



ADDIS ABABA UNIVERSITY

College of Business and Economics, Department of Management.

Executive MBA Program

**Challenges and Prospects of Solar Home System Dissemination in Rural Parts
of Ethiopia**

The Case of Solar Energy Foundation

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College of Business and Economics; Department of Management

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Declaration

I, the undersigned declare that this Research Project is my original work and all sources of materials used for the thesis had been duly acknowledged.

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Certification

This is to certify that Engida Mekuria Fikre has done a study on the topic “*Challenges and Prospects of Solar Home System Dissemination in Rural Parts of Ethiopia; The Case of Solar Energy Foundation*” This study is his original work and all the sources of materials used for the thesis had been duly acknowledged.

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Acknowledgement

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Abbreviations

CO₂: Carbon Dioxide

CRGE: Climate Resilient Green Economy

CSP: Concentrated Solar Power

EEP: Ethiopian Electric Power

FDRE: Federal Democratic Republic of Ethiopia

FiT: Feed in Tariff

GDP: Gross Domestic Product

GTP: Growth and Transformation Plan

GW: Giga Watt

HoA – REC & N: Horn of Africa Regional Environment Centre & Network

IEA: International Energy Agency

IFC: International Finance Cooperation

IRENA: International Renewable Energy Agency

ISEI: International Solar Energy Institute

KWH: Kilo Watt Hour

LCOE: Levelled Cost of Electricity

LED: Light Emitting Diodes

MoWIE: Ministry of Water, Irrigation and Electricity

MW: Mega Watt

NASA: National Aeronautics and Space Administration

NGO: Non-Governmental Organizations

O&M: Operation and Maintenance

PV: Photo Voltaic

REF: Rural Electrification Fund

RET: Renewable Energy Technology

SEF: Solar Energy Foundation

SHS: Solar Home System

SMS: Short Messaging Service

SREP: Scaling up Renewable Energy Program

SSA: Sub Saharan Africa

TERI: The Energy and Resource Institute

TWH: Terra Watt Hour

UEAP: Universal Electricity Access Program

UNEP: UN Environments Program

W/m²: Watt per meter square

Abstract

The Ethiopian government aspires to reach middle income status by 2025 through its Growth and Transformation Plan. The Growth and Transformation Plan is a development plan of the government of Ethiopia. Its objective is to bring transformative social and economic changes in Ethiopia that will enable it to become a middle income country by 2025 (FDRE, 2011).

Only 2% of the rural population of Ethiopian has access to Grid Electricity, solar technology provides the Ethiopian government with the opportunity to address energy challenges without the need to implement expensive power generation projects, transmission and distribution networks. The objectives of this study is to assess the Challenges in Solar Home System dissemination in rural Ethiopia, to propose the possible solutions to overcome the challenges, to highlight the extent to which Policy makers, Business people and financial institutions can support companies like SEF in the SHS dissemination in rural Ethiopia.

Qualitative data analysis was undertaken in the study and interviews were conducted to collect the required data. A sample of four stakeholders which are directly related to solar power business were studied. Although the case company is Solar Energy foundation, the other three stakeholders were involved in the interviews to gain more input in to understanding the challenges and possible solutions towards solar home system dissemination.

The findings of this study indicate that there are major challenges that hinder the dissemination of solar home systems in rural parts of Ethiopia and possible solutions to overcome these challenges are highlighted. The output of this study can be useful to the Ministry of Water, Irrigation and Electricity and in particular to the Ethiopian Electric Power company.

Key Words: Ethiopia, Solar Home Systems, Challenges in SHS dissemination and possible solutions

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Chapter 1: Introduction

1.1 Background of the Study

Solar energy is the most abundant energy resource on earth. The solar energy that hits the Earth's surface in one hour is about the same as the amount consumed by all human activities in a year (IEA, 2010). The Sun is very reliable, pollution free, inexhaustible and renewable source of energy. Sustainable energy concept needs serious attention as energy prices are always on the rise, environment is being polluted, and resources are being depleted.

Solar home systems (SHS) are stand-alone photovoltaic systems that offer a cost-effective mode of supplying useful power for lighting and appliances to remote off-grid households. SHS is an ideal solution for rural areas that are not connected to the grid (Commercial power). They can be used to meet a household's energy demand fulfilling basic electricity needs. Globally SHS provide power to millions of households in remote locations where electrification by the grid is not feasible. SHS provide power for low power appliances such as light bulbs, radios and small TVs and can be used to charge mobile phones. Photovoltaic (PV), as the name implies, is a means of converting sunlight directly into electricity. Producing electricity by means of solar panels causes no threat to the environment and has no rotating parts and causes no material depletion (Tetteh, 2014). By making use of Photovoltaic system, we can power up light bulbs, household's electrical gadgets, equipment and appliances and operate water pumps.

Solar electricity has an obvious advantages in accessibility, cost and reliability compared to traditional means of rural electrification. In the mid to long term solar electricity will also be competitive price wise when compared to grid electricity. The relative benefits of solar power compared to the traditional alternatives are on the rise because of rapidly declining costs, improving quality and reliability, and proven models of technology diffusion (ISEI, 2012).

According to a World Bank report, some 1.2 billion people do not have access to electricity, which limits their opportunities to improve their welfare. Most of these people are residents of 20 developing countries in Asia and Sub-Saharan Africa, and about 80 percent live in rural areas in those countries (World Bank 2013). Providing access to electricity is actually an integral part of

socio-economic development. The benefits of having access to electricity include; increase in the level of income of a household, productivity and employment due to access to electronic media and improved household lighting; having better communication by being user of mobile phones, having electric light will provide the households with better security to move at night and attend night classes which will help raise level of education. Lacking access to electricity is therefore considered a major impediment to development.

Renewable energy can be defined as any energy resource that is naturally regenerated over a short period of time and derived directly from the sun (such as thermal, photochemical, and photovoltaic), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass). Renewable energy does not include energy resources derived from fossil fuels, waste products from fossil sources, or waste products from inorganic sources. Global investments in renewable energy, increased by 32% in 2010, to a record US\$211 billion. The increase was mainly because of wind-farm development in China and small-scale solar PV installations in Europe (*UNEP, 2011*). Africa achieved the largest percentage increase in investment in renewable energy among developing regions excluding the three big economies. Total investment on the continent is increasing, largely, because of strong performance in Egypt and Kenya.

Ethiopia has a large population with a rapidly growing economy and very low level of electrification (*ISEI, 2012*). Photovoltaic systems are cost-effective and reliable means to increase access not only to electricity but also to information and communication through mobile devices, Radio receivers and TV sets. PV is already an important source of power for the mobile network in Ethiopia – it will also be important for providing powers to the social institutions such as schools, clinics and water supply.

The Ethiopian Government's Climate Resilient Green Economy (CRGE) strategy and the five-year Growth and Transformation Plan (GTP) are explicit in addressing energy access problems, quality of supply, and productive energy use in the context of new energy policies and planning (*TERI, 2012*).

A solar electrification roadmap for rural Ethiopia is already started and includes model projects, professional solar training and initiating local solar businesses. Highly economic solar systems, available to rural population, generate additional purchasing power and open new financial capabilities for sustainable rural development. Ethiopia has embarked on ensuring 100 % renewable energy supply (*Ch. Breyer et al, 2009*). This is being achieved using Hydro power plants and other means like wind plant, Solar systems and geothermal energy.

Ethiopia like most of sub Saharan countries is a country abundant solar irradiation which can be utilized as source of Electricity to achieve a sustainable development program; it is necessary to explore the possible sustainable energy sources and their potential in Ethiopia. It is also necessary to give the proper attention to the technology, have the right strategy and work on creating the right consumer awareness.

The case company of this study; Solar Energy Foundation (SEF) is an International NGO established in Germany in 2005 and registered in Ethiopia in 2007. (*SEF, 2015*). The objective of the foundation is to create access to renewable energy for rural households in Ethiopia. Since its registration, it signed different project agreements with regional and federal bureaus. So far, it has disseminated over 30,000 different sized solar lighting systems and trained and employed 64 staff in the foundation's training center (*SEF, 2015*). The foundation has also provided several trainings to officials from different energy bureaus' staff, microfinance institution groups, and others.

We could see that there is more gap to be filled in providing access to electricity for the rural population in Ethiopia. Solar Energy Foundation is contributing its part in this regard.

1.2 Statement of the Problem

The electricity consumption rate in rural Ethiopia is very low compared to that of the urban coverage. This is mainly due to the difficulty and expensiveness of connecting the 83% of its rural population living in isolated villages to a centralized electric grid (*TERI, 2014*). As per different researches made by scholars in different countries (*Keriri, 2013*), (*Tetteh, 2014*), (*Ketlogetswe 2009*); Solar Home Systems are the ideal, environment friendly and sustainable means energy to provide electric power to such scattered rural villages. Not enough research has been made in the Ethiopian context, Hence in this study the researcher is highlighting the challenges faced by

companies working on the solar Energy dissemination specifically in the rural part of Ethiopia. The study is also suggesting the possible solutions to support the companies working in the Solar Power implementation so that the adoption rate will increase to enable more people in remote villages get access to clean and sustainable energy.

The current installed capacity of solar power systems in Ethiopia is merely 5 MW and the immediate demand for SHS is estimated to be up to 300 MW (*SEF 2015*). Most of the current installed 5 MW power system is used by Ethio Telecom for powering up their equipment in off-grid sites (*IFC, 2010*). Solar Energy Foundation Ethiopia is currently pioneering in the Solar Power System implementation in the rural parts of Ethiopia. SEF has so far disseminated over 30,000 different sized solar lighting systems and trained and employed 64 staff in the foundation's training center (*SEF, 2015*). The researcher has identified that there is a huge gap to be filled by the Government and business people to help address the challenge faced by such companies and support the country's sustainable development. This study is looking in to the challenges faced by solar power system vendors in their SHS dissemination for rural Ethiopia.

Most of the households in the rural villages depend on Kerosene lamps for lighting and wood and charcoal for cooking. This has adverse effect as it emits a lot of carbon damaging the environment and also not good for the health of the people using it. Among the benefits of having Solar Home systems is to enable the rural population to have access to night education which can raise the level of education of the country. Being able to get a means to charge their mobile phones, the rural public can easily get access to information by using their mobile phones.

Africa has enormous solar radiation which can be harnessed in many ways to solve its energy crisis and stop relying on fossil fuels. Based on the country level, Africa's share of globally installed capacity of PV is less than 1%, meanwhile the world solar map clearly reveals that the African continent receives the highest amounts of solar radiation between 300 and 350 W/m² annually (*Tetteh, 2014*). This shows that African continent is suitable for implementation of solar energy projects.

Different researches have been conducted regarding the challenges in adoption rate of sustainable Energy (Solar Home Systems Adoption) in Africa; to mention few of the countries where sufficient

research has been done include countries like: Kenya, Ghana and Botswana; (*Keriri, 2013*), (*Tetteh, 2014*), (*Ketlogetswe 2009*). Similar studies have also been done to identify the challenges in Solar Home System Adoption in Ethiopia. To mention an example; (*Schutzzeichel, 2012*) from International Solar Energy institute based in Germany has conducted a research on “ Ethiopia Solar, The Initiation of Solar Trade in Ethiopia 2005 - 2011”. The study has set forth a foundation for establishing pilot projects, training/ education facility and own microfinance facility. It has also identified the lack of awareness by the rural population as a major stumbling block for quicker dissemination of solar power systems in the country. Other studies conducted in Ethiopia include those done by (*Aklilu, n.d*), (*Alemshet, 2010*) and (*Samuel et al, 2015*). There has been no evident comprehensive research on prospects and challenges in Solar Home System dissemination in rural Ethiopia. This study therefore sought to find out the prospects and challenges faced by Solar Power System Vendors in their pursuit of Solar Home System dissemination for the scattered and disadvantaged rural population in Ethiopia.

1.3 Research Questions

1. What are the Challenges in Solar Home System dissemination in Rural Ethiopia?
2. What are the possible solutions to overcome the challenges?
3. What roles can the Policy makers, business people and financial institutions play in facilitation for companies like SEF to flourish and do better in their Solar Home System implementation for the rural villages in Ethiopia?

1.4 Objectives of the Study

The General objective of this study is to assess the Challenges and Prospects in Solar Home System Dissemination in Rural parts of Ethiopia, The case of Solar Energy Foundation. The Specific Objectives are designed as follows:

1. To assess the Challenges in Solar Home System dissemination in rural Ethiopia.
2. To propose the possible solutions to overcome the challenges.
3. To highlight the extent to which Policy makers, Business people and financial institutions can support companies like SEF in the SHS dissemination in rural Ethiopia.

1.5 Scope of the study

This research project seeks to solely focus on the challenges for Solar Power System dissemination faced by companies like Solar Energy Foundation in Ethiopia. Although there are different types of renewable energy (like hydro power, Geothermal and wind energy), the author only limits his findings on solar energy systems in Ethiopia. The scope of this piece of work is also limited based on the literature availability and within a specific time frame of its execution. Due to the fact that the topic is very wide, the author is not able to present all the full literature range in the aspect of challenges in Solar Home System implementation but rather will examine an overview of the main issues and areas concerning the objectives of this study. For the purpose of this research project, the author wishes to limit his findings from Interviews, printed materials, electronic materials and other internet web related sources related to the subject. Some of the information provided in this piece of work might be classified business information.

The scope of this work pertaining to limited literature availability, accuracy of the information and the time frame of executing this research cannot serve as an impediment in conducting this research to meet the objectives.

1.6 Significance of the study

The findings of this study could be used by the Ministry of Water and Energy and Ethiopian Electric and Power Corporation to help fill the huge gap between energy supply and demand, especially in the rural part of the population. It will also indicate possible roles that can be played by the policy makers, the business community and financial institutions on how to fill the gaps in energy demand in a sustainable way. The research output could also be used to create awareness in the rural population when it comes to the use of renewable energies like Solar Home system to support them in the fight against poverty, and eventually live a better life.

1.7 Organization of the study

The overall organization of this study is presented as follows with reference to the contents of the individual chapters.

In Chapter one, the introduction about the research project outlines the background of the study, Statement of the problem, Objectives of the study, research questions, scope of the study, Significance and organization of the study.

Chapter two presents, Literature review and will talk about Solar power and rural electrification, system components and maintenance of Solar PV systems, the current electrification status in Ethiopia, trends and projections for the near future, barriers to implementing solar PV systems, empirical studies related to SHS dissemination in rural Ethiopia and some discussion on the research gap. Chapter 3 discusses about the Research Design and Methodology. In Chapter 4 we find details of the data analysis, presentation and interpretation including Stakeholders overviews.

1.8 Research Gap

Numerous studies have been conducted internationally on challenges and prospects of adopting Solar Home Systems in countries like Kenya (Ng'eno, 2014), Ghana (Prosper, 2013) and Bangladesh (Momotaz, 2012).

As mentioned in the Empirical studies section above various studies have been conducted in Ethiopia in the renewable energy adoption. Not enough research has been done on specific topic of Solar Home system adoption in rural Ethiopia. This study will therefore provide some insight and bridge the gap by identifying the Challenges and Prospects of Solar Home System Adoption in Rural Parts of Ethiopia.

Chapter 2: Literature Review

2.1 Introduction

Solar photovoltaics (PV), also called solar cells or just PV, are electronic devices that convert sunlight directly into electricity. The modern form of the solar cell was invented in 1954 at Bell Telephone Laboratories (*IRENA, 2014*). The term “photovoltaics” is derived from the physical process whereby the conversion of light (photons) to electricity (voltage) occurs, the so-called “PV effect”. In 1966, the National Aeronautics and Space Administration (NASA) of the United States launched the first Orbiting Astronomical Observatory, powered by a 1 kilowatt (kW) photovoltaic

array. In 1977, global PV production capacity exceeded 500 kW. In 2002, total installed solar PV capacity exceeded 2 GW and 10 years later, in 2012, it surpassed 100 GW. In 2013, new additions of solar PV alone came to 39 GW and for the first time exceeded the new capacity additions of wind in a given year (*IRENA, 2014*). The year 2014 was estimated to have been another record year, with total installed PV capacity likely to have exceeded 180 GW worldwide at the end of the year. In short, solar PV has come of age and mature commercial solutions are now available to provide competitive power in a complete range of applications from outer space, off-grid and on-grid, from solar lanterns to utility-scale PV parks at the scale of hundreds of MW.

Solar PV systems are one of the most decentralized mode of renewable technologies, in that their modular size means that they are within the reach of individuals, co-operatives and small- or medium sized businesses that want their own generation facilities and the ability to control electricity costs. These small-scale systems represent the largest number of solar PV systems installed, but utility scale ground-mount projects still represent the largest share of total installed capacity.

Solar PV is now a mainstream and mature technology. However, unlike most mature technologies, its costs are continuing to decline and solar PV is increasingly commercially attractive to project developers and to small-scale residential or commercial consumers. Its competitiveness is compounded by the fact that many major markets are experiencing significant year-on-year increases in electricity prices (*IRENA, 2014*).

A solar PV system consists of the solar module, other electrical and hardware components (i.e. the inverter, battery system, electrical cabling, module mounts, controls, etc.). The solar PV systems can be mounted on rooftops or in fields.

Unlike Concentrating Solar Power (CSP) systems, solar PV systems operate in the presence of both direct and diffuse solar irradiation. The higher the level of solar resource, all other things being equal, the lower the system's leveled cost of electricity (LCOE) will be. Siting solar PV systems in areas with high solar resources (usually expressed as annual mean figures in kWh/m²/year or as kWh/m²/day) will therefore minimize the cost of electricity (*IRENA, 2014*).

While its use is small today, solar photovoltaic (PV) power has a particularly promising future. Global PV capacity has been increasing at an average annual growth rate of more than 40% since 2000 and it has significant potential for long-term growth over the next decades. This roadmap envisions that by 2050, PV will provide 11% of global electricity production (4 500 TWh per year), corresponding to 3 000 Giga watts of cumulative installed PV capacity (*IEA, 2010*). In addition to contributing to significant greenhouse gas emission reductions, this level of PV will deliver substantial benefits in terms of the security of energy supply and socio-economic development. Achieving this target will require a strong and balanced policy effort in the next decade to allow for optimal technology progress, cost reduction and ramp-up of industrial manufacturing. This roadmap also identifies technology goals and milestones that must be undertaken by different stakeholders to enable the most cost-efficient expansion of PV.

Achieving this level of PV electricity supply – and the associated, environmental, economic and societal benefits – will require more concerted policy support. Sustained, effective and adaptive incentive schemes are needed to help bridge the gap to PV competitiveness, along with a long term focus on technology development that advances all types of PV technologies, including commercially available systems and emerging and novel technologies.

2.2 Solar Power as a Source of Sustainable Energy

The development of renewable energy sources is necessary for the sustainable development of any country due to depleting fossil fuel level, climbing fossil fuel prices across the world and more recently pressure for reduction emission level. Among various renewable energy sources based technologies, the photovoltaic technology for power generation is considered well-suited technology particularly for distributed power generation (*Jamil et al, 2012*). The large introduction of PV systems may replace or postpone the extension of conventional central stations of electricity production and the investment in grid reinforcement having a positive overall economic impact. The PV system electric power is of particular value when it coincides with the peak demand, as during the summer afternoon peak due to the use of air conditioning units. In addition to this, solar photovoltaic systems can also increase the reliability of the system to which they are connected, can also reduce transmission and distribution losses as they generate the electricity close to the point where it is consumed.

Cutting greenhouse gas emissions is particularly relevant to the developing world, as climate change threatens to disrupt the weakest economies and disadvantage the poorest people. Sea-level rise associated with projected increases in temperature could displace tens of millions of people living in low-lying areas. With climate change, the weakest economies will also be faced with new stresses such as resisting the spread of vector-borne diseases.

According to the International Energy Agency (IEA), in 2008 there were an estimated 1.5 billion people, or 22% of the world's population, living without access to electricity, 85% of whom live in rural areas. The IEA foresees that if current policies do not change, by 2030 there will still be 1.2 billion people without access to electricity. The number of people without electricity will even rise in Sub-Saharan Africa.

The 2.4 billion people who rely on traditional biomass fuels for their energy must collect and burn straw, dung, and scraps of wood to cook their meals. They often go without refrigeration, radios, and even light. The International Energy Agency estimates that if the MDG poverty-reduction target is to be met, modern energy services will need to be provided to an additional 700 million people by 2015 (*Flavin et al, 2005*).

In recent decades, the energy needs of poor people have been met most often via petroleum-based liquid fuels and by extension of the electricity grid, which is powered mainly by fossil fuels and hydropower. These options have benefited from government subsidies and are widely available on world markets. However, these conventional energy systems are often out of reach for people in remote areas, and even in urban slums, they are sometimes too expensive for the poorest to afford.

In addition, in many developing countries, most of the fuel and many of the technologies are imported. Of the 47 poorest countries, 38 are net importers of oil, and 25 import all of their oil. Such an energy outlook for the poor is unacceptable. It is possible to achieve universal access in the foreseeable future, and modern Renewable Energy Technologies (RETs) can play a crucial role in achieving this goal. However, technology alone is not enough and universal access requires sustainable operation and business models, political efforts and targeted public support.

The role of energy, and more specifically electricity, is critical for development. Access to modern energy reduces hunger and improves access to safe drinking water through food preservation and

pumping system (*Rolland, 2011*). It fosters education by providing light and communication tools, it improves gender equality by relieving women of fuel and water collecting tasks, and it reduces child and maternal mortality as well as the incidences of disease by enabling refrigeration of medication as well as access to modern equipment.

Finally, if access to energy is implemented with environmentally sound technologies, it directly contributes to global environmental sustainability. Energy alone is not sufficient to alleviate poverty, but it is certainly necessary and there will not be any major development progress without a growing number of people gaining sustainable access.

2.3 Solar Power and Rural Electrification

The high share of rural population, coupled with the low ability and willingness to pay (affordability), the low per capita energy consumption and the high rate of non-electrified rural areas, has traditionally pushed rural communities to make use of locally available energy sources, mostly biomass from agriculture residues and forest and savannah wood for their daily cooking and heating needs. Unfortunately local biomass and organic waste sources are often exploited in a non-sustainable way and burnt into non appropriate stoves and oven, causing a diffuse problem of indoor air quality.

This has an adverse effect on the health of the inhabitants and could cause problems to our breathing organs. It will also contribute largely to deforestation and hence carbon emission which in turn will damage the ozone layer resulting in environment degradation and resulting natural disasters. Apart from the health and environmental traits the use of kerosene lamps for lighting has another disadvantage; the kerosene fuel it uses has to be imported from outside at a considerable foreign currency at a volatile price in the world market.

In the 1990s, the World Bank identified SHS as the least-cost solution to the problem of rural electrification and supported many SHS programs in developing countries. In India, by 2012, there were 500,000 SHS and 700,000 solar lanterns distributed across the country (*Aggarwal et al, 2014*). These SHS are standalone electricity systems that include a set of solar PV panels, a battery storage system, an optional battery charging controller, and various end-use equipment such as

fluorescent lighting. Because solar PV panels generate DC electricity, the end-use equipment is limited to DC appliances such as light bulbs, unless an inverter is included in the setup.

Of the nearly 260 million unserved rural households, many reside in isolated communities far from the national electricity network (The World Bank, 2008). These so-called “off-grid” communities are generally small and dispersed, consisting of low-income households characterize economically unattractive to potential private-sector energy providers or even government electrification programs that must prioritize the allocation of scarce resources. Unserved consumers are also found in concentrated rural communities close to the grid and already electrified cities or towns. The electrification approaches and costs required to reach these three classes of unserved populations differ significantly, with off-grid consumers requiring more unconventional approaches.

Solar Home Systems are designed to provide reliable electricity for a set load, so there is a lower likelihood of a power shortage assuming that the amount of solar irradiation does not experience drastic variation. However, to ensure that power demanded does not exceed the supply capacity, households must be familiar with the capacity of the system in order to not compromise its reliability. The reliability and power quality of a SHS can be negatively affected by the low quality of its individual components as well as sub-optimal operations and maintenance. According to a survey of SHS set up in Zambia in the early 2000s, over the course of three years none of the households surveyed had experienced any problems with the solar PV panels. However, 25–30% of the batteries needed replacement within two years due to sub-optimal operations and maintenance (*Aggarwal et al, 2014*).

A deep knowledge of the existing and feasible energy infrastructures is fundamental for moving towards the assessment of the economically utilizable renewable energy. Indeed, according to IEA data, 99.6% of the African population without electricity access is concentrated in Sub-Saharan Africa (SSA) countries, reflecting the great disparities in the different African regions caused also by the still unbalanced development of the energy production and transport infrastructures in the continent (*Belward et al, 2011*). Moreover, one has also to notice that in Africa the population access to fossil energy sources too is not always easy.

2.4 The Stand alone Photovoltaic system

Stand-alone off-grid PV-systems that cover the electricity needs of single households, public buildings or commercial units, offer a user-friendly and cost-effective electricity solution. They can replace candles, kerosene and traditional unsustainable biomass, which are often used for lighting purposes, as well as run other applications usually driven by dry-cell batteries or diesel generators. Besides the economic and social benefits, off grid PV systems also have positive impacts on people's health and on the environment due to the reduction of smoke and toxic waste.

The Solar Home System, probably the most known and installed type of renewable energy systems around the world, is already around 30 years old and is the symbol of PV standalone systems. However, the global photovoltaic industry continues to invest in new solutions and in component improvement with innovations such as PV LED lamps, highly efficient storage technologies or self-adaptive charge controllers. Most of all, the wide dissemination of standalone PV systems and their small investment costs has allowed the development of real market approaches that do not depend on subsidies. In general, a stand-alone PV System can be defined as an off-grid-system with one or several solar PV modules and various appliances serving an independent user.

Classical elements of a standalone PV system include: solar module, charge controller, lead-acid battery, inverters and loads (appliances). The maintenance and quality management of these components are key factors for a successful and sustainable operation of PV off-grid systems. Training of local operators and cooperation with service providers can guarantee long-term professional O&M. Every single system component has specific maintenance needs. (*Rolland, 2011*).

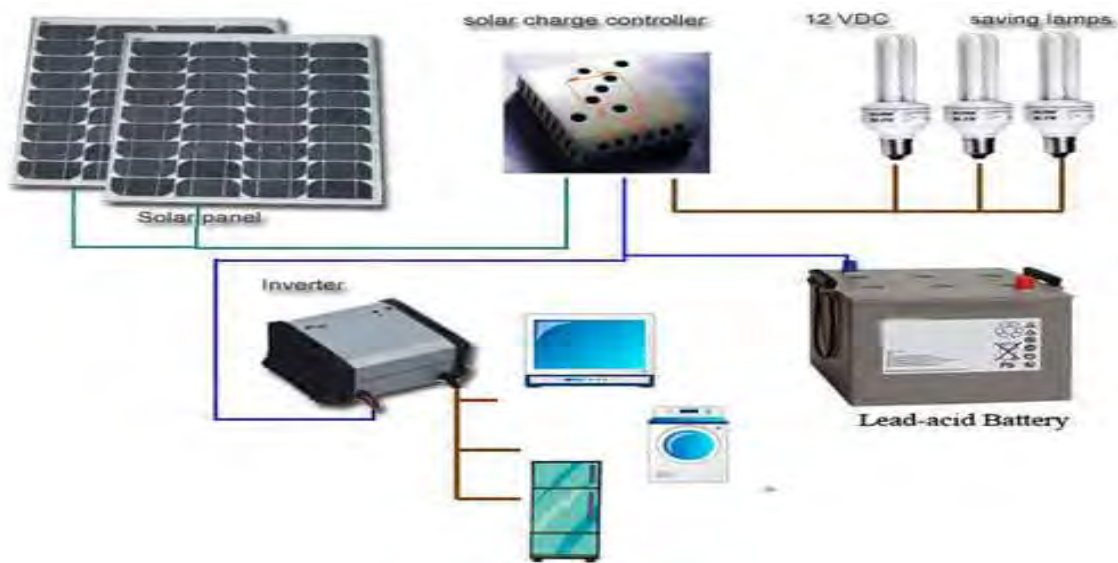


Fig. 1: A typical solar setup of a Solar Home System (Green Homes, 2013).

The above figure shows the basic components of Solar Home System which can also support AC loads. As shown in the figure the system consists of Photovoltaic Module which collects, the sun and converts it to electricity in the form of Direct Current and could be used directly to light DC bulbs, the battery is used to store the electricity so that the energy could be used whenever there is no direct sun light. There is a device called inverter which converts the Direct Current voltage in to an alternating current which can be used to power up directly the normal loads like incandescent lamps, socket outlets that can be used for mobile charging, powering up TV sets and other household appliances. The diagram also shows AC loads like TV sets.

2.5 The Current Electrification Status in Ethiopia

In Ethiopia, overall electricity access is very low compared to the African average. The World Energy Outlook 2010 estimated national electricity access at 17 percent in 2009 compared to 15 percent in 2008 (IFC, 2012). As in most Sub-Saharan Africa countries, the gap between urban access and rural access is huge. Urban electricity access is estimated at 80 percent while only two percent of rural households enjoy grid electricity. Of the total number of connected customers, at least 40 percent are concentrated in the capital city of Addis Ababa.

The power sector is dominated by large hydropower plants. The total generation capacity in Ethiopia was 2,060 megawatts (MW) in 2010, of which about 90 percent is hydro-based, 10 percent is thermal, and less than one percent is geothermal (*IFC, 2012*). Petroleum fuels include gasoline, diesel, jet fuel, and fuel oil for transportation and power generation. Kerosene is used for cooking and lighting.

Ethiopia's energy consumption was estimated at about 31,050 kilotons of oil equivalent (ktoe) in 2009 with a per capita energy consumption of 0.4 ktoe. The national energy balance is dominated by a heavy reliance on traditional biomass energy (wood fuels, crop residues, and cattle dung), which accounts for 92 percent of total energy consumed. Petroleum and electricity contribute only seven percent and one percent, respectively.

As per the report of the Ministry of Water and Energy, 2013, In Ethiopia 90 % of the population use traditional biomass for cooking; 70 % use kerosene for lighting. While all hydrocarbon products are imported from abroad. Grid (commercial power from EEP) is accessible to only 52% of the population.

Two million households in Ethiopia are connected to electricity and the per capita electricity consumption 77 kWh/year. The total system installed capacity is estimated to be 2167 MW which comprises of: Hydropower (94%), Wind and Geothermal (4%) and Diesel Generators (2%) (*Dereje, 2013*). We could easily see that the solar power contribution to the energy system is almost zero.

The energy consumption in Ethiopia from national grid was 3894.0GWh during the 2009/2010 fiscal year. Annual per capita consumption of electricity is 100 kWh which is much lower than the Sub-Saharan Africa average 510 kWh (*Samuel et al, 2015*). Due to Economic growth in recent years, the Electricity consumption in the country has been increased and it is common to see small diesel generators running here and there to bridge the electrification gap in rural and pre urban areas.

2.6 Trends and projections for the near future

As part of the Growth and Transformation Plan, the Ethiopian government recently announced plans to increase the country's electricity generation capacity from the current 2 177MW to 37 000MW by 2037, in a seemingly aggressive expansion program (*Sub-Saharan Africa Power Outlook 2014*). These exponential growth projections are based on meeting the growing domestic demand and supply in the East African region. To support this growth in electricity generation capacity, Ethiopia recently liberalized the energy sector after ratifying a new Energy Proclamation that allows private investors to generate, transmit, distribute, sell, import or export electricity. This new proclamation allows private power companies to operate in the country, and thereby attract more investment in the energy sector.

As per the report of Sub-Saharan Africa Power Outlook, 2014; Ethiopia has significant untapped renewable energy resources, including an estimated 45 000MW in additional hydropower potential, 10,000MW from untapped geothermal resources and significant wind and solar generation opportunities throughout the Rift Valley. Ethiopia will continue to develop its hydropower resources to serve as the backbone of the power system, with many more projects in the planning and preparatory stages. The development of wind energy also plays a critical part, with 8% of production coming from wind farms already built.

This capacity will continue to expand, eventually reaching 20%. Development of the geothermal resources is also gathering steam, with construction going on for the expansion of a pilot plant and other new projects that will make Ethiopia one of the major producers of geothermal energy in the world.

To this end Ethiopia, working closely with other countries and regional organizations, takes into consideration regional power demand in the planning and implementation of the power generation and regional transmission interconnection projects. The expansion of the transmission and distribution networks is also ongoing, targeting universal electricity access nationally and strong regional power system integration. This has led to the construction of thousands of kilometers of transmission and distribution lines, the introduction of higher voltage levels for the transmission of ever larger quantities of energy, the construction and expansion of control centers and other

associated infrastructure. To date, it is interconnected with Djibouti and Sudan as well as to the border town of Moyale in Kenya.

Overall, there is political will in expanding the generation and transmission capacities in the country, which have resulted in most of the planned projects being realized in short spaces of time. Additionally Ethiopia formally decided in late 2013 to open up the electricity generation and distribution sector to private players for the first time in its history. The government-owned Ethiopia Electric Power Corporation has, until now, been solely in charge of power generation, transmission, distribution, and sale of electricity throughout the country. New laws allow private power companies to compete directly with Ethiopia Electric Power Corporation.

Accelerating demand for energy due to increased socio-economic development and growth in Ethiopia for the past seven years has resulted in several initiatives, such as Scaling-up Renewable Energy Program (SREP). The Ministry of Water, Irrigation & Energy (MoWIE) launched the SREP in 2012 with the objective to meet energy demand with renewable energy sources (hydropower, solar, wind, geothermal, and biomass) as an integral part of the energy mix of Ethiopia. The Climate Resilient Green Economy (CRGE) and Growth and Transformation Plan (GTP). The expected outcomes of the programs are increased power generation from 2060 megawatts in 2010 to 10,000 MW, increased electricity access rates from 45% to 75%, and increased current usage from 2 to 4 million coupled with scaling-up of renewable energy dissemination in Ethiopia by 2015 (*HoA-REC&N, 2014*).

2.7 Barriers to Implementing Solar PV Systems

Theoretically, solar energy has a resource potential that far exceeds the entire global energy demand (*Timilsina et al, 2011*). Despite this technical potential and the recent growth of the market, the contribution of solar energy to the national energy supply mix is still negligible. This part of the literature review attempts to address why the role of solar energy in meeting the national energy supply mix continues to be small. What are the key barriers that prevented large-scale deployment of solar energy in the national energy systems? What types of policy instruments have been introduced to boost the solar energy markets?

The main barriers preventing the quick expansion of renewable energy are high initial cost, technical, economic and market limitations (*Tetteh, 2014*). The growth in the implementation of solar energy may also come as a result of Governmental policies and support, especially towards bringing down the investment costs. Governmental policies and risks are the main obstacles hunting the future growth in world solar energy use. Getting electricity from Renewable Energy largely depends on the commercialization of large-scale solar energy technologies that will bring down the investment costs and risks. Generating large quantity of energy from RE for future use depends largely on Governmental climate change policies, and research, development and demonstration by private and public sectors interventions. Costs and pricing are other barriers for renewable energy dissemination.

The market for distributed renewable energy sources is small but growing in Ethiopia. This constrains product and service providers from expanding their services and increase income. However, companies are also part of the system and they are expected to take part in developing the market which they have mostly failed to do (*ISEI, 2012*)

The following are some of the challenges observed when it comes to the Photovoltaic industry in Ethiopia;

- Very few companies have local presence in rural areas. PV systems are desirable and affordable to a considerable segment of the rural population. The major constraint appears to be that products are not available (accessible) where they are wanted.
- PV suppliers have failed to create a supply chain for distribution and service into rural areas. Project based system supply still dominate the off-grid market; few companies work with local level service companies (installers and service providers).
- Few companies have well thought out strategy to expand their market independently. A large segment of the PV business is still project (tender) based.
- There are far too few PV companies in Ethiopia in contrast to the huge potential market. Technical and business knowhow for PV is limited to a handful of companies based in the capital.

- PV companies in Ethiopia are relatively small and unable to take on large projects by themselves. For example, tenders for large number of units are still won by international companies – local companies are sub-contracted for installation.
- Solar product companies have shortcomings in addressing the market and business development aspects of their business.
- There appears to be no means of ensuring industry accountability to customers for products and services rendered. There are no government regulations and there are no industry guidelines for self-regulation.
- PV companies have failed to effectively lobby their case with government. They do not have a common forum to address their challenges.
- There is little specialization in the industry – all PV companies tend to do everything from import to service.

Policies in Ethiopia are generally supportive of renewable energy generation and distribution. Sector strategic plans also state vision for the sector that place renewables at the center. However, policies and visions have not been accompanied by instruments for their effective implementation on the ground. Where such instruments (regulations) have been issued they have either not been easily applicable or effectively enforced (*Ethio Resource Group, 2012*).

- Regulations are not sufficiently attractive to promote investment in manufacturing. This is the view of foreign investors exploring the feasibility of setting up PV module assembly plants in Ethiopia. They all cite legal and financial uncertainty for not investing in the sector.
- Existing regulations do not favor domestic manufacturing. For example, duties are waived for certain PV product imports but a company that seeks to produce these same products in Ethiopia will need to pay taxes for components that are used to make the finished product.
- Regulations are not consistently applied. Import duties are lifted for PV modules – however, there is uncertainty about which products and to what type of importer this applies to. Duties are sometimes applied differently depending on tax officers.

- Useful policies and regulations are pre-empted by cumbersome administrative procedures. This is the case for duties for PV modules, for example: importers have to go through lengthy process of approval through the Standards Authority.
- Regulations that would promote renewable energy have been promised but never realized. The Feed in Tariff (FiT) is an example of this. Rates in the draft FiT are also not attractive (particularly for PV) and would not attract developers as intended.
- Strategies for off-grid services and for non-public actions are not adequately articulated. Broad plans are provided, for example for solar home systems in the Strategic Plan of the MWE, but these are not backed with specific strategies or investment plans for their implementation.
- There is inadequate off-grid power service financing (or subsidy) compared to subsidies for consumers on the grid.
- Access to major PV markets is out of bounds for the private sector. For example, PV for the telecom sector is provided by foreign contractors providing equipment and installation. The private sector is effectively excluded from major public projects.
- A forum for sector actors, including industry and government, is required to address challenges. An informal forum was initiated in 2008 but was later abandoned.
- There is a very narrow outlook for private sector engagement in the sector. Private companies are not taken as drivers of development but just as instruments of meeting government plans-for instance, installing systems for public infrastructure not implementing projects themselves.

Ethiopia starts from a very low market base for distributed renewables. Knowledge, information, finance and other inputs to users and the industry are not adequately available. Although the institutional structures for sector development have been there for decades they have not been effective (*Ethio Resource Group, 2012*).

- Resources available for sector development are inadequate. Financial and technical resources have not been sufficiently attracted.

- Resources already secured from external sources (e.g., WB, GEF) and from the government for sector development or financing users and suppliers have not been fully utilized.
- Financing for projects, industry actors and users from commercial banks and from MFIs has not been sufficiently attracted.
- The financial capacity of local suppliers is not built; on the contrary, tendering large procurements through foreign suppliers diverts resources that could have been used by local companies.
- Technical standards for PV products and services are not available, they are also not monitored. This impacts market development – poor quality works against any promotional effort. A local testing and approval system is not available; external testing and approval take time and money.
- Technical capacity constraints in the sector are not strategically and widely addressed. Capacity development actions are carried out in an ad hoc manner by several institutions – there are also no standards for them.
- The model of diffusion or dissemination for PV in off-grid areas is not clearly articulated. A working model for diffusion (such as the one in Bangladesh) is not available. Sector evaluations are not available to improve strategies and implementation effectiveness.
- Some actions are strategically misguided – for example, tendering out large PV supply and installations to international companies. Resources should be directed to develop a sustainable market and at the same time to develop local financial and technical capacity.
- Sector information is not available at a single source for potential PV customers or other market actors. Knowledge and awareness of the technology is not sufficiently disseminated.
- There are practically no research and development activities for PV systems either in universities or government energy agencies.
- Institutional capability to address the strategic, regulatory and sector development functions described above is inadequate. The REF is not adequately staffed, trained and financed to conduct its functions.

2.8 Potential policy instruments to encourage solar power development

A large number of policy instruments have been implemented to increase power supplies from solar PV. The key instruments we highlight here include feed-in-tariffs, investment tax credits, direct subsidies, favorable financing, mandatory access and purchase, renewable energy portfolio standards and public investment (*Timilsina et al, 2011*). Three rationales are commonly offered for utilizing these policies. One is to encourage the use of low-carbon technology in the absence of a more comprehensive policy for greenhouse gas mitigation, like a carbon tax. The disadvantage of this approach for greenhouse gas mitigation is that it does not create incentives for cost-effective mitigation choices. The second rationale is that expanded investments will ultimately help drive down the costs of those technologies through economies of scale and learning-by-doing. There is clear evidence that scaling-up has driven down unit costs for PV, though not yet to the point that it is cost-effective with conventional alternatives in most cases. It remains to be seen how economies of scale and learning-by-doing will lower its costs. The third and most unambiguous rationale is that subsidization of small-scale, off-grid PV (and other renewable energy sources) to bring electricity to remote and poor areas lacking access is a powerful force for stimulating economic development.

2.8.1 Feed-in-tariff

Feed-in-tariff (FiT) refers to a premium payment to new and renewable energy technologies which are relatively expensive or thus not competitive with conventional technologies for electricity generation. The tariff is based on the cost of electricity produced, including a reasonable return on investment for the producer. It thus reduces the risk to potential investors for long-term investments in new and innovative technologies. This policy has been implemented in more than 75 jurisdictions around the world as of early 2010, including in Australia, EU countries, Brazil, Canada, China, Iran, Israel, the Republic of Korea, Singapore, South Africa, Switzerland, the Canadian Province of Ontario and some states in the United States (REN21, 2010). FIT has played a major role in boosting solar energy in countries like Germany and Italy, which are currently leading the world in solar energy market growth. Mendonça and Jacobs, 2009; argue that FIT promotes the fastest expansion of renewable electric power at the lowest cost by spreading the costs among all electric utility customers. A study evaluating renewable energy policies in EU

countries found that the FIT is the most effective policy instrument to promote solar, wind and biogas technologies (CEC, 2008).

2.8.2 Investment tax credits

Different types of investment tax credits have been implemented in several jurisdictions around the world to support solar energy. In the United States, for example, the federal government provides an energy investment tax credit for solar energy investments by businesses equal to 30% of expenditures on equipment to generate electricity, to heat or cool and on hybrid solar lighting systems. Besides the investment tax credit, the US federal government provides an accelerated cost-recovery system through depreciation deductions: solar energy technologies are classified as five-year property.

In Bangladesh, the primary driver of the PV market is microcredit finance that led to the substantial growth of privately owned Solar Home Systems (SHS) (IDCOL 2008).

Investment tax credits schemes are criticized for their impacts on government revenues. For example, the investment tax credits in the United States would cost approximately US \$907 million over 10 years (Renewable Energy World, July 31, 2008). The tax rebate system in New Jersey would cost \$500 million annually to reach the goal; to avoid such high costs, the State Government decided that only systems 10 kW and smaller would qualify for rebates, and systems larger than 10 kW would have to compete in a tradable solar renewable energy credit (SREC) market (Winka, 2006).

2.8.3 Subsidies

Direct subsidies (versus tax credits) are a primary instrument to support solar energy development in most countries. The subsidy could be investment grants or capacity payments, soft loans (e.g., interest subsidies), or output or production based payments. The Spanish government launched a program to provide grants of between €240.40/m² and €310.35/m² in 2000 to solar thermal technologies. In India, capital subsidies initially used, were funded either through donor or government funds. Solar hot water systems, solar cooking systems and concentrating solar cookers receive capital subsidies of, respectively, Rs. 1,500, Rs.1, 250 and Rs.2000 per square meter. The

primary reliance on capital subsidies was criticized because it incentivized capacity and not necessarily production (Sharma, 2007). In response to these changes, government policy for PV in India has recently been revised. Currently, a production-based subsidy offered by the government has been supplemented by a combined feed-in-tariff of about Rs. 15/kWh for solar PV and solar thermal projects commissioned after March 31st, 2011, for up to 25 years (CERC, 2010). Remote village electrification programs receive even higher levels of subsidies. One such program that aims to establish a single light solar PV system in all non-electrified villages in India by 2012 has 90% of the system cost covered by the government subsidy. In the case of below poverty line (BPL) families, 100% of the system cost will be underwritten by the state governments (MNRE, 2006).

2.8.4 Renewable Energy Portfolio (RPS)

Many countries, particularly developed countries, have set penetration targets for renewable energy in total electricity supply mix at the national or state/provincial levels. To meet the targets, electricity suppliers (e.g., utilities, distributors) are required to have certain percentage of their electricity supply coming from renewable energy sources. These standards are commonly known as renewable energy portfolio standards (RPS). The standards can be supplemented with a trading regime where utilities with limited renewable electricity content in their overall supply portfolio, and high cost for renewable energy expansion, can meet their obligation by buying certificates from those with higher renewable electricity content or lower cost of expansion, as illustrated by Tradable Green Certificate (TGC) schemes in Europe. In the United States, 31 out of 50 States have introduced RPS. The standards range from 10% to 40% (Hawaii by 2030). Several states have created an RPS with specific standards for solar energy. The New Jersey RPS required that 6.8% of the electricity sold in the state be renewable by 2008, of which 0.16% was to come from PV. This created a stand-alone market for solar renewable energy credits (SRECs), whose market price was capped through the use of an “alternative compliance payment” (ACP) of \$300/MWh. In 2010, New Jersey revised its RPS to require 20.38% of its electricity to come from renewables by 2021. In addition, 2,518 GWh from in-state solar electric facilities must be generated in 2021 and 5,316 GWh in 2026 (DSIRE, 2011). Similarly, Nevada’s RPS mandates that 20% of state electricity come from renewable resource by 2015. Of that, 5% must come from solar power

(NREL, 2008). RPS contributed substantially to the realization of large scale CSP plants, such as the 500 MW CSP project in the Imperial Valley in California.

2.8.5 Financing facilitation

In India, the Shell Foundation worked with two leading banks in India, *viz.* Canara Bank and Syndicate Bank, to develop renewable energy financing. This initiative helped the banks put in place an interest rate subsidy, marketing support and vendor qualification process. Using the wide network of their branches, the interest subsidies were made available in over 2,000 branch offices in the two states of Kerala and Karnataka. Within two and half years, the programs had financed nearly 16,000 solar home systems, and the subsidies were gradually being phased out. Whereas in 2003 all sales of PV home systems were on a cash and carry basis, by 2006, 50% of sales were financed (Usher et al, 2006).

In Bangladesh, the Rural Electrification and Renewable Energy Development Project established microcredit financed facilities that resulted in the installation of over 970,000 solar-home systems (SHS) between 2003 and May 2011. Having exceeded its expectations, the program now has a target of 1 million SHS systems by 2012 (Uddin et al 2008). This model has been built on the microcredit banking system pioneered by Grameen Bank and now adopted by numerous organizations (IDCOL 2008).

The Spanish government launched a program of low-interest loans for solar thermal applications (7-year loans with interest rates at 2%-3.5% below commercial rates) in 2003 (Institut Català dEnergia, 2003).

2.8.6 Public investment

One of the main drivers of solar energy development in developing countries continues to be direct public investment. Many developing countries host a number of government and/or donor-funded projects to support solar energy under their rural electrification programs. The rapid development of the PV industry and market in China is mainly due to government support, implemented through a number of rural electrification programs. National and local levels programs for rural electrification were the major driving force for solar PV market expansion in China in the late

1990s and early 2000s. The major programs supporting PV programs are Brightness Program Pilot Project, Township Electrification Programs, and China Renewable Energy Development Project. The Brightness Program Pilot Project, launched in 2000, plans to provide electricity to 23 million people in remote areas by 2010, using 2,300 MW of wind, solar PV, wind/PV hybrid and wind/PV/diesel hybrid systems. Inner Mongolia, Gansu and Tibet were selected as pilot provinces, and a RMB 40 million grant was allocated for the project (Ma, 2004). The Township Electrification Programs, launched in 2002, installed 268 small hydro stations and 721 PV, or PV/wind hybrid systems by 2005 (PMO, 2008). The overall investment was RMB 2.7 billion, and 15.3 MWp of PV systems were installed during the life of the program. The China Renewable Energy Development Project (REDP), also launched in 2002 and supported by a GEF grant, provided a direct subsidy of US\$1.5 per Wp to PV companies to help them market, sell and maintain 10 MWp of PV systems in Qinghai, Gansu, Inner Mongolia, Xinjiang, Tibet and Sichuan.

Developing countries initiated programs with the help of bilateral and multilateral donor agencies are mainly facilitating solar energy development in developing countries. For example, the World Bank has launched a rural power project in the Philippines, aimed at the installation of 135,000 solar systems; totaling 9 MW installed capacity. In addition, the International Finance Corporation finished a 1 MW grid-tied PV with hydro hybrid project in the Philippines (Prometheus Institute, 2007).

2.9 Empirical studies related to SHS Dissemination in rural Ethiopia

Some related studies are conducted by different researchers in Ethiopia and abroad specifically on the challenges and opportunities related to rural electrification in the country. The researcher could not find enough researches on the prospects and challenges in adopting Solar Home Systems in rural Ethiopia. However, different studies have been conducted on the topic related to rural electrification in the country. To mention few; (*Dereje, 2013*), (*Alemshet, 2010*) and (*Aklilu, n.d.*), (*Samuel et al, 2015*) have conducted researches on challenges and opportunities in rural electrification in Ethiopia. There are also similar studies made in Africa and Asia. To mention few of these studies; (*Ng'eno, 2014*) from Kenya, (*Prosper, 2013*) of Ghana and (*Momotaz et al, 2012*) from Bangladesh have conducted studies on the topic of Solar Home System in their respective countries.

Dereje from the Ministry of Water and Energy; has emphasized the fact that there is a huge Renewable Energy potential in Ethiopia which is distributed through all regions and markets. He also mentioned the country has a favorable condition for private developers to participate in the Renewable Energy development. This presentation tried to cover all renewable energy sources like; Hydropower, Wind, Geothermal and Solar Energy sources. In his presentation he highlighted the fact that the country will be climate resilient and have zero carbon growth by 2025. The study has talked about the national energy policy and pointed out its benefits such as: Ensure a gradual shift from traditional energy to modern energy, provide reliable supply of energy at an affordable prices, streamline the development and utilization of energy resources and give priority to indigenous energy resources to attain self- efficiency. On top of above mentioned benefits the policy will increase energy efficiency and ensure environmental sustainability. As per Dereje's presentation the Government of Ethiopia with the collaboration of Chinese Government has prepared Solar and Wind energy master plan for the whole nation. This has been thought to help identify the need and large scale implementation of Wind and Solar energy systems in Ethiopia. It will also help to predict the cost and construction requirements of the Solar and Wind power generation and distribution projects. The master plan has made some analysis and came up with the following projections; Ethiopia has a capacity of 1,350 GW of energy from wind and 2.199 million TWh/ year of solar energy reserve.

Aklilu's study is exploring the opportunities and bottlenecks to rural electrification through stand alone or self-contained systems. The study has characterized the rural areas in Ethiopia as having either low-density settlements with relatively large distances between households, or villages with fewer inhabitants. This has hindered the use of modern sources of energy such as energy from hydropower. This mode of settlement has left most of the rural inhabitants to continue on the course of the current use pattern of traditional energy sources, is bound to have highly negative consequences for the rural economy at large, as well as the environment and the ecosystem balance. The natural resource base for the generation of modern sources of energy such as: Hydropower, Wind and Solar energy is plenty in Ethiopia. There are also favorable economic, environmental and energy policies. As per the study some of the opportunities for rural electrification are; the fact that Ethiopia has several rivers that carry huge amount of water; the country stands only second in Africa next to the Democratic Republic of Congo. The country has

exploitable potential of 40,000MW hydropower of which only 2% has been utilized so far. Aklilu has also reiterated the fact that Ethiopia has exploitable resource of 106GW solar energy with an average insolation of 5kwh/m²/day and the country has exploitable reserve of 10,000MW wind energy with an average speed of 3.5-5.5m/s, 6 hours/day. He has pointed out the fact that the economic, environmental and energy policies issued recently encourage use of renewable sources of energy and attract the private sector and the huge market potential (the country has the second largest population in Africa) can also be mentioned as an opportunity in the industry. Low purchasing power owing to the poverty prevailing in the country. Low managerial capacity and experience for mobilizing communities and potential investors, the widespread misconception about the private sector, unfair regulations that discriminate against technologies that are especially suited to rural areas are some of the threats to the rural electrification as mentioned in Aklilu's study.

Alemshet's study focuses on solar PV based rural electrification, its impact on environment and socio-economic development in Rema village. He has looked in to three different scenarios of users like: typical households, small scale business center and public services. The study has gone in to energy demand calculations for each scenario. Decentralized PV based rural electrification improved the livelihood of Rema village. As per the study the PV based rural electrification has improved the socioeconomic activities of villagers and quality of life. Using PV electrification, it was possible to supply clean water, improve the quality and services in clinics and schools, and decrease deforestation and Carbon dioxide emission. The existing capacity of PV in the village doesn't meet the demand and a new model is proposed to meet the demand. Alemshet identified that the main limitation of PV rural electrification is the high cost of investment which the rural communities cannot afford. The high level of technical skills required for maintenance and the small number of solar technicians available in the village is also a problem of village as per the study. The study has highlighted that implementation of solar PV can give enough lighting time, can increase the amount of income generation, provide access to information and entertainment; it also increases the quality of services in health clinics and schools. It can increase the contribution of solar PV in the socio economic development in rural livelihoods.

Samuel et al have publicized a Journal on "Resource assessment and optimization study of efficient type hybrid power system for electrification of Rural District in Ethiopia". Their study aimed at

assessing wind and solar energy resource potential, identifying options and designing of large scale feasible Renewable Energy Source to provide electricity for Werder district in Somali region-Ethiopia by harnessing power from renewable energy resources. Three power supply options namely hybrid renewable power system, standalone diesel generator and grid extension options have been considered. They have considered Techno economic analysis and hybrid PV/wind/diesel generator system became economically feasible for the proposed site as per their study. They have made use of optimization and simulation programs in order to select among the feasible systems they have considered, namely Solar, wind and diesel generation systems. The Journal has also considered parameters like, high renewable penetration, less annual diesel consumption, less unmet load, less capacity shortage and small leveled cost of energy in the assessment.

Ng'eno, 2014, in her study about the “Factors Affecting the Adoption of Solar Power for Domestic Usage in Kajiado County, Kenya” has highlighted that the people of Kitengela have not adopted enough of solar power technology to the extent they need to adopt. Those who have adopted are using solar home systems for charging their Mobile phones and for lighting only. This may be due to the fact that they have never received any formal or informal training on solar systems and those who had, were trained up to the certificate level on solar systems by the Solar technology providers who only train on their products and are not based in the area but make visits from time to time. This implies that the level of knowledge and awareness of solar technology and its use in the area was relatively low. Her study also concludes that lack of daily income and access to secured loans from banks and microfinance institution influenced the adoption of solar technology. The individuals who had saving accounts were able to secure loans and easily adopt the use of solar power systems. Finally, the study pointed out that the presence of alternative sources of power that may be cheaper to install might have deterred them from adoption of solar technology. The longer the distance is from the vendors of alternative sources, the higher the chances of adopting to use of solar Home Systems.

Bedzo Prosper, 2013, in his study “Entry Plan for a Solar Product Manufacturing Company, Case: Suntrica Limited and Ghana” has emphasized the fact that, the government of Ghana in its policy on energy and rural electrification considers renewable energy as the main alternative in achieving the “2020 target of electricity for all in Ghana”. Ghana has an enabling business environment and

the government has been supporting foreign donors and investors in the development of renewable energy projects. The most recent among these projects is the solar street lighting for all academic institutions and hospitals in Ghana. The passage of the renewable energy law is regarded as welcome news which will provide more opportunities for foreign investors or Small and Medium Enterprises in entering the energy market. The author believes that Suntrica Limited, a pioneer in this business in other African markets can achieve its goals and aspirations in entering the Ghanaian market. The study has highlighted that the time is now for Suntrica to decide on the suitable entry modes and to consider answering the question on when to enter and who to contact in entering the Ghanaian market. Although there might be some challenges in new markets at the early stage, Suntrica is already present in 40+ global markets and the study trusts Suntrica's vast experience which could lead to success in the Ghanaian market.

Momotaz et al, 2012 in his Journal, "Customer Satisfaction of the Solar Home System Service in Bangladesh" has concluded that Solar Home System service has profound and far reaching economic, socio-cultural and demographic impacts on life and living of the rural people in Bangladesh. As per the journal SHS service has significant and sustained impact on household and commercial activities. By watching TV and following up media people are now keeping informed about the latest state of sports, business, culture and political developments. Most of the respondents in the study are found just satisfied with the Solar Home System in Bangladesh. Some dissatisfactions are observed due to some service quality variables like convenient use of the system, longevity of the SHS, sustainability of the SHS, availability of loan from the system providers, maintenance cost of the system, warranty support of the SHS, credibility of the providers, friendly behavior of the personnel, catalog etc. provided with the system and availability of the parts of the system in the local market. Momotaz reiterated that the service providers should take proper care of these variables to improve the overall service quality of SHS service in Bangladesh. The service providers should offer a good quality system at a reasonable price with adequate capacity and longevity to meet up the requirements of the customers. Moreover they should maintain a better after sales service at reasonable cost for the customers for convenient use of the systems and also arrange training on technical and better service delivery to their personnel. The study considers only the users of Solar Home Systems in some areas of the country.

Chapter 3: Research Design and Methodology

3.1 Research Approach and type

The research approach in this study is predominantly Qualitative which makes use of primary and secondary data to answer the research questions and achieve the study objectives. The study will be a case analysis analysis regarding the challenges and prospects in Solar Home System dissemination in rural parts of Ethiopia. The case company considered for this study is Solar Energy Foundation. This study will be mainly exploratory focusing on the challenges in disseminating SHS in the rural population in Ethiopia. The study will be carried out by interviewing the management of the Solar Energy Foundation, A representative from the Ministry of Water, Irrigation and Electricity – Rural Electrification Fund, International Funding Cooperation - a World Bank group supporting on Solar Power System projects in the country and an administrative official of Rema which is one of the rural villages who have adopted solar power systems.

Qualitative research can be defined as an “array of interpretative techniques which seeks to describe, decode, translate, and otherwise come to terms with the meaning, not the frequency of certain more or less naturally occurring phenomena in the social world (*Prosper, 2013*). This type of research technique is used during the data collection and data analysis stages of the proposed research project.

Qualitative research methodologies differ from quantitative methodologies based on the focus of the research; its purpose; researcher involvement; sampling size; research design, including participant pre-tasking; data source, type, and preparation; methods of data analysis; level of insights and meaning extracted (*Prosper, 2013*). It is also possible to use qualitative methodologies alone in addressing organizational challenges or in combination with other quantitative methodologies. Qualitative research is a kind of informative research that tries to tell the researcher how and why things happen the way they do.

Qualitative research draws data from several sources, namely “people, organizations or institutions, texts, settings and environments, objects, artifacts, media products, events and happenings. In comparing qualitative with quantitative research, the latter can be defined as exact

measurement of something that is been carried out. In business related research processes, quantitative methodologies normally measure the behavior, opinions or attitudes of consumers.

3.2 Data Collection

The data for this study is collected mainly by interviewing the Solar Energy Foundation Management, International Finance Corporation, Rural Electrification Fund and an administrative official from Rema Village were also interviewed to support the analysis as they are main stakeholders in the business. Secondary data sources will also be consulted to be able to achieve the research objective.

There are two major types of data that have dominated the field of research methods. These data emanate from primary and secondary sources. The primary data refers to the facts and information collected by researchers for specific purposes. The methods for primary data involve interview techniques which can be used in different forms such as personal direct contact, phone, e-mail or other communication media.

The secondary sources of data for this study would be gathered from books both printed and in electronic formats, academic articles, reports, documents and journals. The researcher may add value by analysis of impartial secondary sources. Secondary data can be found in all written materials such as books, articles, and reports. In this research project, data would be gathered from both primary and secondary sources. The primary data would be gathered from interviews.

The researcher was able to record the interviews conducted with Solar Energy Foundation and IFC representatives and then transcribe and reviewed the data before including them in this study. The writer didn't get the approval to record the interview with REF representative, hence the data was collected by taking short notes during the interview and memorizing and writing them in detail after the interview. The interview with the administrative official of Rema village was done by phone and main points about the end user experience are included in this study.

3.3 Instrument of Analysis

Qualitative content analysis according to Mayring (2003) is the method used to analyze the data. The main part of the analysis is qualitative. This can be supplemented by quantitative analysis,

such as analysis of frequency. This is designed to ensure inter-subjective understanding and control of method, which is a criterion of qualitative research according to Mayring. Therefore answers turned out not to be very long or detailed. Interviews had to be translated. As a consequence, it is not possible to attach value to analysis of every single word within the interviews. Furthermore, the author does not want to generate completely new theory but to rely on existing literature. This is reasoned in order to achieve a more feasible approach by integration in former experiences.

Procedure of qualitative content analysis

1. Selection of basic raw material

The basic population is the Solar Power System vendors in Ethiopia. It consists of approximate 21 solar power system vendors, Rural Electrification Fund from the Government side, and the end users which have adopted the technology. The interview was conducted with Solar Energy Foundation - a prominent Solar Power vendor, representatives from IFC (World Bank Group) and Rema wereda administrative official.

The researcher has conducted problem focused interviews with the above four stakeholders regarding the challenges and prospects of Solar Home System dissemination in the rural parts of Ethiopia. The interviewees are responsible personnel in their respective organizations and the three out of four interviews were made in Amharic language. The fourth one from IFC was conducted in English language. The interviews were recorded and transcribed.

2. Question of Analysis

Direction of Analysis: The present research concerns challenges and prospects of solar power implementation. The interviews should motivate the participants to think and report on their actual feelings, their cognitive state and their previous experiences in the solar power dissemination. According to the content analytic communication model the direction of analysis is to make statements about the emotional, cognitive and actual background of the text.

Theoretical guided differentiation of question: This study concentrates on the challenges and prospects of solar power systems. The interviewees made statements about their experience of

the challenges faced, possible actions needed and actual actions that are being taken by different stakeholders.

3. Procedure of Analysis

The strength of this procedure of analysis is described by Mayring (2003) in following previously fixed steps of analysis. These separate steps make it inter-subjectively comprehensible and verifiable. This makes it possible in turn to convey it to other subjects and to transform it into a scientific approach.

4. Analysis / evaluation by means of categories

The objective of qualitative content analysis is to establish a system of categories that explains the basic population. While interpreting the basic material, the process of analysis is repeated in various loops. Therefore, categories are developed in a reciprocal relationship between theory and concrete material.

3.4 Ethical Consideration

Up on writing this thesis and doing the interviews, the researcher will put in to consideration the ethical principles. The purpose of the study will be explained to the participants and corresponding acceptance approval will be sought from the interviewees in order to establish trust and credibility. Regarding the right to privacy of the interviewees, the researcher will not put participants at risk, by maintaining the confidentiality of the identity of each participant. In all cases, names are kept confidential, thus, collective names like ‘interviewees’ will be used. The researcher will not Suppress, falsify and invent findings to meet his and/or participants’ needs.

Chapter 4: Data Analysis, Presentation and Interpretation

4.1 Stakeholders' Overview

4.1.1 Overview of Solar Energy Foundation – SEF

SEF-Stiftung Solarenergie, first established in Germany in 2004, is currently operated in Ethiopia, Philippines, and Kenya with the aim of “alleviating poverty in developing countries by promoting the use of renewable sources of energy, mainly solar power”. SEF started its pioneer Ethiopian project in the now called ‘solar village’, *Rema*, and a nearby village called Kechemober, about 250 km away to the north of Addis Ababa, capital of Ethiopia. It was in Rema, a remote village of about 6,000 households who were dependent on kerosene and fire woods for lighting and cooking, that SEF installed 1,100 solar home systems in 2006. It later expanded its solar centers and addressed the other parts of the country. SEF, so far, has introduced solar systems and solar lanterns not only for individual users, but also for institutions such as rural primary schools and clinics. In addition to solar home systems (SHS), solar street lights, solar water pumps, and solar TVs are also other solar-based technologies that SEF has been providing to the rural users.

SEF has been a pioneer in rural SHS installations in Ethiopia and considers its approach as “holistic” and “an approach that is binding social and financial sustainability together”. The governing approach of SEF, according to the founder, is “the profit-oriented affiliated enterprises led by the non-profit foundation and not vice versa”.

SEF has set up an International Solar School in Rema in order to provide a supply of well-trained solar technicians to maintain the systems. The six-month training course covers solar theory, business management and work experience.

SEF also got its own daughter-company called Sun Transfer which produces (assembles) solar system components. It has got a spacious compound (15,000sqm) from Ethiopian government for further building of solar PV industry locally. SEF introduced a service network of solar centers that are basically established by its graduates from ISEI and form a group of four and five to sell, install, promote, and provide maintenance services in the rural areas of Ethiopia.

4.1.2 Overview of Rural Electrification Fund

Rural Electrification Fund is a project office established by The Ethiopian Government, MoWIE. There is an Alternative Energy Technology Development and Promotion Directorate operating under MoWIE. REF is established and directed by Alternative Energy Technology Development and Promotion Directorate. It is established by proclamation; Rural Electrification Fund is responsible for securing funds, floating tenders and purchasing Solar Power Systems for rural Households and institutions like Schools and Clinics. REF has so far implemented 30,000 Solar Home Systems in rural parts of Ethiopia and it is currently implementing 11,000 SHS, which adds up to 41,000 SHS. Rural Electrification Fund has also electrified 915 institutions (Schools and Clinics) using solar power systems, 370 are for rural schools and 545 for clinics in the rural parts of the country. REF has planned to implement 4000 solar power systems through loans to be secured from CRGE (Clean Resilient Green Economy), a program supporting REF in Solar power projects implementation.

4.1.3 International Finance Corporation – IFC

The International Finance Corporation (IFC), a member of the World Bank Group, is the largest global development institution focused exclusively on the private sector. IFC helps developing countries achieve sustainable growth by financing investment, mobilizing capital in international financial markets, and providing advisory services to businesses and governments.

The World Bank-supported programs provided 42 million people with new access to electricity between 2000 and 2013 – most of them in South Asia and Africa. Bank Group financing, combined with advisory and analytical services, knowledge products, as well as policy support, has also helped launch and scale up renewable energy generation and energy efficiency at national, sub-national and municipal levels. During 2000-13, the Bank supported projects for the construction and rehabilitation of about 98,362 kilometers of transmission and distribution lines and about 13,499 megawatts of generation capacity to improve access to reliable energy (IFC, 2014).

4.1.4 Rema Village

Rema is a remote rural village found in the north of Addis Ababa. In this remote rural village the solar energy foundation has installed over 2000 small solar home systems with 10Wp PV module, gel lead acid battery, charge controller and four LED lights (Breyer et al 2009). It provides lighting and power small entertainment devices such as radio for not more than two hours. The foundation also installed a solar powered water pump to provide fresh drinking water that will save from walking two hours to fetch water (Breyer et al 2009).

Before the solar foundation began to install the solar PV the villagers were using diesel generator but turned to solar PV due to the increasing cost of diesel. When seeing the first cost diesel generator is an interesting option for the buyer. The major costs become after it starts operating. It is also difficult to maintain a diesel generator due to lack of spare parts. [Breyer et al 2009]

In Rema village, the initial PV system is fully funded by Solar Energy Foundation. After installation the customers pay for the battery replacement and maintenance costs in each month. If a system fails it will be maintained and replaced by technicians in solar center. The due will be paid from the collected money. Customers pay the monthly fee at 12 stations and a person is employed to take control of the payments (Alemshet, 2010).

4.2 Challenges in Solar Power Dissemination in Rural Parts of Ethiopia

The author of this research project conducted four separate interviews with stakeholders involved in the Solar Power business in Ethiopia to have a concrete view of the challenges faced by the case company. The interview questions were designed taking in to consideration the objective of this research project and the research questions which need to be answered at the end of the study.

In order to make a suggestion that will be concrete and elaborate on the challenges in solar power dissemination by the case company, the interviewed answers need to be combined and compared. The answers to the questions in the interviews conducted by face to face interviews were gotten from Solar Energy Foundation manager in Ethiopia; ministry of water, Irrigation and Electricity (Alternative Energy Technology development and promotion directorate – Rural Electrification

Fund). A phone interview was conducted with administrator of REMA village who is the first rural village to adopt solar power systems by Solar Energy Foundation.

The answer to the question “what are the main challenges you faced in Solar Power System dissemination in the rural part of Ethiopia?” seems to have different answers. The representative of Solar Energy Foundation, in his interview explained that one of the challenges is accessibility of the rural population as they are living far from main roads and are scattered. This makes it difficult to reach the rural population as there are very difficult or no roads to reach the villages by car. The second main challenge is the lack of awareness by the rural population about alternative energy sources and their benefits. The villagers need to be convinced about solar power systems and the availability of reliable after sales services. Most of the Solar Home systems in the market currently do not have the needed resources to provide installation and after sales services; they just sell the boxes which makes it difficult to the users as they don’t have any one to support them in case the equipment fails to work which is the case as Solar Home System technology by its nature requires after sales support. The third challenge is lack of enough financial resource by the solar vendor be it an NGO or a business company, in order to be able to meet the huge demand in the remotest and scattered villages and considering the cost of Solar systems; dependable and sizable financial capability is a requirement. When it comes to the government policy and standard requirements; the interviewee mentions that though it is duty free to import solar power systems, the process and permit requirement by the responsible certifying organizations which are is complicated and delaying.

Same question was raised to the representative of IFC (International Finance Corporation), part of the world Bank group that deals with the private sector, and he has explained the single main challenge in the Solar Power dissemination in Ethiopia is getting the foreign currency to fund the import of quality assured solar products. Although World Bank is lending money to fund such projects it is by no means enough to meet the huge demand for the solar power system in the country. The second main challenge is that the regulatory part has to be more flexible to invite bigger players to the market and facilitate import and installation of quality assured solar products. The industry is heavily regulated and is not achieving what it is supposed to achieve due to the rigid regulatory system. The third main challenge according to IFC representative is poor control of quality of the solar system products in the country. Due to the poor control too many low quality

products are entering the market which affect the end user satisfaction negatively. Lack of awareness of quality solar products is also observed as a challenge by IFC.

As per Rural Electrification Fund - a project office under the Ministry of Water, Irrigation and Electricity / Alternative Energy Technology Development and Promotion Directorate; the main challenge in solar power system dissemination is securing the fund to purchase the solar power systems. World Bank was the main source of fund so far which was funding the projects by REF but it is expected to stop the fund any time soon. The other major challenge is the value added tax imposed on such systems which has increased the cost to the end user. There is also a challenge experienced as delay in providing the service due to longer internal process by REF.

4.3 Possible solutions to overcome the challenges and implement SHS as required by the rural population

When asked about the possible remedial actions to overcome the challenges in solar home system implementation, the IFC representative stated that in order to help overcome the main challenge which is getting the required foreign currency to fund such projects; IFC is providing credit facility for the import of quality assured solar products. Initial 20 million dollar had been loaned towards funding import of solar power products and another 120 million dollars is coming for specifically importing quality assured solar products. Though this might help to slightly fill the current gap between supply and demand, it obviously is not enough to address the growing demand in the rural areas. The Ethiopian government should come up with other sources of donors in order to finance solar projects and to be able to reach the government's target of reaching the required level of electrification.

As per IFC's representative; In order to help improve the regulatory challenge, IFC is working with six different government agencies namely the Energy Authority, the Standards Authority, Ministry of Energy, Revenue and Customs, Conformity Assessment Enterprise and Ministry of Trade. This consists of firstly understanding the regulatory issues the main one being the sector is heavily regulated but could not effectively achieve what it is aimed to achieve. Addressing quality control issue has been at the center of the problems here and IFC, Energy Authority and Standards Authority have come up with a success story by developing a mandatory quality standard which

is CES 140 which was adopted in January of 2016. This quality standard is developed in conformity with global standards in to consideration other similar standards in countries like Kenya, India and Bangladesh. The next step is working with the ministry of trade on the import procedures linked with the quality standards and performing the required market surveillance. This helps to have an efficient and effective regulatory regime in place so that those companies with good products can be encouraged and the ones having poor quality products be discouraged.

Apart from the support on the quality awareness and having regulatory regime in place, IFC is engaging itself in consumer education campaign. This campaign is said to be the largest single budget of all the programs IFC is running currently in the country. The campaign has been running since September of 2015 and is being carried out via media campaigns like radios, TVs and road shows. As per the market research conducted by IFC, there is relatively better awareness about solar power systems in Ethiopia compared to other similar countries. But it is observed that the people's knowledge about quality of solar products is found to be minimal. IFC is campaigning towards addressing the quality awareness issue. IFC is working to create the awareness of the people on how to identify good quality from the bad. An example of such effort is the fact of having a dedicated SMS number that will be used to get any necessary information about solar products.

Another support area IFC is working on is called Business Support Services which is linking up solar companies with local partners in order to establish stronger base and have big players in the country. Working with Microfinance institutions is also another component IFC is focusing on to help the rural population get access to easier financing mechanism which will help remove the upfront cost barrier and raise the local demand.

In order to make the Solar Power System dissemination better, the representative of Solar Energy foundation suggests that the Government should involve the solar vendors and come up with a workable regulations and permit requirements so that the huge demand for solar home systems can be met. He also mentions that Government and the other stakeholders should work towards creating the required awareness so that the rural population understands about the benefits of the solar technology and move towards adopting it.

According to the interview with SEF representative, building proper training centers for solar technicians is the other requirement that could solve the issue of after sales service and help in the awareness creation. This can be done jointly by the government and the business community who are working in solar power system sector. In order to improve the affordability of the solar power systems the regulatory body needs to encourage varieties to products to enter the market legally via recognized vendors so that the end user will have to choose the one that meets his financial capability.

The SEF representative went on and said that the Ethiopian government has to work towards discouraging and stopping the illegal vendors as they are importing poor quality solar products in to the market which can affect the end user satisfaction as such products may not have longer life and lack after sales services. This has got demotivating effect on the solar vendors who are working legally and who have got the required human resources for the installation and support services. Banks like Development Bank of Ethiopia could play an important role in providing financing to SMEs working in such sectors and which are located closer to the end user. The current trend is that the requirement by the Bank to get finance can be met only by bigger vendors. Micro financing institutions can also get involved to providing loans to the rural population in order to finance solar power systems.

The representative from MoWIE, Rural Electrification Fund stated that, as a solution to overcome the challenge of funding the Solar power projects, REF is looking at another funding organizations like Norwegian government who promised to provide a grant enough to implement up to 50,000 solar power systems. In order to overcome the other problem area of long process preventing quick solar project deployment, Alternative Energy Technology Development and Promotion Directorate is working on restructuring of REF.

4.4 Government plans to facilitate the Solar Power Dissemination in Rural Ethiopia

The question “What is being done by the Ministry of Water, Irrigation and Electricity to help improve the solar power System implementation” was answered by a representative from MoWIE, Rural Electrification Fund. Accordingly, the Ethiopian Government through REF is working hard to secure the required funds in order to import and implement solar power systems for the rural

population. It also works as a support in facilitating and controlling the quality of solar products being imported in to the country.

From the interview with the representative of International Financing Corporation, it is understood that the solar power sector is not given the priority it requires compared to the case in other countries like Kenya and Bangladesh. He also went on and mentioned that the Ethiopian Government has planned to implement 3.6 Million Pico solar and 400 Thousand solar home systems as part of its GTP2 program. IFC is advising and supporting the Ethiopian government towards achieving this target set as part of GTP2 specifically in the solar power projects. The support could include arranging for loan facility to the Development Bank of Ethiopia and also playing an intermediary role between the private sector and the Government. He emphasized that the main constraint is on the supply side especially getting the foreign currency to import quality assured solar products. Once this issue is addressed then it will be much easier for the vendors to be able meet the growing demand. Unless this issue is resolved working on boosting the demand could be counterproductive as the current demand itself is far from being met.

As per IFC's representative, there should be a stronger solar association who could play the intermediary role IFC is currently playing and facilitate the solar business. He suggested the currently existing solar association should be strengthened in order to be able play the intermediary role as IFC's current program lasts only maximum for another two years. He also went on and emphasized that the Government should work on easing the current bureaucratic and complicated regulation. As an example he mentioned his experience in Bahirdar as he was presented with a big regulatory document that shows the mandatory requirement for solar companies to work in the region which is discouraging. Instead he suggested focus should be given to controlling the quality of products in their market as he has witnessed that the majority of the solar products in the shops there are of poor quality.

Another interview question "How is the payment for the solar systems made by the end users for the Solar Power System they are using?" was posed to REF's representative. In his response he said that, Payments by household users is made in such a way that 5 % is being paid upfront as a down payment and the remaining 95% will be paid monthly within 5 to 7 years. The institutional users (Schools and clinics) will get the solar power system on a grant basis. Development Bank of

Ethiopia is responsible for collecting the loans from the SHS users. The cost to acquire a SHS by the rural villagers could vary from 4000 birr to 22000 birr depending on the capacity of the solar home systems which range from 8 Watts to 130 Watts.

When replying to the question “what kind of relationship is there between REF and other solar power vendors?” REF representative responded by saying, REF is responsible for monitoring the imported products and services by the solar vendors working in the country. Currently quality inspection and approval is being done by Conformity assessment organization which is under the Ethiopian Standards Authority

During the interview with REF the Author has understood that the Ethiopian government has a program called “Climate-Resilient Green Economy (CRGE)” which has a vision “Achieve middle-income status by 2025 in a climate-resilient green economy”. If Ethiopia were to pursue a conventional economic development path to achieve its ambition of reaching middle-income status by 2025, Green House Gas emissions would more than double from 150 Mt CO₂e today to 400 Mt CO₂e in 2030. Ethiopia’s development could result in unsustainable use of natural resources, in being locked into outdated technologies, and in losing an ever-increasing share of GDP to fuel imports. Ethiopia would lose the opportunity of making its development sustainable (FDRE, 2011). Electricity is a fundamental enabler of modern economic development, from powering cities and fuelling industrial activity to pumping water for irrigation purposes in agriculture. If not adequately scaled up to support economic development, it also risks becoming a fundamental bottleneck to growth. To support economic development at an annual growth rate of more than 10% that the government aspires to, it is necessary to expand electric power supply at a rate of more than 14% per year (FDRE, 2011). In order to meet such a demand and supplement the current main renewable energy supply which is Hydropower, developing and promoting Solar Power systems is by any means a necessary measure.

In his interview the representative from REF continued and mentioned about a program called, Universal Electricity Access (UEAP). This is a program hosted by Ethiopian Electric Power Corporation and funded by the government of Ethiopia, World Bank, African Development Bank, and Bank of Arab Development for Africa. The UEAP is an umbrella program executed by EEP provide grid-based electrification in rural towns and villages over a 10-year horizon. The

interviewee has mentioned that there is a possibility the activities and projects currently being undertaken by REF could be covered by UEAP in order to increase capacity and meet the ever increasing demand. The accomplishments of the UEAP over the past four to five years have been remarkable—both in terms of connecting new customers and electrifying new towns and villages (IFC, 2012).

4.5 End User experiences

To gain an understanding of the end user's experience on the Solar Home Systems, The researcher has interviewed the administrative official from Rema wereda who have started using Solar Home Systems seven years ago. In his response to the question “What was the impact of Solar Home Systems on the lives of the people of Rema Wereda?” the official from Rema has admitted the impact the Solar Home System has on the lives of the village was huge. 2000 households were benefiting from the Solar Home Systems which support lighting bulbs, and sockets to power up their Radio receivers and Tape recorders. Street lights were also powered by solar power systems which enabled the residents move freely at nights and were able to attend night classes.

As per the official's response, the main benefits of having Solar Home Systems include; having better health due to the fact of avoiding kerosene lighting which are known to cause breathing problems and diseases affecting the Lung. There is a clear cost benefit as the residents don't have to spend huge money on buying kerosene to fuel their lamps. Students can study better under the clean and better light from Solar Home Systems and avoid the risk of having fire accidents from the Kerosene lamps. Rema village is recently connected to Grid electricity and the residents are still having the Solar Home systems and use them when there is an outage from the Grid power. The residents are experiencing some lack in the support of the solar power systems as the solar vendors are focusing on other villages that are not yet connected to the Grid power.

Solar Energy Foundation is the company who has implemented the Solar Home Systems in Rema village, trained technicians and continued supporting whenever there is failure in the system. SEF was working as a non-profit organization in which case the system was being implemented with a small upfront payment and the villagers were paying 7 birr – 14 birr per month depending on the

usage. This continues until the total system cost is paid up and SEF recovers its cost. This might take 5 to 7 years.

Chapter 5: Summary, Conclusion and Recommendation

5.1 Summary of the findings

This research project is set out to study the challenges and prospects in solar power system dissemination in rural parts of Ethiopia. Solar Power Systems are being considered as a viable option of providing electricity and power to rural areas all over the world. It has multitude of benefits including but not limited to:

- Solar Home Systems are the most viable and environmentally friendly power solution to electrify the rural population.
- It offers a better life standard for the rural population as it easily provides street lighting solutions for home and streets, with access to power up the radio, TV and mobile devices.
- It helps the people get a better access to information which in turn could limit the continuous migration from rural to the towns.
- Solar power systems supplement a countries economic growth by providing quick and sustainable electrification especially to the rural population. In the case of countries like Ethiopia, most of its population lives in the rural areas.

The challenges in solar power system dissemination in rural Ethiopia can be summarized as follows:

- Solar projects are not given the same level of priority like other energy projects in Ethiopia
- Lack of foreign currency needed by the solar vendors to be able import the system
- Low quality solar products being sold in shops without proper license to import such products.
- Unavailability of enough funds for solar projects.
- Poor quality solar products in the market affecting end user satisfaction.
- Microfinance institutions are not involved in lending money for the purpose of solar power system acquisition

- Most rural areas are difficult to access which is impeding the solar power implementation
- The existing solar association is not strong enough to take the responsibility of promoting solar systems and playing an intermediary role between the government and the solar vendors.
- Lack of workable regulatory framework to import and implement solar power systems
- Not having enough technically trained solar technicians to be able to properly install the system and provide after sales services.

5.2 Conclusion

There is a huge gap between the demand for solar power systems and the actual supply by the current solar equipment vendors in the country. Based on the discussion during the interviews the demand is as high as 14 Million solar power systems and the current installed number of solar power systems are estimated to be 100 thousand.

The main challenges in disseminating the solar power systems in rural areas are lack of prioritization of the technology by the government, unavailability of enough foreign currency to import the quality assured solar products, not having a workable and easier regulatory framework in place and lack of control of the poor quality products entering the market.

In order to bridge the gap between supply and demand and address the above mentioned challenges The Ethiopian Government, World Bank through one of its groups called IFC are working closely. The writer understands that not enough is being done to include solar power systems as one of the options to reach the goal of meeting electrification target. Solar power systems can play an important role in meeting the growth transformation plan by increasing the electrification in the rural part of the country in a sustainable manner.

As mentioned in the methodology section, this research study used qualitative methods to analyze the required data in order to understand the challenges in disseminating solar power systems in rural Ethiopia. The case company under study was Solar Energy Foundation which is the pioneer in the solar power industry here in Ethiopia and few other countries. Interviews were conducted with the representative of Solar Energy Foundation, International Financing Cooperation, MoWIE

Rural Electrification Fund and an administration official from one of the prominent adopters of the solar power technology called Rema.

5.3 Recommendations

The interviews conducted and literatures reviewed regarding the challenges and prospects of solar power dissemination in rural Ethiopia lead to the following recommendations:

- The Ethiopian Ministry of Water, Irrigation and Electricity should give the required emphasis for solar power implementation in the rural parts of the country.
- The current issue of having low quality solar products in the Ethiopian market should be addressed with at most urgency.
- The reputable Solar equipment vendors in the country should be encouraged so that they could play their role in the solar power implementation
- The MoWIE should work more closely with IFC (the World Bank group responsible for the solar power projects in the country), so that the country could benefit from the Bank as it is the case in other similar countries.
- Microfinance Institutions should be encouraged to involve in the solar power projects enabling rural households to get loan for acquiring solar systems.
- Consumer awareness on solar power systems has to be created so that the users could identify bad quality products from the good ones.
- There has to be enough training facility to bring up the required number of professionals in solar power system to facilitate after sales services so that the operation would easily be available.
- The existing solar association should be reinforced so that it could work side by side with IFC and take over the intermediary activities when IFC ceases to operate which is after 2 years' time.

5.4 Suggestions for Further Research

The main focus of this study is on the challenges and prospects of solar home system dissemination in rural Ethiopia. The study mainly focused on the challenges and solutions as observed and faced by the case company – Solar Energy Foundation. In order to address the issue of electrification in the rural parts of our country the researcher recommends further research works to be conducted on grid connected solar power systems which can serve a village or small town apart from standalone solar home systems.

Other areas of renewable energy sources like wind farms should be studied similarly as these could help the Government increase the electrification rate and meet its target in a sustainable way.

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Interview Questions

A. Interview Questions to the Solar Energy Foundation Representative in Ethiopia

1. Can you please explain about SEF?
2. What are the main challenges you faced in Solar Power System dissemination in the rural part of Ethiopia?
3. What is the potential and need for such systems in the rural part of the country as per your observation?
4. What should be done as a solution to facilitate the Solar Home System Dissemination?
5. How is the acceptance level of Solar Home Systems by the rural population?
6. As per your observation, what are the challenges faced by the rural population to acquire Solar Home Systems?
7. What does your organization came up to help the people own Solar Home Systems?
8. What is the current installed number of SHS in Rural part of the country?

B. Interview Questions to Rural Electrification Fund Representative; Part of Ministry Of Water, Irrigation and Electricity.

1. Could you please explain the role of your ministry in renewable energy dissemination?
2. What is the ministries plan to increase solar power implementation in rural part of Ethiopia?
3. What has been done so far to encourage Solar Energy companies come to Ethiopia and remain there?
4. Is there any experience sharing mechanism with those countries who have pioneering in Solar Power generation and distribution?
5. What are challenges faced from the Solar companies and the rural population to implement the Government's strategy in renewable energy capacity growth?
6. Is there a Government body who supports Solar Energy Companies to come and invest in the country?

C. Interview Questions to a representative of a rural village who have adopted Solar Hope Systems.

1. Is there an observed benefit and life improvement from using solar home systems in your village?
2. What is the main challenge to Adopt Solar home systems in the village?
3. What challenges did you observe during the usage of the system by the residents?
4. Any suggestion for improvement in the system?
5. Is there a demand for additional solar power system in the village?

D. Interview questions to the Representative of International Financing Cooperation (a World Bank Group)

1. Could you please give me a brief description about your organization?
2. What are the main challenges faced by Solar Energy companies in Ethiopia?
3. How do you see the level of solar power adoption in Ethiopia compared to other countries on a similar level?
4. What is your recommendation to improve the solar power system dissemination in rural part of Ethiopia?
5. What is the Solar Power System utilization in the rural part of the country as per your observation?
6. What is the potential market in the rural Ethiopia for Solar Power systems as per your data?