EVALUATION OF SOLAR AND BIOGAS UTILIZATION AS HOUSEHOLD ENERGY SOURCE IN YEM SPECIAL DISTRICT, SOUTH NATION NATIONAL PEOPLE REGIONAL (SNNPR) SOUTH-WEST ETHIOPIA.

M.Sc. THESIS

SINTAYEHU MECHA ROGE

HAWASSA UNIVERSITY, WONDOGENET COLLEGE OF FORESTRY AND NATURAL RESOURCES

OCTOBER, 2019

EVALUATION OF SOLAR AND BIOGAS UTILIZATION AS HOUSHOLD ENERGY SOURCE IN YEM SPECIAL DISTRICT, SOUTH NATION NATIONAL PEOPLE REGIONAL (SNNPR) SOUTH-WEST ETHIOPIA.

SINTAYEHU MECHA ROGE

THESIS SUMMITED TO:

DEPARTMENT OF ENVIRONMENTAL SCIENCE, WONDOGENET COLLEGE OF FOREST AND NATURAL RESOURCE, HAWASSA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF THE MASTER OF SCIENCE IN RENEWABLE ENERGY UTILIZATION AND MANEGEMENT.

OCTOBER, 2019

APPROVAL SHEET I

This is to certify that the thesis entitled **‘‘evaluation of solar and biogas utilization as household energy source in Yem special district, south nation national people regional (SNNPR) south-west Ethiopia’’** is submitted in partial fulfillment of the requirements for the degree of Master of Science with specialization in Renewable Energy Utilization and Management, Wando Genet College of Forestry and Natural Resource, and is a record of original research carried out by **Sintayehu Mecha** Id. No.**MSc/REUM/R0015/10**, under my supervision, and no part of the thesis has been submitted for any other degree or diploma. The assistances and help received during the course of this investigation have been duly acknowledged. Therefore, I recommend that it be accepted as fulfilling the thesis requirements.

D/R SOLOMON T/MARIAM (Ph.D.)  _____

MAJOR ADVISOR Signature date

PROFESSOR TSEGAYE BEKELE _____ _____

CO-ADVISOR signature date

APPROVAL SHEET II

We, the undersigned, members of the board of examiners of the final open defense by Sintayehu Mecha have read and evaluated his thesis entitled ‘‘**evaluation of solar and biogas utilization as household energy source in Yem special district, south nation national people regional (SNNPR) south-west Ethiopia**’’. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of masters of Science in Renewable Energy Utilization and Management.

_____	_____	_____
Name of the Chairperson	Signature	Date
D.r Solomon T/M		
Name of Major Advisor	Signature	Date
_____	_____	_____
Name of Co-advisor	Signature	Date
_____	_____	_____
Name of Internal Examiner	Signature	Date
_____	_____	_____
Name of External Examiner	Signature	Date
_____	_____	_____
SGS approval	Signature	date

ACKNOWLEDGEMENTS

First above all, I would like to thank the Almighty God for his unreserved gift. All the achievements are due to his permission. Secondly, I am very appreciative to Dr. Solomon T/Mariam my major advisor, in Addis Ababa institute of technology for his professional support. Thirdly, I would like to say thank you my co advisor professor Tsegaye Bekele for your unreserved help throughout my thesis work and my progress thesis work. The door of Professor Tsegaye Bekele office was always open when I get difficulties. He consistently help me during my thesis work. He progressively help me from the start of proposal work up to the end of my thesis work. He allows me this thesis to be my own work. Fourthly I am very much thankful to MRV Project for the financial support which helped me to undertake field survey research activities. I would also like to thank all the staff of Yem special district Water, mine, and energy office, the enumerators, and all the respondent households who participated during the survey and data collection. Last but not least, my overwhelming appreciation goes to my wife Aynalem Nesibu and my entire family and all my intimate friends who encouraged me during the course of study.

STATEMENT OF AUTHOR

I hereby declare that this thesis is my original work and has not been presented for a degree in any other University.

SINTAYEHU MECHA _____ _____

Name of author signature date

ID: MSc/MREU/R00015/10

Table of Contents

List of acronym and abbreviations

CFLS	Compact florescent
CRGE	Climate resilient green economy
CSA	Central static agency
EIA	Environmental impact assessment
FIT	Feed in tariff
GTP	Growth and transformation plan
IEA	International energy agency
IEO	International energy out look
MDG	Millennium development goal
MOWE	Ministry of water and energy
NAMA	Nationally Appropriate Mitigation Action
NGO	Nongovernmental organization
QSAE	Quality stander authority of Ethiopia
REF	Rural electric found
RPS	Renewable energy portfolio
REU	Renewable energy utilization
SHS	Solar home system
SNNPRS	South nation national people regions
SLM	Sustainable land management
USAID	Unite state agency for international development

List of table

List of figures

Evaluation of effectiveness of renewable energy source (biogas, solar) in Yem special district

Sintayehu Mecha Roge

Email: mechasintayehu@gmail.com, +251996554046

Abstract

The electric situation in Ethiopia is still very centralized to its capital city. Only 4.8% of the rural population had access to modern energy source. This shows that greater than 95% of the rural population in Ethiopian still live without electricity. This situation was also worsted in the research study area. The objective of this study was to evaluate solar and biogas utilization as household energy source in Yem special district. The research was designed by descriptive survey research design. A total of 232 out of which 210 randomly selected and 22 purposively selected biogas users were included in the present investigation. The data was collected through structural questioner and focused group discussion and analyzed by use of SPSS version 20 software. The data was analyzed by using descriptive statics, existing situation were interpreted by using frequency, percent and presented by using table and figures. Based on the finding of the research. The awareness of the household head has positive effect on utilization of renewable energy source (solar and biogas) and adverse effect of kerosene and firewood. Lack of awareness, quality of renewable energy source, maintenance and shortage of accessory are major utilization constraints in the district. In this research, those awarded and owner of solar/bio householders have improved their livelihood condition and they got different social and economic benefits. The social benefits were educational benefit, healthy benefits, and working time in the evening and economic benefit to save money, solar and biogas are substitutes kerosene value and provided suitable environment for small income generating activists like mobile charging in the study area. From the present finding it is concluded that, utilization of solar and biogas provided economic growth, quality of education, health benefit, and access to information for the rural community of Yem. And it solve households energy problem in the house.

Key Words: *Renewable energy source, solar and biogas energy utilization*

1. INTRODUCTION

Energy is one of the basic element of economics and social development. It contribute to healthy and educational service, delivery, and help to meet the basic human need such as food and shelter. But now energy is one of the major challenges of the world faces today, touching all aspect of our lives Bekele, et al, (2016)**.** According to the international energy agency and united nation organization report (2014), 1.4 billion roughly 22% of people in the glob still lacks access to basic electricity. Kebede and Mitsufuji, (2017) and World Bank, (2015), many of these, approximately 90%, being people located in Africa and Asia. As well, most of the people who do not have access to electricity are part of the rural population. These peoples are highly dependent on firewood and use of kerosene lamps for lighting theirs home at night Morrissey, (2017). Issues related to the use of these types of energy for example, have health risks (e.g. flammability of kerosene, respiratory impacts of firewood burning), high costs and absence of constant supply NAMA, (2016), degradation of forest coverage as well as climate change, difficult for children for studying at night, and businesses usually cannot continue operating after dark Steve,(2013).

The international energy agency (IEA) estimated that 85%of the people without electricity live in rural area in developing country, Pode, (2013) in semi-urban and remote rural area of the Africa and south Asia. In Africa many poor families reside in electrified region including Ethiopia but still many lack of electricity for economic reason. The electric grid are also often extremely unreliable in the developing countries this is due to generation capacity shortage, poor transmit ion, poor distribution infrastructure and host of other operational issues.

In Ethiopia 83.2% of the population live rural area, where the modern energy service are rarely available and only 4.8% of the rural population had access to electricity. Tessama *et al.*, (2013). The electric situation in Ethiopia is still very centralized to its capital city. Many locations outside the capital do not get proper attention. Poor people cannot afford to have electricity for their daily activities. Many remote areas like geographically step up step down areas and are not connected to national grid lines. Since expanding the national grid in those isolated areas is very expensive and are not cost effective, renewable energy source (solar & biogas) could be an effective alternative to fulfill the electricity requirement in these off-grid areas. Recently use Solar Home System (SHS) is growing fast for solar electricity, though it has high initial cost. As a developing country Ethiopia and its people are suffering from power and electricity shortages. But the geographical situation and favorable climate conditions provide tremendous opportunity to utilize solar and biogas power for almost every aspect of our rural, urban, semi urban livelihood of Ethiopia population.

Although, solar electricity in Ethiopia has introduced in the mid 1980's Hilawe, et.al, (2011) but the countries solar energy sector is still situated at early stage GTZ, (2007) and dissemination and adoption of SHSs in the country is facing many challenges Abadi, (2016). The occurrence of these challenges can be understood as, during GTP-1 (2011), more than 3 million SHSs was planned to disseminate by the end of 2015(E.C) AfDB, OECD, UNDP (2016): however, the target has not been achieved even with efforts from the Rural Electrification Fund (REF), private solar companies, NGOs, and foreign aid

missions. Similarly, in the study area, i.e., Yem special district, in its respective office, during GTP I period it was planned to disseminate 3000 SHSs, and to set 40 biogas plants, especially to rural households, who are living far from the national electricity grid (district Sector GTP l, 2011). But only 388 rural households are adopted the systems during the specified period (The district sector GTP I performance report, 2016). The district's report also declares that household awareness limitation, accessibility of technology, utilization constraints were negatively affected the plan. Following the end of GTP I period, the district water, mine, and energy office also prepared GTP II plan for the period of 2016 – 2020. In this plan they have drawn goal to disseminate 6000 SHSs and 140 biogas for rural and off- grid areas. Unless, efforts in identifying the challenges that keep the rural households to not to adopt the renewable energy technology undertake, it will be difficult to make the planned tasks as effective as possible. Therefore, understanding those challenges which are facing the rural areas households' to utilize renewable energy technology is very necessarily to make the current and following plans effective.

For most of rural areas households in the study area kerosene lamps, dry cell batteries, and firewood remains the predominant fuel for lighting (The district livelihood report, 2016). According to (The district livelihood report, 2016), due to the rural Kebeles landscape, population spread and rural households' density cause grid extension in some regions to be inefficient and costly. Due to this fact in the area modern lighting sources like electricity are both unavailable and unaffordable for many in the near future; the use of firewood's, dry cell batteries, and kerosene lamps for lighting are likely to continue. This was because of different reasons either economic, geographic, education, political and awareness as well as lack of opportunity for technologies.

Statement of Problem

Ethiopia like many other developing African country in particular, still suffer from lack of reliable, effective electricity accesses in many part of the country. But the country is endowed with a variety of renewable energy resources including hydro, wind, geothermal, solar and bio-energy. The gross hydro-energy potential of the country is estimated at 650,000 GWH per year of which 25% (160,000 GWH per year) could be economically exploited for power. Woody biomass resources estimate for the standing stock and annual yield is about 1,149 million tons and 50 million tons respectively (Report et al., 2013). According authore above to secure the rural energy accesse is enhancing energy user of the communities by promoting renewable energy technologies like solar home system, and biogas and thereby decreasing dependence on fuel wood and reducing the importing kerosene. We Ethiopians have much potential for renewable energy source .Institutional, financial, and technological capability act as important factors for reaching desired level of renewable electricity production and utilization. But we lack of information and integrated research in this field. The main household energy source of rural population in Yem special district were kerosene and firewood and animal dug. Even if the people of Yem started to use renewable energy source, begin from 2011. But the technology it does not diffuse through the community. It is also possible that a village has had visits by politicians or government officials who have made unsuccessful promises to bring electricity to each village of the district. So this paper deeply will look at and evaluate the household effectiveness of alternative renewable energy source in Yem special district. The major people of Yem live in rural area, geographical scatter and greeter than 5km far from grid power accesses and geographically step-up and step-down land future settlement of

population. This implies, it needs huge budget to expand the grid power. There is high demand for power availability in the remote village in other cause GTP II plan is waiting for achievement. There for, this study will intended to evaluate the effectiveness to household utilization of solar system and biogas in Yem special district.

1.1 General objective of the study

To investigate the effectiveness and livelihood improvement of solar and biogas users in Yem special district of Southern Nation Nationalities People's Region state (SNNPRS), Ethiopia.

1.2 Specific objectives

- To assess the household level of awareness about renewable energy source (solar and biogas).
- To assess the determinant factors for rural household to use solar and biogas energy source in YEM special district.
- To evaluate the social and economic benefit of solar and biogas energy and life improvement of users.

1.3 Research question

- What are the level of awareness to renewable energy utilization?
- What are determinates factors to utilization of solar and biogas energy source in rural community of Yem?
- What are the social and economic benefit of solar and biogas energy and how the life of users changes?

1.4 Significances of the study

Begin from 2011 the rural community of Yem started to use household solar home system and biogas, this was due to promotion taken by expert from energy office, NGO like SLM, and several stockholder involvement in the promotion. Even the solar home system technology is promoted by several actors, it does not been diffuse throughout the rural community as we need and does not achieve the millennium development goal in 2015, if the process is ongoing this manner.

The research result will be used to dissemination of the solar home system, biogas setup and enhancing the community utilization new energy source and to achieve the millennium development goal of the energy sector plan. So the study result will be used by concerned government organizations, energy experts, local solar home system suppliers, and NGO and privet promoters to take measure for sustainable energy service. The result will be also used for effective planning and new technology transfer for rural community in Yem.

1.5 Scope and Limitation of the Study

1.5.1 Scope of the Study

Geographically, this study is limit to rural areas of Yem special district in SNNPRS of Ethiopia. Conceptually, this research is limits to effectiveness of renewable energy source (solar light & biogas) at the household level.

1.5.2 Limitation of the Study

During the field work a number of limitation occurred**.** These were non-availability of house hold respondent; one challenge tackled in the study area was farmers were not punctual at time. And time shortage is another limitation occur during field work.

2. REVIEW LITERATURE OF THE RESEARCH

2.1 Rural electrification

Widespread electrification of rural areas started during 1930s, mainly in the United States and the more economically advanced European countries (Freon, 2016).

According to this author united State Agency for International Development (USAID) designed a model of rural electrification in the early 1970s and the model was replicated in developing countries. Now-a-days rural electricity dissemination can be achieved by either centralized supply or decentralized approaches (Feron, 2016).

The centralized approach refers to connecting villages and remote areas to a national grid, which is often owned and operated by a public utility.

Rural electrification through centralized approach involves high capital cost. As a result, remote, less-densely populated areas remained far behind the access to regular and uninterrupted electricity. In contrast, decentralized approaches for rural electrification access to power is not provided by a national grid, but instead generated locally near the place of consumption. Decentralized power supply may be of two types: Mini-grids and Stand-alone systems. The most common energy sources for mini-grids are diesel generators, small-scale hydropower, small photovoltaic power stations, or diesel-wind hybrid systems FOLEY, (1990). Stand–alone systems generate electricity right next to the place of consumption, and are almost exclusively used for small-scale energy demand on household or small business centers. Most common technologies for rural electrification are diesel generators, solar photovoltaic (Solar Home System) and small wind generators. A study undertaken by the World Bank for 11 countries reveals that rural electrification results great benefits such as improvements of health facilities, better health from cleaner

environment as households reduce use of polluting fuels for cooking, lighting and heating, improved knowledge through increase access to television and better nutrition from improved knowledge and storage facilities from refrigerators(WB, 2008).

2.2 Rural electrification challenges

The international energy agency (IEA) predicts that in 2030, if no new policy to alleviate energy poverty is introduced, 1.3 billion people (some 16% of the total world population) will still be denied electricity most of whom in South Asia and Africa (Study *et al.*, 2010).

Rural electrification is defined here as the process by which access to electricity is provided to households or villages located in the isolated or remote areas of a country. Remote or rural regions lacking electricity supply are often characterized by well identified challenges.

Rural communities are also often highly dispersed with a low population density and characterized by a low level of education, low load density generally concentrated at evening peak hours, and low revenues. Adding to these challenges, the rural poor without access to electricity either spend relatively large amounts of their scarce financial resources on energy, or a disproportionate amount of time collecting firewood.

2.3 THE RURAL ENERGY ACCSSESS IN ETHIOPIA

Energy access is among the key elements for the economic and social developments of Ethiopia. Traditional and modern energy source are the major component of energy sector in Ethiopia. As more than 80% of the country's population is engaged in the small-scale agricultural sector and live in rural areas, traditional energy sources represent the principal sources of Energy in Ethiopia Renewable,et.al, (2012). Domestic energy requirements in rural and urban areas are mostly met from wood, animal dung and agricultural residues. At

the national level it is estimated that biomass fuels meet 88 % of total energy consumed in the country. In urban areas access to petroleum fuels and electricity has enabled a significant proportion of the population there to employ these for cooking and other domestic energy requirements.

Access to biomass fuels has declined significantly in all areas of the country and drastically in some parts. Reduced access to woody biomass has had serious developmental and social impacts. Less access to wood means more has to come from other sources of biomass to meet demand for fuel. This has eroded the balance between what goes in for agricultural production and animal manure for fertilizer, and what goes out of it, i.e. food for humans and animals.

According to the minister of water, Irrigation and energy (MoWIE) a survey by the Central Statistics Agency (CSA) in 2004 showed that about 71.1% of the total households use kerosene for lighting followed by firewood (15.7%) and electricity (12.9%). A higher proportion of urban residents use electricity (75.3%) for lighting, while the use of kerosene (80.1%) and firewood (18.5%) are predominant in rural areas NAMA, (2016).

Major types of cooking fuel used by all households are firewood, leaves, dung cakes and kerosene. The study by CSA at the country level, suggests that about 81.4% of the households use firewood, around 11.5 % cook with leaves and dung cakes and only 2.4 % use kerosene for cooking. The majority of rural households use firewood (84.4 %) and few of them (12.7 %) use leaves and dung cakes.

The use of modern source of cooking fuel such as butane gas, electricity and kerosene for cooking is uncommon in the rural areas (0.4 %). Use of kerosene is common in urban areas

and stands at 13.8 % following firewood (65.4 %). Charcoal (7.7 %), electricity (2.4 %) and leaves (5.3 %) are also used by urban households. On the other hand, only 0.2 % of the households in rural areas are observed to use charcoal for Cooking (Renewable, Program and Final, 2012)

2.4 Electrification Strategies and Programs in Ethiopia

According to minister of water and energy (MOWE), the Growth and Transformation Plan (GTP) of Ethiopia outlines the five-year strategic development plan for all sectors from 2011 to 2015 Solar, (2012).

The strategic directions for the energy sector during the five-year period are development of renewable energy, expansion of energy infrastructure, and creation of institutional capacity that can effectively and efficiently manage energy sector development.

The Ministry of Water and Energy through the REF has planned to electrify off-grid households and businesses through solar PV systems. The strategic plan for 2015 indicates dissemination of 150,000 Solar Home Systems, 3,000 institutional solar PV systems, 16 million improved stove and 300 solar pumps. The REF has also planned to disseminate 3 million solar lanterns in rural areas of the country. The required investment outlay to achieve the anticipated target is over US$50 million.

The Climate Resilient Green Economy (CRGE) strategy (2011) is recent strategy that has relevance to the energy sector Solar ,(2012).

The greenhouse mitigation actions proposed in this strategy are mostly energy related including the scaling up of energy efficient cook stoves, increased use of renewable energy sources, and displacement of fossil fuels. In this regard, wide scale dissemination of solar lanterns and solar PV systems in off-grid areas will displace kerosene use for lighting. To

meet the Growth and Transformation Plan (GTP) target and go beyond it in a sustainable manner, market channels for solar lanterns, solar PV systems and other appropriate renewable energy technologies must be developed. As it stands now, the market and the market channels are not well developed for these products, technical and financial capacities of the private sector are low, and the awareness levels of stakeholders and consumers is low.

2.5 Rural community energy accesses in Ethiopia

2.5.1 **Accesses to elec**tricity

Measured as the percent of people that have a household electricity connection. The electricity connection may vary by quantity (e.g., hours of availability in a day), quality (e.g., rated voltage and frequency), and use (e.g., light bulb to a wide range of end-uses) (Renewable, et al, 2012).

2.5.2 Accesses to modern fuel

Measured as the percent of people that use electricity, liquid fuels, or gaseous fuels as their primary fuel to satisfy their cooking needs. These fuels include liquid petroleum gas (LPG), natural gas, kerosene (including paraffin), ethanol, and biofuels, but exclude all traditional biomass (e.g., rye wood, charcoal, dung, and crop residues) .

Access to modern fuels is also needed for heating. In most cases, populations without access to modern fuels for cooking also rely on solid fuels for heating. However, available data refer mainly to fuels used for cooking.

2.6 Energy use and household incomes

Access to modern renewable form of energy in rural areas plays a crucial role in income generation activities Peck, (2009) and Bekele,et.al (2016)**.** Electricity will enable rural community to setup micro-enterprises, co-operative societies, small grocery shops, electrical appliances store. Rural electrification distribution and maintenance infrastructure will create secondary job opportunities for local community and create job opportunity for humans Punjab,et.al, (2016). Renewable electricity access will revitalize local small scale business by mechanizing the activities that increases productivity of different tasks and those households have accesses to RE source or electricity economically saved.

2.7 Energy and household healthy

Peoples in the globe are still consuming traditional biomass to fulfill their basic energy needs for example heating, cooking and lighting Asaduzzaman,(2013) and Peck, (2009). According to the argument all of these activities pose serious chronic effect on health. Women and children are very susceptible to these health hazards (Punjab,et al, 2016). Indoor air pollution caused in order to fulfill these basic needs led to various health problems mainly diseases as asthma, blindness, and heart diseases. This has resulted in low life expectancy of woman and pre-mature death of infant. Access to electricity enabled to store vaccination and medicine in refrigerator. This has a vital importance particularly in the areas where medical facilities are located far from the community and entail significant time to commute in case of emergency Peck, (2009).

2.8 Energy and household perception of environment

Rural community have low perception on environmental impact due to unclean energy use. Use of clean energy enabled to use energy efficient appliances. This has helped to keep

indoor environment clean and safe. Moreover use of RE sources will reduce the use of traditional fossil fuels avoiding deforestation. In this case agricultural biomass, cow dunk could be considered that would reduce deforestation. Natural resource depletion and climate change are other environmental benefits Punjab,et.al, (2016).

2.9 Energy use and household education

In rural areas school children do not get enough time to study. They often found busy in helping their parent with livelihood work. If they get some time after this back-breaking work they learn. Not having access to electricity in rural areas kept them away from study during night. Electricity will extend study hours after dusk when they return home from field. Mechanization of small household business will free these small children from strenuous work as a result of this available time they could use for study. Access to electricity will provide them chance to work with computer and other audio visual advanced educational materials Peck, (2009) and NAMA, (2016).

The role of electricity in sustainable development and to achieve MDGs has been realized worldwide and global efforts to provide electricity in rural areas have been increased. There are mainly two approaches for providing access to electricity in rural areas of developing countries Peck,(2009).

ONE: Developing centralized and large infrastructure mainly power plants based on fossil fuels, central grid i.e. transmission and distribution system, and other supporting infrastructure.

TWO: Developing decentralized system with large contribution of renewable sources. This goes well with local energy demand specifically energy need of the poor from

developing countries, which are mainly depend on biomass and other traditional sources to meet their energy demand.

2.10 Concept of Energy for lighting (Household Solar home system and biogas)

2.10.1 Solar-system

Solar home system (SHS) are small PV system that offer convenient of electricity for light. It is consist of small PV penal, charge controller, wire and connected switches. (Asia, 2015)

An important component of solar system are PV solar panel, which is convert sun light in to electricity. The battery store the energy for use at night or during the cloud weather.

The charge controller is the device that manage the electric flow through the system and protect battery from damage. Typically solar home system (SHS) operate at 12-volt direct current (DC) and use compact florescent lamp (CFLS) or light emitted diode (LED) and small appliance to make the best use of the provided power.

2.10.2 Concept of biogas system

Biogas is primarily a mixture of methane and carbon dioxide produced by the bacterial decomposition of organic materials in the absence of oxygen. Depending on the source of organic matter, biogas typically contains 50-70% methane, 30-40% carbon dioxide, and trace amounts of other constituents, such as hydrogen sulfide, hydrogen, nitrogen, Independence, (2014).

Today, methane accounts for nearly 9% of domestic greenhouse gas emissions. Thirty six percent of these emissions come from the agricultural sector, equivalent to over 200

million tons of carbon pollution. While methane's lifetime in the atmosphere is much shorter than carbon dioxide, it is more efficient at trapping radiation Independence, (2014).

2.11 Household lighting effectiveness of solar home system and biogas plant

The effectiveness of the solar system was depended on price of energy source, quality of energy source and availability of the technology in the community.

2.12 Occupation and renewable energy use

The dominant occupation of the villagers including consumers of renewable (solar home system, biogas) are farmers and livestock holders. Independence, (2014) and Feron,(2016)**.** There are limit number of renewable energy users likes solar and biogas, the occupations are teachers, policemen and business men.

2.13 Household Satisfaction with kerosene lighting

According to the Sub-city, (2013) the majority of household expressed a high degree of dissatisfaction with kerosene lighting service, this is because of the cost, quality of light, and convenience of lighting received from kerosene lamp.

In general it is disadvantage to the rural community lighting opportunity, due to smoke emitted irritate eyes, its lighting lamp is unsafe and kerosene lighting cause fire.

2.14 Household interest in purchasing renewable energy source (solar/biogas)

85% of the rural house hold community of the Ethiopian population are interest in buying solar lighting product and other renewable energy technology. The interest were for the service of lighting, cooking, Mobil charge, for better quality of light, for radio, for television and for other service Sub-city, (2013).

2.15 Affordability for the renewable energy source (solar and biogas)

Solar lantern are cheaper in the long term than kerosene and batteries. The accumulative saving would repay the initial cost long before the end of the systems useful life of 2to 3 years Sub-city, (2013).

According to Sub-city,(2013) argue that, the availability of credit for solar lantern will also make it possible for poor rural house hold to be able to afford them.

2.16 Consumer information about renewable energy source (solar and biogas)

The rural population generally awareness of the solar lighting product is limited. And can be further increased with the mass information campaigns through TV and radio. The demonstration and promotion be made by retailers and sector supported organization such as REF and SLM.

Consumes needs to be informed about the choices available to them, their cost, and what quality assurance and warranties they can be expected.

2.17 Substitution of kerosene

There are about 1.9 million SHS households in rural Bangladesh, the decrease in kerosene consumption amounts to over 40 million liters of kerosene saved annually due to SHS adoption (Asaduzzaman, 2013). The argument conclude that solar home system consumption does not substitute the biomass consumption. However it may be noted that ownership of the SHS replace conception of fossil fuel such as kerosene.

2.18 Effectiveness of biogas technology

Biogas is a good renewable energy source; it is also known as landfill gas and is produced by wet organic waste decomposing under anaerobic conditions in a landfill (Aladeitan, 2011).

2.18.1 Benefit of biogas

Biogas provides poor rural women and men in developing countries like Ethiopia and African country with clean and renewable energy all year round (Aladeitan, 2011).

According to argument electricity generated by biogas lights the lamps that allow children to study in the evening. It frees women from the time-consuming chore of collecting firewood and enables them to undertake value-added activities.

According to author above biogas technology is beneficial to reduction of unsustainable fire wood, save cattle dug, kerosene, and chemical fertilizer utilization. And biogas fuel in rural kitchens are now free of smoke and ash, for a healthier household environment. According to the arguments fertilizer, the organic residue that is an end-product of the biogas process increases the productivity of agricultural products.

2.18.2 Socio-economic characteristics of biogas

They are dependent (explanatory) and independent variables that explain information about the household. They include only variable of the respondent (household head) gender, age, marital status, literacy level, and family size.

2.19 Household expenditure for cooking and lighting service

Kerosene spend the large portion of the monthly expenditure for lighting and fire wood accounts for cooking Rom *et al.,* (2017). Energy expenditures unrelated to light use include

expenditure on mobile phone charging, charcoal, batteries not used for lighting, and electricity bills.

2.20 Kitchen lighting and cooking

It is expected that users of SHS, especially those households that have connection in kitchen, enjoy better indoor environment and are protected from indoor air pollution, which is one of the main reasons for women's suffering from diseases such as asthma, cancer, pregnancy related problems, still births, etc. Report *et al.*,(2013).

The argument conclude that interest, among users the rate of SHS connection to the kitchen is higher for female headed households than that for male headed households. It depicts the differential preferences of usage by different sexes. Although all the household members are the users of the SHS, however, when the decision for preferences for differential usage is made by different sexes, the distribution for connection for different usage differ Feron, (2016).

2.21 Conceptual framework

In order to show the effectiveness of utilization of solar and biogas in different dimension, some variables are identified and selected taking in to consideration of social, economic and technological dimension for rural sustainable household lighting source. To have common framework that provides basic understanding of the household solar and biogas electrification and its final result of conceptual framework is designed in the 2.1.

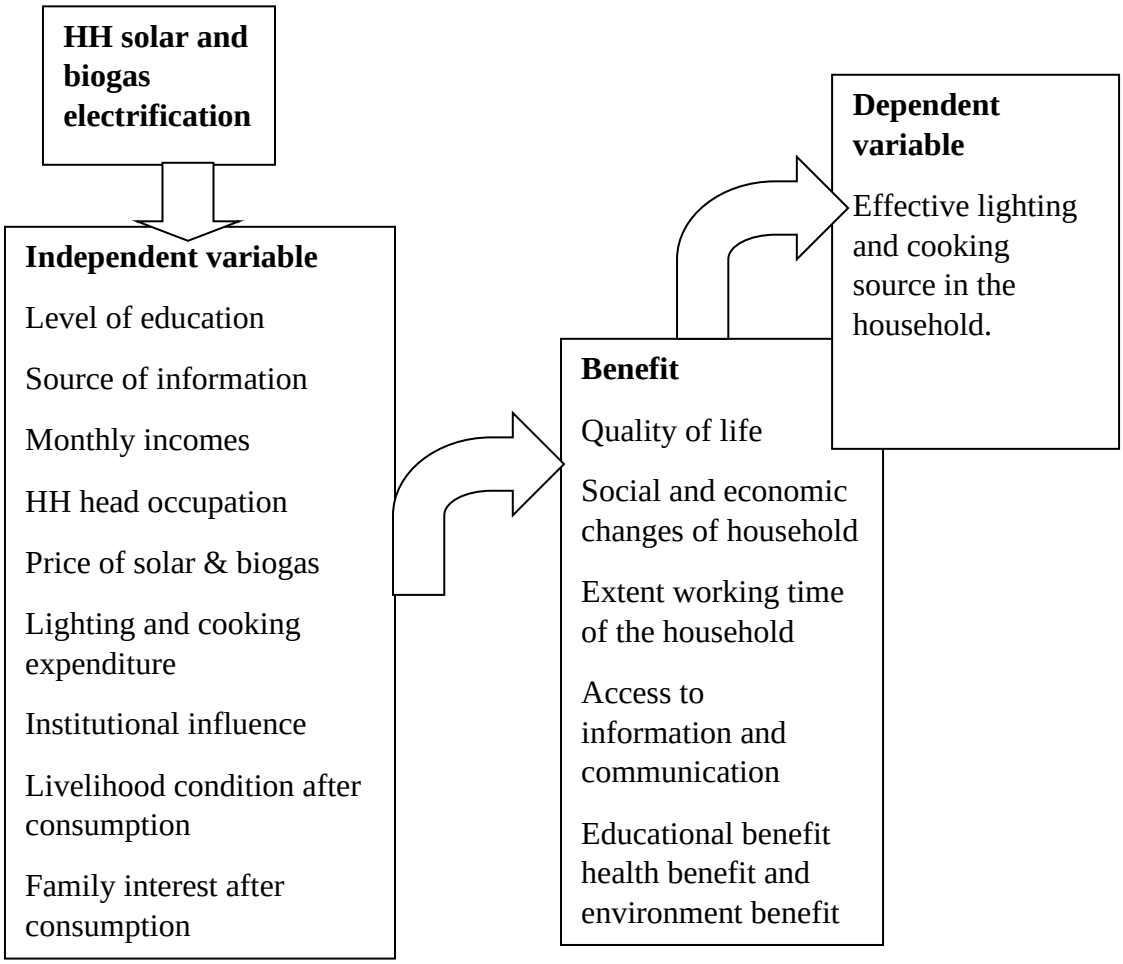


Figure 1: Conceptual framework

So this conceptual framework is connected as electrifying rural household by solar and biogas in the presence of independent variable influence, they get social and economic benefits and finally households have effective lighting source.

3. : MATERIALS AND METHODES

3.1 Description of the study area and research methodology

3.1.1 Description of study area

The study was conducted in Yem special district which is located in SNNPRS region state of Ethiopia.

3.1.2 Location:-

Yem special district is located (7037'N to 8001'N and 37022'E to 37038'E) in the north western apex of the Southern Nations Nationalities and People's Region (SNNPR), Southern Ethiopia. It occupies a surface area of 724.5 km^2 (SNNPR IEP, 2010). Yem is bordered by Oromia region in the north and west, Gurage zone in the north-east and Hadya Zone in the east. The Gibe River forms the eastern boundary. The principal town of the district is Saja, situated some 242 km southwest of Addis Ababa, on the Addis Ababa Jima tarmac highway.

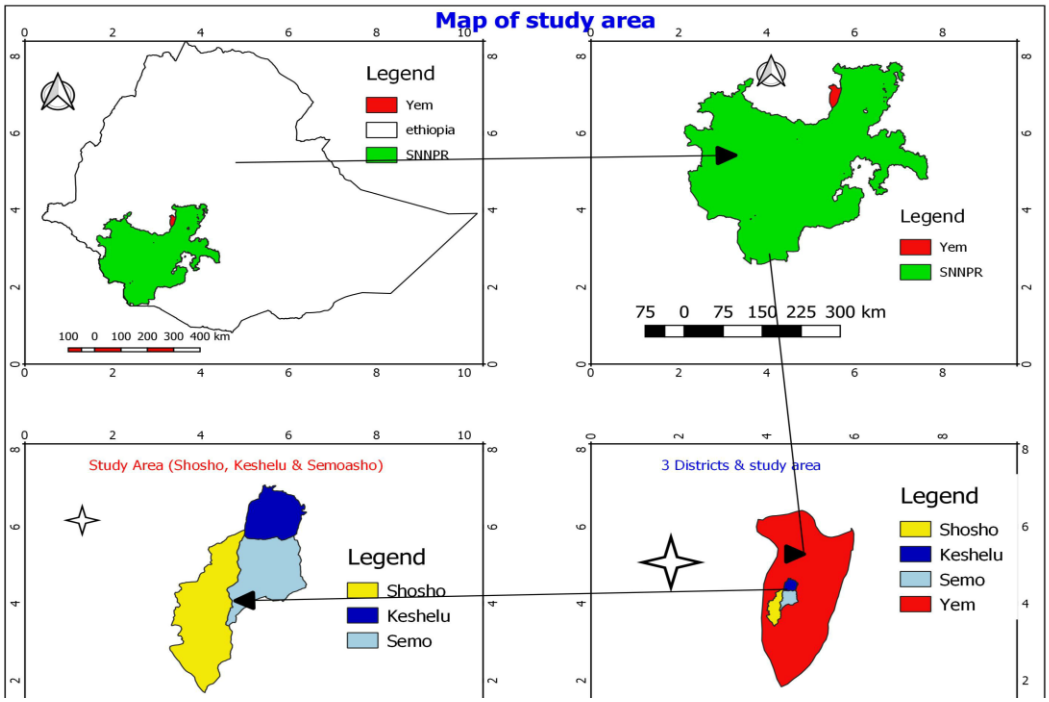


Figure 2: Map of the study area

3.1.3 Topography of the district

The district had three agro climatic zones; namely, Dega (highlands) (18.38%), Weynadega (midlands) (57.65%) and Kola (lowlands) (23.97%) (ERTTP, 2003). Elevations ranging from 907-2890 meters above sea level. It receives a rainfall in the range of 900-2200 mm with a bimodal pattern from mid of February to May and June to September. The mean annual temperature was in the range of 12-30^{0}C (SNNPRs, IEP, 2010).

3.1.4 Demographic characters

According to population and housing census of 2007 the total population of the district was 80,657 and in 2017 the total population of the district was projected to be 102,436 out

of this 50,911 are males and 51,525 are females YWFED,(2017), with a population density of 111.3 persons per km^2 FDRE PCC, (2008).

3.1.5 Economic characteristics

Mixed farming system was the main livelihood pattern. The main crops produced in the area are Enset and cereals (bread wheat, food barley, Teff and Maize) and pulses (Fababeans and filed Peas). Households obtain most of their cash income from crop, livestock and livestock product sales rlp, (2005), the large proportion of the district's land area is highly rugged and too steep. The steepness of the topography makes the farming system difficult, although people in the area are settled and mainly depend on cereal crop farming and Enset cultivation. Yem is a cereal and Enset livelihood zone, Enset is the main staple, but the full set of annual field crops is cultivated: wheat, barley, Teff, maize, and pulses (filed Peas, Fababean) us Aid, (2005)

3.1.6 Electricity supply situation of Yem

Regarding to electrification only the district main town, 3 municipal administrative town, and additional 14 Kebele had electrified before and after 2015. Beside that due to the topographic settlement of population in the district all house hold bounded under 14 Kebeles were not supplied except nearby Kebele office. The district has total 4 municipal town and 33 rural Kebele, still 19 rural Kebeles have no access to electric and commonly 80% of the house hold use kerosene lamp and firewood for lighting and firewood, agricultural residuals, dug coke for cooking service (YEM WIE OFFICES REPORT, 2017)

3.2 Research methodology

3.2.1 Research design:

Descriptive survey research design was adopted. Descriptive design helped to describe record, analyze and report condition that exist

3.2.2 Research approaches

The research study used both qualitative and quantitative approaches. The data was collected to study the effectiveness of solar and biogas utilization in Yem special district. Therefore the researcher was be able to use these mixed method to conceder analyze and gather more data from the community. The weakness of qualitative approach was solved by quantitative approaches

3.2.3 Site selection

The study was employed in Yem special district which is located in South Nation National and People Region state (SNNPRs) Ethiopia.

The district was purposely selected to investigate the household effectiveness of solar and biogas energy utilization and to find better way to electrifying the people at home land by using descriptive survey design method. This is because due to large number of people live in remote area of the district and several peoples had no access to grid electricity and people settlement in the district is scatter form rather than condense and suitable for grid electrifying way.

3.2.4 Sampling techniques

Three Kebeles (Shosho, Keshly and Semoawasho) were selected purposively because these Kebele were beneficiary of the solar home system technology in 2015 by rural electric found (REF) program through the help of government and biogas by national biogas program(YEM WIE ANNUAL REPORT, 2015). So the researcher selection of the Kebele was based on former beneficiary of technology and the land feature of Kebele or population settlement are not suitable for grid power expansion. The sampled households were selected purposively due to the small number of biogas adopter and solar users were selected randomly from three Kebeles. The argument like more a homogeneous population, the smaller the sample size is found to be representative Israel, (2012).

3.2.5 Sampling size

The appropriate sample population size would be determined by using a simplified formula provided by Yamane (196) to determine the required sample size at 95% confidence level, degree of variability=5% and/or level of precision=6%, $n = \frac{N}{1+N(e)2}$

Table 1 Determinats

Name of Kebele	No of house hold	Sampling (n)	Total no of population
Shosho	1091	100	5455
lower Kesheley	850	79	4250
Semoawasho	788	73	3940
Total (N)=	2729	232	13645

Total house hold is= 2729.

N=2729, confidence interval (e) = 6% whereas n=232

Where n is the sample size, N is the population size (total number of households in the three Kebeles), and e is the level of precision. .

All 22 beneficiary of biogas under the three Kebele were taken as sample, as their number was small. And remaining 230 sampled households were beneficiary of either solar and kerosene or firewood and they were selected randomly. For this purpose list of all beneficiary of biogas, and households in each sample Kebele would been taken from the respective Kebele administration offices.

3.3 Data source

Qualitative and quantitative data were gathered from both primary and secondary data sources. The primary data was collected from individual household, the key informants, and focus group discussion. To support the primary data the secondary data were collected from water and energy office solar dissemination report and biogas set up, published and unpublished document, books, and journals.

3.4 Data collection methods

Qualitative techniques was used mainly to assess how renewable energy use change the life style of house hold, and to assess the effectiveness of these energy source. This include structural and semi structural house hold survey, checklist for key informative interview and focus group discussions

3.4.1 Household Survey

From 252 sampled households 93.25% of the households were investigated in survey. Whereas 6.75% of the households were not returned the paper.

The researcher gather detail information from sample house hold through survey. Structural and semi-structural interview schedule and questioner was prepared in English language and translated in to Amharic language to collect information or data related to research issue such as respondent characteristic and relation to familiarity in using solar and biogas. For the household survey the researcher would selected six data collectors (two for each Kebele) and they were trained about the data collection for two hours using the interview of household survey by the researcher. The questionnaire would pre-tested on non-sample households to check its appropriateness for gathering all the required information

3.4.2 Key informants interview

For semi- structural interview, the KIs were selected by using snowball method. Two individuals were asked randomly to give name of two individuals, who are knowledgeable and they are living in the area for long time and user of solar and biogas. Out of four person identified at each Kebele, the frequently appeared two person were selected for KIs

in each Kebele. In this way total 6 household heads and 2 experts from water and energy office, totally 8 KIs were selected.

The researcher prepared semi structured questionnaires to capture detail information from key Informant interview. This interview the semi-structured questions were; awareness, utilization barriers, and benefit of utilization of solar and biogas.

3.4.3 Group discussions

With regard to FGDs, the participants for the discussion were drawn from different social groups following purposive sampling method. This is in line with Nnamdi, (2014) that studied the adoption of SHSs among Industries and Residential houses in Southern Nigeria, also used purposive sampling to select the focus group discussion participants. Therefore, from three Kebele total of 10 individuals, 4 solar users, 2 biogas users, 3 kerosene and firewood users and 1 solar seller were involved in the discussion.

The discussion ‘is about renewable energy utilization barriers, and benefit of solar, biogas to household as social, economic, educational and health value. The main purpose of these focus group discussions is to generate in-depth information on some of the survey findings and other issues that may not have been adequately captured by the structured questionnaire in survey. Each group discuses separately in order to minimize fear and to make them feel free to express their true feelings. During the discussions other follow-up questions are pose in order to make the responses as clear as possible.

3.5 Data collection procedure

The data were collected from three Kebele to conduct the study, six data collectors were involve in the data collection processes. They are fluent in Amharic and Yem language, for each Kebele two data collectors would select.

For collecting true data from the respondent the data collectors takes two hours training about the question, how, when, ,and to whom the question is distribute. The data collection would take four weeks, each data collectors would spent full weekends days in their Kebele and researcher supervise them. The semi-structural interview and the focus group discussion with key informative were held by researcher with in four weeks side to side questioner. The Kebele administrative agent persuade the respondent, support data collectors and enumerated true data.

3.6 Method of data analysis

The descriptive statics like frequency, percentage and crosstabs by using the SPSS software version 20 and micro excel were adopted during the analysis of data.

3.7 Data Presentation

Finally tables and figures such as histograms and pie-chart will be used to present data for different studies variables. Concluding remarks, recommendations and discussions are basically based on computed frequencies, and percentages will analysis

4. RESULT AND DISCUSSION

4.1 Socio-economic characteristic of the households head

To evaluate the effectiveness of solar and biogas utilization in Yem special district, about 252(100%) households were taken from three purposively selected rural Kebele. From this total 235(93.25%) household respondent were returned. But the data collected from three Kebele respondents were incomplete. As the result 172(74.1%) males and 60(25.9 %) female and total 232(92.06%) respondents' data were taken for statically analysis purposes.

4.2 Background information about the respondent

The household head were asked to indicate their back ground information like gender, age, marital state and literacy level.

Table 2 Gender of the respondent

Sex	Frequency	Percent
Male	172	74.1
Female	60	25.9

Source: household survey (n=232)

4.2.1 Sex

As shown table 2 above, 172 males and 60 female and total 232 respondents' data were taken for statically analysis purpose. This implies that the large number of the respondent were male than females. This might be so because most homes are dominated by males as household heads. This however will not affect the responses from the respondents thereby creating any form of biasness.

4.2.2 Age of the respondents

From the table below 79.4% of the population were aged between 18-40 This shows that the largest population of the respondents age were blow 40 years this implies, they are young and middle of age enough as a result they were able to understand the current issues related to renewable energy source(solar and biogas) utilizations. And also from total 198 solar and biogas users 156 of them were aged blow 40 years. This implies that as the age of the household heads increases, the households' transition towards the use of modern energy source become decreases. It is means that as the age of the household heads increases, the households' to stack on using the energy source they are used to practice. In other way those young household were more adopters of the technology.

Table 3 Age of respondent

Age	Frequency	Percent
18-30	48	20.7
30-35	92	39.7
35-40	44	19
40-50	38	16.4
Above 50	10	4.3

Source: household survey (n=232)

4.2.3 Marital status of the household respondents

From total respondents 71.6% of the respondents were married, 19% of the respondents were single, the remaining respondents were divorce and widowed respectively. This show that more population of the respondents were married means they are stable and have positive responsibility of their family and again they can participate different community

activity's likes community discussions, community works and trainings. Through different community participation the household heads shear ideas and skills related better way of living. And from total 198 solar and biogas users 163 were married. These shows that those married household head were more adopter of the technology.

Table 4 Marital status

Marital status	Frequency	Percent
Married	166	71.6
Single	44	19
Divorced	18	7.8
Widowed	4	1.7

Source: household survey (n=232)

4.2.4 Household head literacy level.

From the sampled population 71.6% of the household head respondents were educated primary, secondary and college or university respectively. And the remains 28.4% of the respondents were illiterate. Since in the study area solar was the dominant energy source for lighting, this means greater than 85.4% household were user of solar and biogas. Compared with 71.6% of literate households 79.1% of the population had solar and biogas in their home and also there were 6.3% household head use solar from 28% of illiterate household in the study area. These shows that educated household heads were more quickly adopt the technology. Means literate household head, unlike the illiterate household head, can understand everything that are transmitted through Medias, formal and informal meetings, government agents, can read brochures and leaflets about the new technologies, and so on. Beside that those educated household heads had knowledge about

how to operating appliance of solar and biogas as well as they maintains simple faller of technology and also they can understand environmental impacts. The KIs said that there were ill iterated household in the area that use solar light, and gain usage experience ability from neighbor household users.

Table 5 Literacy level

Literacy level	Frequency	Percent
Primary	98	42.2
Secondary	52	22.4
College or university	16	6.9
Illiterate	66	28.4

Source: household survey (n=232)

4.3 Household head level of the awareness to utilization of renewal energy source (solar, biogas)

4.3.1 Household head energy source for lighting

Solar, kerosene, firewood, and biogas were the main energy source for lighting in the district. Large number of the respondent's data of the table show that 75.9% of the respondent were solar users, and remaining 11.2%, 9.5%, and 3.4% respondents were kerosene, biogas, and firewood users respectively. This show that solar was the dominant source of energy for lighting in the district. More respondents in the area were interest in solar technology. This is because solar light is more illuminate, and it is simple for operation. This finding is opposite where compared to empirical study taken by

Renewable,et al, (2012) concluded that; higher proportion of rural community use kerosene (80.1%) and firewood (18.5%) are predominant in rural areas.

This showed that using kerosene in rural area is declining. It might be due to people awareness is increasing in using advanced technology.

Table 6 HH lighting and cooking source

Lighting source	Frequency	Percent	Cooking source	Frequency	Percent
Kerosene	26	11.2	Kerosene	34	14.7
Firewood	8	3.4	Firewood & animal dug	175	75.4
Solar	176	75.9	Biogas	22	9.5
Biogas	22	9.5	Other source	1	0.4

Source: household survey (n=232)

4.3.2 Household head cooking source of the district

As table 6 showed above that firewood and animal dug, kerosene, biogas, and few number of other source were the main source of energy for cooking purpose. The 75.5% respondents were user of firewood and animal dug for cooking purpose. Other 14.7%, 9.5%, and 0.4% respondents were user of kerosene, biogas, and other source for cooking purpose, respectively. This showed the higher number of respondents were still uses of firewood and animal dug for cooking in unsafe way in the research investigation area. The

present report was line with the report during the group discussion which is, “Disease like blindness, heart disease like hypertension were commonly affect rural mothers, due to unsafe kitchen energy use”.

4.3.3 Household head occupation

In the research area total of 71.6% of the respondent were farming for production of different cereal crop and animal products, 10.3%of the respondents were labour workers, 6% of the respondent were occupies on small business activities and the reaming 12.1% of the respondents were skill worker like masonry in house contraction. This show that large population of the community in the study area were occupied by farming, like that of the empirical study investigated by Independence, (2014) and Feron,(2016) , most solar and biogas holder households in rural area are famers.

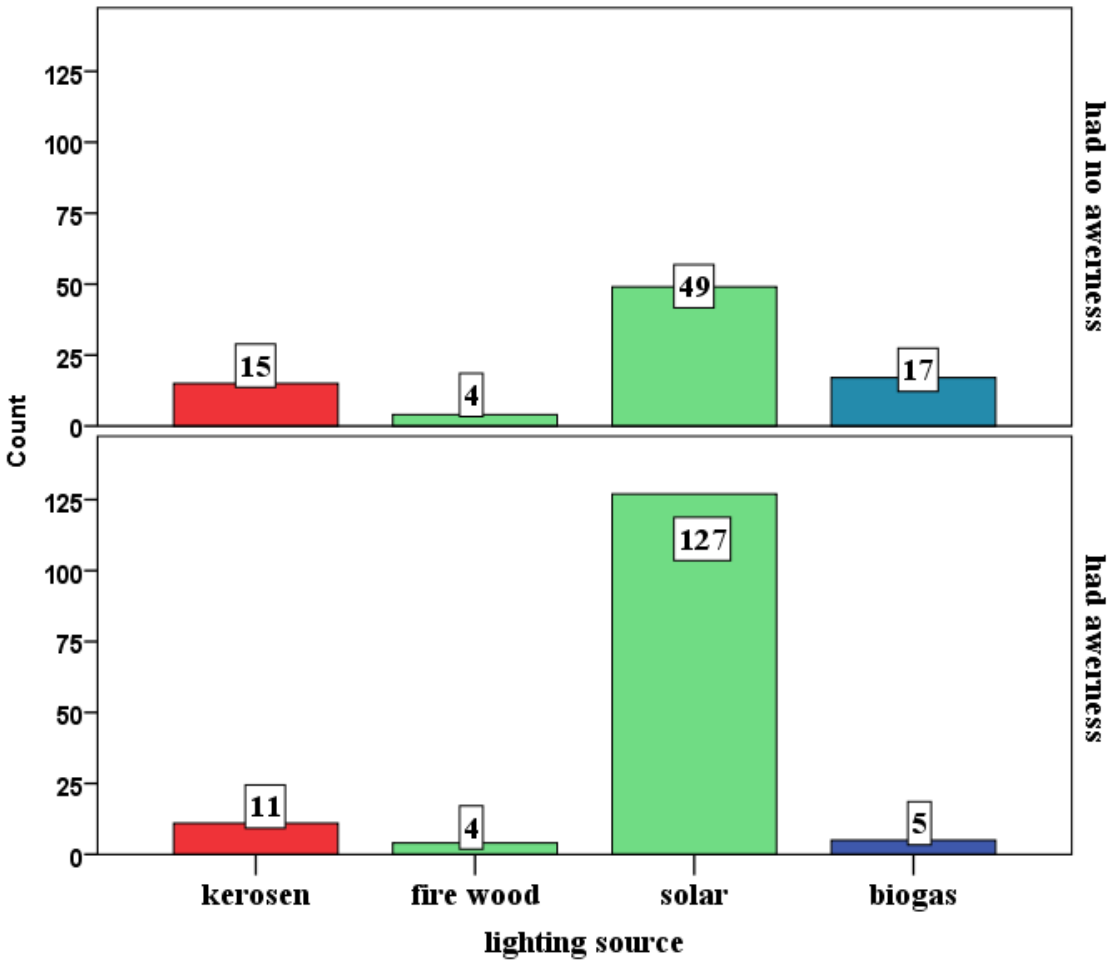
Table 7 Household head occupation

Occupation	Frequency	Percent
Farming	166	71.6
Labour	24	10.3
Business employer	14	6
Skill worker	28	12.1

Source: household survey (n=232)

4.3.4 Household head awareness about renewable energy utilization.

In the figure 3 below total 176 solar users' households 127 of the households had awareness about renewal energy source as well as have aware about adverse effect of kerosene and firewood, and 49 of them were solar users but have no awareness. Also regarding to biogas users 5 households had awareness about utilization of biogas and remaining 17 households had no awareness. Statically showed this to be statically significant with the P- value of =0.000 at 0.05 significant value. There for it can be concluded that there is significant positive relation between awareness and energy chooses for lighting in the remote area. This implies that those households who have more awareness in the district were users of renewable energy source. There for the result is congruent with the research reported by Sub-city, (2013).



Household survuy(n=232)

Figure 3 Relation between awareness and household energy choose

4.3.5 Source of household head awareness for renewable energy source

As it can be seen from the table below 19.8% of the respondents were got information or awareness from formal and informal trains, 29.7 of the respondents were gained awareness from market centers. The 25.4% of the respondents were gained awareness from community discussion and participation, while the 21.6% of the respondents were got the information from governmental and nongovernmental agents or institutions and the lastly 3.4% of the respondents were got from other source. This shows participating different

community activities and market centers were the main source of information in the rural community.

Similar in FGD; those household members didn't participate discussion had no information about solar and biogas this implies that, participation on different community activities and market centers take large portion to create household awareness about renewable energy source and utilization. This shows that gaining awareness renewable energy source does not limited to formal education. It is possible to share experience from different source such as community participation and market centers.

Table 8 Source of awareness

Source of awareness	Frequency	Percent
Formal and informal training	46	19.8
Market center	69	29.7
Community discussion	59	25.4
GOVE and non-GOVE agent	50	21.6
Other source	8	3.4

Source: household survey (n=232)

4.3.6 Solar and biogas utilization and institutional influence

This descriptive analysis results were based on the data collected from the key informants and focused group discussion (FGD). The KIs responded that the nearby government institutions, through energy experts, schools, health extension workers, and others such as

agriculture development agents affect the supply of the systems and the rural household's renewable energy utilization by providing different services such as awareness creation, training to both the users and solar sellers as well as biogas masonry, quality control, price regulation, and material and technical supports. The institutions mainly the district water, mine, and energy office, through energy experts, created market chain between local solar vendors and whole sellers in order to supply standard solar system materials to the rural end users. According to FGD participants, institutions can influence rural households' SHSs purchasing possibilities when privet SHS selling shops were decentralized at a village level.

The institutions has reduced the cost of transportation and the probability of the early dysfunction of materials through the guarantee given from the vendor to the potential user or buyers and this condition, in part, increased the interest of households to purchase SHSs.

Similarly 90% of household respondent were in agreement (Table 9) with the governmental institution (through kebele administrative agents, district office energy experts, healthy extension experts can influence positively on purchasing solar/biogas and they providing service like awareness creation, price regulation, and quality control by governmental organization have positive effect on utilization of renewable energy source (solar/biogas).

From findings one can understand that provision of services supports were found to be important institutional factors that can affect the rural household' solar and biogas utilization.

Table 9 Institutional influence on solar &biogas users. (ST.A=strongly agree, A=agree, ST.DA= strongly dis agree, DA= dis agree)

Items		ST A	A	DA	ST DA	Total
governmental institution (through KEBELE administrative agents, district office, healthy extension experts can influence positively on purchasing solar/biogas	Frequency	118	91	21	2	232
	Percent	50.9	39.2	9.1	0.9	100
providing service like awareness creation, price regulation, and quality control by governmental organization have positive effect on utilization RES	Frequency	136	70	18	8	232
	Percent	58.6	30.2	7.8	3.4	100

Source: household survey (n=232)

4.4 Determinates of the renewable energy utilization (solar and biogas)

4.4.1 Price of renewable energy source (solar, biogas)

39.7% of the respondents were indicate the technology was faire and it has the power to change our energy problems, 49.1% of the household head respondents were said the price

of the technology were expensive; example the initial cost to installing biogas was unfair and this was the main determinate factors that reduce mass utilization of renewable energy source. Eleven point two of the respondent were said the technology was cheap and it is possible to the price and adopt the technology. From this one can concluded that it is possible to reduce the price challenges of RE source. Might be by increasing the technology accesses. And providing credit for households have no able to perches on cash

Table 10 Price of renewable energy source

Price of renewable technology	Frequency	Percent
Faire	92	39.7
Expensive	114	49.7
Cheap	26	11.2

Source: household survey (n=232)

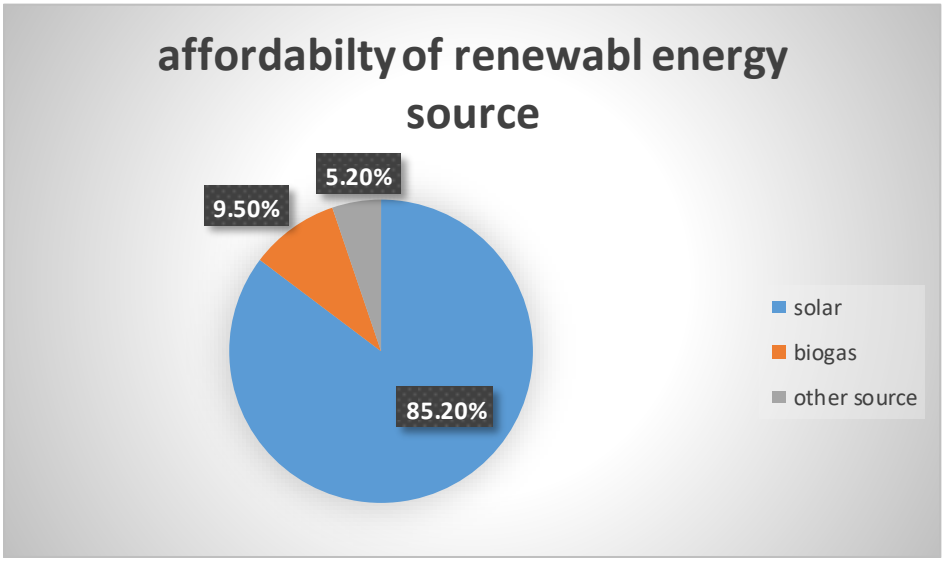
4.4.2 More affordable and renewable energy source in the study area

Only 9.5% of the respondents said biogas is affordable technology in the community, and it is used in addition to lighting and cooking, it is best for sanitation and kitchen quality but high population of the respondent were no share the idea. This is/was because they said very high initial cost, power is not sufficient, and applicability is limited to lighting and cooking rather than radio and tap recording, mobile charging and watching TV.

Solar: solar is the popular affordable energy source in the research area in the graph below 85.2% of the household head respondents were indicate that, the technology affordable and

interested. Beside that households used solar electricity mostly for lighting, mobile charging and for tape recorders. Again during the focused group discussion (FGD); participants said that, to buy solar, no one need wealth in economy.

Others source: There were 5.2 % of the respondent are affordable energy source in our community. Such energy source are kerosene, cell battery. From the result we can understand that; solar is more affordable energy source in the research study area.



Source: household survey (n=232)

Figure 4: **Affordability of energy source in study areas**

4.4.3 Renewable energy (solar and biogas) utilization constraints.

As table 11 shown below shortage of awareness, maintenance problem and unappropriated usage are most tackling utilization problems of the renewable energy source. This means from the table 72(31%) of the household head respondent were point out that shortage of awareness is the main constraint of their technology utilization. The remaining 25.4%, 29.7%, and 13.8% of the household head responded that maintenance, inappropriate usage, and quality of the energy source respectively were another constraints of the renewable

energy utilization. This implies that the rural community or users of the district needed awareness supports.

Table 11**:** Energy utilization constraints

Solar and biogas utilization constraints	Frequency	Percent
Shortage of awareness	72	31
Maintenance problem	59	25.4
Inappropriate usage	69	29.7
Quality of energy source	32	13.8

Source: household survey (n=232)

4.5 Benefit of renewable energy (solar and biogas) utilization

4.5.1 Lighting source and expenditure before install solar/biogas

Before installing solar/biogas, kerosene was the most prevalent source of the lighting in the survey area though dry cell and candle were also used in few causes. Table below showed the result of the energy source for lighting and expenditure before solar/ biogas installing in their home. Greater than sixth eight percent of the population were purchase kerosene for consuming, 16.4% of the population were purchase dry cell and others 11.6%, and 3.4% were purchaser of candle and other energy source respectively. Normally kerosene, dry cell and candles were purchase from local market in the community.

Table 12 Lighting source expenditure

Lighting source expenditure	Frequency	Percent
Kerosene purchaser	159	68.5
Dry cell battery purchaser	38	16.4
Candle purchaser	27	11.6
Other	8	3.4

Source: household survey (n=232)

4.5.2 Household head monthly expenditure for lighting and cooking before and after utilization of solar and biogas

From the sampled population 48.7% of the household head were got 200-500 birr expenditure for lighting and cooking service, mostly for kerosene. Greater than thirty three percent of the respondents had expenditure above 500 birr for lighting and cooking purpose. And there were 17.7% respondents had been their monthly expenditures below 200 birr. This implies that above 48.7% of the households in the survey area were purchase kerosene, dry cell, candles for lighting and either collect or buy firewood and animal dug for cooking purpose and they have average monthly expenditures between 300-500 Ethiopia birr. After getting solar/biogas for their home lighting, greater than 62.9% of the households their expenditure for kerosene and other local energy source could reduce and finally household income saving increased. This finding is line with the empirical study by (Rom *et al.*, 2017) found that; Kerosene spend the large portion of the monthly expenditure for lighting and fire wood accounts for cooking.

Table 13 Monthly expenditure for lighting and cooking before and after RE used.

Monthly expenditure for lighting and cooking before install sol/bio	Frequency	Percent	M/expenditure after installing solar/bio	frequency	Percent
Below 200	41	17.7	Below 200	146	62.9
Between 200-500	113	48.7	b/n 200-500	17	7.8
Above 500	78	33.6	Above 500	68	29.3

Source: household survey (n=232)

4.5.3 Household solar/biogas electricity consumption

The researcher found in the study area almost 75.9% of the household head use solar tube light for illumination of their house and only 9.5% of the household head use bio gas for lighting and cooking in their house. Peoples in the area were consumed solar electricity for light and mobile charging largely. Beside that there were people that consumed solar electricity for listing radio and tape recorder and watching TV. And biogas light for cooking lighting. This implies that more population in the study area use solar electricity for quality lighting, mobile charging, and for access of information and communication. They use radio, tape recording for and TV watching purpose and few household use biogas for lighting and cooking purpose.

4.5.4 Incomes generating activity by their energy choose

Respondents are asked to mention weather there is/was any incomes generating activity in their house. Only 65.5% of the respondents were respond positively, the reaming 34.5% of

the respondents had no run any income activist. In this study, observable income generating activist under solar/biogas electricity are small business like café and grocery lighting activity, mobile charging, few machinery work like cutting hear and access to information and entertainments by the solar electricity. But in the study biogas technology does not run business activity this is because biogas needs additional technology to run business activity. In general 2.2 % of the respondent were run café and grocery work by the solar light, 38.4% of the respondent run mobile charging activist and they charge one mobile for two Ethiopian birr and they got addition incomes 100-200birr. Only one household heads had shop of cutting hear by solar machine. This work is similar with the empirical work of Peck, (2009) and Bekele,et.al,(2016)

Table 14 Income generating activity

Income generating activity	Frequency	Percent
Café & grocery lighting	5	2.2
Mobile charging	89	38.4
Machinery	1	0.4
Access to information and entertainments	57	24.6
Non	80	34.5

Source: household survey (n=232)

4.6 Household head monthly saved money before solar/biogas.

The household head were asked to indicate monthly saved money before install solar/biogas; 49.1% of the respondents were indicates that their monthly money were blow 200 birr, 25% of the respondents were their monthly money were fall between 200-1000birr. This show that majority of the household head respondents were their monthly

saved money below 200 Ethiopian birr. This shows most of the household in the area spent their money, might be by purchasing kerosene and other local energy source and it was difficult to saved money greater than 200.

Table 15 : Household monthly saved money before and after installation of solar and biogas**.**

Monthly saved money before install solar/bio	Frequency	Percent	Monthly saved money after install solar/bio	Frequency	Percent
Below 200	144	49.1	Below 200	40	17.2
200-1000	58	25	200-1000	67	28.9
1000-15000	42	18.1	1000-1500	46	19.8
1500-2000	10	4.4	1500-2000	36	15.5
2000-3000	6	2.6	2000-3000	22	9.5
Above 3000	2	0.9	Above 3000	21	9.1

4.7 Household head saved money after consumption

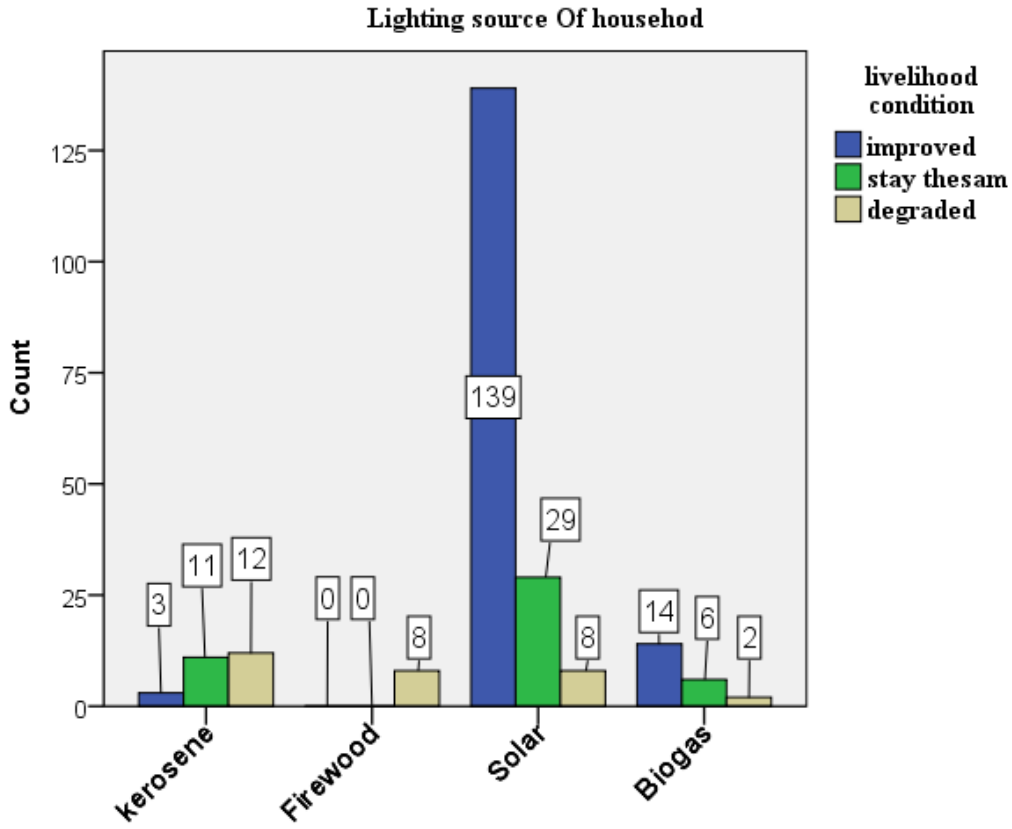
The household head were asked to indicate the change of the monthly saved money in term of the economic asset after utilization of the solar and biogas. 17.2% of the population from the respondents were indicate that their money had no shown any changes in their economy. The remaining 28.9%, 19.8%, 15.5%, 9.5%, 9.1% of the respondents money saving were change from 200-1000, 1000-1500, 1500-2000, 2000-3000, and above 3000

Ethiopian birr. This implies that large number of the household head respondent's money saving were increased directly in b/n 200 and 3000 Ethiopian birr. And utilization of solar and biogas provided a good environments for woman's involved in income generating activity. Woman in rural area do stitching and embroidery work for their Owen and for income generating activity as well. This finding is similar with the pervious empirical work of (Punjab, et.al, 2016) they found that; Renewable electricity access will revitalize local small scale business by mechanizing the activities that increases productivity of different tasks and those households have accesses to RE source or electricity economically saved.

4.8 Livelihood condition after consumption

In the figure below shows that; 139 and 14 solar and biogas user's households' livelihood condition after utilization had economically improved. And they said there were valuable economic changes. The 29 and 6 of the solar and biogas user respondent were responded that their livelihood condition after utilization of the renewable energy stay the same respectively and the 8 and 2 of the household head livelihood condition were degraded. These shows that; solar and biogas user's livelihood were improved in the area. As compare to kerosene and firewood consumers more people in the study area have interest in utilizing renewable source like solar and biogas and increased their living conditions economically and socially. In addition to that, the chi-square of statics showed this to be statically significant with P-value of =0.000 at 0.05 significant value. There for it can be concluded that be there is positive relation between lighting source and household livelihood condition. Their incomes were observably improved, there is in increment of house safety and they improve health care. FGD participants also Saied that; in their Kebele children used to study up to primary level only before install solar light in their

home. But after getting solar and biogas light some of the children were studded even up to college. This show that student drop out rat from the school is decrease.



Source: household survey (n=232)

Figure 5: Livelihood condition after consumption

4.8.1 A kind of changes due to utilization of renewable energy technology

Children study more in the evening and increase safety are perceived the most important changes by the solar and biogas adopted households. Household lighting from biogas or solar increased facility of household works in the evening mostly for the woman's and access to information and communication are also observable change has been expressed

by participants in the focus group discussion of the households. This show that as clear household lighting increased children reading more and increase workable time of the woman in the evening. Also an important point raised in FGD were utilization of biogas provided household hygiene, celery from biogas increase land fertility.

4.8.2 Family satisfaction after consumption solar/biogas

24.1% of the respondents were strongly increase their family satisfaction, 57.8% of the respondents were replied their family satisfaction after consumption increased and remaining 9.5% and 8.6 % of the respondents were replied their family satisfaction were strongly decrease and decrease respectively. This showed that 81% of the populations were interest by the technology. And most of them have solar technology in their home for lighting, radio and tape recording and TV purposes and they get dissatisfaction with kerosene light. Similar study investigated by Peck, (2009) and Bekele,et.al,(2016) were foud that; high degree of dissatisfaction with kerosene lighting service, this is because of the cost, quality of light, and convenience of lighting received from kerosene lamp. In general it is disadvantage to the rural community lighting opportunity, due to smoke emitted irritate eyes, its lighting lamp is unsafe and kerosene lighting cause fire.

Table 16 Family satisfaction after consumption

Family satisfaction	Frequency	Percent
Strongly agree	56	24.1
Agree	134	57.8
Strongly disagree	22	9.5
Disagree	20	8.6

Source (n=232)

4.9 Socio-economic benefit of the solar and biogas

4.9.1 Solar and biogas light used to extended working time

According to the survey in the study area the working hours, influence the economic development directly. But people's behaviors, society concept in the community, culture and religious effect on working hours in the district. To find out the impact of renewable energy source (solar/biogas) on household working hours; information of household member working duration were collected before and after utilization of the technology. Table blow summarize the information about household working duration in the house. Before installing solar/bio in the study area 77.6%, 79.3%, and 83.6% of the women, men and children were their working time was "between" 2-3 in the evening, 17.7%, 16.4%, 13.4% were their working time is "between" 3-5 and only 4.7%,4.3% and 3% were consumed long time in the evening. After installing the solar and construction of biogas there were observable change of household working time of women, men and children's. This means 54.7%, 40.1% and 53.4% women, men and children respectively increased their working duration to 3-5 hours. This show that renewable energy like solar and biogas technology utilization increase the working hours. So women's, men and children work more and engaged social and economic benefit directly or indirectly

Table 17 Working hours of women, men, and children in the house evening.

	Women		Men		Children	
Before installing solar / bio	Working hours	Percent	Working hour	Percent	Working hour	Percent
	2-3	77.6	2-3	79.3	2-3	83.6
	3-5	17.7	3-5	16.4	3-5	13.4
	5-6	4.7	5-6	4.3	5-6	3.0
After installing solar/biogas	2-3	29.3	2-3	41.4	2-3	39.2
	3-5	54.7	3-5	40.1	3-5	53.4
	5-6	15.9	5-6	18.5	5-6	7.3

Source: household survey (n=232)

4.9.1.1 *Activity performed by household women in the evening before and after installing either solar or biogas*

In the research area solar and biogas have no similar purposes, more households were consumer of solar, this because by the solar light household were enjoy more than biogas. They used mobile charge for information, watching TV, listing radio and tape. But households use biogas for limited purpose; it used for cooking small household foods and household lighting for short times. So women were active in utilizing solar and biogas technology, as shown table below the summery of activity performed by the women before and after installing solar/bio technology. In the village, majority of the women are housewife and basically stay at home. In the evening time they are busy by household related work. Before installing the technology 128(55.2%) of the women were engaged

with household work and 80 (34.5%) of the respondents were indicate that women were engaged socialization with relatives and 10.3% of the women were spent sleeping. But after installation of solar/ biogas women got more time to engage household related works, listing radio and tape recorder watching TV, reading, and socialization.

Similar works investigated by (Study *et al.*, 2010) were identifed that remote or rural area lacking electricity supply are characterized by well identified challenges, such as low level of education, low load density generally concentrated at evening peak hours, and low revenues. Adding to these challenges, the rural poor without access to electricity either spend relatively large amounts of their scarce financial resources on energy, or a disproportionate amount of time collecting firewood.

Table 18 Activity performed by woman before and after install solar/bio in the evening

Activity performed women before installing solar/bio	Frequency	Percent	Activity performed by women after installing solar/bio	Frequency	Percent
Household work	128	55.2	Household work	93	40.1
Socialization	80	34.5	Productive/business work	17	7.3
Sleeping	24	10.3	Socialization	42	18.1
-	-		Household work &watching TV	15	6.5
-	-		Household work, reading &socialization	51	22.0
-	-		Household work, listing radio &tape recorder, reading, watching TV &socialization	14	6.0

4.9.1.2 *Activity performed by household men in the evening before and after installing either solar or biogas*

Before installing solar/ bio 33.6% of the men were engaged household work. But 23.3% of men were engaged household related work and socialization. 34.2% of men were engaged socialization & reading before installing solar/biogas, but after installing solar/bio greater than 56% were engaged socialization, reading, listing radio and tape, and watching TV.

Table 19 Activity performed man before and after install solar/bio in the evening

Activity performed by men before installing solar/bio.	Frequency	Percent	Activity performed by men after installing solar/bio.	Frequency	Percent
Household work	78	33.6	Household work	46	19.8
Socialization& reading	84	36.2	Productive/business work	18	7.8
Sleeping	23	9.9	Socialization	36	15.5
Household work &socialization	47	20.3	Household work ,sleeping &watching TV	46	19.8
		-	Household work, sleeping & socialization	54	23.3

4.9.1.3 *Activity performed by household children in the evening before and after installing either solar or biogas.*

An observable change occur among the children in solar and biogas installed households. Before installation solar/bio 16.8% household children read in evening, 19.8% household children spent their time on playing and 63.4% of the household children spent their time by sleeping. After installation of the renewable energy source (solar/bio) in the household 62.9% of the household children engage themselves in reading. Beside that 29.3% of household children in watching TV, reading and sleeping and only 7.8% of household children engaged in some sort of playing or entertainments and sleeping.

Table 20 Activity performed by household children in evening.

Activity performed children before installing solar/biogas	Frequency	Percent	Activity performed by children after installing solar/bio	Frequency	Percent
Playing	46	19.8	Reading	146	62.9
Reading	39	16.8	Playing sleeping	18	7.8
Sleeping			Watching TV, reading &sleeping		
	147	63.4		68	29.3

4.9.2 Educational value

Electric lighting in households generally improves household condition for education.

Biogas and solar (SHS) experts from water and energy office during key interview (KI) point out that possibility of school going children to study under electric lights in the evening to be a very important issue. Carbon less clear light encourages children to engage in more studying. In addition to that researcher to new educational value of solar and biogas; questions does solar/biogas easy and extended time of reading. The empirical study investigated in utilization of renewable energy source by (Punjab, Alleviation and Sppap, 2016) and (Peck, 2009) also found that, the access of electricity in rural area provide household to enhance educational skill, children extent the studding hours and they also provide small productive works.

Table 21 Does solar/biogas easy and extended time for children reading

Agreement	Frequency	Percent
Yes Strongly agree	130	56
Yes Agree	85	36.6
No disagree	4	1.7
No strongly disagree	13	5.6

Source: household survey (n=232)

About 56% and 36.6% households were strongly agree and agree that solar makes easy and extended time for reading. Similarly biogas have appositive educational value. Light from biogas make easy and extended time reading for children.

Reading under kerosene light creates straining on the eyes. But solar and biogas light improves the household condition in remote rural area for quality education. The survey

from study area confirms that carbon less clear light motivate rural children to engage more time in reading and studying. Children in SHS households get the benefit of improved light and extended time for reading and studying, which dragging the under privileged children in electricity less area to the main stream of development and aggravating to reach in sustainable development and they help millennium development goal of the Ethiopia (MDG).

4.9.3 Solar and biogas for healthy value.

Similarly educational impacts solar and biogas light also improved household condition for quality health. Health-related issues can be considered from the household point of view as well as from the rural health institutions. In household level, solar and biogas sustain fresh indoor air due to lack of carbon and smoke free light. At the same time health related awareness program form TV and radio has an impact in household level. In the survey 69.8% of the respondent had awareness about disease due to smoky source energy utilization kerosene and firewood. They said that solar and biogas light have different benefits related to heath, such as by improving healthy from clear and non-carbon light utilization, reducing polluting fuel for cooking and increase knowledge through increase access to mobile communication. And 30.2% of the household respondent had no awareness about disease caused by utilization of smoky energy source. These findings is line with the another finding investigated by the (WORLD BANK, *(*2008) for 11 countries in London revealed that utilization of renewable energy source in rural area results great benefits such as improvements of health facilities, better health from cleaner environment as households reduce use of polluting fuels for cooking, lighting and heating, improved

knowledge through increase access to television and better nutrition from improved knowledge and storage facilities from refrigerators

Table 22 Do you hear/now disease due to carbon concentration energy use

Respondents agreement	Frequency	Percept
Yes; eye, heart, and lunge disease	162	69.8
No; I do not now/hear	70	30.2

Source: household survey (n=232)

4.9.4 Renewable energy utilization (solar & biogas) decrease the incidence of disease caused by soot from fire wood and kerosene.

Respondents in the research survey area express that solar and biogas improves the indoor air quality. They point out that kerosene lamps create smoke, which increase the incident of respiratory and eye, lung and heart diseases. Table below represents respondent agreement on SHS decreases incidence of diseases.

In the survey 81.9% households express that solar and biogas decrease the incidence of diseases. Members of the survey households also state that health related program on TV and radio increase their knowledge base on health and sanitation. Besides, mobile messages on vaccination program helps them to take necessary action on due time. Off course fresh indoor air, regular health related awareness program in TV & Radio, health concern mobile message and reduce accident from kerosene lamps are important factors which improve health and sanitation of solar and biogas installed households member on a long-term basis. Only 18.1% of the respondent had negative perception with the concept of the question.

Table 23 Does utilization of solar and biogas decrease the incidence of disease caused by utilization of firewood and kerosene.

Respondents agreement	Frequency	Percent
Strongly agree	134	57.8
Agree	56	24.1
Strongly disagree	24	10.3
Disagree	18	7.8

Source: household survey

4.9.5 Solar and biogas substitute kerosene and firewood

One of the main uses of the solar and biogas were for lighting in the study area. For solar depending on the capacity of the solar panels, households would have 2-5 lighting points or bulb. In addition to survey of household head, from researcher observation those more lighting points a household had, the lower the use of kerosene for lighting, which is mainly used in areas. While other possible uses of kerosene include cooking, this is a costly alternative to biomass cooking fuel and hence is rarely seen in rural households of the study area.

For biogas since the capacity of biogas in household level is from 4(four) meter cube to10 (ten) meter cube. The amount of gas under this dome does not give sufficient light and other cooking purpose, if the owner set more than two lighting point or bulb, the only possibility was one lighting point and one cooking stove for one biogas. This opinion was happen again during the focus group discussion (FGD) and key interview (KI). According to the idea of the respondent's biogas is the top technology next to solar in reducing kerosene and firewood lighting and cooking in the community.

Figure 6 Discussion on benefit of solar and biogas

In the table 24 summarize about the amount of lighting and cooking monthly expenditure and amount of monthly reduced expenditure after installing solar and biogas and substitution agreement. In table 13 above nearly 82.3% of household respondent said that the total monthly expenditure for lighting and cooking purpose is greater than 200 Ethiopian birr, this means the list annual lighting and cooking cost was 2400 Ethiopian birr. After installing sol/bio almost 92.3% of the household head lighting and cooking expenditure cost were reduced. And 90.4% of the respondent were agreed by substitution of kerosene, dry cell, and firewood by sol/bio.

Given that there are about 198 solar and biogas households in study area, the decrease in kerosene and firewood consumption amounts to over 2400birr was saved annually due to solar and biogas utilizing.

Table 24 Reduced expenditure for lighting & cooking, substitution agreement reduced expenditure after install sol/bio

Reduced expenditure	Frequency	Percent
Below 200	17	7.8
Between 200 &500	147	63.4
Above 500	67	28.9

5. CONCLUSIONS AND RECOMMENDATION

5.1 Conclusion

From the sampled population in the study area 75.5%, 14.7%, 9.5% and 0.4% populations were their lighting source in the house were solar, kerosene, biogas and firewood respectively. These showed that greater than 86% of household used renewable energy source (solar and biogas).

The household heads need to use solar light as the first solution for growth and to tackle lighting problem in their house. But some of the household had awareness limitation, even large number 198 of sampled populations were solar and biogas users. From the sampled population 132 of the respondents had awareness about the use of renewable energy source and have awareness about adverse effect of use of kerosene and firewood light.

The finding concluded that 71.1% of population occupation were largely on farming both cereal crop and animal products. Due to that, farmers in the area needed to use better illumination in the evening and to enhance their economy through farming and improve living condition which was raised during the FGD and survey data analysis.

Formal and informal training, market centers, community discussions and government and non-governmental agents were the main source of information and awareness in the area. . In study area 39.7, 49.1, 11.2 percent of sampled population, indicated that the price of the solar/biogas was fair, expensive and cheap, respectively. Beside that there were 49.1% people did not accept the idea and they said poor households cannot afforded the technology. In addition to that shortage of utilization awareness, maintenance and shortage

of accessory and quality of technology were the main solar and biogas utilization constraints in the research area.

In the study area 9.5% households were use biogas only for lighting and cooking but biogas owners expect another's applies service like running TV, radio and tape recorder, this was because household were falls informed by expert from water and energy sectors and other stack holders.

Relatively 139 users and 14 biogas users' household livelihood condition were changed economically and socially. Beside that their house quality was increased, their feeding system were changed, the source of information and communication is also increased. Solar and biogas light also have healthy benefit, it is also found that the technology owners get fresh air and reduce accident related to kerosene and firewood use. Increasing economic growth, quality of education, health benefit and access to information can be significantly improve productivity, skill and livelihood condition of rural community of Yem.

5.2 Recommendation

Price of the renewable energy source is one of main barrier of the utilization raised in the study. Therefore, access to credit should be strengthened to the households, who are unable to purchase by themselves.

There should be considerable provision of different services such as access to technical training and supports to the solar systems sellers and biogas masons to increase availability of quality standard solar and biogas

Supporting by investment on utilization renewable energy source to rural households have positive result to secure rural development as well as secure SDG of the country.

Since agriculture is the main occupation in the study area, income generating activity from celery pit of biogas for agriculture is very limited. Use solar for irrigation and organic fertilizer from biogas celery pit should be promoted to increase land productivity

REFERENCES

Abadi, T.Y (2016). Optimizing the Technical and Social Benefits of Solar Photovoltaic Technologies in Ethiopia. Addis Ababa University.

Aladeitan, Y. M. (2011) 'The use of biogas technology in small scale farms in Nigeria', pp. 265–268.

Asaduzzaman, M. (2013) 'The Benefits of Solar Home Systems An Analysis from Bangladesh' (December).

Asia, S. (2015) 'Making Renewable Energy a Success in Bangladesh : Getting the Business Model Right Making Renewable Energy a Success in Bangladesh ':, (41).

Bekele, G., Negatu, W. and Eshete, G. (2016) 'Determinants of Household Energy Deman in Ethiopia : The Case Study of Addis Ababa City', 3(1), pp. 1–14.

Engineering, I. (2014) 'Renewable energy development in rural areas using SCADA', pp. 216–2

ERTTP (Ethiopian Road Transport and Travel Program), (2003).district Integrated Development Program YEM report. PAN African Consultancy Group.

Federal Democratic Republic of Ethiopia Population Census Commission (FDRE PCC), (2008).Summary and statistical report of the 2007 population and housing Census Population Size by age and sex. United Nations Population Fund (UNFP) pp 113.

Feron, S. (2016) 'Sustainability of Off-Grid Photovoltaic Systems for Rural Electrification in Developing Countries : A Review', pp. 1–26.

Gujarati, D. N. 2004. Basic Econometrics (4th Ed.). New Work, NY: The McGraw−Hil

Hilawe, L., & Getenet, T. 2011. Ethio Resource Group. Christian Aid Ethiopia.

Independence, I. E. (2014) 'Biogas Opportunities Roadmap', (August).

International Energy Agency (IEA). 2015. *Energy Poverty*. Paris: International Energy Agency.

Israel, G. D. (2012) 'Sampling the Evidence of Extension Program Impact 1', pp. 1–9.

Kebede, K. Y. and Mitsufuji, T. (2017) 'Technological Forecasting & Social Change Technological innovation system building for diffusion of renewable energy technology : A case of solar PV systems in Ethiopia', 114, pp. 2016–2018.

Levin, T. and Thomas, V. M. (2016) 'Energy for Sustainable Development Can developing countries leapfrog the centralized electri fi cation paradigm ?', *Energy for Sustainabl Development*. Elsevier B.V., 31, pp. 97–107.

Morrissey, J. 2017. "The energy challenge in sub-Saharan Africa: A guide for advocates and policy makers: Part 2: Addressing energy poverty" Oxfam Research Background.

Nationally Appropriate Mitigation Actions (NAMA). 2016. Proposal for Off-grid rural electrification in Ethiopia, MoWIE, April 2016, Addis Ababa, Ethiopia, 49p.

Nnamdi, E. 2014. The Adoption of Solar Photovoltaic Systems among Industries and Residential houses in Southern Nigeria. MSc Thesis. Mid Sweden University, Östersund Campus, Sweden. p38.

Peck, P. (2009) 'The Role of Decentralized Renewable Energy for', (June).

Pode, R. (2013) 'Financing LED solar home systems in developing countries', *Renewable and Sustainable Energy Reviews*. Elsevier, 25, pp. 596–629.

Punjab, S., Alleviation, P. and Sppap, P. (2016) 'Impact Assessment of Household PV,

Renewable, U., Program, E. and Final, D. (2012) 'Federal Democratic Republic of Ethiopia Ministry of Water and Energy', (January).

Report, F. *et al.* (2013) 'Power from the Sun : An Evaluation of Institutional Effectiveness and Impact of Solar Home Systems in Bangladesh'.

RLP, (2005). SNNPR livelihood Profile: Survey Data conducted in September 2005, YEM,

Rom, A. *et al.* (2017) 'The Economic Impact of Solar Lighting : Results from a randomised field experiment in rural Kenya', (February).

Steve, D. 2013. SHSs for Rural Electrification in Developing Countries, Benedict and St. John's University, 33p.

Solangi, K. H. et al. (2011) 'A review on global solar energy policy', Renewable and Sustainable Energy Reviews. Elsevier Ltd, 15(4), pp.

'Solar energy vision for Ethiopia' (2012).

Stojanovski, O., Thurber, M. and Wolak, F. (2017) 'Rural energy access through solar home systems: Use patterns and opportunities for improvement', Energy for Sustainable Development. International Energy Initiative, 37, pp. 33–50.

Study, C. et al. (2010) 'ELECTRIFICATION POLICIES'.

Sub-city, K. (2013) 'Lighting Africa Program Ethiopia Market Intelligence', (604).

Tessama, Z. *et al.* (2013) 'Mainstreaming Sustainable Energy Access into National Development Planning : the Case of Ethiopia'.

USAID, (2005). Ethiopia Southern Nations, Nationalities and Peoples Region (SNNPR) Overview of livelihood profiles: SNNPR follow-on to regional livelihoods Baseline Study. pp37.

World Bank. 2015. *Energy Overview*. Washington D.C. World Bank.

World Bank. The Welfare Impact of Rural Electrification: A Reassessment of the Cost and Benefits: An IEG impact evaluation, 2008, pp. 39–52.

YEM water and energy office annual report, (2017)

YEMspecial ditrict performance rport,(2016)

YEM special district GTP plan,(GTP, 2011)

GTZ. 2007. Eastern Africa Resource Base: GTZ Online Regional Energy Resource Base: Regional and Country Specific Energy Resource Database: VII - Best Practice Case Studies

Appendix 1

Questions for Interviews and Focus Groups Desiccation

Questionnaire to be filled by Household's Head

Objective:

Dear respondents, the purpose of this questionnaire is to gather primary data about evolution of effectiveness renewable energy source (solar & biogas). The study is for partial fulfillment of the requirements for Master's Degree in Renewable Energy Utilization and Management at HAWASA University, WONDOGENET College of Forestry and Natural Resource. I confirm you that all data will be used only for academic purpose and your responses will be kept confidential.

Instructions:

No need of writing name

Tick your answer on the letter and write space provided.

Back ground information

1, gender A, Mel B, female

2, age A 25-30 B, 30-35 C, 35-40 D, 40-50 E, Above 50

3, mitral status A, married B, single

4, Literacy level A, Literate (can read and write) B, illiterate (cannot read and write)

How many children are attending school/college/university from your house hold?

4, Primary school----------secondary school----------college----------university----------

5, total family size---------- (in number)

6, are you house hold head A, yes B, no

User information and other related issue about solar home system

7, Have you awareness about renewable energy source?

A, yes B, no

8, what is the energy source that you are using in your home for lighting

A, kerosene B, fire wood C, biogas D, solar E, dry cell battery

9, what is energy source that you are using in your home for cooking?

A, kerosene B, fire wood C, biogas D, solar E, dry cell

10, do you know solar lighting used for home lighting and other energy service?

A, Yes B, No

11, if your answer in question 9 is no please answer question below

What is your energy source? A, biogas B, biomass c, dry cell D, other

_____

12, are you satisfied by solar light? A, yes B, no

13, if the answer in question 11 is yes what is your implication? _____

Socio-economic information

14, what is your occupation before solar installation in your home? A, farming B, labor C, skill working service D, business employer E, other _____

15, what is the occupation of your wife or spouse?

A, farmer B, labor C, business unemployed D, skill working service E, other _____

16 what is the total monthly income that you earn before the installation of solar or biogas in your home?

A, 200-500 birr B, 500-1000 birr C, 1000-1500 birr D, 1500-2000 birr E, 2000-3000 F, above 3000 birr

17, in generally what is your livelihood condition after renewable energy utilization in your home?

A, improved B, stay the same C, degraded

18, what are kind of change after consumption of biogas and solar?

A/increase safety B/ communication entertainment C/

19, what are the activity performed by woman, man and children before and after install solar/bio in the evening?

Woman		Man		Children	
Before	After	before	After	Before	After

20, if your answer question 16 A, improved how? _____

B, degraded why? _____

Source energy for lighting and expenditure

21, what is the energy source for lighting and expenditure before solar installment in your home?

A, kerosene B, dry cell battery C, candle D, other _____

22, what is the amount of birr monthly your expenditure before installation of solar-light for lighting service _____

23, is there any other cost that you expenditure related to healthy, other house hold service

A, yes B, no

24, if your answer in question 20 is yes for what purpose and what is its amount monthly expenditure_____

Productivity

25, is there any income generating business/productivity after utilization renewable energy in your home? A, yes B, NO

26, if your answer is yes in question 22 write your implication _____

If you say no again write the reason _____

27, is alternative energy utilization create jobs opportunity? A, yes B, no

28, if your answer is yes how? _____

29, what are the solar electricity consuming activity in your home?

A, for light only B, for light and mobile charge C, for light, Mobile, and radio D, for light, mobile, radio and television

30, what is satisfactions of your family after consumption of the above question 26?

A, strongly satisfied B, satisfied C, no more satisfied

Pleas tick mark the following question below the table (A=strongly agree, B=agree, C=dis agr)

NO	Benefits of renewable energy source	A	B	C
31	Solar –light is used to replace kerosene, dry cell battery, and fire wood			
32	Using Solar system is/was benefit to increase incomes, children study at night, changes quality of livelihood, and its used to gain information technology			
33	Solar home system provides more health benefit for house hold members, in particularly humans.			
34	Providing service like awareness creation, price regulation, and quality control by government organization have positive effect on utilization of renewable energy source (solar, biogas and improved stove).			
35	Utilization of house hold solar system and biogas save money.			
36	House hold solar system installation make easy to family get new information.			
37	Renewable energy utilization decrease the incidence of disease caused by soot from firewood and kerosene utilization.			

Barrier from the respondent point of view

38, write down the working hour of duration and activity performed by men, women and children in the evening before and after installing solar and biogas----------

Questioner for key informant interview

1, Do you know solar and biogas/is there one of technology in your house?

2, have/had you look any change on you economy, life, and family after installation of technology?

3, what you say about renewable energy source for your Nabors or if someone ask you it?

4, is/was application and user barrier during the utilization?

5, what is change of your monthly income after utilization of renewable energy source?

6, is/was the price of renewable energy is fair in your community? If not why explain briefly

Question for experts

1, is/was community in the districts awarded about renewable energy source? If no what are the challenge

2, how the utilization of solar and biogas impact rural household? Is there any utilization barrier?

3, from solar and biogas which technology is acceptable in the household? Why

Questioner for group desiccation with selected households heads

1, is/was renewable energy source (solar and biogas) is useful for electric and other energy service? Discussed your answer in term of economic value, social value, and environmental value.

2, which renewable energy source is more preferable by rural community in this district? Why? Discussed.

3, what are the renewable energy (solar and biogas) utilization barriers? Discussed

4, discuses educational and health value of solar and biogas utilization

Appendix 2

Figure 7 participants in focus group discussion