be higher than MMK 1,000/kWh). In addition, fuel prices can be extremely volatile, making it challenging to secure and maintain reliable fuel supply in remote areas.

Solar home systems are separate photovoltaics systems for individual households. They provide reliable energy because they require little maintenance. Typically, they have light, It has an output capacity of less than 150 W, which is only sufficient to supply power for small devices and cellular phone charging. The main disadvantage of this solution is that it cannot support larger loads for residential use and utility operations.

Mini-grids combine generation assets with distribution grids of sufficient scale to cover off-line villages or townships. They can support residential and manufacturing loads. In some cases, there are also large commercial employees such as a small manufacturing plant or a communication tower around a village.

While mini-grids typically have a production capacity of between 10 kW and a few hundred kW, there are case studies of larger MW mini-grids that provide power for entire townships in Myanmar. Therefore, mini-grids are residential and it has the potential to play an important role in providing reliable electricity outside areas where productive and anchored loads are served.

According to DRD's estimates, about 4,312 of these off-grid systems provide electricity to at least 70% of the households in the villages where they are located and can therefore be classified as mini-grids as shown in Table (3.3).

Table (3.3) Number of Existing Solar Mini-Grid by States and Regions

States and Regions	**Solar Mini-Grid**
Ayeyarwady	56
Mandalay	10
Shan	32
Sagaing	14
Magway	9
Mon	1
Chin	1
Kayin	9
Kayah	56
Nay Pyi Taw	2

Source: Department of Rural Development, 2021

The Department of Rural Development (DRD) has launched a renewable energy-based electrification program, mostly using PV stand-alone systems and micro-grids. Currently, the Department of Rural Development (DRD) is distributing these systems free of cost, so the need for finance will soon become a hindrance.

Free gifts, they are often observed to reduce the perceived value of the supply option, leading to early failure rather than to sustainable operation. Private enterprises engaged in renewable energy rural electrification request a contribution from beneficiaries for system costs and operation.

Rural electrification is quantitative while constraints such as quality and affordability still need to be met, renewable energy can overcome these constraints when opening up the private sector as a partner. Many partners can make a substantial contribution to the overall target; They will afford the valuable decision and will of the village receivers. Up to now, slow growth has encouraged rural people to engineer their own supply solutions. Private industry and NGOs have contributed to some extent. Their main challenge is the long-term financial exposure required.

3.4 Development of Solar Power Mini-Grid Project in Myanmar

A renewable mini-grid consists of three main subsystems: consists of three main subsystems: (i) generation. This includes power sources (solar panels, turbines, or engines); batteries, Includes chargers and inverters. These determine the amount of electricity the system can produce. (ii) Distribution. It involves the distribution of electricity to consumers through a grid that covers the community. Different choices can be made for the grid: DC or AC; single- or three-phase; base or grid ready. This means it can connect to the main grid when it reaches the community. (iii) Consumption. It has meters, power limitations; electrical outlets and lights; Includes all equipment in the area of use, including fans and TVs.

Solar photovoltaic systems use sunlight to generate electricity directly. Solar systems are very versatile and can be used for a variety of applications, such as rural electricity generation systems for rural households. The stand-alone or grid-tied mini-grids, solar farms that sell power to the grid, rooftop solar to power offices and factories, as well as traffic signals and communication towers in remote areas. Installation costs have fallen significantly in recent decades, making solar more competitive compared to conventional technologies in many countries.

A solar photovoltaic panel that converts sunlight into electricity. The section emits maximum energy when sunlight is perpendicular to its surface; Therefore, its actual output depends on the season. It varies greatly depending on latitude and time of day.

Production depends on atmospheric humidity. It also depends on local weather conditions such as dust and cloud cover. Photovoltaic panels should be installed at the best angle to get maximum solar exposure. It is important to note that solar resources can vary by location and season.

In Myanmar, the solar resource at the peak of the rainy season in August is about half of the solar peak in April. The design of a solar mini-grid system should take these differences into account by choosing the appropriate capacity of solar panels and batteries. Assessing available solar energy resources is an important first step in investigating the feasibility of a solar mini-grid.

Designing a solar mini-grid system is a complex engineering task, and improper design will affect the technical performance and economic feasibility of the system. A solar mini-grid system typically includes the following main components:

Solar panels: These generate electricity in the form of low voltage direct current (DC). Mini-grid systems use multiple panels. They should be facing south to capture the most sunlight. In Myanmar, it is usually at an angle of 15-25 degrees. Panels should be installed where there is minimal shade throughout the day.

Batteries: These should be deep cycle type batteries specially designed for photovoltaic systems. Although more expensive than car batteries, they last longer and are more cost-effective in the long run. Batteries are typically the weakest element of a system and require adequate maintenance.

Charge controller: This prevents overcharging and deep discharging of the batteries.

Inverter: It converts low voltage DC power to high voltage alternating current (AC) power. Larger systems may have more than one inverter. Small grids that run on DC power do not require an inverter.

Table (3.4) shows the components of a solar mini-grid servicing 200 households.

Table (3.4) Components of Solar Mini-grid Servicing

Component	Quantity	Unit Costs (USD)	Total Costs (USD)
Primary Components			
PV modules	24	245.00	5,880.00
PV array rack	4	350.00	1,400.00
Charge Controller	4	480.00	1,920.00
System housing	1	1,735.00	1,735.00
Inverters	4	1,490.00	5,960.00
Batteries	96	225.00	21,600.00
Data logging system	1	375.00	375.00
Earth ground system	1	230.00	230.00
DC wires	200	1.50	300.00
		Subtotal	**39,400.00**
Balance of System Components			
Lamps	400	3.00	1,200.00
Power sockets	200	3.50	700.00
Pre-payment meters	200	48.00	9,600.00
Power limiters	200	12.00	2,400.00
2.5mm^2 single wire	6000	0.35	2,100.00
1.5 mm^2 twin wire	4000	0.45	1,800.00
Lamp post	200	10.00	2,000.00
		Subtotal	**19,800.00**
Street Lighting			
Stand-alone streetlights	20	790.00	15,800.00
		Subtotal	**15,800.00**
Total		**75,000.00**	

Source: ADB Myanmar Off-Grid Renewable Energy Demonstration (2017)

Mini-grid project developers should initiate a communication process with the local community early during the planning and design phase of a mini-grid system:

i. It is most often beneficial to first meet with the local leaders to introduce the project idea and design to gain their support for the project and civil organizations It is often beneficial to first meet with local leaders and representatives of local public services and local businesses.

ii. After the involvement of local opinion leaders. The planner should work with them to organize one or more public meetings to which all potential electricity consumers are invited.

iii. If possible, the mini-grid project developer should consider different future electricity consumer groups; their needs; More specific information about expectations and plans for electricity use should be gathered.

iv. The local management organization required for the mini-grid should be discussed and agreed with the local community. Village Electrification or Mini-Grid Management Committee roles and responsibilities of local operation and maintenance technicians to be selected and trained among the electricity bill collectors as well as community members should be discussed and agreed to be established locally.

v. At the initial community meeting, a small gender-balanced management team that already represents the community should be selected as a communication bridge between the village and the planner.

vi. If possible, Brief written drawings and graphical information about the planned mini-grid system to local future electricity customers; its installation; Basic information should be included, including its performance and potential for consumers and the cost level for certain lamps, mobile phone chargers, fans, TVs, typical electrical appliances such as refrigerators etc. The required community management organization should be explained as well.

vii. In the planning and design phase; the project developer should educate the local community about the efficient use of energy and the potential efficient use of energy.

viii. During the course of the planning stage, the mini-grid developer should find out what kind of consumer capacity building is required among consumers for safe and efficient use of electricity.

ix. All communication with villagers should be and the content of information should be at one level and language should be understandable to those with less formal education.

The capacity building of a mini-grid project is possible because when local communities become aware of a potential mini-grid project, they need time for community discussion and can present their questions and concerns to the planner or village management group.

This group is also responsible for organizing meetings with villagers to discuss the mini-grid system if needed. Small meetings with different groups of people, such as women only, local small business owners and local public service providers, can give people a chance to discuss their specific questions and concerns.

The village management team may request a meeting with the planner whenever necessary. This community delegation may develop into a temporary or community mini-grid or electricity management group.

The information may be posted on a poster placed in a central location in the village (such as a community meeting hall) or by the household. It can be provided in brochures sent to the public and any business. Feedback from the community can lead to adjustments in the system based on the estimated future electricity needs of the region.

The developer is the village electricity management committee. How to effectively manage electricity bill collectors and village operation and maintenance technicians; Financial and technical training needs to be identified.

Relevant capacity building and training programs shall be developed based on the existing capacity and development potential in the community with special responsibilities in the management of the relevant village electricity system.

Experiences from other villages where mini-grids are already operational can be used in the design of the capacity building program. It is important to avoid difficult technical information and special terms. Instead, Questions relevant to the consumer community should be addressed.

A feedback mechanism from the community to the project developer should be made clear so that all villagers can raise their concerns and ask further questions. The village management team is an ideal instrument for regular two-way interactions between the mini-grid project developer and the local community.

A large number of international development organizations, banks and corporations are working on various rural electrification projects in Myanmar. As part of the electricity infrastructure development project in Myanmar, the Asian Development Bank developed a geospatial plan to install solar mini-grid systems in 12 villages in the tropical zone (Magway, Mandalay and Sagaing regions). Off-grid renewable energy investment opportunities. 80% of the installation cost is funded by ADB and the remaining 20% is contributed by the villagers.

The International Finance Corporation (IFC) is providing domestic households with solar lamps, It also supports Myanmar's National Electrification Plan by implementing its Lighting Myanmar program in Myanmar, which provides solar home systems and potential off-grid systems. The project was launched in 2016 and is planned to be completed in 2022.

The German Society for International Cooperation (GIZ) has completed its "Rural Electrification in Myanmar" project, commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ). The project, implemented during 2016-2018, also supported the NEP and aimed to create a policy framework and capacity building, particularly in the area of renewable energy-based mini-grids (GIZ).

Pact, a non-profit international organization with the support of ABB, Chevron and Shell is working on providing Myanmar's local communities with solar home systems and mini-grids (Pact, 2018). Overall, the electricity sector accounted for 27.8 percent (US$20.7 billion) of foreign direct investment in Myanmar during the period 1988-2017.

The United Kingdom has established a £ 15 million (Kyat 30 billion) fund to be used until 2020 for carbon reduction and renewable energy in ASEAN countries, including Myanmar. The fund's resources will also be directed toward conducting feasibility studies for wind and solar projects.

CHAPTER IV
SURVEY ANALYSIS

4.1 Profile of Ye Nan Gyaung Township

Ye Nan Gyaung Townshipis situated in the Central of Myanmar. The township area is East to West 24 miles and South to North 22 miles. This township is 650 feet above sea level as it is in the low-lying plains. The climate of Ye Nan Gyaung Township is tropical wet and dry season with the maximum temperature at 44° C and the minimum temperature at 13° C. The township borders with Nat Mauk Township in the East, Chuk Township and Kyauk Pan Tung Township in the north, Pwintphyu Township and Salin Township in the West, Magway Township in the South.

Ye Nan Gyaung Township total area is 388.96 square miles and the township population is 160709 with 110771 (69%) are living in rural area and 49938 (31%) in the urban area. This township is comprised on 145 villages, 29 village tracts and 14 wards.

The following table (4.1) shows the number of houses, households, wards, 3village tracts, villages and population by gender of Ye Nan Gyaung Township.

Table (4.1) Houses, Households, Wards, Village Tracts, Villages and Population

Description	Houses	Households	Wards	Village Tracts	Villages	Population
Urban	10774	11145	14			49938
Rural	22852	24427		29	145	110771
Total	**33626**	**35572**	**14**	**29**	**145**	**160709**

Source: General Administration Department, Ye Nan Gyaung Township (2021)

The following Table (4.2) shows the ethnic population of Ye Nang Gyaung Township.

Table (4.2) Ethic Population

Description	Number
Kachin	12
Kayin	37
Chin	6
Mon	28
Myanmar	160569
Rakhine	43
Shan	14

Source: General Administration Department, Ye Nan Gyaung Township (2021)

The following Table (4.3) shows the population growth rate and gender ratio of Ye Nan Gyaung Township.

Table (4.3) Population Growth Rate and Gender Ratio

Description	Number
Previous Year Population	159921
Current Year Population	160709
Increase Population	788
Growth Rate	0.491
Male	75078
Female	85631
Gender Ratio	1:1.14

Source: General Administration Department, Ye Nan Gyaung Township (2021)

Ye Nan Gyaung Township economy has a primarily agricultural economy, with a large proportion of the population involved in farming. This township groundnuts, sesame and onion are sold to Yangon Region and others townships.

Table (4.4) shows number of workers by profession in Ye Nan Gyaung Township.

Table (4.4) Number of Workers by Profession

Description	Number
Government Employee	3213
Services	754
Agriculture	23435
Livestock	420
Trading	6250
Industry	890
Fisheries	137
Casual Labors	1120

Source: General Administration Department, Ye Nan Gyaung Township (2021)

The following Table (4.5) shows the working population and unemployment rate of Ye Nan Gyaung Township.

Table (4.5) Working Population and Unemployment Rate

Description	Number
Working Population	55199
No. of Workers in Workplace	36216
Unemployment Population	18983
Unemployment Rate	34.39

Source: General Administration Department, Ye Nan Gyaung Township (2021)

The income level is vital important to be develop the socioeconomic conditions of the township. The Ye Nan Gyaung Township per capita income has been increased year by year as shown in Table (4.6).

Table (4.6) Per Capita Income of Ye Nang Gyaung Township

Financial Year	Kyat
2017-2018	3520524
2018-2019	3937824
2019-2020	400813

Source: General Administration Department, Ye Nan Gyaung Township (2021)

Table (4.7) presents the gross domestic product of Ye Nan Gyaung Township.

Table (4.7) Gross Domestic Product of Ye Nan Gyaung Township

Kyat Million

No.	**Particular**	**2018-2019 (GDP value)**	**2019-2020 (Planned Value)**	**2019-2020 (Achievement)**		
				Value	Implementation	Increase (%)
1	Production	216934.0	280744.5	227460.5	81.0	4.9
2	Service	43077.1	52741.1	44969.8	85.3	4.4
3	Trade	116437.6	147796.3	125779.5	85.1	8.0
	GDP	376448.7	481281.9	398209.8	82.7	5.8

Source: General Administration Department, Ye Nan Gyaung Township (2021)

Table (4.8) shows the solar electricity supply works in Ye Nan Gyaung Township by the Department of Rural Development (DRD).

Table (4.8) Solar Electricity Supply Works in Ye Nan Gyaung Township

Financial Year	**No. of Villages**	**No. of Households**
2018-2019	19	1272
2019-2020	6	534

Source: Department of Rural Development, Ye Nan Gyaung Township (2021)

According to data Table (4.8), 19 villages and 1272 households got solar electricity supply from Department of Rural Development in (2018-2019) financial year and 6 villages and 534 households got solar electricity supply from Department of Rural Development in (2019-2020). Out of 145 villages, only 25 villages have solar mini-grid electricity in Ye Nan Gyaung Township.

Table (4.9) shows an example of a load profile for an average household. It accounts for the number of appliances and the duration that each appliance will be used.

Table (4.9) Estimation of Average Household Demand

Appliance	Watts	Duration Time
LED Lights	5	5 Hours
Phone Charger	5	3 Hours
Television	30	4 Hours

Source: Department of Rural Development, Ye Nan Gyaung Township (2021)

4.2 Survey Design

The study was using descriptive method based on primary data and secondary data. The primary data is conducted to access the benefit of mini-grid solar electricity systems in Ye Nan Gyaung Township, Magway Region. The information collected from 250 rural households from 5 villages which have got solar electricity system by Department of Rural Development (DRD). The sample are selected by using simple random sampling method. The survey is carried out in June and July 2022, with self-structured questionnaire.

The survey questionnaires were divided into three parts. Part (I) is characteristics of respondents. Part (II) is the electricity utilization in the study area. Part (III) shows the benefits of using solar electricity system by Department of Rural Development (DRD). The survey questionnaire was attached in Appendix. Table (4.10) shows the sample of study.

Table (4.10) Number of Sample Household

No.	Village Name	Total Households	Household of Respondent
1.	Kantar	146	50
2	Watlaut Ywarthit	153	50
3.	Yonesake	153	50
4.	Ngalanta	136	50
5.	Mainmahla	132	50
	Total	**720**	**250**

Source: Survey data, 2022

Sample Size Formula

$$n = \frac{\frac{z2 \; x \; p \; (1-p)}{e2}}{1+(\frac{z2 \; x \; p \; (1-p)}{e2 \; N})}$$

Where;

n = sample size

p = probability = 50%

Z = the standard normal score set at 1.96 (95% confidence interval)

e = 5% margin of error

4.3 Survey Findings

This section presents the characteristics of respondents, main electricity sources in the study area, and benefits of using solar electricity system by Department of Rural Development.

4.3.1 Characteristics of Respondents

The characteristics of respondents designed to information of respondents such as gender, age level, marital status, education level, occupation status and income per month as shown in Table (4.11).

Table (4.11) Characteristics of Respondents

Description	No. of Respondents	Percentage
Gender		
Male	187	74.8
Female	63	25.2
Total	**250**	**100**
Age level (Years)		
Between 21 to 30	26	10.4
Between 31 to 40	90	36.0
Between 41 to 50	134	53.6
Total	**250**	**100**

Educational Level		
Primary School	30	12.0
Middle School	87	34.8
High School	113	53.2
Graduated	20	8.0
Total	**250**	**100**
Marital Status		
Single	37	14.8
Married	213	85.2
Total	**250**	**100**
Occupation Status		
Farmer	128	51.2
Shop owner	26	10.4
Government employee	20	8.2
Casual labor	45	17.7
Vendors	31	12.5
Total	**250**	**100**
Income per month		
Less than 100,000 Kyat	38	15.2
100,000 Kyat – 300,000 Kyat	146	58.4
More than 300,000 Kyat	66	26.4
Total	**250**	**100**

Source: Survey data, 2022

Regarding from 250 respondents (Table 4.11), 187 respondents (74.8%) were male and remaining 63 respondents (25.2%) were female. In the study of respondents age level, 26 respondents (10.4%) were between 21 years to 30 years, 90 respondents (36%) were between 31 years to 40 years and 134 respondents (53.6%) were between 41 years to 50 years. The highest percentage of respondents were high school level and the lowest percentage of respondents were graduated level. The majority of respondents were married and farmer in the study area. In the study 250 respondents' income per month, 146 respondents (58.4%) got between 100,000 Kyat to 300,000 Kyat, 66 respondents (26.4%) got more than 300,000 Kyat and 38 respondents (15.2%) got less than 100,000 Kyat.

The majority of respondents are male and they are head of households. Mostly respondents are middle adulthood level and they have known how to use a modern technology. And also, mostly respondents are familiar with modern technology because they are high school educated level. The majority of respondents are middle income level.

4.3.2 Electricity Utilization

Electricity is one of the basic needs for development of a country and for promoting living standards. In rural areas and urban areas, the electric sector plays an important role for infrastructure development by providing reliable and affordable electricity to industries, commerce and households. Table (4.12) shows the main electricity source of the study area.

Table (4.12) Main Electricity Source

Description	**No. of Respondents**	**Percentage**
Government National Grid	0	0
Solar Electricity System by DRD	250	100
Total	**250**	**100**

Source: Survey data, 2022

Above from Table (4.12), all of respondents said that they have got electricity from solar electricity system by Department of Rural Development in their villages. Because the government nation grid is not installed in the villages. Therefore, the Department of Rural Development is implemented the solar electricity system in the study area of Ye Nan Gyaung Township, Magway Region by government budget, contribution of public and loan from World Bank.

The Department of Rural Development allowed to use the electrical materials of household includes at least three LED lights, mobile phone, DC Television and DC Fan. The following Table (4.13) shows the purpose of using solar electricity system by Department of Rural Development.

Table (4.13) Purpose of Using Solar Electricity System

Description	Overall Percentage
Lighting	100
Watching DC Television	65
Mobile Phone Charging	100
DC Fan	20

Source: Survey data, 2022

Above from Table (4.13), 100% of respondents are using lighting for their home from solar electricity system by Department of Rural Development, 65% of respondents are watching Television, 100% respondents are using mobile phone charging and 20% respondents are using DC Fan respectively.

The solar electricity system is provided by Department of Rural Development in their villages. The solar electricity system is predominantly used for three purposes: lighting, television, and cell-phone charging.

This solar electricity system recipients each received three LED lights. Indoor lights are powered 5 hours for 60 Watt and 8 hours for 100 Watt per night. The village lighting committee is opened in the villages every day from 6:00 P.M to 11:00 P.M. And, the village lighting committee is prohibited to cooking and irons.

The solar electricity system is providing for the easy-to-use modern electronic equipment and to get a knowledge from entrainment such as television and mobile phone. Therefore, the households got a benefit from the solar electricity system by Department of Rural Development.

The following Table (4.14) shows the duration of using solar electricity system in the villages.

Table (4.14) Duration of Using Solar Electricity System

Description	No. of Respondents	Percentage
Lighting		
Less than 5 Hours	158	63.2
More than 5 Hours	92	36.8
Total	**250**	**100**

DC Television Less than 2 Hours More than 2 Hours	 216 34	 86.4 13.6
Total	**250**	**100**
Mobile Phone Charging Less than 2 Hours More than 2 Hours	 250 0	 100 0
Total	**250**	**100**

Source: Survey data, 2022

According to result of 250 respondents (Table 4.7), the majority of respondents was used less than 5 hours for lighting, less than two hours for DC Television and less than 2 hours for mobile phone charging. Mostly respondents said that they used 3-Watt LED Bulb or 5-Watt LED Bulb for their house lighting system.

Table (4.15) Monthly Cost of Electricity Before Solar Electricity System

Description	No. of Respondents	Percentage
Less than 5,000 Kyat	82	32.8
5,001 Kyat to 10,000 Kyat	107	42.8
10,001 Kyat to 15,000 Kyat	36	14.4
15,001 Kyat to 20,000 Kyat	15	6.0
More than 20,000 Kyat	10	4.0
Total	**250**	**100**

Source: Survey data, 2022

Above From Table (4.15) monthly cost of electricity before solar electricity system, 82 respondents (32.8%) spent less than 5,000 Kyat, 107 respondents (42.8%) spent between 5,001 Kyat to 10,000 Kyat, 36 respondents (14.4%) spent between 10,001 Kyat to 15,000 Kyat, 15 respondents (6.0%) spent between 15,001 Kyat to 20,000 Kyat and 10 respondents (4.0%) spent more than 20,000 Kyat respectively.

Most of respondents said that they have not got solar electricity system by Department of Rural Development in their village, they bought candles, kerosene lamp oil and diesel fuel for household generator or community generator.

Table (4.16) Monthly Cost of Electricity After Solar Electricity System

Description	No. of Respondents	Percentage
Less than 5,000 Kyat	216	86.4
5,001 Kyat to 10,000 Kyat	34	13.6
Total	**250**	**100**

Source: Survey data, 2022

According to result of 250 respondents (Table 4.9) monthly cost of electricity after solar electricity system, the majority of respondents have less than 5,000 Kyat for their household electricity. The most of respondents said that they are paying 100 Kyat for one LED Bulb per night to the village lighting committee. If more LED Bulb use, the respondent will have to pay more money.

Before the solar electricity system has received in the village, the household's monthly cost for electricity is less than 5,000 Kyat has 32.8 percentage. After the solar electricity system has received in the village, the household's monthly cost for electricity is less than 5,000 Kyat has reached to 86.4 percentage. This situation mentioned that the households have reduced electricity cost from solar electricity system in their village. Therefore, this condition is cost saving for the households in the survey area.

4.3.3 Benefits of Using Solar Electricity System

The following Table (4.17) shows the improvement after using solar electricity system such as work activities, studying, cost saving for electricity, protection crime and entertainment.

Table (4.17) Improvement after Using Solar Electricity System

Description	No. of Respondents	Percentage
Working Activities	84	33.6
Studying	18	7.2
Cost Saving for Electricity	108	43.2
Protection Crime	28	11.2
Improve Knowledge from Media	12	4.8
Total	**250**	**100**

Source: Survey data, 2022

Regarding from 250 respondents (Table 4.17), 84 respondents (33.6%) said that they have easily to work activities of their household in the evening time because the household got electricity from solar electricity system by Department of Rural Development. The most of respondents (108 respondents or 43.2%) answered that this solar electricity system is cost saving for their household electricity.

Within 250 respondents, 28 respondents (11.2%) mentioned that street lighting reduced the protection crime in the villages. 18 respondents (7.2%) are studying their lesson in the evening time and 12 respondents (4.8%) have improved knowledge from watching television or social media. Therefore, the solar electricity system in the village is benefits for the village households in the study area.

Table (4.18) shows the public areas using solar electricity system in the study area.

Table (4.18) Public Areas Using Solar Electricity System

Description	**No. of Respondents**	**Percentage**
Rual Health Care Center	65	26.0
Village Administrative Office	20	8.0
Monastery	128	51.2
Religious Hall	37	14.8
Total	**250**	**100**

Source: Survey data, 2022

Regarding from 250 respondents (Table 4.18), the majority of respondents said that monastery is highest percentage using solar electricity system followed by rural health center, religious hall and village administrative office in the village.

The benefits of using solar electricity system by Department of Rural Development, the most of respondents answered that they have agreed to cost of saving for electricity, business improved, education, health and social in their villages as shown in Table (4.19).

Table (4.19) Benefits by Using Solar Electricity System

Description	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Cost of Saving for Electricity	15	235	0	0	0
Business Improved	10	213	17	10	0
Education	5	208	15	22	0
Health	18	212	15	5	0
Social	12	191	38	7	2

Source: Survey data, 2022

From Table (4.19), mostly respondents said that they have got e a variety of benefits to adopting a solar electricity system. The solar electricity system provide power for households, schools, clinics, or small businesses. Having this bright light at night can deter dangerous wildlife or their consumption of crops and livestock.

The households are replacing the kerosene lamps and candles that were used in the past for lighting. Having to buy diesel fuel and/or candles can be a daily expense removed by solar electricity system.

Having a solar power system allows children to study and small businesses to continue producing at night. This increases the self-sufficiency of the population, raises their income and allows them to begin to lift themselves out of poverty.

Children can do their homework in the evening with the right lighting. Classes at the school may continue in the evening. Livestock thefts have decreased. Villagers can keep a good eye on their animals. Fires and accidents were reduced due to candles and kerosene lamps. Parents need not worry about children playing with candles and kerosene lamps.

It is safer to move in the village after dark, e.g., to go to the pagoda, attend meetings, or visit neighbors. Incidents of snake and insect bites have reduced as snakes, scorpions, and other creatures can be seen at night. Health care staff are more easily available for emergency patients during the evening.

Watching TV is entertaining (e.g., football, films, and shows) and helps to keep villagers better informed through news and documentary programs. Mobile phones can be charged and young people especially like to communicate online. With lighting in the village meeting hall, monastery, library, and other public spaces, it is easier to arrange different activities in the evenings.

Small-scale distributed solar electricity system offers a solution to the national electricity issues. The solar electricity system for services such as lighting, television, mobile phones, fans, and more. Furthermore, storing the electricity in a battery will allow electricity to be used for hours into the night.

CHAPTER V

CONCLUSION

5.1 Findings

Electricity plays an important role in the socioeconomic development of rural areas. In Myanmar, the gap of the electrification level between urban and rural areas is very large. The study is conducted on Ye Nan Gyaung Township. This township is situated in the Central of Myanmar. total area is 388.96 square miles and the township population is 160709 with 110771 (69%) are living in rural area and 49938 (31%) in the urban area. This township is comprised on 145 villages, 29 village tracts and 14 wards.

The study is used the self-structured questionnaire and collected on 250 households of 5 villages in Ye Nan Gyaung Township, Magway Region. These 5 villages have got solar electricity system by Department of Rural Development (DRD).

The most of respondents are male and age between 41 years to 50 years. Mostly are high school level and married. The majority of respondents are farmer and the most of respondents have got between 100,000 Kyat to 300,000 Kyat.

The majority of respondents are male and they are head of households. Mostly respondents are middle adulthood level and they have known how to use a modern technology. And also, mostly respondents are familiar with modern technology because they are high school educated level. The majority of respondents are middle income level.

All of respondents said that they have got electricity from solar electricity system by Department of Rural Development in their villages. Because the government nation grid is not installed in the villages. the Department of Rural Development is implemented the solar electricity system in the study area of Ye Nan Gyaung Township, Magway Region by government budget, contribution of public and loan from World Bank.

The Department of Rural Development allowed to use the electrical materials of household includes at least three LED lights, mobile phone charging, DC Television and DC Fan.

This solar electricity system recipients each received three LED lights. Indoor lights are powered 5 hours for 60 Watt and 8 hours for 100 Watt per night. The village lighting committee is opened in the villages every day from 6:00 P.M to 11:00 P.M. And, the village lighting committee is prohibited to cooking and irons.

The solar electricity system is providing for the easy-to-use modern electronic equipment and to get a knowledge from entrainment such as television and mobile phone. Therefore, the households got a benefit from the solar electricity system by Department of Rural Development.

The majority of respondents was used less than 5 hours for lighting, less than two hours for DC Television and less than 2 hours for mobile phone charging. Mostly respondents said that they used 3-Watt LED Bulb or 5-Watt LED Bulb for their house lighting system.

The most of respondents said that they are paying 100 Kyat for one LED Bulb per night to the village lighting committee. If more LED Bulb use, the respondent will have to pay more money.

Before the solar electricity system has received in the village, the household’s monthly cost for electricity is less than 5,000 Kyat has 32.8 percentage. After the solar electricity system has received in the village, the household’s monthly cost for electricity is less than 5,000 Kyat has reached to 86.4 percentage. This situation mentioned that the households have reduced electricity cost from solar electricity system in their village. Therefore, this condition is cost saving for the households in the survey area.

Small-scale distributed solar electricity system offers a solution to the national electricity issues. The solar electricity system is services such as lighting, television, mobile phones, fans, and more. Furthermore, storing the electricity in a battery will allow electricity to be used for hours into the night.

There are a variety of benefits to adopting a solar electricity system. The solar electricity system provide power for households, schools, clinics, or small businesses. Having this bright light at night can deter dangerous wildlife or their consumption of crops and livestock.

The households are replacing the kerosene lamps and candles that were used in the past for lighting. Having to buy diesel fuel and/or candles can be a daily expense removed by solar electricity system.

Having a solar power system allows children to study and small businesses to continue producing at night. This increases the self-sufficiency of the population, raises their income and allows them to begin to lift themselves out of poverty.

Children can do their homework in the evening with the right lighting. Classes at the school may continue in the evening. Livestock thefts have decreased. Villagers can keep a good eye on their animals. Fires and accidents were reduced due to candles and kerosene lamps. Parents need not worry about children playing with candles and kerosene lamps.

It is safer to move in the village after dark, e.g., to go to the pagoda, attend meetings, or visit neighbors. Incidents of snake and insect bites have reduced as snakes, scorpions, and other creatures can be seen at night. Health care staff are more easily available for emergency patients during the evening.

Watching TV is entertaining (e.g., football, films, and shows) and helps to keep villagers better informed through news and documentary programs. Mobile phones can be charged and young people especially like to communicate online. With lighting in the village meeting hall, monastery, library, and other public spaces, it is easier to arrange different activities in the evenings.

5.2 Policy Implementation

The development of the solar electricity system projects required multiple rounds of discussion with villagers to explain the benefits and contributions from the community, as well as contract negotiations. The villagers were able to rely on support from Department of Rural Development (DRD) to facilitate these discussions, which they considered highly instrumental. Without such support, projects will be more difficult and costly to implement.

The Department of Rural Development (DRD) is implementing a scheme called Evergreen where the villages receive funds that establish a revolving fund that can be used for various purposes by the villagers. Sufficient villager and villager unity is needed to co-manage the village fund. This program strengthens community cohesion, capacity building to manage community funds and promoting gender balance in decision-making committees is key. This has greatly benefited from Evergreen's past experience in implementing projects in those communities.

Streetlights are highly appreciated by villagers for improving nighttime security. Benefits include more socializing after dark being able to see snakes on the road means fewer snake bites and less animal theft. In most of the pilot sites, villagers requested additional street lights after the initial installation and were willing to pay for the additional costs.

The potential for mini-grid development in the tropical zone is great, especially in Magway Region and Sagaing Region. In Magway Region, many areas are not connected to the grid and have access to renewable resources. Sagaing Region is a province so large that only a few power grids can cover it, and it has vast resource potential. As the mini-grid for the Mandalay region covers large areas of the country, the overall potential is very small and there are only a limited number of locations suitable for power grid investment, most of which are close to existing grids.

The government implement the solar electricity system projects for rural households because some rural areas have away from nation grid can enjoy the electricity generated by solar electricity system. Moreover, Large solar electricity system projects often require men and women for everyday operations and maintenance work.

The solar electricity system projects hire unskilled or semi-skilled labors from the nearby villages. Usually, labors in rural areas depend on manual work and often lack modern skill sets.

The solar electricity system projects can help drive new skill development and enable the rural households to aim for higher income. Further, these projects also create various temporary employment opportunities and supply of electricity for rural households in Myanmar.

The government implement the solar electricity system projects for rural households because some rural areas have away from nation grid can enjoy the electricity generated by solar electricity system. The government should be supported mini-grid in the country. In this way, the living standards of the people will be improved and the country will develop continuously.

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SURVEY QUESTIONNAIRE

I am studying Master of Public Administration at Yangon University of Economics. I have designed the following questionnaire for "**A STUDY ON THE BENEFITS OF SOLAR ELECTRICITY FOR RURAL DEVELOPMENT IN MYANMAR (Case Study: Ye Nan Gyaung Township, Magway Region)**" which is a requirement for my thesis work as an integral part of the study to complete the Master Program.

The participation in this survey depends on your wish. The information given by you will be strictly treated as confidential. I hope that you will participate in this survey and make it a success by providing correct answers to all the questions. I would highly appreciate if you participate to answer the following questionnaire. It will take only approximately 15-20 minutes.

Village Name: ______________________, Village Tract Name: _____________________

Part I. Characteristics of Respondent

1.	Gender	(a) Male ☐ (b) Female ☐
2.	Age level (Years)	(a) 21 – 30 ☐ (b) 31 – 40 ☐ (c) 41 – 50 ☐ (d) 51 – 60 ☐
3.	Marital Status	(a) Single ☐ (b) Married ☐
4.	Education level	(a) Primary school ☐ (b) Middle school ☐ (c) High school ☐ (d) Graduated ☐
5.	Occupation	(a) Farming ☐ (b) Livestock ☐ (c) Shop owner ☐ (d) Private employee ☐ (e) Government employee ☐ (f) Casual labor ☐ (g) Vendors ☐
6.	Income per month	Kyat

Part II. Electricity Utilization

1.	Where do you get main electricity source?	(a) National grid ☐ (b) Solar Electricity System by DRD ☐
2.	What is your purpose of using solar electricity system	(a) Lighting ☐ (b) Watching DC Television ☐ (c) Mobile Phone Charging ☐ (d) DC Fan
3	How many hours per day for lighting?	Hours
4.	How many hours per day for electric appliances?	Hours
5.	How many hours per day for family business?	Hours
6.	Does the household use the following electric appliances, which are powered by electricity from the solar electricity system?	(i) Telephone (a) Yes ☐ (b) No ☐ (ii) Television (a) Yes ☐ (b) No ☐ (iii) Sound equipment (a) Yes ☐ (b) No ☐ (iv) Entertainment (a) Yes ☐ (b) No ☐
7.	What is the size in watt power (WP) of the solar electricity system to provide electricity at home?	Watt Power ______________
8.	How much do you pay a monthly the solar electricity system by Department of Rural Development?	Kyat
9.	How much do you spend electricity before solar electricity system?	Monthly Cost ________________ Kyat
10.	How much do you spend electricity after solar electricity system?	Monthly Cost ________________ Kyat
11.	In case of power failure, what backup equipment does the household use?	(i) Candles (a) Yes ☐ (b) No ☐ (ii) Kerosene lamp (a) Yes ☐ (b) No ☐ (iii) Battery (a) Yes ☐ (b) No ☐ (iv) Generator (a) Yes ☐ (b) No ☐

Part III. Benefits of Using Solar Electricity System

1.	Improvement after using solar electricity system in your household.	(a) Working Activities ☐ (b) Studying ☐ (c) Cost Saving for Electricity ☐ (d) Protection Crime ☐ (e) Improve Knowledge from Media ☐
2.	Public area using solar electricity System.	(a) Rural Health Care Center ☐ (b) Village Administrative Office ☐ (c) Monastery ☐ (d) Religious Hall ☐ (e) Others (Specify ___________)

Benefits of Using Solar Electricity System

Description	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
Cost of Saving for Electricity					
Business Improved					
Education					
Health					
Social					

Thanks for your respond.