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Increasing Rural Electrification through the Devergy Solar PV Nano Grid System in Tanzania

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Declaration

I, Akil Jacobs, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

Signature....................................

Date...

Acknowledgements

Many people have helped me along this journey, from the planning stage to the end. I would first like to thank the Most High, through the creator all things are possible and this thesis is proof of that.

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Abstract

Tanzania is facing energy problems throughout the entire country, but in rural areas where the majority of the population lives, the energy problems are extreme. Many solutions are being researched, specifically renewable forms of energy such as solar, biomass, and wind energy. As a means of allowing inaccessible populations, to gain access to energy. SHS have been in Tanzania for over 40 years and still the problem of rural electrification exists. This paper describes a new approach to solving an old problem. It analyzes the benefits and the drawbacks of the Devergy Nano Grid Solar Approach, in Melela, Tanzania. Also, it examines the external factors that create barriers for the solar sector and the Devergy the solar energy company, such as a lack of a renewable energy policy, purchasing power of the rural population, solar markets, and the current energy statues in the country. This paper is based on both qualitative and quantitative data, Focus Group Discussions (FGDs) with consumers, suppliers, and energy institutions, and 80 household surveys within Melela, Mororgoro and Dar es Salaam in Tanzania. In the paper it is shows the Devergy Solar Approach in comparison with solar home systems (SHS). It was found that Devergy as a shared Nano grid system, was able to decrease transaction costs of solar to a level that allows for more accessibility than SHS in rural areas. Devergy operates as a small energy company that provides a solar resource, maintains it and through that, eliminates various barriers stopping many rural villagers from gaining access to electricity. With this new approach, Devergy focuses on a niche in the renewable solar sector, which is to provide solar energy that is cheaper and more easily accessible. Also, the issue of not having a renewable energy policy is addressed within this paper, in terms of its impact on the development of the sector.

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List of Acronyms

According to the Africa Infrastructure Country Diagnostic (AICD)

Agence Francaise de development (AFD)

Alternate Current (AC)

Direct Current (DC)

UK Department for International Development (DFID)

European Union (EU)

Focus Group Discussions (FGD)

Foreign direct investment (FDI)

Gross Domestic Product (GDP)

Government of Tanzania (GOT)

Human Development Index (HDI)

Hectors (HA)

International Chamber of Commerce (ICC)

Independent Power Producers (IPP's)

International Energy Agency (IEA)

Kilowatt Hour (kWp)

Millennium Challenge Corporation (MCC)

Millenniums Development goals (MDGs)

Ministry of Energy and Mineral (MEM)

Million of ton of oil equivalent (MTOE),

Mega-Watts (MW)

Norwegian Agency for Development Corporation (NORAD),

Non Government Organizations (NGOs)

Photovoltaic (PV)

Renewable Energy (RE)

Renewable Energy Association (REA)

Renewable Energy Fund (REF)

Solar Household System (SHS)

Small Power Producer (SPP's).

Small Power Producers Agreements (SPPAs)

Sustainable Solar Market Packages (SSMP)

Statistical Computer Software Known (SPSS)

Solar Water Heating (SWH)

Tanzania Electric Supply Company Limited (TANESCO)

Tanzania Energy Development and Access Project (TEDAP).

Terawatt Hours (TWH)

United Nations Development Program (UNDP)

United Nations Industrial Development Organization (UNIDO)

United States Dollars (USD)

Tanzania bureau of standards (TBS)

Value Added Tax (VAT)

World bank (WB),

World summit on Sustainable Development (WSSD)

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1 INTRODUCTION

The Millennium Development Goals (MDG) list specific objectives that need to be achieved by the global community by 2015, in order to have a sustainable planet. This includes abolition of poverty, hunger, universal primary education, women's empowerment, reduced infant mortality rates, disease, and decreasing mental health issues (IEA 2010). Energy was not directly mentioned in the eight MDGs, but it is widely understood that energy is a precondition to sustainable development (Modi, McDade et al. 2005). At the World summit on Sustainable Development (WSSD) in Johannesburg, it was stated that: "access to energy facilitates the eradication of poverty" (UN, 2002, p.12)[1].

One of the major barriers that hinder achieving the MDGs that the global community and large development institutions such as the United Nations Development Program (UNDP), World Bank (WB), International Energy Agency (IEA), and United Nations Industrial Development Organization (UNIDO) face, is that Sub-Saharan Africa with the exclusion of South Africa, 72 percent of the population have little or no access to modern forms of energy (IEA 2010). The regions access to modern energy is the lowest in the world. An estimated 791 million people used 40 terawatt hours (TWh) of energy, which is equivalent to the consumption of the state New York, with a population of 19.5 million (IEA 2010). When compared, New York has over a 2050 kilowatt hour (kWp) per capita as opposed to the 52 kWp per capita of Sub-Saharan Africa, with the exclusion of South Africa (IEA 2010).

The international community has long been aware of the direct correlation between income levels and access to modern energy (IEA 2010). Countries whose population live on less than 2 dollars a day are the majority of the energy poor, and large portions

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[1] *This would include actions at all levels to:* (a) *Improve access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services and resources, taking into account national specificities and circumstances, through various means, such as enhanced rural electrification and decentralized energy systems, increased use of renewables, cleaner liquid and gaseous fuels and enhanced energy efficiency, by intensifying regional and international cooperation in support of national efforts, including through capacity-building, financial and technological assistance and innovative financing mechanisms, including at the micro- and meso- levels, recognizing the specific factors for providing access to the poor;*

of their populations usually rely on some form of biomass as a form of energy, instead of more modern forms of electricity. Access to modern energy is one of the keys to development, such a basic lighting, cooking, mechanical power, transport, entertainment, hospitals, clean water, education and business facilities all require or work better with modern electrical energy. A lack of electrical energy is a hindrance to the social, environmental and economic growth of any region or country.

In the case of Tanzania, many social institutions such as universities, hospitals, businesses and corporations are unable to reach their full potential due to a lack of electrical energy. Most people conclude their daily activists and return home before dark, businesses operate mainly during the daytime, especially within rural areas, where over 75 percent of Tanzanians live (MEM 2013).

In order for Tanzania to begin charting a path to a more sustainable future for its citizens, specifically in the rural areas where the majority of the countries population lives, the Government of Tanzania (GOT) needs to allocate funds toward the expansion of its energy sector in a sustainable manner. Sustainable development according to the Brundtland commission is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UNCF, 1987, p-37)[2].

Tanzania is plagued with high transmission and distribution losses as a result of the majority of hydropower plants being located in the south of the country, and energy being transported great distances to reach northern cities, such as Arusha, Moshi, and MWanza (Kihwele, Hur et al. 2012). Investments and sustainable development can be made in renewable forms of energy such as solar, geothermal, biofuels and wind energy. These forms of renewable energy can help decrease transmission losses by being more cost effective in the long term and more accessible to isolated rural communities. Renewable energy can also address issues such as ecosystem and resource management with proper development initiatives.

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[2] *The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and*
The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

An energy transition is believed to be necessary for future sustainable development throughout the world and in Africa, but this transition has yet to take shape on a scale that could be considered a major shift. This shift is based on whether or not countries such as Tanzania are willing to invest in new forms of energy. In essence, does Tanzania want to evolve in terms of its energy development like that of the west, meaning energy largely based on coal and fossil fuels that are harmful to the environment? Or does Tanzania want to evolve in a new direction with new forms of energy that are cleaner?

There are companies within Tanzania trying to make this energy transition take place. One of these companies is Devergy. Devergy is a renewable solar energy company based in Tanzania and Ghana. Their aim is to overcome barriers within rural energy sectors. The current barriers that they face are the high cost of solar systems, low purchasing power, and limited utilization of solar technology for enterprise activities (Kassenga 2008). It also aims to address deficiencies in rural electrification, specifically in remote communities in a manner that is cost effective and environmentally friendly. This research paper aims to gain insight into Devergy's approach as well as look at their solar nano-grid system. By understanding Devergy both in practice and approach, insight can be gained into whether or not different renewable energy companies can address the problems of rural electrification and deforestation in Tanzania.

In order for Tanzania to make sound investments and create proper policies that can address the needs of its citizens, sound research must be done on different approaches and policies needed to make them more successful. The core of this research includes the assessment of benefits as well as drawbacks of the Devergy approach and their photovoltaic solar energy nano-grid system on villagers in Melela, Tanzania. This includes assessing whether or not there is the potential for scaling up their renewable solar energy system to reach more villages for improved livelihoods. Stakeholders, and key informants in the energy sector in Tanzania were also a major part of this research. In order to understand the Devergy approach and their photovoltaic solar energy nano grid system in a village setting, research was also done on villager's assessment of the resource, the Devegy's approach, Tanzania energy policies, investment both internal and external, economics, energy institutions, climate, social awareness and acceptance.

Tanzania, like many other sub-Saharan countries suffers from lack of a modern energy. Its main source of energy comes from traditional biomass, and imported oil (Kihwele, Hur et al. 2012). Analyzing existing sources of energy and new sources of energy can aid in understanding where new forms of energy can improve or have failed to address existing problems with energy. This can facilitate the planning of future development and build Tanzania's energy sector in a manner that is sustainable. The research will show the Devergy approach and how it impacts communities and households, and if there is potential for future developmental possibilities.

This research looks at the economic, social, and both long term and short-term benefits of having access to the Devergy approach in the Melela village. The data is based on both research as well as extensive literature on the subject of the SHS, and large and small grid solar. Solar is used as a catalyst to drive economic increases as well as social benefits. In order to assess the influence of the solar nano grid, it is necessary to assess how households in Melela and different villagers livelihoods have changed as a result of this approach.

The assessment will give an overall view of what villagers think about Devergy and if their lives have been changed in both positive and or negative ways. It also shows why some villagers have access to the approach, and others do not. This shows what can be done to increase this particular energy resource for everyone in Tanzania.

2 BACKGROUND

The background chapter will give an overview of Tanzania's energy sector, with a specific focus on solar energy and policy. Tanzania is approximately 945,203 sq. km, of that, 885,800 sq. km is land and 61,500 sq. km is water. This includes Pemba and Zanzibar, which are separate islands off the coast of Tanzania but are still under the Republic (CIA 2012). Tanzania borders seven countries; Zambia, Democratic Republic of the Congo, Burundi, Rwanda, Uganda, Mozambique and Kenya (MEM 2013). The climate of Tanzania varies; in costal areas the climate is tropical and in the highlands, temperate (CIA 2012). The highest point in the country is 5,895 meters, Mount Kilimanjaro, which is the highest point in Africa and the lowest point is zero at the Indian Ocean.

Figure 1: Map of Tanzania and it bordering countries (CIA 2012)

Tanzania has a population of 49.6 million people, 80 percent of which live in rural areas, and less than 5 percent has electricity (Ahlborg and Hammar 2011). The population is growing at a rate of 2.9 percent per annum, and is projected to reach 64 million by 2025 and 83 million by 2035 (MEM 2013). Tanzania also has a low Gross Domestic Product (GDP) per capita rates at 201 out of 229 different countries, which equals an annual income of $1,500 United States Dollars (USD) (CIA, 2012). The economy of Tanzania is based on agriculture, which equals 25 percent of the country's GDP, provides 80 percent of the population with jobs and also equates to 85 percent of the total exports (CIA 2012). Tanzania's main exports are coffee, cashew nuts, gold, manufacturing and cotton. Imports are mainly consumer goods, machinery, transportation equipment, industrial raw material and crude oil.

According to the Human Development Index (HDI), Tanzania ranks low in terms of human development, ranking 152 out of 187 countries worldwide (Malik 2013). The average life expectancy of a Tanzanian is 61.24 years as of 2014, and adult literacy at age 15 and up, is 67.8 percent as of 2010. Tanzania's infant mortality rate is 43.74 deaths per 1,000 births and ranks the country at place 49th in the world (CIA 2012). Within the context of factors stated before, Tanzania is still optimistic about being able to develop into a middle-income country, which can provide more opportunities and a better life for its citizens by 2025.

The majority of Tanzanians live in isolated parts of the country where it is difficult to connect them to efficient power sources. Isolated communities do not have proper infrastructure; paved roads, power lines and functioning government institutions such as police presence, hospitals, and governing bodies to enforce the rule of law. These communities lack even the most basic medical facilities (Ahlborg and Hammar 2011).With high levels of energy poverty in Tanzania, there is a need for electrical energy as a means to reduce energy poverty.

According to the Africa Infrastructure Country Diagnostic (AICD) Africa south of the Sahara; 48 countries are operating on 68 gigawatts of energy, which equals Spain's energy consumption. When South Africa is excluded, the total falls even further to 28 gigawatts for 47 countries in Africa south of the Sahara, which equals Argentina's energy consumption (Eberhard, Foster et al. 2008).

Africa south of the Sahara's energy problem and more specifically Tanzania's energy deficiency is due partly to a lack of public and private sector investment in both renewable and non-renewable forms of energy. The total public and private sector investment in Africa south of the Sahara is one billion dollars per year. This has been the case for the past decade. The investment total is equal to 0.1 percent of the GDP in the region, and is insufficient in keeping pace with its economic growth (Eberhard, Foster et al. 2008).

The energy problem in Tanzania is complex due to a variety of factors. In the event that communities with low income gain access to grid electricity, most of the isolated, hard to reach rural communities could not afford the monthly electrical bills based on dependency from fluctuating incomes. The seasonal imbalances of daily wages differ from urban centers to rural areas. There is little or no incentive for electrical companies to provide rural areas with electricity, due to the cost of expanding the electrical grid system and annual average per capita GDP of 1,500 USD, which is even lower in rural areas. This deepens the dilemma of energy poverty in Tanzania. TANESCO, is Tanzania's main electrical entity. It is is a public company and the main electricity producer, transmitter and distributor in Tanzania. It currently supplies 60 percent of the nations grid electricity (MEM 2013). It is also in a state of decline due to high transmission and distribution losses, revenue loss, high tariffs, and an aging infrastructure.

2.1 Tanzania Energy Sector

Tanzania's energy consumption is 66 percent of the average consumption in Sub-Saharan Africa, making its energy consumption and statues one of the lowest in Africa and the world (MEM 2013). In 2009, Tanzania consumed 19.6 million ton of oil equivalent (MTOE), 1.7 MTOE were net imports. In 2010 the country is estimated to have consumed 22 MTOE's. 23 percent of total imports, approximately US 1.5 billion USD are petroleum products. Biomass represents the largest energy consumption in the country, and was 88.6 percent in 2009 (MEM 2013). The main biomass product is charcoal made from wood. It is the largest source of household energy in the country, with half of the consumption taking place in Dar es Salaam, whose total consumption levels in 2002 were 5.8- 8.6 million sacks of charcoal (174,000 to 258,000mt of charcoal) (Mwampamba 2007). Of the 11.4 percent that remains in Tanzania energy consumption, 1.8 percent is from electricity and 9.2 percent is from petroleum products.

2.1.1 National Energy Consumption

Figure 2 Displays a pie chart of the total consumption of energy in Tanzania, including various sectors, if Tanzania is to reach a balanced energy sector that does not rely some much on biomass, it has to invest more in other forms of energy, specifically RE.

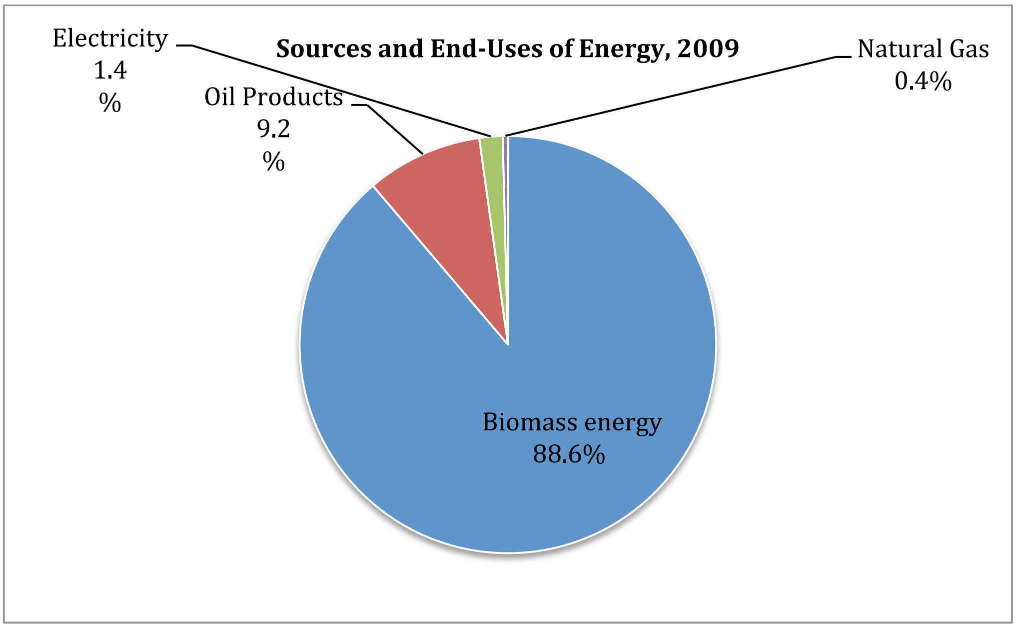


Figure 2: Overview: The sources of energy and percentage used (MEM 2013)

Due to the large consumption of biomass products in the country as shown in figure 2, there exist environmental and health issues. Forests are being cut down at a rate of 62,00- 421,000 hectors per annum, to supply a demand of 1 million tons of charcoal (Mwampamba 2007). In order to supply the demand, an estimated 30 million cubic meters of wood is required. An estimated 80 percent of the biomass that is consumed in the country is used in the residential sector for cooking (MEM 2013).

2.1.2 Desired electrical appliances

Table 1 displays electrical appliances that are desired by villagers in Tanzania and the table displays the nominal power that is needed to operate each appliance. The table also displays welfare increasing, time saving or household (HH) expenditure reducing items. The list is compiled of items found in HH connected to diesel powered mini grids on Mafia Island, Tanzania (Ruud 2013).

Table 1: This table displays the nominal power watts for appliances in rural setting throughout Tanzania (Ruud 2013).

Electrical appliance Nominal power (Watts)	*Nominal power (Watts)*
Small refrigerator/freezer	100 – 150
Medium size TV	150
Computer/laptop	100
CD-player	40
Rice cooker	300
Sewing machine	100
Table fan	15
Large refrigerator/freezer	400 – 450
Average intensity light bulb	40
Cell phone charger	4
Radio/clock radio	5
Small electric kettle < 1 liters	500
Egg boiler	300
Small ceiling fan	30
Electrical mosquito protection	20

2.1.3 Monthly electrical demand

Table 2 Average monthly electrical demand of rural HH is linked to the 1.4 percent of electrical consumption in Tanzania in the pie chart in Figure 2, Table 2 represents the daily and monthly consumption of electricity per kilowatt-hour in a rural setting.

Table 2: Average monthly electrical demand of rural HH (Ruud 2013)

Average peak household Demand (daily) (KWP)	**Average monthly household Consumption (KWP)**	
0,15	54	Typical estimate
0,25	90	High estimate
0,35	125	Maximum estimate

2.2 Tanzania's national grid

Table 3 displays the installed capacity of Tanzania's national grid system: 1001 Mega-watts (MW). Hydropower contributes 561 MW or 56 percent to the total installed capacity to the national grid. Thermal generation plants that use natural gas support the remaining 44 percent (Ruud 2013).

Table 3: On-grid generating capacity in Tanzania Tanzania's national grid system (Ruud 2013)

Name	Type	Capacity (MW)
Kidatu	Hydro	204
Kihansi	Hydro	180
Mtera	Hydro	80
Pangani	Hydro	68
Hale	Hydro	21
Nyumba Ya Mungu	Hydro	8
Ubungo	Natural Gas	100
Tegata	Natural Gas	45
IPPs	Natural Gas/ Diesel	282
Imports	Uganda/Zambia	13
Total		1001

Only 15 percent of the population consumes energy from the national grid. This segment of the population is usually located in urban areas such as Dar es Salaam, Morogoro, MWanza, Moshi, Arusha and other large cities. The 15 percent that receive power from the grid receive an unstable supply of energy, due to political, economic and technical reasons, such as lack of trained staff, lack of economic investment and policies. Power outages and load shedding are often frequent, and adds to the levels of loss. As of 2010 there was a combined loss of 25 percent, 5.3 percent (% of Generation) form transmission losses and 19.7 percent (% Energy Fed into MV Network) for distribution losses both commercial and non-technical. Distribution losses of this quantity are far below acceptable industry standards. Plans to address these issues have been put in place by various national institutions, such as TANESCO, Energy and Water Utilities Regulatory Authority (EWURA) but the problem still exists (Kihwele, Hur et al. 2012).

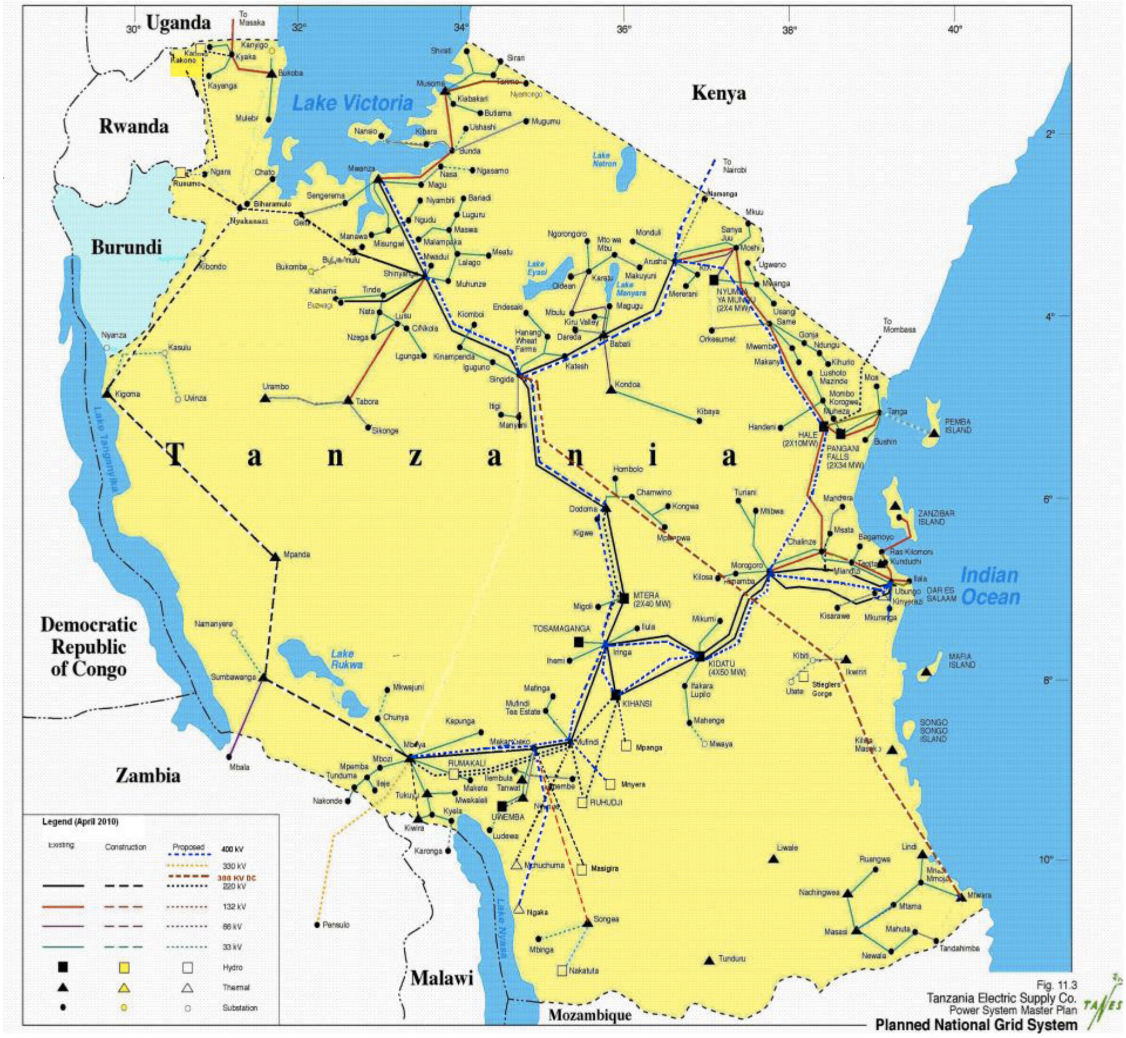


Figure 3: National Grid transmissions Network (Ruud 2013) it shows the national grid transmission network. It also shows that in the south and western part of the country the gird is non-existent, and it also indicates the off grid systems throughout the country.

The figure 3 also illustrates the layout of the Tanzania – TANESCO grid system. The grid travels to the majority of the major urban areas in the country, but vast amounts of the country have not been electrified as indicated in the figure. There has been an effort by the GOT to extend the national grid system, but the initiatives are slow to take shape, leading to off-grid power generation.

2.2.1 Existing off-grid generating capacity in Tanzania

Table 4 displays the off-grid generating capacity in Tanzania. The table is based on the number of units, which range from off grid solar to gensets and their capacity to produce energy.

Table 4: Off-grid generating capacity in Tanzania, Displays the off-grid generating capacity in Tanzania (Ruud 2013)

Name	**Number of off-grid Units, gensets, solar etc.**	**Capacity (MW)**	**Fuel type**
1. Kigoma	14	12.5	Industrial Diesel oil (IDO)
2. Songea	6	8.2	IDO
3. Mpanda	4	2.7	IDO
4. Mbinga	2	2.0	IDO
5. Biharamulo	2	1.0	IDO
6. Ngara	2	1.0	IDO
7. Mafia	2	0.9	IDO
8. Tunduro	4	2.0	IDO
9. Ludewa	3	1.3	Gas oil, GO/IDO
10. Liwale	2	0.8	IDO
11. Somanga	3	7.5	Natural Gas
12. Sumbawanga	4	5.0	IDO
13. Kasulu	2	2.5	IDO
14. Kibondo	2	2.5	IDO
15. Loiondo	2	5.0	IDO
16. Namtumbo	1	0.3	IDO
17. Mtwara	9	18.0	Natural Gas
18. Bukoba	4	2.4	IDO
19. Masasi	3	4.5	IDO
Total		79.9	

Isolated towns are often electrified with isolated power systems that use mainly diesel fuel, as shown in the table above. There are 19 total plants, two of which operate with Natural gas in Somanga and Mtwara. Annually, the GOT spends 45 million US$ on 50 million liters of diesel fuel in order to power diesel generates that collectively are estimated to produce 55 MW of power in total (Ruud 2013). Diesel gensets ranging from 300 Watts (W) to 10 Kilowatt (KW) also contribute to the off-grid capacity of Tanzania. The exact number of off-grid diesel gensets operating in the country is unknown, but is estimated to be in the range of 40 – 50 MW (Ruud 2013). Diesel gensets are used mainly to provide household, large and small businesses, private and public building with electricity. But the majority of small diesel generators are usually connected to the national grid and they supply the remaining 0.5 to 5MW.

There are also a few small hydro plants that operate off- grid power generation and that are in construction in isolated areas that offer between 1-5 MW of installed capacity (Ruud 2013).
Solar power is also a contributor to off-grid power generation in the form of solar PV homes systems in rural areas, micro-scale solar Photovoltaics (PV) and micro-scale centralized solar PV stations. Solar home systems mainly consist of solar panels on the roof that supplies light and cell phone charging. Micro-scale solar PV, operates on small isolated grid systems that usually supply power to schools, small businesses, ground water pumps and a few households. Micro-scale centralized solar PV stations are areas that supply solar power and people can come to use computers, charge cell phones as well as other power consuming services. There is an estimated 40 MWP of micro solar PV operating in Tanzania (Ondraczek 2013).

As of 2013, 6 MW of solar PV are operating throughout the country, including the police stations, hospitals, streetlights, households and telecommunication (MEM 2013). Over 50 percent of the solar energy in the country is used to power homes in pre-urban and rural areas (MEM 2013). The GOT has been raising awareness about solar, through demonstration campaigns on how to use solar, for both domestic and industrial uses. This has helped to influence both solar installations and institutions (MEM 2013). The GOT has also removed Value Added Tax (VAT) and import taxes for solar components such as panels, batteries, inverters and regulators, which in turn has allowed end-users to buy solar for a more affordable price (MEM 2013).

2.3 Rural Energy and history with Solar Development in Tanzania

Tanzania is endowed with a multitude of resources, ranging from hydropower, biogas, natural gas, biomass, coal, wind and thermal energy. But due to the vastness of the country coupled with low population density in remote regions, it makes grid extension costly and hard to implement (MEM 2013). The average person per square kilometer is 51, with a maximum of 3,133 in Dar es Salaam and a low of 13 square kilometers in Lindi (Statistics 2012). Additionally less than 7 percent (2.2million) of the rural population in Tanzania has access to electricity (MEM 2013).

Electrification in Tanzania is among the lowest in the world, but specifically is one the lowest in sub-Saharan Africa. The average consumption per capita in sub-Saharan Africa is 552 KWP per annum and Tanzania is less than 100KWP per annum (MEM 2013). This is due to different factors: Unskilled staff, poor management, inadequate maintenance and unbilled and metered electrical consumption (Karekezi, Kithyoma et al. 2003). Considering the factors stated above, the government of Tanzania has made it clear that it aims to have a diverse and nonconventional approach toward rural electrification in order to meet the projected demand of 4,700 MW by 2025 and 7,400 by 2035 (MEM 2013).

Tanzania has had difficulty with its energy sector dating back as far as 1973 (Ondraczek 2013). This included a spike in gas prices, which caused energy to become less affordable. Transportation cost increased, agriculture suffered as a result of lack of transportation, and there was a rippling effect that influenced all sectors of society including, economic, social and environmental (Ondraczek 2013). As a result of this difficulty, it fostered a new phase of energy enlightenment.

Consequently, Tanzania along with Kenya, decided to seek more stable forms of energy that would not fluctuate in cost, like gasoline. The first solar initiative in East Africa began in Kenya (Ondraczek 2013). As a result of Kenya's initiative, and due to Tanzania geographical location in relation to Kenya, both began to shift to forms of renewable electrical energy. Tanzania's initiative in its early years was driven by the demand from schools, churches, health care centers, and other rural social institutions (Ondraczek 2013).

The initial structure of Tanzania's solar market structure has two sectors. Solar PV and Solar Thermal. Thereby there has been a consistent increase in the solar PV market over the past 40 years (Ondraczek 2013). The growth of the market is largely due to donor- funded programs of the government, as well as private investment and local Non Government Organizations (NGOs) that promote and aid in the development of solar markets throughout different regions in Tanzania.

Tanzania reached 40,000 solar homes in 2008, with an annual average of 4,000 to 8,000 new homes being solar electrified annually (Ondraczek 2013). In a survey from 2007, it was concluded that approximately 0.6-1.0 percent of rural homes are using solar energy as their main source of energy compared with the grid electricity, which is a two percent electrification of rural households (Ondraczek 2013). Though there is progress in the solar sector, there is still a need for more effort and initiatives started by the GOT, and the international investment community, to develop Tanzania's energy sector to combat energy poverty and deforestation.

2.4 Renewable and solar energy sector in Tanzania

As shown in the figure 4, Tanzania has a large amount of potential for solar energy. It has at its disposal 2,800 – 3,500 hours of sunshine annually and a radiation of 4 to 7KWp/m2 per day (MEM 2013). It is estimated that 27 GWh of electricity demand could be supplied via solar power. Solar PV fields of about 15,000 hectors (Ha) of land or 0.02 percent of Tanzania's land mass could theoretically supply 27 GWh of power. This is theoretically possible because Tanzania has already allocated over 25 percent of the country to be used for its sugar industry and national Wildlife reserves such as the Serengeti and Selous Wildlife and Game Reserves (UN-ICC 2005).

Tanzania has an abundance of renewable energy (RE) resources that are still dormant and are waiting to be exploited, for example, hydro, geothermal, solar, and wind. Roughly 4.9 percent of all energy generated in Tanzania is from renewable energy sources such as, captive generation in sugar, tannin and sisal factories, solar, and small hydro plants, excluding large hydro. The total goes from 4.9 to 40 percent with large hydro (MEM 2013). The plan for renewable energy in Tanzania is to increase RE (excluding large hydro) from 4.9 to 14 percent by 2015 (MEM 2013). The objective is to rely less on large hydro, due to it fluctuation as a result of drought and climate change. The growth of Solar PV has gone from 300kWp in the late 1990's, to 1.2MWp in 2003 to 3-4MWp in 2009 (Ondraczek 2013).

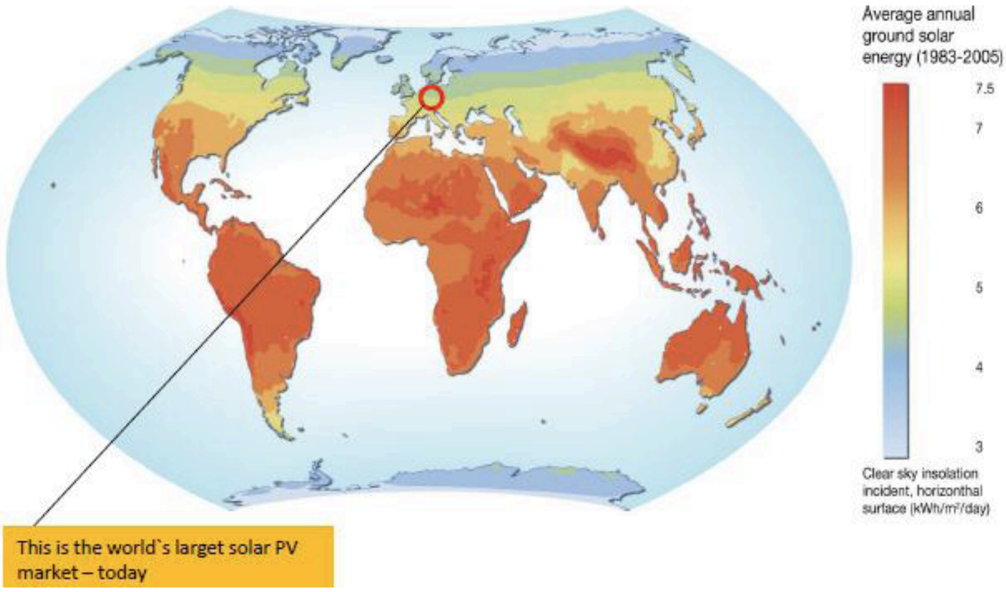


Figure 4: Global solar insolation map (B. T. Marissa Jackson Ræstad 2012) indicates the various levels of solar energy throughout the world.

This indicates that the solar sector is growing but still needs more assistance by the GOT through education and the creation of a RE policy, which may lead to further investment by the private sector. This investment in RE can help to facilitate rural electrification through out the country.

2.4.1 Different solar systems and characteristics

Table 5 displays the five main types of Solar systems. The stand-alone solar home, grid connected solar home, and the hybrid solar home etc. The table shows a general break down of various solar systems and their general capacity, from the systems life expectancy, energy capacity, price etc. It shows how certain forms of solar technology is suited for cities, while other solar is better for rural electrification, the chart explains why different solar technology is suit for different regions, battery capacity, size, connection to grid electricity and cost.

Table 5: Five main types of Solar systems, DOD- Depth of discharge (Kalogirou 2013, Ruud 2013)

Case assumptions	**Stand-Alone SHS**	**Grid connected SHS**	**Hybrid SHS**	**Stand-Alone solar farm**	**Large grid solar**
Sell power back to grid, Net Metering	No	Yes	No	No	Yes
Payback Time	5-10 Years	5-10 Years	5-10 Years	NA	NA
Access	Rural Areas	Central and Urban Areas	Rural Areas	Rural Areas	Central and Urban Areas
Estimated Life expectancy, 1.Solar panels, 2.Inverter and 3. DOD 20% Battery	1. 25-30 Years 2. 15 Years 3. 25 Years	1. 25-30 Years 2. 15 Years	1. 25-30 Years 2. 15 Years 3. 25 Years	1. 25-30 Years 2. 15 Years 3. 25 Years	1. 25-30 Years 2. 15 Years
Clean Energy	Yes	Yes	Yes	Yes	Yes
Reliable source of Energy	Optimal Daytime	Optimal Day and Night	Optimal Day and Night	Optimal Day and Night	Optimal Day
Upfront Cost	High	High	High	Very High	Very High
Easily Transportable and scaled up	Yes	Needs the grid	Yes	No	No
Most Utilized	Single HH	Single HH	Single HH	Community	Community, and helps power the grid
Solar Connected to Grid	No	Yes	No	No	Yes
Battery	Yes	No	Yes, but also uses other RE can supplement	Yes	No
Common Capacity	30-50KW	30-50KW	30-50KW	1000KW - 1500KW and More Depends of initiative	1000KW - 10MW and More Depends of initiative
Peak/Average Load	10/3-5KW	10/3-5KW	10/3-5KW	500/200-300KW	500/200-300KW

2.5 Stand alone solar home/ farm, SHS

The stand-alone SHS is a self- sustaining system that functions without being connected to an electrical grid, which is a interconnected network of supplying electricity from the producers to the consumers. Solar energy is the only energy used in the household (Ruud 2013). The stand-alone solar farm also known as the stand-alone solar PV system is an off grid system that is used mostly in rural areas without an electrical grid system. The Stand-alone station does not have a electrical substation (Ht Yard) to transfer electricity from the solar system to the electrical grid. These are the slight differences that differentiate between stand-alone stations and large grid solar farms. Also, most of the solar homes today are mainly used for energy efficient lighting with LED lights and limited TV and computer use. Figure 4 below displays the schematic of a SHS. The schematic shows two different processes. One is from PV array to Direct Current (DC) and the other is from the PV array which are sunrays that go toward the charge controller, battery storage, inverter and the then to the Alternate Current (AC) loads. This system shows the basics of the SHS, from sunrays to the current load, which represents the power source for various appliances.

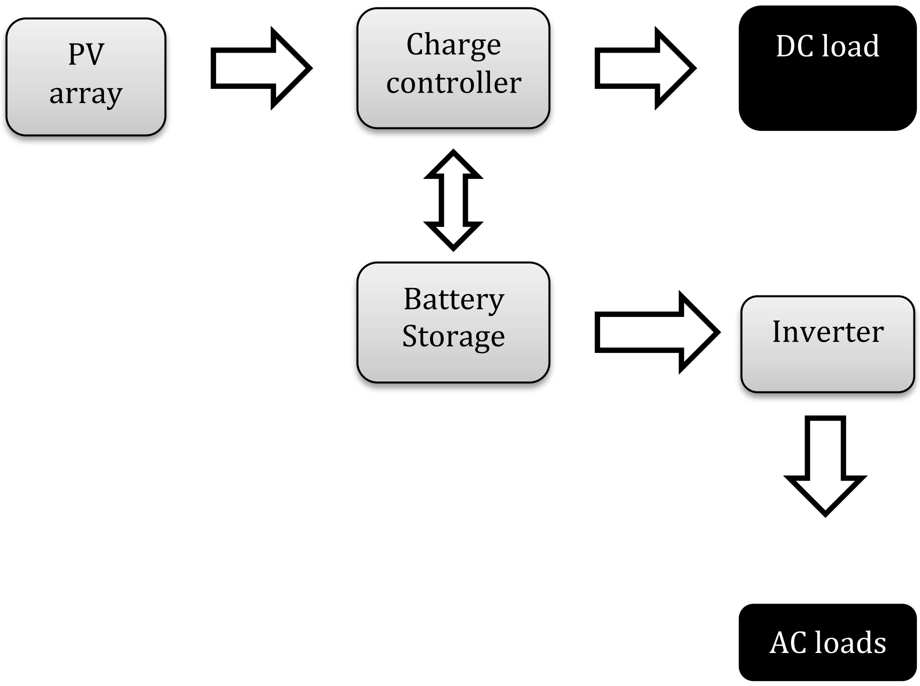


Figure 4: schematic of a SHS (Kalogirou 2013)

2.5.1 Grid connected SHS and Large grid solar

The grid connected SHS is a system that relies on both solar and the electrical grid to supply energy to the household. This system is best utilized in urban households where daytime electricity can be supplied via solar panels and night when solar is not optimal, excess electricity can be used from the grid (Kalogirou 2013).

Large grid solar's main purpose is to distribute electricity. Ht yard also known as an electrical substation, transforms voltage from low to high or the inverse. It also is the link to the grid, because it bridges electricity from the producer to the consumer and is the last stop before electricity is transmitted into the electrical grid. As well as the life expectancy of solar and convectional sources of energy, solar has an estimated life expectancy of 25 years while diesel powered generators, which are the main suppliers of off-grid electricity in Tanzania, are estimated to last 10-12 years(Ruud 2013). Further more, the grids in urban areas that are operating today do not have the capacity to adjust to power created from solar farms. Figure 5 displays the schematic of a grid-connected solar system. Power travels via PV arrays into an inverter or power conditioner then to a distributional panel, where it is distributed to AC loads or Electric utility grid.

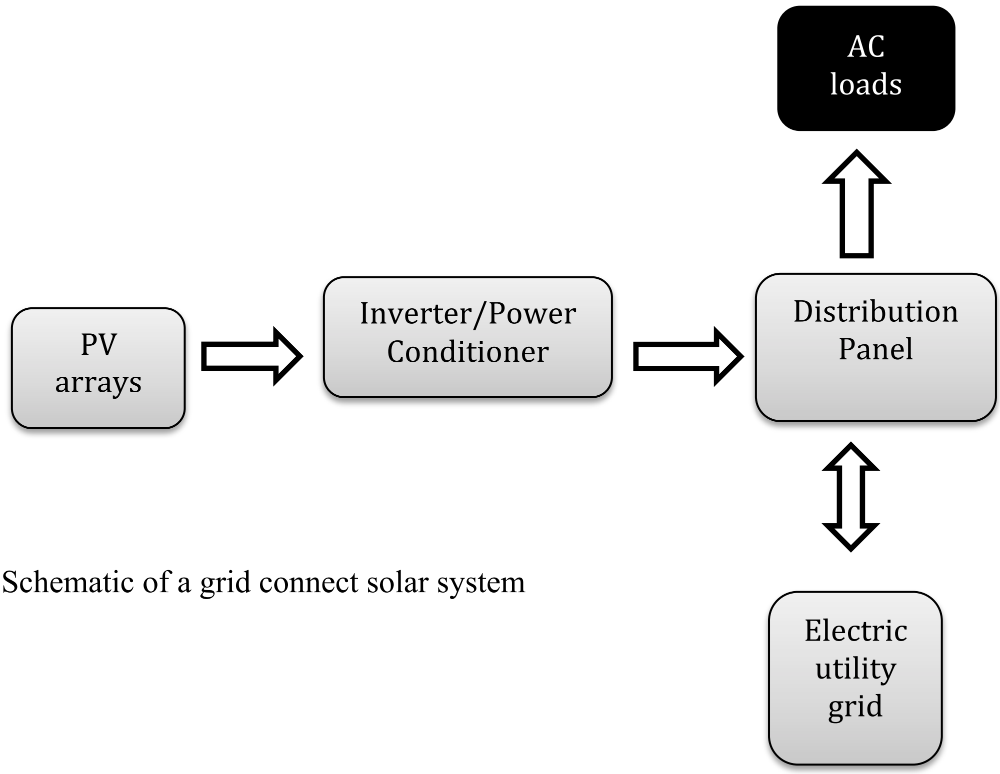


Figure 5: Schematic of a grid connect solar system

2.5.2 Hybrid SHS

The hybrid SHS is a recent breed of SHS. Solar is not the only source of power. The system is coupled with alternate renewable energy sources such as generators that use biofuels. Wind and biomass to be used during night and or evening when solar is not an optimal option. Figure 6 displays the schematics of a hybrid system, which shows that energy can enter the system via PV or an alternate sources of energy such as wind or a generator and then flows through the system via a rectifier or directly to AC load.

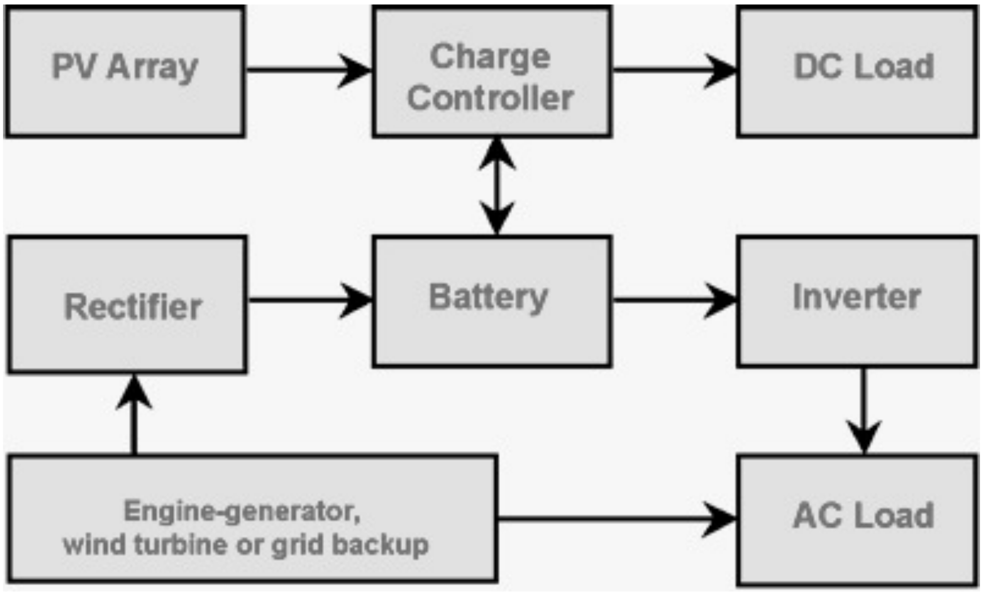


Figure 6: schematics of a hybrid system

2.6 Renewable solar energy stakeholder

2.6.1 National Institutions

The Ministry of Energy and Mineral (MEM) functions as an institution that was created to develop and manage both the mineral and energy sectors in Tanzania. Its responsibilities are to formulate policies that will create an environment that facilitates stakeholder interest and or investment, as well as the promotion of renewable energy. The MEM acts as a complementing organization to the entire mineral and energy sector. Because of its role as policy maker, it operates as the brain and conscious driving force of any initiative, and the overall direction of the mineral and the energy sector.

Figure 7 is the structure of Tanzania's electricity Industry. The figure shows the structure of the electrical system from the top with MEM, and ending with the consumer. The figure also displays and how each part of the structure is linked.

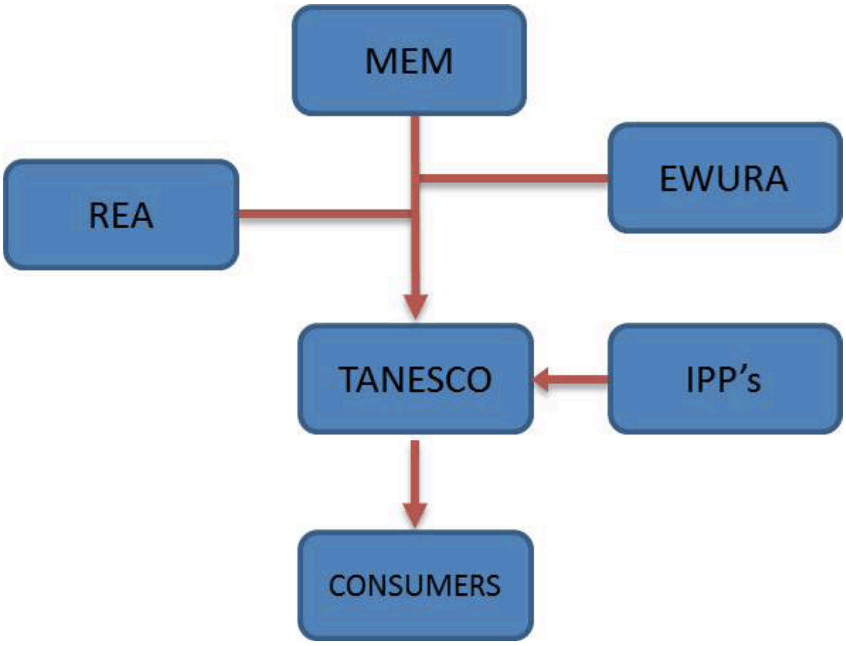


Figure 7: Structure of Tanzania's electricity Industry (Kihwele, Hur et al. 2012)

The MEM complements Renewable Energy Agency (REA) through its role as a policy monitor and promoter of rural electrification and development of the country's off-grid sectors. It influences TANESCO's development as the country's main supplier of electricity through the policies it creates, and through acts that are implemented to help TANESCO with electrical production such as Independent Power Producers (IPP's) and Small Power Producer (SPP's). These are usually small private companies that sell generated power to TANESCO or directly to consumers. Lastly, EWURA is basically a condensed and concentrated version of MEM. Through the guidance of MEM, EWURA aids in the development of the energy sector in Tanzania by working as a regulatory system. It Oversees contracts, non-negotiable tariffs pertaining to private renewable energy projects for rural electrification (MEM 2013).

The EWURA "is an autonomous, regulatory authority established by the Energy and Water Utilities Regulation Act" (MEM, 2013, p.37). The main focus of the Act is to provide technical and economic regulations for electricity, natural gas, petroleum, and the water sectors in Tanzania (MEM 2013). It has also helps to create the SPP program which "is a system of regulations, standardized contracts, and avoided cost–based non-negotiable tariffs pertaining to private small (under 10 MW) renewable-energy power projects to supply the TANESCO grid and enable these entities to supply electricity directly to isolated rural communities (MEM, 2013, p.36).” As a result of EWURA regulations and tariff system, it enables private sector investment to both grid projects and isolated grid projects, currently nine Small Power Producers Agreements (SPPAs) have been made with TANESCO aiding in the sectors development through investment. Tariffs for SPP are undated every year based on TANESCO’s avoided cost (MEM 2013).

REA was created in 2007 as an autonomous body under the MEM (MEM 2013). There are a variety of objectives that REA promotes, but rural electrification, and improved access to modern energy resources in rural areas in Tanzania is their main objective. Through the objectives stated above REA intends to support rural economics, social development and the production and use of energy in a sustainable manner. The GOT helps REA with funds and contributions from surcharges on grid electricity, developmental partner co-finances, and the private sector (MEM 2013). REA aids with the financing of eligible rural energy projects through Renewable Energy Fund (REF) and acting as an overseer of the production and review of applications for funding. “It also states guidelines, selection criteria, standards, terms and conditions for the allocation of grants, building capacity, and provides technical assistance to project developers and rural communities” (MEM, 2013, p.37)

The GOT has been vocal in trying to raise awareness about the benefit of renewable energy both at the domestic and industrial level. It has also gone as far to add Value Added Taxes (VAT) and import taxes on various solar parts; panels, batteries, inverters and regulators. It also gives support through REA by adding solar market packages for facilities and households. REA has been establishing schools and vocational training institutes for maintenance repairs and design of solar energy. Also, REA is funded by a grant program, which supplies electricity to rural areas in Tanzania. These programs are linked to private enterprise, which develop modern solar lights for schools, clinics, businesses and households.

Oikos East Africa NGO’s main objective is to install solar PV systems in primary and secondary schools in Ordonyo, Sambu, and Narenanyuki wards in the Arumeru district of Tanzania. Tanzania Renewable Energy Association (TAREA) is a NGO based in Tanzania and their main objective is to bring together actors in the RE sector to promote RE and rural electrification. TAREA is also one of the main organizations in Tanzania pushing for a RE policy, to further develop the RE sector (TAREA 2012). Millennium Challenge Corporation (MCC) is installing 45 solar PV systems in secondary schools, 10 in health care centers, 120 in dispensaries and municipal buildings, 25 in villages market centers, all of which have no access to electricity in the Kigoma region (MEM 2013). Swedish International Development cooperation Agency (SIDA) and UNDP are joining with business developments in 16 regions. Technical and market training is given to solar retailors as well as technical and vocational school instructors. This also includes networking among solar industry stakeholders, policies and institutional support. The European Union (EU) is funding 15,000 solar homes through association's members in the Lake Victoria region with micro financing from Stanbic Bank of Tanzania and subsidy from REA (MEM 2013).

Through REA and other donors, the GOT has been financing various solar PV programs throughout the country, as a means of targeting areas that are off the grid. The purpose is to generate solar energy that is lower in cost and more environmentally friendly than electricity from generators and kerosene. REA through SSMP provides solar electricity to public facilities and households. Currently 80 villages in the Rukwa Region are under development through SSMP and 5 more regions and 8 districts are scheduled for development (MEM 2013).

REA has also established vocational education centers as a means to provide training for systems design, maintenance, repair and installation (MEM 2013). Also connected to REA is the Lighting Rural Tanzania Grant Program, which supports private enterprises developing and transporting a variety of solar lighting products to rural communities, businesses, hospitals, clinics, and rural households (MEM 2013). REA also supports programs that specifically supports women's energy needs, through education and training projects. Oikos East Africa is an NGO that helps to install solar PV in both primary and secondary schools as a means to promote the use of RE. (MEM 2013). The NGO is located in the Oldonyo Sambu and Nagarenanyuki ward in the Arumeru distict. The EU has financed 15,000 solar homes with micro-finance loans, through association members in the Lake Victoria region, consisting of Standic Bank, and subsidies from REA.

The Millennium Challenge Corporation is installing solar PV systems in 10 health centers, 45 secondary schools, 120 dispensaries, municipal buildings and businesses throughout 25 village market centers that are without access to grid electricity in the Kigoma region, through the SSMP method (MEM 2013). SIDA and UNDP provide help in the growth of business services to 16 regions throughout Tanzania. The services include training and marketing for solar dealers, technicians and vocational school teachers. They specifically facilitate networking with solar industry stakeholders, policy and institutional encouragement, as well as national quality standard control.

2.7 Financers of Tanzania's energy sector

The financial system in Tanzania has 20 different commercial banks that get support for development partners (MEM 2013). The World Bank has a credit line of 23 million USD with Tanzania Energy Development and Access Project (TEDAP). The credit is supervised by the Tanzania Investment Bank which finances renewable energy in Tanzania and have already financed two mini grids from the credit line (MEM 2013).

TANESCO receives public sector financing from the GOT, by way of multilateral and bilateral donors (MEM 2013). TANESCO also borrows from banks in the commercial sector for working capital. " IPP, Emergency Power Producer (EPP's), and, Small Power Producer (SPP's) are companies that are independent, both in equity and debt, with some of it sourced externally. SPP's have access to the Tanzania Energy Development and Access Program (TEDAP) credit line " (MEM, 2013, p.37).

Support is provided to the GOT via development partners, who offer assistance in coherence with the country's policies and strategy for the development of the energy sector, including RE. The current commitment by GOT's energy partners are 1.5 trillion Tanzanian Shilling (TZS) (US$ 1 billion), specifically the Developmental partners who allocates 350 million USD out of the 1 billion USD (MEM 2013). The UNDP is also involved in the development of Tanzania's energy sector by providing technical support through the analysis of financial gaps that hinder the achievement of three intertwined objectives of their “Sustainable Energy for All” initiative for 2030. The three objectives are “Universal access to modern energy services, doubling the global rate of energy efficiency, and doubling the share of renewable energy in the global energy mix” (AGECC 2010).

NORAD, SIDA, and the United States Agency for International Development (USAID) are expecting to provide support and or funds for the development of the RE sector, through allocating funds for the specific purpose of rural energy and renewable energy (MEM 2013). Agence Francaise de development (AFD) has created a 20 million euro credit line to be accessed through domestic commercial banks for both rural energy and renewable energy development (MEM 2013). UK Department for International Development (DFID) and The EU are contributing as well, DFID through a 30 million Euro soft loan to Tanzania, which is a loan with a below market interest rate. The EU is helping to develop Tanzania’s energy sector through the financial support of 5 mini grids and the possibility to scale up the initiative (MEM 2013).

2.7.1 Tanzania’s investment environment

Foreign direct investment (FDI) increased as Tanzania opened up to the world economy as a result of the deregulation of its economy following the end of Nyerere’s term as president of Tanzania. This benefitted Tanzania in terms of development from the private sector (Bigsten and Danielsson 1999). Tanzania has been transformed from having very little foreign investment in the 1980’s to 250 million USD in 2003. Only Uganda has more investment than Tanzania in East Africa (Modi, McDade et al. 2005). Sectorial distribution, in which FDI is focused, includes mining 39 percent, manufacturing 22 percent, tourism 13 percent, agriculture and paltry 7 percent. The percentage of FDI in terms of regions are as follows: 40 percent of mining is in MWanza, Shinyanga and Mara, 36 percent of capital investment is in Dar es Salaam and 24 percent is in agriculture and tourism in Arusha, Morogoro and Iringa.

2.7.2 Tanzania’s investment policies

A new energy policy was created in Tanzania in 2003, and its main objective is to ensure energy that is reliable, affordable and available to all its citizens including urban, pre-urban and rural (MEM 2013). It also ensures that energy is used in a sustainable manner that supports the country's development goals, which are to develop Tanzania to a middle-income country that respects the environment and meets the needs of its citizens. Tanzania's investment policy is also conducive to creating a market-based economy that is moving away from a centrally planned economy (Modi, McDade et al. 2005). They include the following;

- Unrestricted right to international arbitration in the case of disputes with the Government (MEM 2013)
- Import duty drawbacks on raw materials
- Zero-rated VAT on goods manufactured for export
- Straight-line accelerated depreciation allowance on capital goods
- Unrestricted right to repatriate profits and capital

2.7.3 Energy policy description and objectives

Different objectives of the energy policy stated by (MEM 2013)
Enhance the development and utilization of indigenous and renewable energy sources and technologies.
Adequately take into account environmental considerations for all energy activates.
Increase energy efficiency and conservation in all sectors.

Key points in the policy
Private sector participation, through the development of a market economy for energy development
Establishment of regulation regimes such as financial regimes to regulate the energy sector

The development of domestic energy sources and economic energy pricing can be used as a catalyst to a more effective and efficient energy sector. This allows the GOT to utilize its own resources, which can drive down the cost of energy as well as the carbon footprint added by importing and using foreign oil. Economic energy pricing can also create a more realistic view as to the cost of electricity in relation to the price of crude oil or hydropower. This reduces the reliance on the GOT and prevents it from being used as a crutch to aid the energy sector in the event of fluctuating in energy prices.

Furthermore, the encouragement of private sector participation in energy markets is at the forefront of the energy policy. Tanzania is a free market economy and in order for the sector to reach its full potential, investment is vital. But investment needs regulation and the GOT has expressed that it plans to have the proper regulatory regimes in place to monitor and aid the development of the sector. Regulatory regimes are a system of rules and the capacity to enforce those rules; Regulatory regimes can aid the energy sector and the country in many ways. One way is by providing rectification for unbalanced gender impact from inferior energy services, as well as allowing for more transparency by having a clearer financial sector and a more balanced revenue generation and cost service (MEM 2013).

The Rural Energy Act of 2005 paved the way for the REA. The Act created a rural energy board, fund and agency, which is responsible for the promotion and development of rural electrification in Tanzania. The funds provide grants to TANESCO for rural grid extension through investment. It also develops rural energy projects from other organization besides TANESCO. The electricity Act of 2008 created a general framework for MEM and the EWURA to work, by creating boundaries for EWURA’s tariff system, through the provisional and permanent licensing system (MEM 2013). The Act also created parameters for EWURA’s monitoring, enforcement, rural electrification strategy, ministerial plans, resolutions procedures and the possibilities for reorganizing Tanzania’s electricity sector.

PPP Act no.18 of 2010, created a framework of rules, obligations and regulations in which the public and private sectors can engage specifically in Tanzania’s energy sector. The framework consists of penalties, financial management, dispute resolutions, control requirements, remedies, and assistance from public parties. “The Act also created the PPP Coordination Unit within the Tanzanian Investment Centre, and a PPP Unit in the Ministry of Finance” (MEM, 2013, p.16). Also, the Environmental and Land Policy, legislation influencing renewable energy development, of the Environmental Management Act 204; National Land policy, Ministry of Lands and Human Settlements Development of 1997, and the National

Environmental Policy of 1997 (MEM 2013). These are a variety policies and legislation that have impacted the renewable energy sector in a positive manner, and given the sector direction and a foundation.

2.8 Devergy approach

The Devergy Approach was created in South America to address the energy problems existing in developing countries. Established in 2008, Devergy's main objectives are to provide sustainable energy that is environmentally friendly and accessible to people with low income. The Devergy Company provides energy that is socially acceptable by villagers. Their approach provides energy to rural communities that may be located in difficult to access areas that are economically unstable. It gives them an opportunity to gain access to electrical energy that they approve. Many of the rural communities that Devergy provides energy for, have been marginalized, for economic, social and political reasons, such as low budget, lack of social organizations and little political influence (Devergy 2010).

The Devergy approach is a communication-based approach that entails research on the community before the development and implementation of the electrical energy resource. The research is done in order to understand the economic, social, and political situation. Additionally, Devergy wants to understand if electricity is available as well as desired and if it is within the company's budget to provide the resource based Cost Benefit Analysis (CBA). The Devergy team holds village meetings before installation and insists that all villagers, elders, and leaders are present. They have an open dialogue about the resource and whether or not they want it, how much it will cost, and the nature of the energy resource.

"Devergy's energy service is based on village – sized energy micro grid, which provides solar power to households and businesses. Users can connect lights and appliances such as radios, TVs and refrigerators (Devergy 2010)."

Access to the resource is not based on literacy, gender or community status, it is based on the individual's finances. Devergy aims to combat climate change, environmental destruction, and energy poverty. Devergy believes that through providing electricity in a sustainable manner, they can empower people with low income as they develop from energy poverty to energy sustainability.

The Devergy approach is non-conventional in the sense that it is a modern electrical company existing in a rural setting with a modern form of electrification. Villagers are a part of the project in terms of decision-making. They decide whether or not they would like to have the resource, but in terms of ownership and management responsibilities, Devergy is in control (Devergy 2010). After Devergy has communicated with the village elders and community, the nature of the resource is further explained. The KWP cost and the down payment price that is needed for installation is negotiated. This ranges from US$ 6 -12 dollars. Devergy will then proceed with the installation of the resource.

What make the Devergy approach different from SHS

Table 6 Compares the Devergy approach with SHS, the table gives a comparative description of the two and describes topics that are relevant to rural communities such as cost, standards, ownership etc.

Table 6: Devergy approach Compared with SHS (Devergy 2010, Ruud 2013)

Characteristics	Devergy Solar Approach	Solar Home System
Initial Capital Investment	10,000TZS	5,000-10,000TZS
Payment Plan	No payment plan, pay as you consume	Ranges 5-15 years, 5,000TZS per Month
Ownership	No	Yes
Accessibility	Easy, once Devergy is present. Villager can request Solar resource, But Villager must live within the Radius of 20 meters to 4 houses	Various Depending on location of Solar Market and Capacity and funds, Also Solar markets located in Big cities and Towns
Top Down /Bottom Up Approach	Bottom up	Bottom up, individual Capacity and initiative
Lights- Separate/ Included	Included	Bought Separate
Long/Short Term Benefit	Short term	Long Term
Community/Single	Community, 5HH Solar system	Single
Installation	Included	No Included
Hindrance- Under Developed Markets, Spare parts	Spare parts taken care of, resource no dependent on Tanzania Solar Market	Dependent on Tanzania Solar Market, Spare parts not taken care of.
Solar Standard in Tanzania	Not hindered	Hindered By Standards In Tanzania
Maintenance	Included, Solar engineer	Not Included
Solar panel, Inverter, Battery and wiring	All included	Must Purchase, all together or separately
Clean Energy	Yes	Yes

Figure 8: Devergy metering device

Each house that is connected has a power meter, as shown in the figure above. The meter shows how much energy the household is consuming and when the energy will be depleted. Also, each metering system is connected via satellite to Devergy's management center.

Devergy's management center works directly with engineers that are located in various villages that the company supplies. The engineers that work for Devergy are also locals within their community. They are given formal training by Devergy's staff of official engineers in Dar es Salaam, on how the system works, and how it should be set up and repaired. By providing individuals in the community with solar engineering training, Devergy aims to employ and empower, by providing low-income communities with jobs and training that can aid them in the present, as well as in the future. Devergy pays the engineers a base salary and they operate within the community as representatives for the company as well as workers. Currently there are 15 employees both men and women working in the Devergy energy company, which are empowering both genders.

2.8.1 The Devergy Solar System

Figure 9: The Devergy solar system

The Devergy approach is a mixture of the individual SHS approach and a small grid system. The core of the system is similar to that of a SHS. It has a solar panel that transfers energy to an inverter that sends energy directly to the household or is stores via a battery. The key factor that separates Devergy from a SHS, is that it connects a maximum of five households to one solar resource instead of one solar system for one household. Also, Devergy maintains and repairs the system thus adding another dynamic to their approach. The Devergy approach has found a balance between individual solar households and the large solar grid system.

Figure 10: Devergy 7watt light bulb

Devergy is trying to provide people with low-income a solar energy resource, without the task of the individual having to understand the technology and maintenance. This also eliminates individuals having to search for loans or finances that they may not have. Devergy requires an initial payment of 10,000 Tzs (US$ 6 to 12 dollars) to receive instillation with a metering system, and 2, 7 and 11-watt light bulbs. The criteria requires that you are located within 20 meters of the nearest solar electrified home. Devergy's payment system mirrors that of telecommunication companies in Tanzania. After the resource has been installed, the consumer is able to buy vouchers from local stores or Devergy engineers within the village. The vouchers allow the consumer to gain access to the benefits stream (solar electricity) for a certain amount of time depending on the cost of the voucher. The smaller the voucher, the less access there is to the benefit stream. The consumer pays for as much solar energy as they can afford.

2.8.2 Devergy Technology specs

Table 7 gives an exact description of Devergy's solar resource, from its maximum power at 30-Watt Peak (WP), to its optimum operating power at 17.5 (VMP). This table allows for the Devergy solar resource to be looked at within the context of Table 1 & 2, which looks at rural communities in Tanzania's appliance desires and how much each appliance consumes in terms of energy.

Table 7: The Devergy System Solar Panel 30W-12V Ploy Crystalline

STC- Standard Test Conditions, V- Voltage, A-Current W- Max (energy 2014)

STC: Irrandiance 1000W/m Am1.5spectrum	**Module temperature 25 °C**		
Maximum Power at STC	Wp	30	W
Optimum operating Voltage	Vmp	17.5	V
Optimum Operating Current	Imp	1.72	A
Open Circuit Voltage	Voc	22.5	V
Short Circuit Current	Isc	1.85	A

Also, table 2 looks at the amount of energy consumed in a rural setting on a daily and monthly basis, and from this, the viewer is able to see how much energy Devergy is able to supply in comparison to the average consumption of rural HH.

Table 8: The Devergy System Solar Panel 30W-12V Ploy Crystalline NOCT:

Nominal Operating Cell Temperature (data only for references) 45$\pm$2 °C (energy 2014)

Temperature Coefficient of Pm (%)	-0.47/°C
Temperature Coefficient of Voc (%)	-0.34/°C
Temperature Coefficient of Isc (%)	0.045/°C
Operation Temperature	-40°C to 85°C
Maximum System Voltage	600VDC
Power tolerance	>0%
Surface Maximum Load Capacity	60m/s (200kg/sq. m
Warranty on Electrical performance	10years 90% +25years 80%
Product Warranty	2years
Number of Cell in the series	36

Table 8 shows the basic functions of the Devergy resource, from it optimal operating temperature, to its warranty and the number of cells per series.

3 Research questions

3.1 Research questions and objectives

What is Tanzania's national policy on renewable energy and does it help or hinder the solar sector?
What are the drawbacks of the Devergy approach in relation to villagers?
What are the benefits of the Devergy approach in relation to villagers?
What can be done to scale up the Devergy approach and its renewable solar energy, and to improve livelihoods in Melela, Tanzania?

3.2 Objectives

To discuss the benefits and drawbacks of the solar mini grid in Kololo village in Melela, Tanzania
To discuss the potential for scaling up the solar mini grid for improved livelihoods in Kololo village in Melela, Tanzania
To discuss external influencing factors such as a lack of a renewable energy policy, low standards and insufficient investment in the energy sector on Devergy's approach and solar technology

3.3 Thesis Outline

To answer the research questions and to address the specific objectives, research was conducted on how solar is utilized and managed. Research was conducted at the household level, and looked at villagers that invested in the Devergy approach, and those that did not. Also assessed, was the impact of how policies and investment at the governmental level could influence the Devergy approach at the household level. Lastly, the research focused on the economy of different households; those with and without the approach, opinions on the solar approach and how to scaled it up in order to improve the livelihood of all villagers and to help combat energy deficiencies in Melela and in the broader context, Tanzania.

This study begins in an abstract manner then becomes more concentrated. This is done to allow the reader to gain a full understanding of the approach taken toward answering the research questions and objectives. The contextual background will present the layout of Tanzania, its energy deficiencies and status, the subjects involved, and the different measures that have been taken to supply energy. This will be presented in chapter 2. Chapter 3 will focus on research questions, chapter 4 the methodology, theoretical framework and description of the areas studied. Chapter 5 will show the results. Chapters 6 and 7 will be the discussion chapter, and conclusion and recommendation.

4 Research Methodology and Methods

This research paper is based on three and a half months of field research in Melela, Tanzania. The research followed a qualitative and quantitative approach. The quantitative approach consisted of focus group discussions and household questionnaires.

Figure 11: Map of Tanzania, Circle points at Melela, (Map 2014
)

The questionnaires were designed to meet the needs of each individual approach. Direct observation combined with literature from the Devergy website, was used as a secondary data source for data collection. The design of the research was kept under constant analysis, as the study progressed and as it grew it was continuously reassessed.

A mixed method approach was chosen in order to cross check the research. By cross checking the approach with both qualitative and quantitative data, the research has a strong basis due to the ability to triangulate between the two sets of data.

4.1 Study Area/ Setting

Figure 12: Map of Morogoro and surrounding regions, Circle points to Melela

Mvomero is 1 of 6 districts in the Morogoro region in Tanzania, and has a solar electrification ratio of 4.5 kWp(m2 day) (Hammar 2011). The village of Melela is located in the Mvomero district.

4.1.1 Aerial shot of Melela, Tanzania

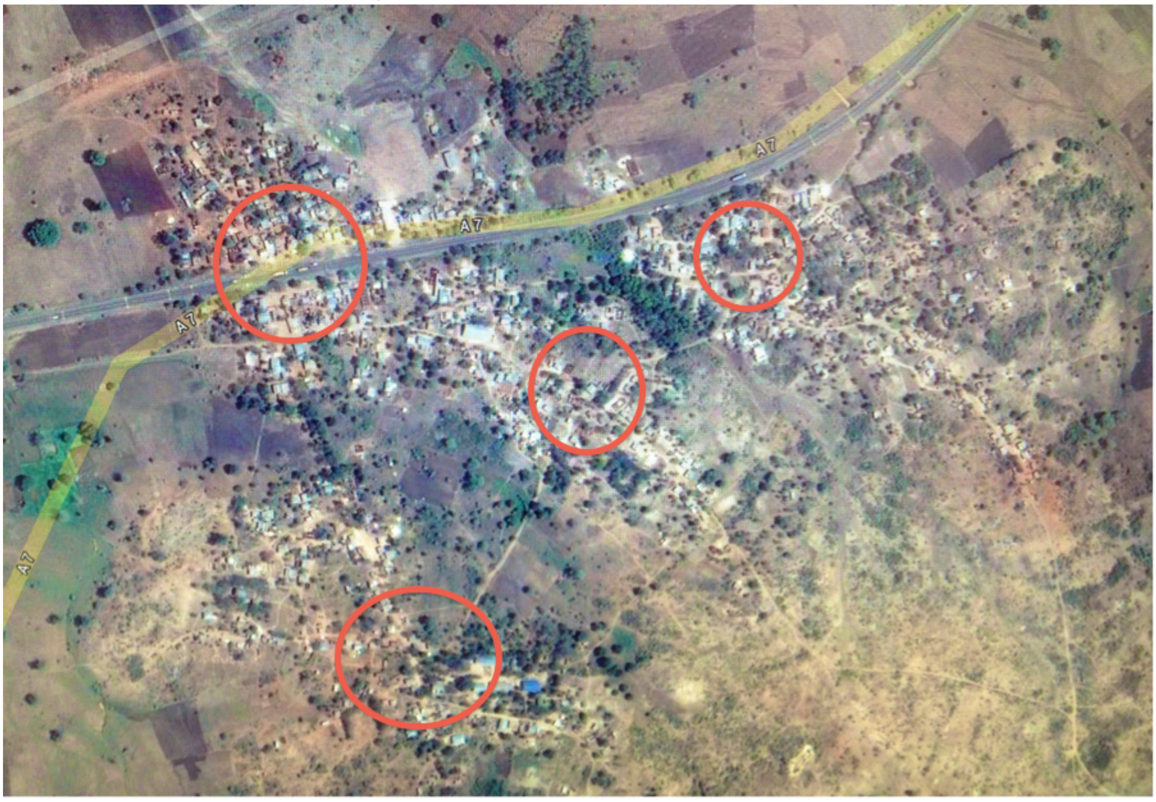


Figure 13: Aerial shot of Melela, Tanzania circles indicate high concentrations of house

The Mvomero district is a rural area in Tanzania and farming is the primary income generator. There are 19 sub-districts within the Mvomero district. The Mvomero district is approximately 11,731 sq kilometers and is 16 percent of the landmass of the Morogoro region (NBS 2013). As of 2012, the total population of Mvomero district council is approximately 312,109 which is 15 percent of the total population in the Morogoro region (NBS 2013).

Mvomero is moderately populated and has a population density of 37.9 people per sq. kilometer as opposed to 95.8 people per sq. km in Dar es Salaam (NBS 2013). There are 100 villages in the Mvomero district, each of which has an average population of 2,805 (NBS 2013). Out of the estimated 312,109 people that live in the district, there are 61,653 households and an average of 4.3 people per household (NBS 2013).

The village of Melela is a village in the Mvomero district. The village was selected due to a variety of factors. This includes potential solar radiation and the presence of the Devergy solar technology and company. The Devergy energy company has solar electrified 200 households in the village of Melela. The company was selected as a case study to look the benefits and drawbacks of their approach on the lives of villagers.

Before any research was undertaken, all stakeholders were informed about the nature of the study, to see if locals would cooperate with research being done in their village. The Devergy energy company was also informed of the nature of the research and they were in full cooperation with the research and its objectives. Upon receiving full cooperation by all stakeholders and observing the potential for informative and effective research in Melela, the decision was made to engage the community and complete the objectives of the research.

The research site was chosen because Devergy and their solar resource were there. The findings of this research can give insight into Devergy's solar mini grids and whether or not they have a positive or a negative impact on people's lives. This can possibly be useful in the future to aid Tanzania with its current energy issues.

4.2 Sampling Methods

Stratified random sampling was used on households with and without solar to assess the Devergy approach. This particular method was used to ensure that the local villagers in Kololo, who were the primary target population, were given an equal opportunity to be a part of this sample. Stratified random sampling ensures that the group under examination is represented in the sample. The population is split into two subgroups and independent samples of each are chosen (Bruce L. Berg 2012).

Local villagers were identified for focus group discussions FGD's as well as household questionnaires, with the help of key informants such as the Devergy engineers and village leaders, who were based in the village. The other method used was Purposive Sampling known as Judgmental sampling and falls under nonprobability sample. Researchers use special knowledge about a group to identify subjects the represent the population (Bruce L. Berg 2012). This approach was chosen because there were already specified key informants that were targeted for research, such as REA, TANESCO, Melela Village government, and participants in the focus group discussions.

These two different methods were chosen as a means to cross check data taken from focus group discussions on the benefits and drawbacks of Devergy's solar nano grid in Melela, to see if the data coincided with the HH questionnaires. The aim of approaching the data in such a manner is to create a stronger full body of research due to triangulation and the various perspectives on focused areas of the research.

Table 9: Description of data collection

Quantitative and qualitative interviews conducted during field work		
Quantitative HH interview	Key Informant Interviews	FGD Interviews
80	7	3

4.3 Data collection

Data collection consisted of qualitative FGD's, in-depth interviews and quantitative household questionnaires. Both methods used in the data collection process are explained in further detail below.

4.3.1 Key Informant Interviews

Key informant interviews were taken with; TANESCO, REA, Devergy energy company, Village engineers, and solar business owners. Key informant interviews are a form of qualitative interviewing that allows for first hand knowledge of a community or specific topic (UCLA 2014). Key informants are not necessarily gatekeepers, but they may have specific knowledge that cannot be accessed via FGD's and HH interviews. For example, it was used to gain insight into the inner workings of the Devergy energy company, such as how it was created, and the effects of Tanzania's lack of a renewable energy policy on the company's growth. It was necessary to interview the founder of the Devergy energy company and other top ranking officials, such as Devergy's solar engineers.

These interviews were conducted in order to understand the context in which solar exists within the village of Melela, as well as to understand the external context that affects Devergy's solar energy in that village. This includes governmental policies, investment in the sector, and TANESCO grid electricity. The village leaders and solar engineers made it possible to arrange talks with the Devergy CEO, organize FGD's and created an environment of acceptance within the Melela village. This in turn made it possible to be able to administer stratified random sampling, by providing lists of villagers that met the necessary requirements, including electrified and non-electrified households.

4.3.2 Translator and Questionnaires

Translators were hired to assist with the data collection in Melela, TANESCO, REA, Devergy and solar business owners. They were also selected based on work ethic, ability to speak both Kiswahili and English, as well as prior experience in the field. Translators were given a thorough description and training on how questionnaires should be filled out and administered in a manner that was ethical, culturally sensitive, gender sensitive, and still met the objectives of the research.

Various discussions about the aim and evolution of the research took place between the translators and myself. By allowing discussions, the research team was able to benefit from the sharing of ideas. Certain questions that were not clear to the translators and might not be clear to villagers were changed or reworded.

After training and discussions took place, the research team administered a trial test in which villagers in Melela were provided with the research questionnaire. From that trial, the research team was able to identify potential issues regarding the translators administration of the questionnaire, and were subsequently able to detect questions that were either not applicable or redundant. As a result of the trial, the research team was able to make the changes necessary to move the research forward in an effective and efficient manner.

4.4 Household Survey

HH questionnaires were conducted in Melela. They consisted of both closed ended questions that were exact, there by limiting the participant's response and open-ended questions that allowed respondents to express their own interpretation of the answer. This gave the data a broader range by having two types of questions and answers. The aim was to allow the facilitation of triangulation, and many questions were reworded in order to check for consistency. HH questionnaires were meant to create insight into the household's composition, energy consumption, assets, family members, jobs description and income. 80 questionnaires were administered, 40 to households that were electrified by solar and 40 to households without solar electrification.

4.4.1 Focus Group Discussions

FGD's were administered in Melela as a means of gaining awareness into the villager's perception of the Devergy solar technology, and to understand whether they would continue to support it or not. Most specifically, the aim of the FGD's were to assess whether the Devergy approach toward rural electrification was working in a manner that was beneficial to villagers with solar electricity. Only villagers with solar were interviewed via FGD's because the objective of the research paper is to look at the benefits and drawbacks of Devergy's approach. Without solar electricity, participants would not be able to answer key questions and so were not selected on that basis. Three focus group discussions were administered in Melela. Two groups were mixed gender, including both men and women and one with only women.

Originally, the objective was to administer six focus group discussions, but only three were administered due to villagers being out in the field planting and preparing for the coming rainy season. FGD's also focused on investment issues including the villager's background knowledge about investment its effects on their community, specifically in solar energy. In every FGD there was a female moderator who spoke both Kiswahili and English. She was in charge of making sure no one spoke out of turn and dominated the discussions. All participants sat facing the enumerator and researchers. As each participant spoke, the enumerator provided follow up questions and translated what was spoken from Kiswahili into English, so the data could be collected.

Some of the hindrances and biases are based on culture or gender roles. This may have taken place where there were women in the presence of men, women may have been less vocal about their opinions on Devergy's solar electricity. Also the villagers could have been under the belief that the research team was from a competitor energy company or TANESCO. They may have felt compelled to say negative statements against Devergy in order to express that they wanted grid electricity. The results of the focus group discussions were used to triangulate the quantitative data collected via HH questionnaires.

4.4.2 Key Informant Interviews with the Devergy founder and solar engineers

In-depth interviews were conducted with the co- founder of the Devergy energy company and their field engineer based in Melela. The first interview was via telephone and the objective of the first interview with the co- founder of the Devergy energy company was to understand more of their approach toward rural electrification and the external factors that they face as an energy company operating in Tanzania. The second interview was in Melela with the village solar engineer. It provided a more basic understanding of the objectives of the company and the engineer's interpretation of the benefits and the drawbacks that villagers face as a result of the Devergy approach.

4.4.3 In-depth Interviews with government offices and private business owners

TANESCO, Morogoro and Dar Salam and REA were also interviewed. These governmental agencies gave the research a context in which it categorized each of the renewable energy sectors benefits and limitations, as well as the potential for the sectors to expand and overcome their various issues. The various limitations of the sectors were addressed, including the reasons why these limitations existed.

4.4.4 Direct observation

Direct Observation is when the researcher observes a community, people or a situation instead of trying to be immersed in it, as in participant observation (Bruce L. Berg 2012). In direct observation the researcher does not become an active participant in the context, but observes the context of the situation from an unobstructed point of view (Bruce L. Berg 2012). While conducting fieldwork in Melela for three and a half months and traveling extensively throughout Morogoro and Tanzania, this experience provided me with the opportunity to comprehend the context in which the current energy situation exists in the rural communities, and major cities and towns.

The development and livelihood of certain groups of people in relation to their access to electricity was also important to the research. My direct observation explained the relationship between energy, development and limitations of the government energy company to provide electricity throughout the country, but especially within rural areas.

4.5 Data analysis

In total, 80 household surveys were coded and entered into the statistical computer software known as (SPSS) statistical method, and excel. The quantitative data will be presented as a display of what the field looks like from a statistical perspective. The data will be given a context, which will allow the reader to understand the various points presented in the quantitative data. The quantitative data will then be used to cross-examine the data collected from the qualitative FGDs via tables, graphs and bar graph as means of triangulation to strengthen the data.

The radar chart displayed in the quantitative section of the data is based upon the sustainable livelihood approach. It is based on the Man Whitney U test that is a method of comparison of two independent samples, for example gender and income, then the test seeks to figure out whether or not the samples retains the null hypothesis, which is the relationship to one another based on a statistical level of .05. For the radar chart looks at the mean values of each category and the largest number is given a value of one. The second mean value is displayed in relation to one this shows the range and proportion difference.

Table 10: Description of radar chart

The basis of each category	
Human capital	Education
Social capital	Remittance from family
Physical capital	Household assets
Financial capital	Seasonal salary
Natural capital	Size of land

The qualitative data will be analyzed via content analysis, which is a method of looking through text for specific characteristics and applying those in the research (Bruce L. Berg 2012). The data will be organized in a manner that looks at research starting with the consumer, seller, and lastly, the institutional level. The data is displayed in a manner that explains to the reader the context of both the question and the answer from the perspective of the researcher. It displays the original texts from the various respondents, it allows the reader to clearly correlate the context from the perspective of the researcher and the original text. By organizing the data in such a manner, the reader is able to gain more insight into the meaning of the data while maintaining its original validity.

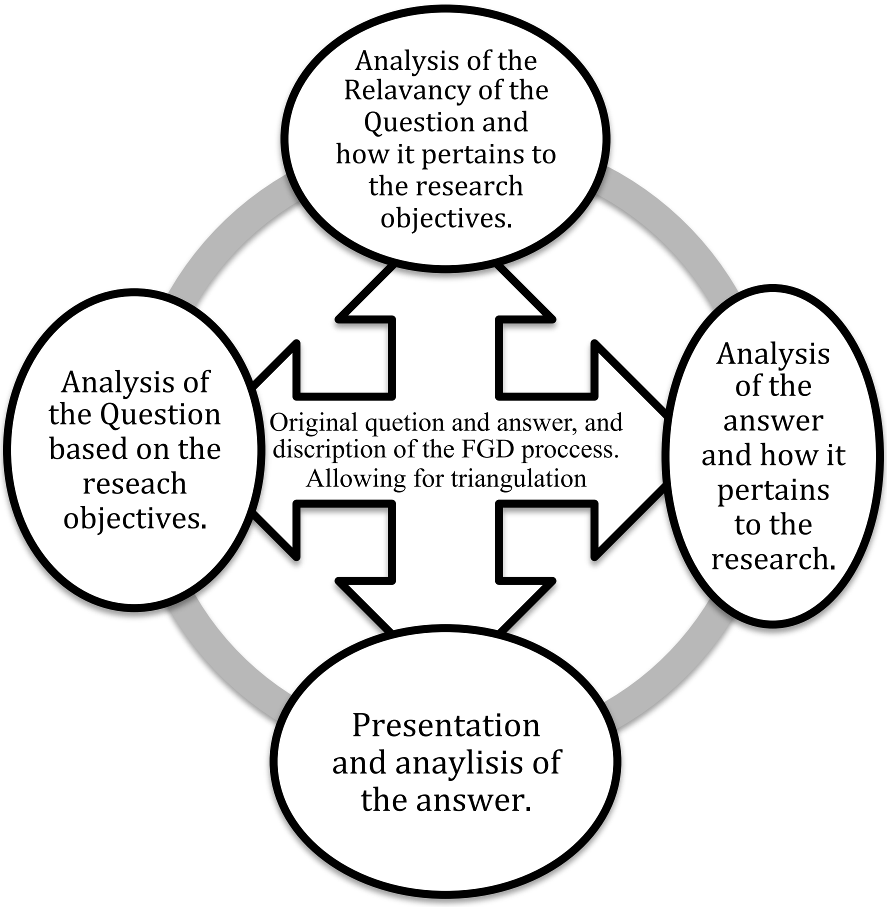


Figure 14: Conceptual framework analysis

The figure above describes visually the basis of the qualitative research presentation. The figure 14 shows how the questions are interoperated in relation to the research object as well as the presentation and analysis of the answer. Also in the middles of the fi show the original question and answer, which allows for the original context to be understood.

4.6 Limitation and Ethics

The methods used for this research were applicable. The research adhered to the necessary code of ethics, which respects a person's wishes not to answer questions, which make them uncomfortable. With adhering to these ethical issues, limits were put on what exactly was asked of certain individuals who decided not to answer questions. Also, in the refining of qualitative and quantitative interviews certain names were omitted in order to adhere to participant's that specified that they would not like certain aspects of their interviews to be released. Respondents were also made aware of the purpose of the research.

The beginning of the planting season was also the same time period as the data collection for this research. As a result of this, the target population was very difficult to reach at times and qualitative focus group discussions had to be scaled back as well as become more flexibility in terms of the number of FGDs and household questionnaires. That was the result of villagers not being available for interviews according to the research schedule. Some of the target population had to be interviewed as they were working or as they were returning home from farming.

The solar technology was not in the village for a whole year. Some of the target population had the technology at varying times, from 1 month to 6 months and so the research will look more at the short-term gains of the technology and people's short-term perception of the technology due to the length of time the technology had been in the village. The last 2 limitations were language and a lack of information on the Devergy energy company. Language was a limitation because I am no fluent in Swahili and as a result of that, was dependent upon the skills and interpretation of answers by field interpreter. Who naturally color data in accordance with their own interpretation, though there was some influence on the data, it is not believed to be much. Also many of the influences were unavoidable.

5 Results

In this chapter the main findings of the research will be presented. First, the demographic of the area, then the benefits and drawbacks of the Devergy approach. Included are the socio-economic impact of the approach and solar technology. The socio-economic impact, refers to the increase or decrease in business opportunities, security and dependability of the resource. The approach and the technology have been assessed through both qualitative and quantitative questions, and they will be presented in two separate sections in the results chapter. The last section in both the qualitative and quantitative chapters will assess whether or not there is the possibility to scale up the Devergy approach, and whether or not solar has a future in the village of Melela and in Tanzania.

5.1 Household socio-economic characteristics

This study was conducted in the village of Melela, which is divided into various sub-villages. The sub-villages applicable for this research are Kololo, Kibaoni Vianzi, Kidai and Majengo. In total 80 respondents were interviewed via household questionnaires, 40 with solar and 40 without solar. Out of the 40 respondents that are connected to solar, 100 percent of the respondents express that this is the first time they have been connected to a modern form of energy such as solar.

Also, of the 40 respondents that do not posses solar, 100 percent want to gain access to solar energy. Five out of the seven main forms of energy in Melela are candles, solar, kerosene, torches, and batteries. All are used for light. Charcoal and firewood are used the most and are not impacted by solar because they are used for cooking. This explains where solar can have an impact, as well as what will remain the same in terms of energy consumption because some forms of energy are used for cooking instead of lighting.

Table 11: Descriptive Chart of Melela solar and non solar

Characteristics	Yes Posses Solar Central Tendency	Do not Posses Solar Central Tendency	P – value
People Household	5[1]	4[1]	.175
People in school	3[1]	3[1]	.188
Age HH Lead	35[2]	38[2]	.910
Closest Houses	<5 meters[2]	5-10 meters[2]	.003
Furthest houses	11-15 Meters[2]	11-15 meters[2]	.849
Size of land	<5 meters[2]	<5 meters[2]	.893
Monthly Income	30,001-40,000 Tzs[2]	> 40,000 Tzs[2]	.088
Agricultural Income seasonal	558,571[1] (n-7)	245,000[1] (n-6)	.510
Education Level	Primary education[1] (89%)	Primary education[1] (88%)	.98
Primary source of livelihood	Farming[3] (90%)	Farming[3] (95%)	.423
Secondary source of livelihood	Business[3] (68%)	Business[3] (67%)	.995
Type of House	Brick[3] (92%)	Brick[3] (95%)	.655

1- mean 2- median and 3- mode

Table 11 is a descriptive chart that shows the demographic of a section of the population in Melela. The data divides the population into two categories, which allows for the reader to understand the difference between people with solar and those without solar. The mean age for villagers that posses solar are 35, and those without are 38, indicating that people that purchase solar are slightly younger than those without solar, with a statistical significance of .188. Number of people per household is a slightly similar; villagers that posses solar have 5 people per household and those without solar have 4 people per household.

Another important statistic to the research is the layout of the houses in Melela. According to the data villagers that posses solar are more concentrated than those without solar. This is important to the research because Devergy is only able to solar electrify houses that are within a 20 meter radius of each other because anything beyond that is not cost effective for Devergy. The statistical significance is .003 and the null hypothesis was rejected, meaning that there is a significant difference between villagers that have solar and those that do not. The data indicates that most of the villagers that have access the Devergy approach live close together. Also, people

that posses solar make a larger seasonal income than those without. It indicates that access to solar may be dependent on one's income. The primary source of livelihood is farming, with 93 percent of people with solar and 95 percent of those without solar are farmers. The largest secondary source of livelihood is businesses between both populations at 68 and 67 percent. Also, the main type of house amongst villagers is a brick house, at 92 percent for those with solar and 95 percent for those without.
As research was conducted in Melela the data that was collected correlates with what was observed amongst the villagers.

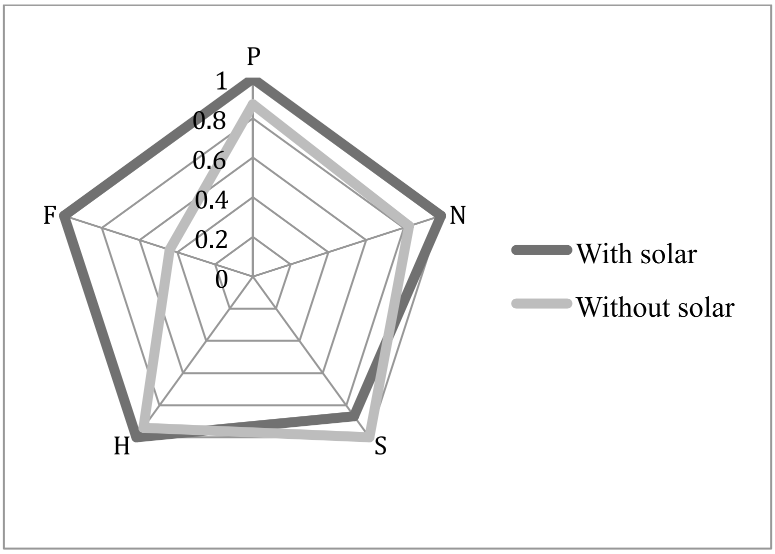


Figure- 15: Radar chart

The radar chart looks at the mean values of each category and the largest number is given a value of one. The second mean value is displayed in relation to one this shows the range and proportion difference. H stands for education, S remittance from family, P household assets, F seasonal salary. At the core of figure 15, it shows that villagers are similar in most categories with the exception of finances. Indicating there maybe other factors that are stopping villagers from gaining access to Devergy's solar technology.

Table 12: Villagers mean weekly energy expenditure

	Yes solar	No solar	P-Value
Kerosene	4,438	3,068	.409
Firewood	4,432	4,595	.799
Charcoal	4,020	5,625	.059
Solar	6,080		

In table 12 the P-value of kerosene is .409, firewood is .799, and charcoal is .059. The P-Value helps to indicate the statistical significance of the data, a value that is close to or smaller than .05 is considered strong in terms of p value. The chart above shows the consumption of various forms of energy on a monthly basis and the variation between villagers that possess solar and those that do not. The figure is based of the mean of each category. Also, the table shows that villagers with solar consumer more kerosene than those without solar.

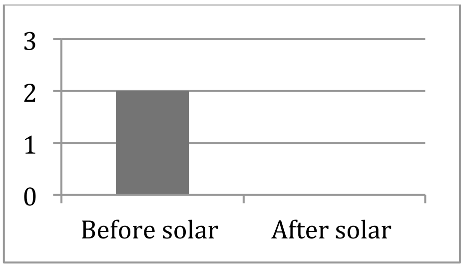


Figure 16: Consumption before and after solar

Figure 16 displays villager's kerosene consumption before and after investing in solar. Each respondent was asked, how often did they buy kerosene before and after investing in solar on a scale of one to six for both categories. Both median values show that solar decreases kerosene consumption.

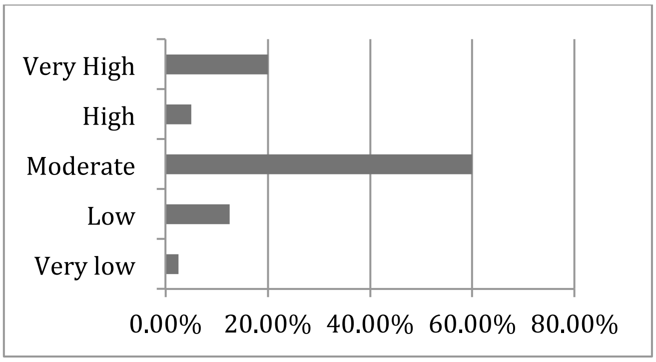


Figure-17: Rating the cost of solar

The original question asked, how do you rate the cost of solar with your other sources of energy used for lighting? Figure 17 shows that 60 percent of respondents have rated solar as a moderately priced energy resource in relation to their other sources of energy, such as kerosene, candles, and torches etc.

5.1.1 Benefits

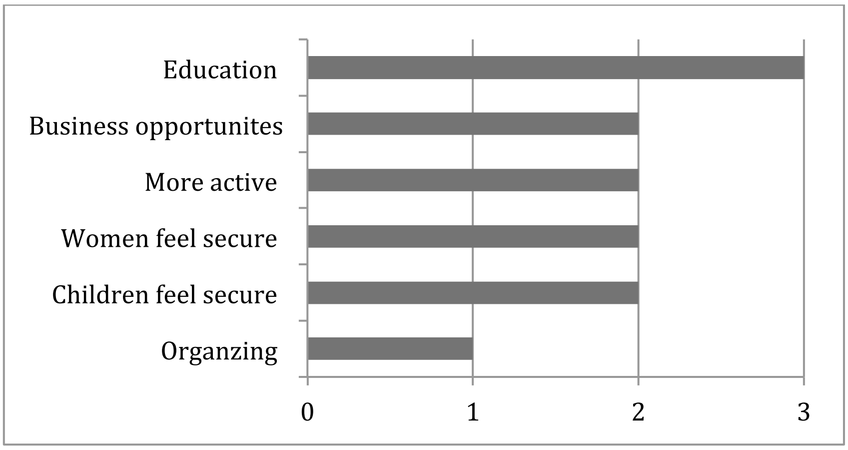


Figure 18: Solar benefits the community

The question for Figure 18 asked in what way does solar electricity benefit the community, gauging each topic on a scale of 1-3? The data shows that education is the biggest benefit of solar electricity. The data only represents the population with solar energy.

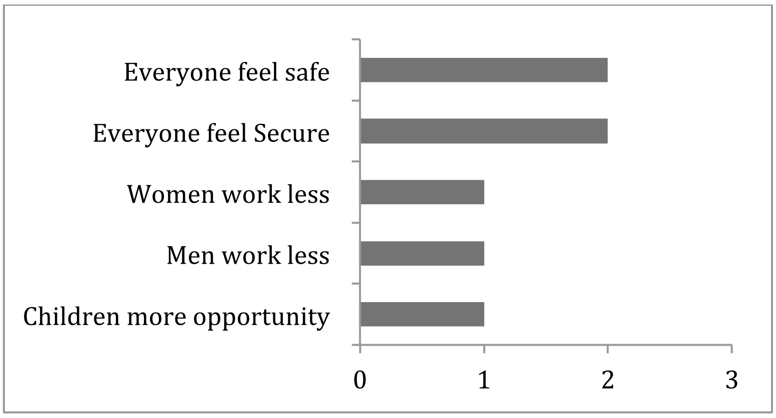


Figure 19: Solar benefits the household

Figure-19 looks at the changes that respondents see in the household as a result of solar; each category is ranked on a scale of 1-3, 3 being the highest. Also, the data only represents the population with solar energy. The data shows that everyone in the house feels safer and more secure as a result of solar, ranking these two topics a 2 on a scale of 1-3.

Table 13: Solar impact on business opportunities

Occupation	Decreased	Stay same	Increased
Farmers (20)			X
Business owners (2)			X
Casual Laborer (1)			X
Officially employed (1)		X	

Table 13 displays the Primary source of livelihood and solar impact on business opportunities. Farming, casual laborers and business owners have all stated that they have experienced an increase in business opportunities as a result of solar.

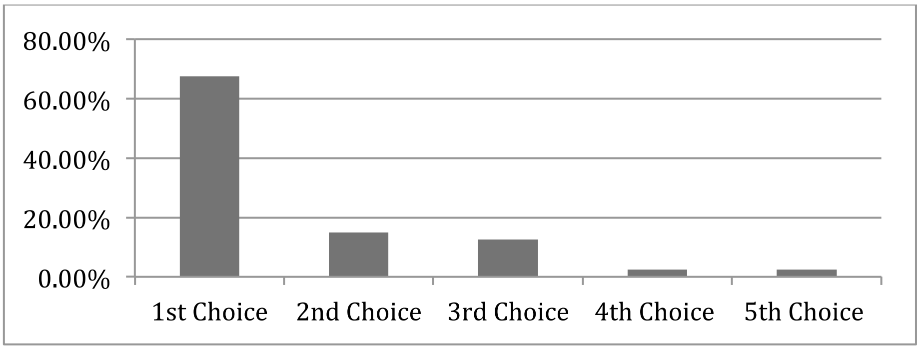


Figure 20: Ranking solar as a first or fifth choice for lighting

The original question for figure 20, if you were given the chance to choose amongst several sources of energy for lighting, where would you rank solar 1 – 5. Over 60 percent voted solar as their first choice.

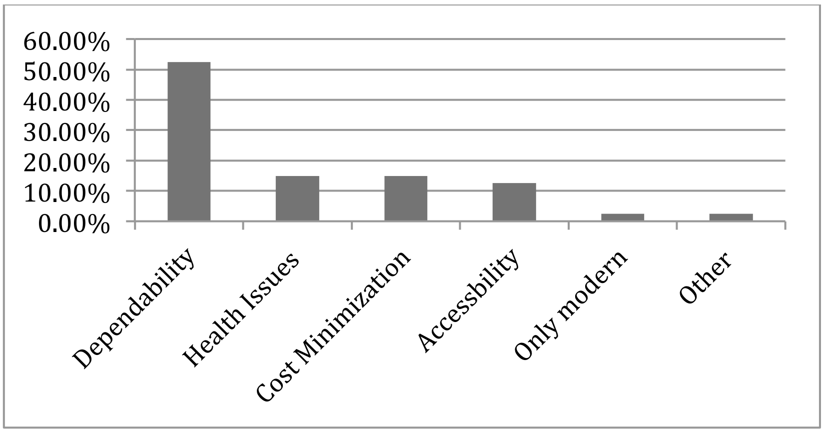
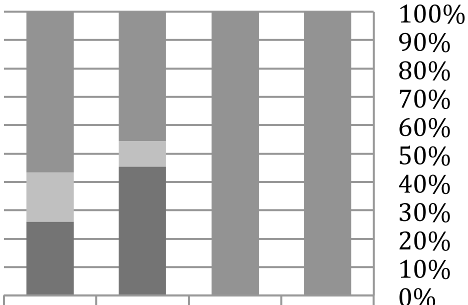


Figure 21: Reason for the first choice in figure 20

Figure 21 shows that if an individual ranked solar as their 1st choice what was the reason for ranking it. The number one reason for respondent ranking solar as their number one choice was the dependability of the technology.

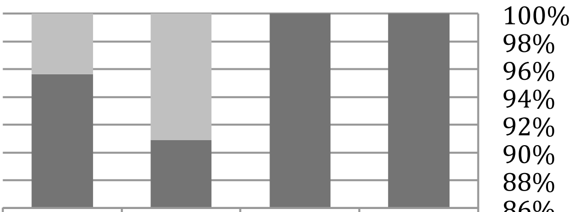
5.1.2 Drawbacks



	None	Once	Twice	Three
Want more control	13	5	5	1
Indifferent	4	1	0	0
Relieved	6	5	0	0

Figure 22: Cross tabulation between solar grid shut downs and wanting more control

Figure 22 shows the cross tabulation between solar grid shut downs and the feeling of not having to repair the grid. The bar chart shows that villagers desire more control over the repair of the solar nano grid. Also, as the solar grid shuts down the want for more control stays at a hundred percent, meaning that no matter what happens respondents want more control over the solar mini grid system.



	None	Once	Twice	Three
No	1	1	0	0
Yes	22	10	5	1

Figure 23: Solar shutdowns and the feeling that solar is beneficial

Figure 23 shows the frequency of solar shutdowns and the feeling that solar is beneficial, the bar chart shows that as the solar grid shuts down the increase in the perception of solar being beneficial is still yes. Even after 3 shutdowns people still think solar is beneficial. Also, the chart shows that the frequency of shutdowns, which is relatively low.

5.1.3 Potential for scaling up

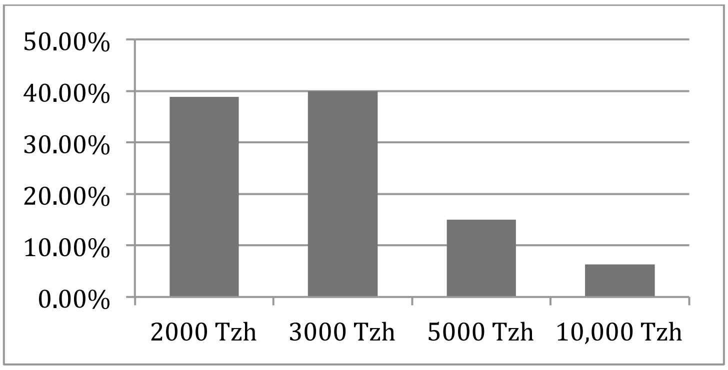
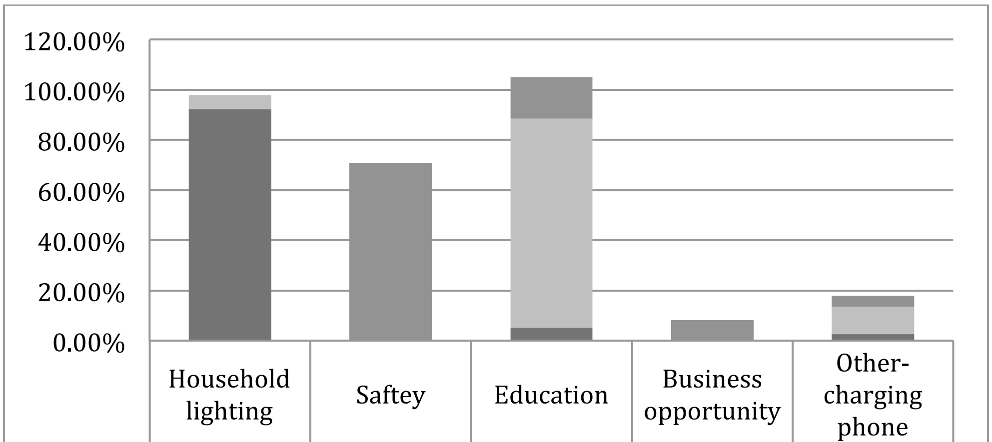


Figure 24: Max villagers are willing to pay for solar technology, when asked about willingness to pay for connection to solar

Figure 24 displays the maximum amount villagers are willing to pay for solar technology installation. 38.8 percent are willing to pay 2,000 Tzs, 40 percent are willing to pay 3,000 Tzs, 15 percent are willing to pay 5,000 and 6.3 percent are willing to pay 10,000 Tzs for solar installation. This is important to understand because the minimum cost for solar installation is 10,000 Tzs.



	Household lighting	Saftey	Education	Business opportunity	Other-charging phone
P3		70.80%	16.70%	8.30%	4.20%
P2	5.60%		83.30%		11%
p1	92.30%		5.10%		2.60%

Figure-25: figure describes the top three reasons for villagers wanting solar and their ranking on a scale of one to three, three being the highest.

Figures 25 displays the reasons for wanting solar first, second, and third priority, The data from these three bar charts gives a clear view of why villagers without solar want solar energy. Also, each of the three charts fall within solar's capacity to attain. Indicating that villagers wants are attainable.

5.2 Qualitative data FGD and key informant

The qualitative data has three sections, the consumers of solar energy, suppliers of solar energy, and solar at the institutional level. These three branches address different perspectives, according to the Devergy approach, and solar energy. The data is organized in a manner that gives the reader the interpretation of both the question and answer from the perspective of the researcher. The data also displays the original transcript of the respondent, in order for the reader to correlate the researchers interpretation with what was stated by the respondent. The letter Q represent question, and A represents answer in the original text. By organizing the data in this manner, the reader can get more insight into the meaning of the data as well as maintaining its original validity.

5.2.1 Qualitative Data, Village FGD

This section of the qualitative data is designed to look at the Devergy approach and its solar resource from the perspective of the consumer. The questions and data will give the reader a context in which the reader can understand the Devergy approach and be able to assess its benefits, drawbacks, and potential to scale up the resources from the villagers perspective.

5.2.2 Reason for purchasing solar, Question-1

Question one is based on the reason for purchasing solar. If the Devergy approach is to be assessed in terms of its benefits and drawbacks in Melela from a qualitative perspective, it is vital to gain insight into the different perspectives of villagers. The question is framed in a manner that allows for the subjects to express their personal experiences, while attaining vital data that can assess the Devergy approach and their solar technology. The question looks at why the subject has decided to purchase solar from Devergy, and what does Devergy have that the subject needs?

The answer to the question indicates underlying needs of villagers in Melela. The main reason respondents purchase Devergy's solar approach is for lighting, which villagers use as a means of helping their children to study. Another reason for purchasing solar through the Devergy approach is to reduce the cost and consumption of kerosene. After using solar some believe it is better to buy kerosene on a daily basis than to buy solar. The answer to this question should also allow the reader to understand villagers needs, and if these needs have been fulfilled through Devergy's approach.

Q- The moderator asked a mix-gendered group of respondents during a FGD-1 & 3, their reason for purchasing solar power from Devergy? After a half a minute of deliberation they responded

A- *Mixed FGD "We need light and our children need to study, these are the main reasons. We thought solar would reduce cost of kerosene and other sources of energy but it is not so. It is actually better to buy kerosene daily than solar."*

A- *Female FGD "To reduce the cost of buying other forms of energy, kerosene, and to charge cellphones. We changed our lifestyle from lamps to modern forms of energy."*

5.2.3 Financial influence, Question-2

Question two assesses the financial influence of solar. In the segment above, the question and answer looked at the villagers needs, and asked if Devergy had fulfilled that need. This question looks at what purpose does that need fulfill. Specifically, within the context of the villagers' financial status, how does this resource affect villagers? The answer should indicate if they have seen any changes in their financial statues as a result of the Devergy approach. Respondent have indicated that they have had increased business opportunities, but this answer is within the context of an all female FGD. But a mixed group has indicated that they have not experienced financial changes.

Q- The moderator asked FGD-3 and 1, about solar investment and how it influences their financial status. One woman answered with her personal experience.

A- Female FGD *"Businessmen can work at later hours because they have light. Also, there are improvements in business because women are able to make chapatti*[3] *and*

[3] Tanzanian fried flat bread

Mandazi,[4] *and have light before the sunrises to get an early start on getting more business opportunities."*

A- *Mixed FGD "Not satisfied, no charges, no financial changes, only change is that we use the solar energy. We don't use firewood, which affects health. Kids are able to study a little bit more, but not daily because it is too expensive. Yes there are positive changes, especially in newborn babies. Cotton used to clean babies ears, nose and other parts are not longer black foam with the residue of the kerosene and firewood."*

5.2.4 Changes in household & village, Question-3

Question three is on the topic of changes within the household and the village as a whole as a result of investing in solar. This is an extension of question two. It encompasses an entire household and village, and not just finances. The household and village can be broken down into a variety of sectors, such as security, social relationships, economics and environmental. The answer will allow for insight into different social sectors within the household and the village.

In both FGD's mixed and female, both men and women feel that security has increased in the household and village but in different ways. The mixed FGD comprised of both men and women felt as though thieves can look into their homes because the houses have light inside, but in terms of overall village safety, they feel safer because people can see more at night, and they can also see insects and snakes. The female FGD feels more secure as well because if they hear a sound they have the opportunity to flick a switch and have instant electricity.

Q- The moderator asked, what changes do you see in your household and village as a result of the solar mini grid.

A- *Female- FGD " People can study more at night. Also people can have chats, discussions, and communicate more and work later. Also I feel more secure when I hear something I can switch on the light, and feel more secure."*

A- Mixed FGD- "More houses have light, now thieves can see in the house. The village is safer because more people are able to see instead of having nothing. Businesses are open later. We can see more insects and snakes better at night and less snakes get in the house because of solar."

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[4] Tanzanian fired circular bread

5.2.5 Scale up RE, Question-4

Question four scaling up RE is designed to look at the Devergy approach from the villagers' perspective, and to analyze how Devergy can continue to expand their approach. It is important to get the villagers' perspective since they are the population that is living within the context of the said approach at the village level. The answer to this question can show specific desires and wants that the subjects have toward the Devergy approach. At this junction in the questionnaire, whether or not this specific desire or want can be attained is not important. What is important is what the villager wants and desires are it relates to the Devergy approach. Based on the data the best way to increase the approach for villagers would be to stop the installation fee of 10,000Tzs.

Q- The moderator asked a mix-gendered group of respondents during a FGD, What is the best way to scale up renewable solar energy in Melela?

A- "*The companies need to connect everything for free and just charge for vouchers, 10,000Tzs for instillation should be stopped, connect for free and just allow the villagers to buy vouchers.*"

5.2.6 Spread knowledge of solar, Question-5

Question five spreading knowledge about solar builds from question four, but it looks specifically at the spreading of knowledge from the villager's perspective about the benefits of solar. According to villages the best way to spread knowledge about the benefits of solar is through village meetings, word of mouth and education.

Q- The moderator asked a mix-gendered group of respondents during a FGD, what are the best ways to spread knowledge about the benefits of solar energy?

A- *"By communicating with each other, this can be the best way, by word of mouth and village meetings and education."*

5.2.7 Invest in Household vs. community grid solar, Question-6

This question specifically looks at whether or not villagers would prefer household solar or nano grid solar. This question is relevant because Devergy provides a shared solar resource. Four to five HH's are connected to each solar mini grid. The answer to this question will show if villagers would rather work together or alone. They prefer nano grid solar because they do not have to spend lots of money on individual solar, and they can depend more on each other.

Q- The moderator asked a mix-gendered group of respondents during a FGD, if it was better to invest in solar at the individual household level or community level. They responded,

A- *"Not for individuals but as a community because we will benefit more, you suffer as a community and help each other rather than by yourself. When something goes wrong investors are there to solve the problem rather then you solving the problem yourself."*

5.2.8 Problems with solar, Question-7

Question seven focuses specifically on the problems that comes along with solar or that are generated by solar. This question was asked in a broad sense to give respondents an opportunity to express their opinion on various issues that they may have with the Devergy approach and its solar resource. The biggest challenge or problem according to the data, is that villagers think Devergy's solar resource is too expensive.

Q- The moderator asked a mix-gendered group of respondents during a FGD, what problems do you face when using solar power?

A- *Mix FGD "The cost of buying electricity everyday is a challenge, yes solar is expensive. The people buying kerosene maybe be spending less money, while you have better light but less money. Sometimes you have money on your meter but no light and you have to contact Fred the local engineer. The bulbs are good they last well over 3 months."*

5.2.9 Recommend solar, Question-8

Question eight recommending solar relates to almost all the previous questions in the sense that if the respondent would recommend the resource to other villages, then the subjects must believe that the resource has positive aspects to it. According to villagers they would recommend Devergy's solar approach but villagers must have money in order to pay for it or nothing will happen without money.

Q- The moderator asked a mix-gendered and female group of respondents during a FGD, Would you recommend Devergy's solar mini grid electricity to other communities? Why or why not?

A- *Mixed FGD "We recommend other villages to get solar because some can pay, but just have not been connected. Depends on the peoples ability to pay, kids can study more, if no money, you will remain the same and kids won't study. Thieves are still there, because the bulbs are inside not outside."*

A- *Female FGD- "We recommend solar to other villages. It increases education for kids and also businesses can be open later. Solar can increase our income; they can have more opportunities for more money, business can stay open later. Cooks can also cook earlier or later and In terms of security, reducing theft and snakes.*"

5.3 Qualitative data, Devergy engineer

This section of the qualitative data is designed to look at solar from the perspective of the supplier. It is important to understand the supplier because they are in constant interaction with the consumer and can supply critical insight into the world of the consumer. Also the supplier can relate solar to other forms of electricity throughout the country and lend a critical eye toward various electricity utility companies such as TANESCO and REA. The data will describe the perspective of the solar engineer in the village of Melela. The solar engineer interacts with villagers on a daily basis and communicates with Devergy, who are suppliers of the resources. The solar engineer has a vital role in the overall function of the Devergy approach and can supply the data and the reader with the inner workings of the approach.

5.3.1 Solar and development potential, question-1

The answer to solar potential development can give insight as to why some villagers in Melela do not have solar and why as a whole the sector it is not developing faster to meet the growing need for electricity. The question was asked in order to cross-examine other answers on the same topic from the perspective of the supplier, institutions, and the engineer. The Devergy engineer states that the sector has developed to its full potential because the price of Devergy's solar energy is low enough for people to afford it. Also politicians have promised electricity but nothing has come to Melela, solar is a tangible electricity resource and has the potential to expand.

Q- The moderator asked the Devergy engineer, has the Tanzanian RE solar sector developed to its full potential? Why or why not?

A- Engineer "Yes, it has developed to its full potential because the price is low and people can afford it. Also its not only here, its in Bagamoyo, Kibaoni, and Dodoma. Investors have invested so it developed. Solar can expand throughout the nation, politicians have been promising electricity and yet there is none, but solar is here and is another option that the people can have in their villages and it can expand."

5.3.2 Is solar adequate for villagers, Question-2

Question two looks at whether solar is adequate for villagers, according to the resources capacity to provide electricity in relation to villagers' desires and needs. According to the Devergy engineer, the electricity provided by Devergys' solar resource is not enough to supply all the villagers wants and desires, these wants and desires may be based on the use of lager appliances such as stoves and TV's.

Q- The moderator asked the Devergy engineer, is the power that is created by the solar grid adequate to meet the demands of the villagers? Why or why not?

A- *"Its not enough, its not fulfilling the people needs. The people aren't able to buy electronics that they want. People have to no way to choose the electronics they want to buy, only the ones the investors say. Most have not transitioned to solar electricity."*

5.3.3 Cost of Solar, Question-3

Question three, cost of solar allows for the cross-examination of solar from previous and future perspectives, REA, TANESCO, and solar suppliers. Also the answer to this question can relate the solar resource and villager's standard of living. According to the Devergy engineer the cost of solar provided by the Devergy approach is low. Also, there have been other sources of power but they were much more expensive.

Q- The moderator asked the Devergy engineer, Is the cost of solar energy too high? Yes or no and Why?

A- *"Solar is to low, before the generator provided electricity for 1,000Tzs per day. Now solar can give you light for 4days for only 1,000Tzs and the danger factor is a lot lower than the TANESCO grid."*

5.3.4 Scaling up solar, Question-4

The answer to scaling up solar looks at the capacity of the Devergy approach to increase its size, as well as the potential within Melela to increase the approach and solar resource, through the understanding of villager's needs and ability to pay for the resource. According to the Devergy engineer there is potential to scale up the initiative even further. Devergy is expanding at a rate of two villages per month.

Q- The moderator asked the Devergy engineer, is there potential for scaling up the solar mini grid in Melela and other sub villages? Why or why not?

A- *Engineer "Yes, there is the potential for scaling up the initiative; Devergy says after every one month, 2 villages are to be connected to the solar mini grid. Imandizi, Kibaoni and Dodoma. There is a demand. People from other villages want the resources and they are planning to expand into other villages that don't have power. Lubungu, Uitemvu, Kepera- The villages bring their request to Alfred and he communicates to Devergy donors that have the money to expand. They are also investing in Ghana."*

5.3.5 Goals of Devergy, Question-5

Question five, goals of Devergy looks at the essence of the approach and its intentions from a business viewpoint. According to the Devergy engineer, Devergy's main intention is to make profit, Devergy looks at areas that TANESCO has not supplied electricity and they invest there.

Q- The moderator asked the Devergy engineer, what is the goal of Devergy and its solar investment?

A- *"The major goal of the company is to make business. They want to make money. They look to see where electricity is not there or where the grid will take a long time and they investor there."*

5.3.6 How can scaling up solar help, Question-6

Question six scaling up solar to help villagers, from the perspective of the solar engineer, it was important to understand villagers desire as well as how their desire works to increase their economy and livelihood. According to the Devergy engineer, solar helps villagers charge their cellphones and helps to generate small amounts of income in the range of 500Tzs for the charging of cell phones. Also in term of health, the solar engineer states that solar does not have that big of an impact on health because people still cook with coal and firewood but in terms of candles being used for light, that has decrease and so villagers' health has increased slightly.

Q- The moderator asked the Devergy engineer, in what way can scaling up solar energy help the Melela village and villagers?

A- *"It has helped in terms of increasing people ability to charge their mobile phones, they use to pay 500 for mobile phone charging. Recently a lot of people are charging phones. Also by charging phones people can make a little money. In terms of health not much because people are still using coal and firewood, instead of using candle people are using light so maybe it helps a little."*

5.4 Qualitative data, Storeowner Key Informants Interviews

This section of the qualitative data is designed to look at solar from the perspective of the supplier. It is important to understand the supplier because the supplier is in constant interaction with the consumer and can supply critical insight into the world of the consumer. Also, the supplier can relate solar to other forms of electricity throughout the country and lend a critical eye toward various electricity institutions such as TANESCO. This specific supplier is located in Morogoro, which is closest city to Melela, and is within a 30 min range by bus. If a villager is going to town they most likely mean Morogoro.

5.4.1 Solar sector Development, Question-1

Question one, solar sectors potential development, is geared toward generating data that will give insight into the development of Tanzania's renewable energy and solar sector. The answer to this particular question can also give insight as to why some villagers in Melela do not have solar and why as a whole the sector it is not developing faster to meet the growing need for electricity. The storeowner believes that the solar sector in Tanzania has not developed to its full potential. He goes on to say that TANESCO, which is Tanzania's utility electrical company is not supporting solar because they do not want the competition.

Q- The moderator asked the storeowner, has the Tanzanian RE solar sector developed to its full potential? Why or why not?

A- *"The sector is not developing because the government is not supporting it, maybe they think it is competition for Tanesco. Also people do not know how to use solar, there are not many places to get educated about solar, not on TV or on Radio. People may hear about solar but don't know anything about it. Also People are too poor, and the cost of solar is too high. With Tanesco you can get connected for 400,000 tsh and that is for life. Also, solar is limited to what it can supply, only TV and lights. While, Tanesco one can have TV, lights and everything."*

5.4.2 Solar and rural energy, Question-2

After looking at the sector and its potential, the question on solar in rural areas was designed to focus the supplier's knowledge toward a rural setting and how solar can existing within a rural setting in terms of the nature of the resource. The answer to this question should show whether or not solar is suited for rural areas. According to the storeowner solar is better suit for rural areas because most rural areas have no electricity and solar is better than having nothing.

Q- The moderator asked the storeowner, is solar better suited for rural areas or is there a market in towns and city centers?

A- *"Solar is better for people in the village because they do not have Tanesco. In towns not so much because they have Tanesco, and when they do buy solar it is for small electronics. When people need to use bigger appliances, solar cannot provide them with enough electricity."*

5.4.3 Boost solar in Tanzania, Question-3

The previous questions dealt with the solar sectors potential and relationship to rural people. This question looks at the how solar can be increases to meet the needs of a growing population. It is relevant because as a supplier of the resource, the storeowner may know ways of attracting customers, and intern boasting the sector. The storeowner states that knowledge about solar energy and the Tanzania bureau of standards (TBS) needs to be increased in order to give people awareness. Also the products in the market must have better standards so people can have faith in the sector.

Q- The moderator asked the storeowner, what can help boost solar as a tangible alternative energy option for Tanzanians?

A- *"People need knowledge about solar. TBS should be more responsible, there needs to be better standards. When you buy solar you do not know what has been inspected by TBS. Many products are made in China and using German labels, this is the problem for TBS. They need to do better."*

5.4.4 Solar cost, Question-3

Question three cost of solar energy, relates to the village FGD, it was vital to triangulate both sides of the sector; the supplier and consumer and what they think about the cost of solar. The storeowner believes that solar is high in cost in relation to the standard of living.

Q- The moderator asked the storeowner, is the price for solar high for people in Tanzania?

A- *"The cost of solar is still high in comparison to the standard of living. Most of the rural people cannot afford solar."*

5.4.5 Tanzanian lives improved by solar, Question-4

Question four, livelihoods improved by solar is used, as a question to cross-examine desire, desire in the sense that most people would like to improve their lives. This question specifically looks at how solar can be used as a tool to aid in that desire for villagers to improve their livelihood. The solar supplier states that solar can aid in children studying, and in business being open later.

Q- The moderator asked the storeowner, how can the lives of Tanzanian people be improved by solar?

A - "Many of the villages are without electricity and with solar students can study in the dark. You can use solar to do work later in areas that have no power."

5.5 Qualitative data, Key Informants, TANESCO Mororgoro & Dar es Salaam

This section of the qualitative data is designed to look at a variety of different branches within the energy sector, such as policies, capacity, and renewable solar energy. The data will look at these various sectors from the perspective of Tanzania's electrical utility company TANESCO. It is important to look at the energy sector of

Tanzania at the institutional level because of the power and influence that it possess, and their countrywide viewpoint. This data will allow the reader to understand various issues within the energy sector and gives the reader an opportunity to put the previous data from Melela and Morogoro into a nation wide and even global context.

5.5.1 RE Policy, Question-1

Question one addresses the RE policy in Tanzania, the data in this section explains why this question is important. If solar and the Devergy approach is to be fully understood, Tanzania's RE policy environment is important to understand because policies create environments, which resources such as solar can develop. Policies provide guidance, as well as show intent, this is vital in an economy that depends on investment for different sectors to grow, specifically solar. Also a lack of policies such as a renewable RE policy can be the cause for various problems within the solar sector in term of its slow development and high cost. According to Dar es Salaam TANESCO respondent, a lack of a renewable energy policy has created a sector without guidance.

Q- The moderator asked the TANESCO representative, how has Tanzania's lack of a renewable energy policy impacted your solar mini grid project in Melela, kololo?

A- *"There is no policy on renewable energy or any guidance. Villagers are scattered and it is expensive to electrify them."*

5.5.2 Solar Future in Tanzania, Question-2

Question two, solar and its future in Tanzania. Continuing with the same framework as the previous question on the issues of policy, it is necessary to also gain insight into the perception of the progress of solar energy as an option for electricity throughout Tanzania and in Melela. The underlying question is, does this resources have the capacity to have an impact on people in Tanzania, to a degree in which they will continue to support it over an extended period of time? According to the Morogoro TANESCO respondent solar does not have a future in Tanzania because it is too expensive and if or when grid electricity comes the people will no longer support it. But according to the Dar es salaam TANESCO respondent solar electricity does have a future in Tanzania because the price of solar is decreasing. Also the respondent states that TANESCO has projects that are in place and that will utilize solar energy, and so the subject reaffirms that solar has a future in Tanzania.

Q- The moderator asked the TANESCO representatives, what is your opinion on solar and does solar have a future in Tanzania?

A- Morogoro Key Informant –"The cost of solar is too high in Tanzania, difficult because it is expensive, so more people go to TANESCO. People use solar who are not connected to the grid, in rural areas. No other option, not sure, but in the future grid electricity is expected to expand and solar will not be welcomed. Grid is better than solar because solar is expensive and is viewed as only an alternative. People that have solar still want grid electricity."

A- Dar es Salaam Key Informant – "Yes, solar has a future in Tanzania. TANESCO wants to invest in a 60 MW project and is in the process of getting land in Dodoma for the future. Concentration of grid electricity, Energy policy they have but not a renewable one. As of now no solar in TANESCO for the last 20 years. Changes in the technology / the prices are decreasing and it will have a future in Tanzania."

5.5.3 RE sector Development potential, Question-3

Question three RE sector potential growth. This question is gear toward generating data that will give insight into the development of Tanzania's renewable energy and solar sector. The answer to this question can also give insight as to why throughout the country solar has not developed, as some believe it can. Also these answers can provide specific data to areas that need to be addressed in order for the sector to develop and reach it full potential. The Dar es Salaam TANESCO respondent believes that the solar sector in Tanzania has not developed to it full potential. The subject goes on to say that people do not possess the necessary education, technical and financial means at the moment, to allow the sector to reach it full potential.

Q- The moderator asked the TANESCO representative, has the Tanzanian RE solar sector developed to its full potential? Why or why not?

A- *"No not yet, technical and financial capacity of the people to buy is not there. Education and the experience are not there."*

5.5.4 TANESCO efficiency, Question-4

Question four, the efficiency of TANESCO, is geared toward gaining and understanding as to why there exists a need for solar electricity in Melela. The answer to this question should indicate why people in Melela are investing in the Devergy approach instead of TANESCO's grid electricity. Also this answer should further highlight some of the deficiencies within TANESCO. According to the Mororogoro TANESCO respondent, the main reason for delays in electrification of Melela is due to budget issues, these issues have pushed back the electrification of the community.

Q- The moderator asked the TANESCO representative, why has it taken so long for electricity to reach villages out in Melela?

A- *"It is because of budget, budget stops the process. Phase 2 project of REA is supposed to bring grid electricity to Melela and district –Mvomero. The project has been pushed back because of budget issues."*

5.5.5 Grid vs. Solar, Question-5

Question five grid vs. solar, is simply a cross-examining question that looks at question two and adds in the dynamic of grid electricity. For example if solar is to have a future in Tanzania, how is it viewed at the institutional level in comparison with grid electricity? The answer to this question should explain the role of solar in comparison to grid electricity. According to the Morogoro TANESCO respondent, solar electricity is view as an alternative to grid electricity. Only where grid electricity doesn't exist, is where solar can exist.

Q- The moderator asked the TANESCO representative, is grid electricity a better option for villagers rather than solar why?

A- *"Grid is better than solar because solar is an expensive and is viewed as only an alternative. People that have solar still want grid electricity."*

5.5.6 Grid electricity reaching Melela, Question-6

Continuing with the same framework as question five, question six grid electricity reaching Melela aims to gauge exactly when will solar and grid electricity encounter one another in Melela. According to question five when these two-resource encounter one another solar will cease to be a main supplier of energy and became an alternative and this question aims to figure out when exactly this will happen. According to the Morogoro TANESCO respondent the project is suppose to start at any moment, a primary survey has already been conducted. But there is no exact date.

Q- The moderator asked the TANESCO representative, when exactly will the grid electricity reach Melela, and can the people afford it?

A- *"Last December, it was suppose to start but anytime from now the project should start. Contactor is new to Tanzania building materials, office, then everything will start. TANESCO has already done a primary survey of where the poles will be and a final survey must take place with both parties. Sometimes they have to relocate people to fit poles and transformers."*

5.5.7 TANESCO problems, Question-7

Question seven major problems in TANESCO, was design to give the respondent an opportunity to give a context to the deficiencies of TANESCO, which impacts the countries electrical sector. The answer to this question can show the reader why Tanzanian's are in need of electricity in different areas of the country. According to the Dar es Salaam TANESCO respondent, TANESCO was doing fine in the 90s but as a result of World Bank polices and privatization Tanzania is behind. Also, lenders do not like to finances companies that have the possibility of being privatized, stating that TANESCO may be privatized in the future. According to the Morogoro TANESCO respondent the biggest problem is a lack of funds to implement projects.

Q- The moderator asked the TANESCO representative, TANESCO's major problems in your opinion and the situation in terms of funding?

A- "Dar Salam Key Informant - *TANESCO was doing fine in the 90's in terms of lenders giving money from the developed companies. Lenders do not want to finance a company that is going to be privatized or is possibly going to be. 2002- plant has not been built until recently – no funds, World Bank policy. As a result of World Bank policy and privatization, Tanzania is behind."*

A- *Morogoro Key Informant –"There are a lot of projects but they haven't been funded yet."*

5.6 Qualitative data, Key Informants, REA

This section of the qualitative data focuses on REA, which operates at the institutional level similar to TANESCO but is specifically geared toward Tanzania's RE sectors development. It is important to look at the energy sector of Tanzania at the institutional level because of the power and influence that it possess, and countrywide viewpoint. REA has a countrywide viewpoint of the renewable energy sector. The data from REA can explain the status of the sector, which can allow the reader to relate the data to Melela. The data will allow the reader to understand various issues of the energy sector and gives an opportunity to put the previous data from Melela and Morogoro into a nation wide and even global context.

5.6.1 Opinion of solar, Question-1

As in TANESCO question two, REA's opinion of solar, was necessary to also gain incite into the perception of the progress of solar energy as an option for electricity throughout the country. The underlying question is, does this resources have the capacity to have an impact on people in Tanzania, to a degree in which they will continue to support it over an extended period of time. According to the respondent at REA the private sector is not investing that much in the sector, and in a country that develops through investment this indicates that solar may not have a future until it has the proper investment. Also the respondent states that solar as a resource is only used as a short-term solution for grid electricity.

Q- The moderator asked the REA representative, what is your opinion on solar and does solar have a future in Tanzania?

A- *"Short-term consumption not for productive uses, short term solution. The grid line is coming from Morogoro to Mikumi, solar is an Intermediate intervention. Intermediate vs. productive uses. Private sector is not investing so much."*

5.6.2 RE policy, Question-2

Question two, RE policy in Tanzania. If solar and the Devergy approach is to be fully understood, Tanzania's policy environment is critical in understanding because policies create environments in which resources such as solar can develop. They provide guidance as well as show intent, policies are vital in an economy that depends on investment for different sectors to grow, specifically solar. The lack of a RE policy can be the cause for various problems within the solar sector in term of its slow development and high cost. This question allows for the cross-examination of TANESCO's question one and REA's question two because they are exactly the same. According to the respondent at REA a lack of policy has stopped some people from investing but not too much, a bigger issue is funding.

Q- The moderator asked the REA representative, how has Tanzania's lack of a renewable energy policy impacted your solar mini grid project in Melela?

A- *"Resource funding and developers need funds. The lack of a policy has stopped people from investing but not so much. Tanesco can play a stronger role they are building dams on the Mapemba and Mmumba river. Projects in climate change and RE fund depends solely on the funding."*

5.6.3 TBS, Question-3

Question three, efficiency of TBS. This question addresses the standard of solar in Tanzania, and by standards, I mean any problem with the resource, such as quality and consumer protection. If the RE solar sector is to increase its development, proper stands must be in place in order for this development to take place. The answer to this question should indicate if Tanzania has the potential to increase the efficiency of its RE solar sector based on efficient standards. According to the respondent at REA the standards for solar in Tanzania are low, one of the main reasons is that China is making solar panel and putting wrong labels, indicating that the international markets are bad as well as the TBS. The respondent goes on to say that policy makers, REA and other stakeholders need to do capacity building to develop better standards.

Q- The moderator asked the REA representative, what are your thoughts on the standards of solar equipment being sold in the market?

A- *"International markets are bad, the Chinese are making panels and putting wrong labels and standards. Policy makers, REA, other stakeholders need to build up the capacity capacity to develop these standards, participation, and capacity building. Tanzania is headed in the same direction as Uganda's RE policy."*

5.6.4 Future and solar, Question-4

Question four the future of solar, in Tanzania has been asked consistently throughout the research because it shows different answers at different levels; villagers, storeowner and the institutional level. The underlying question is, does the solar resources have the capacity to have an impact on people in Tanzania, to a degree in which they will continue to support it over an extended period of time. According to the respondent at REA, they will increase the generation of renewable energy and that it has a bright future in Tanzania. Also the best scenario is that renewable energy reach 15% in the future not including large hydropower.

Q- The moderator asked the REA representative, what is your opinion on Renewable energy and does solar have a future in Tanzania?

A- *"It will increase generation for RE, the best future is one with RE 15% by 2015 December, bright future and a boost in the rural area."*

5.7 Qualitative data, Devergy co-founder

This section of the qualitative data is designed to look at solar from the perspective of the supplier. It is important to understand the supplier because the supplier is in constant interaction with the consumer and can supply critical insight into the world of the consumer, but also the supplier can relate solar to other forms of electricity throughout the country and lend a critical eye toward various electricity institutions such as TANESCO. This specific supplier is located in Dar es Salaam, which is the largest city to Tanzania. That is the main headquarter for Devergy in Tanzania.

5.7.1 Investment in Tanzania, Question-1

Question one, difficulties investing in Tanzania. In understanding the difficulties Devergy has faced in terms of investing in Tanzania, the data exposes problems that may be holding the Renewable energy sector back, from achieving its full potential. According to the co-founder of Devergy, the problem with investing in Tanzania is very little start up money, and a lack of access to credit and equity investors. Also, a lack of reliable data on villagers in different regions is a hindrance to Devergy's investment in Tanzania.

Q- The moderator asked the Devergy co-founder, what difficulties have Devergy faced in terms of investment in renewable solar energy in Tanzania?

A- *"The problem with investing in this sector is access to credit or access to equity investors. What you find is that any start up aimed at investing in Tanzania and other* *developing countries, there is very little money for start up. It is hard to get money to have a concept idea financed, lack of business information and it is hard to do business intelligence in developing countries. Looking at current data is also an issues in terms of kerosene use and candles. The data has a minus ten to a minus 60 rating in terms of accuracy. Meaning that if the data stated that an individual was making 100 dollars a month the reality on the ground was that the individual was making 100 dollars to 160 dollars, a lack of consistency in the data."*

5.7.2 Lack of a Policy Question-2

Question two, lack of a RE policy. If solar and the Devergy approach is to be fully understood, Tanzania's policy environment is critical in understanding because policies create environments in which resources such as solar can develop, this is the aim of question two. The answer to this question will show the impact of a lack of a renewable energy policy on an investing solar company. According to the co-founder of Devergy, Devergy is too small at the moment to be impacted by a lack of a renewable energy policy, but there are issues in terms of paying import duties for certain parts of their solar nano grid system.

Q- The moderator asked the Devergy co-founder, how has Tanzania's lack of a renewable energy policy impacted your solar mini grid project in Melela, kololo?

A- *"The company is too small at the moment to be impacted by the lack RE policy, zero percent on import duties and vat for solar products, but there are a few parts of their solar mini grid system that are not listed in the list of the TRA and so they still pay import duties and for the long term that could be a problem. There is also a problem of the private sector in term of them getting together and lobbying more to promote their interests more in the sector."*

5.7.3 Development potential Question-3

Question three, the potential for further development in the solar sector was asked in order to cross-examine other answers on the same topic from the perspective of the supplier and institutions. The essence of this question looks at Tanzanians and their capacity as a people to support a resource such as solar energy, which is believed to have great benefits for the rural population. According to the co-founder of Devergy, Tanzania has just begun to develop its renewable energy sector and the market for further development is there and is growing rapidly.

Q- The moderator asked the Devergy co-founder, has the Tanzanian RE solar sector developed to its full potential? Why or why not?

A- *"No it has not, the renewable energy sector has just started to develop in Tanzania, and this is just the beginning of a new era in Tanzania and in Africa in term of social enterprises that look at these new pristine markets, such as the rural energy market. Every other week there is a new start up company trying to develop in terms of rural electrification. Also, people in these villages want to be connected to the world, through TV, radio, many of the local want to watch soccer because through that they may feel connected to a larger family of humans whom also support and watch soccer."*

5.7.4 Life expectancy and quality assurance Question-4

Question four, life expectancy and quality assurance of Devegy products was asked in order to assess Devergy's standards toward their solar products and system. The answer to this question looks at the quality of the solar nano grid provided by Devergy and the standards and purchasing environment in Tanzania. According to the co-founder of Devergy, they buy their parts and accessories outside of Tanzania because Tanzania has no protective measures to keep the consumer safe from harm.

Q- The moderator asked the Devergy co-founder, How long will the solar mini grids last for and is there any quality assurance?

A- *"There is always an online quality control, the grid is a smart grid, each tower in Melela has a radio transmitter that provide information about, each single unit, which is then broad casted to the internet, and as long as there is internet the solar grid can be accessed throughout the world. We get our parts from abroad because there is much more care for the customer abroad. In Tanzania, when you walk out of the store with a product it is your problem. There is a lack of policy to keep the costumer safe from harm, when he or she is purchasing something. As long as Devergy can make money they will stay in Melela."*

5.7.5 Expand solar initiative Question-5

Question five, Devergy's initiative toward expanding their approach looked at Devergy's future plans in Tanzania and why they are heading in a particular direction. The answer to this question looks at the goals of Devergy and its plans for the future in Tanzania; this answer will allow the reader to understand how Devergy perceives it customer. According to the co-founder of Devergy, they plan to expand to as many villages as possible as long as TANESCO is not present. Also they must focus on profit because the company is backed by equity investors and must make profit in order to exist.

Q- The moderator asked the Devergy co-founder, do you plan to expand the initiative? Where and why?

A- *"At the Iringa, Mbaya, Arusha and MWazana there is no limit, some of the criteria is not to be connected to the Tanesco grid, and they should not be in the plans for the expansion of the Tanesco grid. We look at the typography of the village, how the households are set up, because it is a grid setup they can connect the core of the village, but some houses are outside of the main core of the village and it would be to expensive to connect the houses that are to spread out because of the cost of wiring, we carry all of the investment, people pay 10,000Tzs for the connection fee but that is it. Each meter installed must generate profit at a certain point. No donor money all the money comes from equity investors. We must always think in terms of profitability due to the nature of the investment, between investor who expect profit."*

6 Discussion

6.1 Core of the Devergy Approach – Education, Business Opportunities, Dependability

Devergy has a bottom-up approach, and it is that which is the core of Devergy's existence and future in Tanzania. The barefoot approach, which is a SHS approach that is slightly different from Devergy, states that the key to overcoming rural solar electrification barriers is demystifying the resource, allowing villager's to have an impact and or deeper understanding of the resources regime rules (Kweka, Synnevag et al. 2012). Demystifying the resource starts with villager's awareness and acceptance and this is at the heart of Devergy's approach. Villagers stated in a mixed FGD that " A seminar was conducted to decide for solar", before the technology is implemented, villagers are informed about the resource and its regime rules. Regime rules are the rules that determine access to a resource (Vatn 2005). In this particular case the resource regime is Devergy's solar resource; the capacity of the solar system and cost. Villagers are also asked whether or not the solar resource can be brought into their community.

Due to the nature of the implementation of the approach, villagers feel more comfortable with Devergy and are able to believe in their approach because it is explained to them and they are involved in the development process. According to Kweka "The reason for the failure of many energy initiatives may be traced to flawed approaches to dissemination, typically the top-down approach to planning and implementing of projects, resulting in failure to address the needs of the intended beneficiaries (p,164)." Expert approach's have been insensitive, top-down, patronizing, expensive and have kept the marginalized from making their own decisions (Kweka, Synnevag et al. 2012). Figure-20 of the quantitative data shows that over 60 percent of villagers chose solar as their first choice as an electrical energy resource. The energy resource is one aspect of the approach but the foundation is the villager's belief in the approach, which allows for the solar resource to fulfill its potential. "Full involvement of the rural communities in the electrification efforts throughout the decision-making process increases their sense of ownership and brings support to utilities' efforts to encourage customers to use electricity wisely once they are connected (Ngwenya, 2013, p.35).” Cohesion between the bottom-up application of the Devergy approach and its solar resource is what equates to the success of the project. Implying that the approach and the resource must have a proper balance, and it is that balance that allows villagers to work longer hours, improve their security, overall health and to develop a better social relationship between villagers, not solely the solar resource.

A common problem with solar PV is the inability to find parts and adequate engineers that can fix panels and batteries, the limited purchasing power of rural people, the initial capital investment, limited experience with PV technology and difficulty accessing finances for end users (Kassenga 2008). Many of these problems have been nullified as a result of the operating framework of the Devergy approach. Devergy provides users with technical engineers and customer service agents that address any problems that may arise. This allows for increased dependability on the Devergy approach, which in turn allows villagers to focus more on benefiting from the resource. This is the major difference between the Devergy approach and SHS.

Devergy allows for a larger impact on villagers education and small businesses due to the nature and the capacity of the approach in relation to the economy and resources of the local population. By allowing villagers the opportunity to purchase solar directly from an energy company, this allows for increased access to the energy resource because the large upfront cost is decreased and the technical difficulty of fixing the resource is eliminated. The result is that the Devergy approach is more accessible for villagers in Melela, because it provides more options as well as a resource that is more affordable than purchasing a SHS from the market especially in the short-term.

6.2 Small solar and the Devergy approach are not the answers for long-term development in Africa

According of the qualitative data “solar is suited for villages because they have no other option, but in towns solar will not work because they have TANESCO. When town people buy solar it is for small electronics, solar cannot provide enough electricity for bigger appliances, storeowner 5.4.2” The storeowner makes the point that solar does not have the capacity to drive big appliances. Many of the appliances that can alleviate poverty are usually larger appliance such as farming equipment, stoves, and the ability to use these appliances simultaneously. Small solar does not have capacity to provide enough energy to use many of the appliances stated above. Indicating that SHS and the Devergy solar resource are limited in what they can provide rural communities.

According to the literature, Africa has the highest level of poverty in the world and the only way of relieving that poverty is through the consumption of modern energy (Davidson and Sokona 2001). According to the World Bank economic growth of 2.5% to 7% per annum is what is necessary for Africa to halve its current poverty rating and be able to achieve its international development goal by 2015 (Bigsten and Shimeles 2007). Meaning that Africa needs solid growth based on tangible energy resources that can drive economic growth in order to keep pace with its MDGs. Solar is often advertised as an alternative energy source that can decrease or eliminate poverty (Davidson and Sokona 2001). According to the qualitative data, FGD section 5.2.8 of the qualitative data states that buying solar everyday is a challenge, because solar is more expensive than kerosene. Also, FGD section 5.2.3 states that as a result of using solar, “no financial changes, only change is that they use the solar energy.” The data indicates that although solar has it benefits such as clean energy, accessibility to rural hard to reach areas, the resource can still be expensive for the rural population.

According to the literature no matter how someone defines poverty (absolute, relative, structural, poverty line etc.) and tries to assess it through a concepts frame, there is little uncertainty that the benefits of PV electrification on poverty alleviation is erroneous or at least, very limited (Villavicencio 2001). SHS is given a zero (on a scale of 0-100) on its ability to mitigate poverty, according to the research of (Begg, Parkinson et al. 2000). The question arises, what purpose does solar serve amongst some of the poorest people in the world if it does not help to build a firm economic base in which villagers can elevate themselves from poverty? The Devergy solar approach will not elevate villagers out of poverty but the approach can have an impact on villagers in a positive way, specifically in the short term. Solar enables villagers to charge cellphones, access to better reading light, and increased small business opportunities. The notion of small solar being able to create mass economic elevation in Africa is false.

In Europe the main people investing in PV technology are the ones ready to take the financial risk and are technically interested (Haas, Ornetzeder et al. 1999). While in Africa it is largely the poor who bear the high cost of SHS (Wamukonya 2007). The Devergy approach has a distinction from SHS; users do not have to purchase the solar system themselves and do not have to worry about repairing the system. This shifts the paradigm of solar in Tanzania, by decreasing transaction costs to the resource. Also, the market institution where solar resources are traded, have been condensed and now exists in Melela, making access quicker and possibly more affordable. Even though there is a shift as a result of this approach, the technical capacity of solar still needs analysis. The electrical capacity of small solar to drive firm economic growth through the use of modern energy consumption by way of larger appliance, such as the electrical stove farming equipment, may not be there. But Devergy still provides a more cost effective small benefit solution, by eliminating the larger overhead cost of purchasing the entire solar system; battery, wiring, solar panel etc.

Villagers that purchase the Devergy approach must pay an initial fee of 10,000 Tzs and then they are allowed to consume, as much electricity as they can afford, in table -12 of the quantitative data the average monthly consumption of solar is 6,080 Tzs. In comparison, a single 14W panel with a charge controller, 5A, battery 32Ah and 2 lights 10W costs 460,000 Tsh and cost per Watt peak (Wp) 2230, the cost of the battery is 80,000 Tsh and the cost of each bulb is estimated a 15,000 Tzs. A two panel, 14W charge controller 5A battery, 50Ah (3) 10W, voltage inverter and phone charger adapter is 695,000 Tzs and cost per Wp is 3261.2 Tzs. The preferred method of payment for SHS is in monthly installments 98% and direct purchase is 2% (Oluka 2010).

Devergy allows villagers to choose to continue using the Devergy solar option or to revert back to traditional forms of lighting, without losing as much money as they would if they bought the entire SHS themselves. With SHS, 98% of villagers pay in monthly installments. According to the Barefoot project in Tanzania villagers within their project must make an initial deposit of 5,000 -10,000 Tzs and a monthly payment of 5,000 Tzs for 5 years to pay off their solar products (Kweka, Synnevag et al. 2012). With Devergy there is no five-year payment plan to own; by eliminating that, Devergy has broken new ground in terms of providing villagers with access to electrical solar energy.

Villagers in a mixed FGD section 5.2.7 of the qualitative data state that "they prefer the Devergy approach to the individual SHS because they benefit more, they suffer as a community and help each other rather than individually. Also when something goes wrong Devergy is there to solve the problem rather than having to solving the problem themselves." Villagers would rather forego a five-year payment plan to own a SHS. They prefer the Devergy approach, even though they are connected to the same solar resource and will not own any solar products. Villagers choose to have Devergy govern their electrical resource, instead of governing the solar system themselves.

6.3 Underlying meaning of the desire to access modern energy

Of the respondents without the Devergy solar approach, there was a 100 percent desire to gain access to the approach. According to the literature more advanced technology provides a decrease in transactions cost, one does not have to go and shop for kerosene, candles and torches at the store because solar can be accessed via a phone call (Leach 1992). The energy transition or the want to transition to a new form of energy by respondents without the Devergy's solar resource may not be caused by desire. It may be caused by the improved distribution of the modern solar electricity. Meaning that the respondents desires is a representation of the individual or community's want to build themselves up or increase their own capacity through new technology (Wilk 1997).

It is the socioeconomic changes that are a result of improved distribution of modern energy that are at the core of the desired energy transition, not just superficial desires (Leach 1992). As technology advances, villagers do not want to be left behind, they want a higher quality of life. The want to be connected to information, sports and social media as well as to be able to access a faster means of communication, for example cell phones, which require electrical energy for charging. The Co-founder of Devergy in the qualitative data section 5.7.3 states “ People in these villages want to be connected to the world, through videos on their cell phones, radio, many of the locals want to watch soccer because through that they may feel connected to a larger family of humans whom also support and watch soccer”. Villagers that posses Devergy’s solar approach no longer have to walk to the store to buy a newspaper to figure out the weather or score of a football game. The Devergy approach allows villagers to access various forms of information, through the electricity it provides access to cell phones, radios and small TV’s, which in turn decreases transaction cost by the individual not having to go to the store to access news and other forms of information.

According to villagers that posses solar (figure -20) of the quantitative data, it shows that solar is the villager’s first choice of energy for light, not kerosene, candles or torches. Coupled with 100 percent of respondents without the Devergy approach desiring the approach, there is ground to assume a desire for an energy transition exists in Melela. Respondent’s desires are a result of an underlying want to breakdown constraint on new forms of energy technology, specifically Devergy’s solar resource. According to Rogers, “Relative advantage is the degree to which an innovation is perceived as better than the idea it supersedes (Rogers Everett, 1995, p.213).” From the villager’s perspective, it may be in their best interest to invest in solar because of the nature of solar energy in relation to its efficiency. According to the quantitative data (figure-20) over 67% of villagers choose solar as their first choice because it provides better light for studying and businesses, than kerosene, candles and torches. The FGDs qualitative data section 5.2.3 describes solar as having economic and social benefits, such as business owners are able to open earlier and close later as a result of the efficiency of solar. Also women that prepare Mandazi and Chapati are able to get an earlier start on the production of their products. Social benefits such as an increase in security as shown in figure-18 & 19 of the quantitative data are also factors. At the core of this observation, is a desire for increased options for end users and products that are cost effective and productive.

By providing the entire solar resource and regulating and fixing the resource, Devergy is able to decrease the cost of solar from its normal market value to a value that is more affordable for villagers. According to (figure-17) of the quantitative data, 60 percent of respondents gave solar a moderate price rating and 12 percent rate solar as low in price. In essence, villagers are paying for the operating costs of solar based on Devergy's set price, an example would be renting a house verses buying a house. Renting a house based on its housing market values is usually cheaper than buying the whole house, especially in the short term. This example is very similar to the relationship between villagers and Devergy. Villagers desire a better energy resource and Devergy provides it for them at a price that is more affordable because Devergy undercuts the normal market value by selling the resource at a price that is closer to the operational cost of solar without a five to ten year payment plan or the need for technical engineers to fix the solar system. Devergy is funded through private equity investors and has to focus on turning a profit and so profit is also factored in to the operational cost of the Devergy solar resource.

6.4 Removal of responsibility for maintenance and the desire for more control

One of the major obstacles of the SHS is limited technical knowledge of installation, operation and maintenance (Kweka, Synnevag et al. 2012). When SHS breaks down, villagers have to hire trained technicians either in the village or in local towns to fix their solar problems, because many villagers do not have the proper training to fix SHS themselves. The barefoot approach tries to empower the villager, specifically women by having them properly trained to fix these problem on their own (Kweka, Synnevag et al. 2012). The barefoot approach and the Devergy approach differ because the barefoot approach is a SHS approach and so villagers must enter payment plans to acquire the whole solar system.

One of the main characteristics of the Devergy approach is that villagers have access to solar power but do not have to repair or construct the resource. As a result of this solar has become more accessible due to the decrease in transaction costs but this new relationship has changed the terms of engagement between villagers and access to solar electricity. With the removal of this responsibility and personal ownership, the approach acts as an institution that sets a governing framework in which villagers must operate in relation to the Devergy solar system.

The data has shown that not having any influence over Devergy's solar technology is an issue for villagers. According to (Figure-22) of the quantitative data it shows the number of shutdowns and the feeling of not having to repair the grid, from the data respondents desire more control over Devergy's solar technology. They desire more control in terms of being able to understand the resource and possessing the actual ability to fix the resource, whenever they desire. This can be perceived as a desire for knowledge; villagers want to understand the resource so that they do not have to be completely dependent on Devergy. This translates to empowerment and a desire to evolve from possibly a state of not knowing to a state of knowing.

A lack of sufficient electrical institutions can also translate into skepticism toward new electrical companies. Villagers in Melela have never had Tanesco electricity. According to the Devergy solar engineer question two of the qualitative data, politicians have been promising electricity for years but have never fulfilled that promise. Devergy is the only company that has provided electricity. That contexts can facilitate miss trust and that may also be one of the root causes for villagers to want more control. They may want to feel as though the resource is theirs and can never be take away. The heightened desire for control can be the want for more trust, sustainability and reliability.

6.5 Policy issues

One of the key factors holding back the renewable energy sector in Tanzania is the lack of a RE policy that gives guidance and stability to the development of the sector. The Dar es Salaam TANESCO representative states "there is no RE policy in Tanzania and as a result of that there is no guidance in the renewable energy sector, section 5.5.1." According to the literature investors fear that when Tanzania gets a RE policy it may take time to evaluate whether or not the policy works, based on trail and error. Trial and error translates to policy reevaluation, which creates a sense of instability for investors, causing them to not commit capital to renewable power generation (Economics 2010). The UNEP and partners believe that risk of changes in the policy environment are one of the vital factors preventing the private sector for investing in RE in developing countries (Ward, Frankhauser et al. 2009).

In section 5.7.1, the co-founder of Devergy states “the problem with investing in the sector is access to credit or access to equity investors, what you find is that in any start up aimed at investing in Tanzania and other developing countries, there is very little money for start up.” One of the challenges for developers is financing in the beginning stages of development. The ability to access funds in order to do feasibility studies and to construct business plans to attract investors is hindering the development rate of increasing rural electrification (GVEP, 2010). In order for rural electrification to take place on a scale that can meet the increasing demand for energy in Tanzania, proper policies must be implemented. “Related policies and/or regulations including energy efficiency policies should be implemented alongside the electrification process to sustain long-term economic development” (Ngwenya, 2013, p.35). Policies as stated above are vital to the development of the energy sector. They allow for increased investment because of sustainability. They build a structure with rules and regulations and provide accountability in institutions such International Chamber of Commerce (ICC). But more than policy there must be belief and trust in the resource, according to the Morogoro TANESCO representative, solar has no future in Tanzania, while the Dar es Salaam representative believe the opposite. There is a lack of belief in the resource and this may come from a lack of direction created by not having a RE policy. Better understanding and communication on RE specifically solar energy is needed at the institutional level.

According to REA, “the lack of a policy has stopped investors from investing but not so much, section 5.6.2.” The literature states “The disappointing progress towards providing sufficient rural electricity has been partly attributed to the insistence on cost recovery, particularly where projects are privately financed, and to the failure to raise the incomes of rural households and effectively design tariffs and adapt regulatory systems that can make electricity more affordable to poorer communities (Ngwenya, 2013, p.34)”. Indicating that increasing rural electrification is a multifaceted problem: policy effects structure, regulations and the design of tariffs, which are taxes or duties paid on products that are either imported or exported. Another issue is rural income levels, all these factors must be addressed to increasing rural electrification.

Addressing this problem starts with a RE policy that provides direction and structure to the sector.

A proper RE policy is necessary if rural electrification is to increase via renewable energy. Currently there have been steps taken to promote Solar Water Heating (SWH) and PV but the government does not seem to want to develop RE beyond its current state based on the government power system master plan, which almost exclusively focuses on hydro power and coal (Ondraczek 2013). Meaning that there may be progress in terms of RE development but the vast majority of the country will not be depending on renewable energy for their development.

Income of the rural population is a vital issue to the electrification of rural communities. If the income of the rural population does not increase then private investors will not be able to make a profit and the same cycle will continue because once the private sector realizes that investing in rural electrification is not in their best interest then they will cease to invest. “The best way to realize the maximum socio-economic impact of the rural electrification program is if government support is long term and sustained. On and off support will not result in any benefit at all. Sustained government support and long-term funding will guarantee a more effective implementation of electrification objectives (Ngwenya, 2013, p.35)”. If the rural population is to have access to energy then it is necessary to eliminate inconsistent and sporadic investment especially with heavy upfront costs.

6.6 Potential for scaling up solar

The co-founder of Devergy states that “the renewable energy sector has just started to develop in Tanzania. This is the beginning of a new era in Tanzania and Africa in terms of social enterprises that look at these new pristine markets, such as the rural energy market. Every other week there is a new startup company trying to develop in terms of rural electrification.” Off-grid PV installation is viewed as having the largest potential for growth in the short-term in Tanzania (Ondraczek 2013). With a rural electrification rate of less than three percent of over 60 percent of the country, there exists a large opportunity for rural electrification (Ruud 2013).

Out of the 40 respondents that do not possess Devergy's solar technology, there was a 100 percent desire to have Devergy's solar technology. A few of the barriers stopping 100 percent of the respondents from being connected to Devergy's solar technology are household's economy as well as population density. According to Table 15 the largest gap between respondents that possess and do not posses Devergy's solar technology is their economy. According to the sustainable livelihoods table respondents with solar make double the income of those without solar energy. Also, in the descriptive chart of Table 1, one of the main disparities between the two populations is how far from each other the households are. Between population density and finances, population is a bit more important in terms of gaining access to the Devergy approach. Once a respondent lives outside of a 20-meter range there is no opportunity to gain access to electricity through the Devergy nano-grid. The Devergy co-founder stated in 5.7.5 *"*some houses are outside of the main core of the village and it would be too expensive to connect the houses that are too spread out because of the cost of wiring, we carry all of the investment".

In section 5.2.5 of the FGD qualitative data villagers state that a quicker way of scaling up solar is "companies need to connect everything for free and just charge for vouchers, 10,000Tzs for installation should be stopped, connect for free and allow the villagers to buy vouchers." The literature supports this claim "Connection costs should be eliminated or spread over time so as to minimize any up-front hindrances to being connected, and electricity tariffs should be affordable but not necessarily subsidized. Effective metering, billing and payment recovery ensure the long-term viability of the electricity supplier and therefore of the electrification process as a whole" (Ngwenya 2013).

One of the fastest ways to scale up the Devergy solar resource would be to drop the cost of installation and just charge for use of the resource. This would allow for full access but this puts more demand on the company in terms of less profit, but in terms of scaling up, it would be the quickest way to increase solar because the demand is there. But there are systemic problems that will still plague the sector and that is low purchasing power on the part of the rural population (Kweka, Synnevag et al. 2012).

Electricity can help both education and small business opportunities but due to low purchasing power many people will not be able to afford it. The storeowner in section 5.4.1 of the qualitative data states, "Also People are too poor, and the cost of solar is too high. With Tanesco you can get connected for 400,000 tsh and that is for life. Also, solar is limited to what it can supply, only TV and lights. While, Tanesco one can have TV, lights and everything." This indicates larger issues in the society, such as lack of investment in education, infrastructure, jobs, and an economic approach that is inconsistent and not sustainable. The nature of the market economy for sub-Sahara Africa has been one of inconsistency, due to the private sectors lack of investment and if Tanzania is to have a more sustainable RE sector is may have to evolve systemically to a system that is based on sustainability instead of sporadic growth.

Tourism is also an area in which solar can be scaled up. "Off-grid tourism is an emerging market field with a potential for several megawatts of off-grid installations (Kirai, 2009, p.9)." A lot of the focus for the SHS and the Devergy solar approach has been concentrated on the rural population, but if solar is to reach its full potential it must be view in all sectors as a potential area where solar can be utilized. Such as eco-tourism, many of these businesses rely on generators but are beginning to transition to renewable energy such as solar, because their prices do not fluctuate as much as a gas generator that will always be subject to the price of diesel or petroleum. "Virtually all off-grid tourism sites rely on generators for electrical requirements (lighting, pumping, refrigeration, communication, etc.). Rising prices for fuel, theft, and a "greening" of expectations among tourists is driving off-grid facilities to reduce dependence on generator power (Kirai, 2009, p.10)." As solar develops, the possibility for more competition also increases and through competition for markets the solar sector may see deceases in price, which can benefit the rural population, eco-tourist population and other solar sectors.

Solar grid connection is also another way of scaling up solar and the Devergy approach in Tanzania, especially where the grid and solar converge. "Consumer demand for grid-connect PV (in response to the need for demand-based solutions for load shedding) and development of grid-connect policy by other African states (including South Africa) will eventually cause the Tanzanian Government to enact grid connect policies (Kirai, 2009, p.12).” The Devergy approach and SHS would benefit from grid connects because people or companies that have excess electricity can sell it back to the grid through metering for a profit instead of lost. Also with an integrated system, there would be less competition between the two sectors and more cohesion. Currently, Tanzania does not allow the selling of electricity back to the grid and the GOT has yet to consider policies that require grid connection clauses. The GOT is open to the allowing of solar PV to be connected to the grid as long as there is no need to pay the seller (Kirai 2009).

Currently once the grid comes into contact with solar it is driven out. According to the Morogoro TANESCO representative, “in the future grid electricity is expected to expand and solar will not be welcomed.” Indicating that the two are in competition with one another. Solar can still be utilized in areas that are hard to reach and unfeasible to supply with grid electricity but in areas where the two meet solar can act as a back up, during blackouts which occur quiet often. “Frequent brown-outs make inverter-battery back-ups an intelligent investment for household and offices. Adding PV to these systems is simple and convenient (Kirai, 2009, p.12).”

Another factor in scaling up solar energy, is the lack of solar manufacturing in Tanzania. The majority of the solar products that are in the country are imports (Moner-Girona, Ghanadan et al. 2006). “In general, PV system prices are higher in Africa than in other parts of the world. For example, a Ugandan may pay two times what an Asian customer pays for an equivalent PV system. High African prices are largely due to taxes and transaction costs in the process of delivering the system (Moner-Girona, 2006, p.42).” Africa and specifically Tanzania must begin to manufacture solar energy in order to boost the sector and drop the cost of solar. Tanzania must also initiate more competition within the sector and a reduced tariff system, similar to that of Kenya that has cheaper solar produces than most African countries.

6.7 TBS- Tanzania bureau of standards

Standards are one of the biggest obstacles for Tanzania's solar sector. The REA representative states that " International markets are bad, China is making panels and putting wrong labels and. Policy makers, REA and other stakeholders need to build up the capacity to develop theses standards, through participation and capacity building." Solar is an emerging market in Tanzania and for the sector to develop to its full potential proper standard must be put in place. SHS in Tanzania are considered expensive to marginalized rural communities (Oluka, 2010, p.53). When the resource cost is coupled with low standards that do not protect consumers from faulty products, growth in the sector decreases drastically. Marginalized populations do not have the financial opportunity to gamble with their money and so they abstain from supporting solar due to low standards. According to the literature "TBS is not legally able to enforce its standards, so there have been problems with quality control of modules and components in the market. Private installations largely occur outside of any code or standards and there is no standard procedure for inspection of PV systems (Kirai, 2009, p.13)."

Devergy co- founder states "we get our parts from abroad because there is so much more care for the consumer abroad. In Tanzania, when you walk out of the store with a product, it is your problem; there is a lack of policy to keep the customer safe from harm, when he or she purchases something." The underlying meaning can be that the government does not want solar to develop to its full potential. The solar storeowner section 5.4.1 states that " the sector is not developing because the government is not supporting it, maybe they feel like it is competition for TANESCO." Proper standards and polices are vital to the progress of the solar sector and when these vital institutions are not functioning, the belief in government is drastically reduced and the perception can grow that through this neglect, the government does not want specific sectors to grow. The government of Tanzania does not seem to want to go much beyond this point in terms of solar and its policies. Their master plan for electricity indicates that hydro and coal are their main focus (Oluka, 2010, p.53).

Solar Storeowner Morogoro – "Tanzania bureau of standards (TBS) should be more responsible, there needs to be better standards. When you buy solar you do not know what has been inspected by TBS. Many products are made in China and using German labels, this is the problem for TBS. They need to do better."

6.8 Perception of the Devergy solar approach, and solar

There are mixed views on the Devergy approach and solar electricity as an energy resource, at various levels from the consumer to energy institutions such as TANESCO, the perception alternates between positive and negative as well as useful and useless. According to a study in the Siha District of Tanzania, benefits of SHS are mixed. Only 16% indicate that they use their solar system for income generating activities, 84% use the resource for just lighting (Oluka 2010). The use of small scale solar differs amongst users; some people use it for education, lighting, security and to increase small business opportunities. The individual and their education about the solar and its capacity create misconceptions and or variations in perception of solar. The solar storeowner states 5.4.1 of the qualitative data that, " People do not know how to use solar, there are not many places to get educated about solar, not on TV or on Radio. People may hear about solar but don't know anything about it." Mixed perception can also be influenced by the distribution of education amongst the rural population in Tanzania.

Mixed FGD in Melea state "We recommend other villages to get solar/ Devergy approach because some can pay, but just have not been connected. Depends on the peoples ability to pay, kids can study more, if no money, you will remain the same and kids wont study. Thieves are still there, because the bulbs are inside not outside." The point being made here is one of a mixed perception; villagers recommend the Devergy solar resource but with stipulations, mainly money. They state that solar can help children study more but that requires money and without the proper funds solar will not benefit the individual. This points to larger issues within the country, in terms of income, jobs and the ability to progress in terms of having a better life. According to the CIA world factbook, poverty rate in Tanzania is 36% and solar regardless of its benefits cannot alleviate core issues such as systemic poverty (CIA 2012).

Furthermore, one can add that poverty is also influencing the perception of solar because solar access can be an obstacle for marginalized communities in relation to the SHS and also due to the limiting alleviation of poverty (Ondraczek 2013). The Dar salaam TANESCO representative state with the context of the perception of the development of the sector that- “No not yet, technical and financial capacity of the people to buy is not there. Education and the experience are not there.”

In an all-female FGD in section 5.2.9 of the qualitative data Female FGD states- “We recommend solar to other villages. It increases education for kids and also businesses can be open later. Solar can increase our income; they can have more opportunities for more money, business and stay open later. Cooks can also cook earlier or later and in terms of security, reducing theft and snakes.” The perception of solar fluctuates based on gender, business, and income and based on need. The FGD of all female is in stark contrast to that of the mixed FGD. That is likely based on gender roles, uses for solar, small business opportunities, security and the proximity of all these various topics in relation to solar. If someone is a chef and never cooks at home where the solar resource is located then their perception of solar maybe that is not of any use.

Women in rural settings are based more in the house, in term of chores, cooking, cleaning and taking care of children. These various sections of the woman’s daily life indicate that women often operate within the proximity of their solar resource on a consistent basis and are able to benefit from the solar resource. At the core of this point maybe that women due to the nature of their daily activity and jobs are more in contact with solar and are able to benefit from the resource more than men who do not spend as much time cooking and cleaning and doing household chores. According to a study in Siha, Tanzania an estimated 3.5 hours is added to daily activity as a result of solar, 79 percent of end users agreed that their workdays were extended because of solar (Oluka 2010). Meaning that individuals that are at home are able to utilize the resource and extend their day, and the majority of these recipients are women.

A few of the women in this particular FGD were chefs and were able to prepare their food earlier in the morning and later at night due to the better light source provided by solar, which increased their small business income. “Indirect income earning activities are also taking place due to availability of light. The women beneficiaries are highly satisfied with the system, because it makes it easier for them to cook at night and finish their household's chores comfortably (Macwan, 2013, p.4)."

6.9 Funding and Development for rural electrification and the Devergy approach/ solar

Funding is vital to the development of rural population and any sector in the country based on Tanzania's shift from a planned economy to a market economy (UN-ICC 2005). When ask about grid electricity in Mlelela and the reason it has taken so long the TANESCO Mororgoro representative stated that, "It is because of budget, budget stops the process. Phase 2 project of REA is supposed to bring grid electricity to Melela and district –Mvomero. The project has been pushed back because of budget issues." The private sector of which Tanzania and many other African countries are dependent due to the nature of the market economic system which was suggest by the world bank has failed sub-Sahara Africa collectively. The private sector has not lived up to the promises expected of it in the 1990s, the sum of private sector investment has averaged 300 million per year in the last decade, which falls far below what is needed to keep up economic growth or help with access to electricity. The sum of aid and private investment in sub-Sahara Africa amounts to 0.1 percent of GDP (Bhattacharyya 2006).
Throughout this research money on the part of the consumer has been an issue as well as from the energy institutions, such TANESCO and REA.

TANESCO Morogoro Key Informant "There are a lot of projects but they haven't been funded yet."
TANESCO Morogoro Key Informant – "Private sector is not investing so much."
REA Key Informant - Projects in climate change and RE fund depends solely on the funding.

There are systemic problems that must be address if the rural population is to move forward in terms of development. Solar will not be allow to reach it full potential due to the hindrances of a lack of a RE policy, funds, purchasing power in rural communities, investment and knowledge of solar. The Devergy approach address the high overhead cost of solar and relies on private equity funding. But do to the hindrances stated above will be suppress as a result of these issues. One of the major obstacles in implement RE is no the technical aspects of the project but the absence of low cost long term funding(Buragohain 2012).

7 CONCLUSIONS AND RECOMMENDATIONS

This study has assessed the perceptions toward the Devergy Approach and its solar resource as well as its impact amongst the rural community of Melela, Tanzania. It has also looked at the potential for scaling up the approach based on perceptions and desires of consumers, suppliers, and energy institutions. Furthermore, the study looks at the external factors that aid, and also hinders the sector from reaching its full potential. The reasoning behind the development of this study stems from the renewable energy frontier that is emerging in order to combat Africa's large energy deficiencies, specifically in rural areas.

The study consists of a field survey that included the needs of villagers. The perception was based on qualitative data that showed villagers desires in terms of solar energy and grid electricity. The study also assessed the Devergy approach's impact on villagers. This also included quantitative data that triangulated the qualitative data and displayed obstacles that hinder the Devergy solar approach and the rural population from m achieving access to renewable energy. It was found that the Devergy approach had a positive impact on villagers, including increased small business opportunities, better lighting, decrease in kerosene usage, and a decrease in transaction cost, but there have also been complaints about the cost of solar specifically in the qualitative data. The issue of cost is still an obstacle, due to the low purchasing power of rural communities.

Cost and electrical capacity are still factors for Devergy. They have managed to decrease the cost of solar due to the nature of the approach, but rural purchasing power is still very low and must be addressed if the approach is to reach its full potential. Another major issue is that SHS and small solar still are unable to provide villagers with large amounts of energy that can drive large economic development. Despite these two factors, Devergy has had success in enabling access to solar energy through their approach, and the majority of villagers agree that Devergy's solar power is moderately priced. Villagers also agree that access to solar without having to incur the cost of maintenance and the purchasing the resource themselves, is a benefit.

By eliminating these various barriers, villagers are able to have more options other than traditional forms of energy such as candles, torches, and the use of kerosene. Further more, of the respondents that do not possess solar, more would like to gain access to the approach, but due to low purchasing power and or location, other villagers have not been connected. Based on the data, cost and income are factors but location may be just as important for solar electrification within a rural setting as income. Income is often times viewed as the number one obstacle for rural electrification but location is even more important than income. This is due to the characteristics of income and location, location does not fluctuate as much as income meaning that your location often times pre-determines your access benefit stream (solar technology). Income can fluctuate with seasonal rains or the global economy, indicating that there are more factors that can allow villagers to the benefit stream and so increasing their chances of gain access to solar technology.

Villagers have suggested that Devergy decrease the installation cost from 10,000Tzs to zero, so that all villagers that meet the criteria could be given access to the solar resource. This could be a potential option for scaling up the resource at a faster rate, by dropping the transaction cost to zero, Devergy would allow for full access. This as good as it may sound may also not be feasible due to Devergy being funded by equity investor that require profit in order to continue funding the approach. Also, the 10,000Tzs is not a huge barrier but more of a gesture of belief in the Devergy approach and technology.

At the institutional and supply level, there are varying perceptions on the development and the uses of solar in Tanzania. REA and the Dar es Salaam TANESCO representative agree that solar has a future in Tanzania, but states that the sector is being held back by a lack of funding and proper standards in the country. The solar supplier blamed the GOT for many of the problems in the sector, specifically the lack of education amongst people in Tanzania, regarding the benefits of the resource. Throughout the research the underlying theme or issues is a lack of funds to develop the sector to where it need to be. This indicates a larger issue within the countries market system. There has been little investment in the renewable and energy sector on a scale that could keep up with the growth of the economy or population. This is exacerbated by the lack of a renewable energy policy that can give direction and structure. This would in turn create an environment that investors could feel more confident in investing in Tanzania's energy sectors, specifically renewable energy sector.

In conclusion, taking into account the massive amount of the rural population without access to a modern energy source, Devergy provides villagers with a energy option that is more accessible than SHS. Devergy has dropped the transaction cost by maintaining the resource and possessing the resource within the company. As a result of this, villagers have far less overhead costs when accessing solar. This has opened solar access to a degree that shows that there is potential for further development, based on the large decrease in transaction cost and the short term gain of the approach and its resource.

Reference list

1, J. M. (2013). "Impact of Solar Energy in Rural Development in India." IJSRD - International Journal for Scientific Research & Development| Vol. 1, Issue 9, 2013 | ISSN (online): 2321-0613: 1-5.

AGECC, U. (2010). "Energy for a sustainable future." Kandeh K. Yumkella. Chair of the.

Ahlborg, H. and L. Hammar (2011). Drivers and barriers to rural electrification in Tanzania and Mozambique–grid extension, off-grid and renewable energy sources. World Renewable Energy Congress. Policy Issues. Linköping.

B. T. Marissa Jackson Ræstad, R. G. A. P. S. (2012). "Rural electrification: The potential of solar PV off-grid systems." NORPLAN AS.

Begg, K., et al. (2000). "Initial Evaluation of CDM type projects in Developing Countries." Universidad de Surrey, Guildford.

Bhattacharyya, S. C. (2006). "Renewable energies and the poor: niche or nexus?" Energy Policy **34**(6): 659-663.

Bigsten, A. and A. Danielsson (1999). "Is Tanzania an emerging economy." Report to the OECD, Gothenburg and Lund, Sweden.

Bigsten, A. and A. Shimeles (2007). "Can Africa reduce poverty by half by 2015?" Development policy review **25**(2): 147-166.

Bruce L. Berg, H. L. (2012). Qualitative Research Methods for the Social Sciences. United States of America, Karen Hanson

Buragohain, T. (2012). "impact of solar energy in rural development in India." International Journal of Environmental Science and Development **3**(4): 334-338.

CIA, U. (2012). "The world factbook, Africa, Tanzania ". 2014, from https://http://www.cia.gov/library/publications/the-world-factbook/geos/no.html.

Davidson, O. and Y. Sokona (2001). "Energy and sustainable development: key issues for Africa."

Devergy, F. D. P., Gianluca Cescon (2010). "Devergy developing energy " Devergy developing energy Retrieved December 8, 2014, from http://www.devergy.com/.

Eberhard, A., et al. (2008). "Underpowered: the state of the power sector in Sub-Saharan Africa."

Economics, V. (2010). "GVEP International." A Potential Role for AMCs in Promoting Green Mini-Grids in Tanzania: 1-33.

energy, V. (2014). "Victron energy blue power." Retrieved December, 2014, from http://www.victronenergy.com/.

Haas, R., et al. (1999). "Socio-economic aspects of the Austrian 200 kWp-photovoltaic-rooftop programme." Solar energy **66**(3): 183-191.

Hammar, L. (2011). Distribution of wind and solar energy resources in Tanzania and Mozambique, Chalmers University of Technology.

IEA (2010). How to make modern energy access universal?

Kalogirou, S. A. (2013). Solar energy engineering: processes and systems, Academic Press.

Karekezi, S., et al. (2003). Renewable energy development. workshop on African Energy Experts on Operationalizing the NEPAD Energy Initiative, June.

Kassenga, G. (2008). "The status and constraints of solar photovoltaic energy development in Tanzania." Energy Sources, Part B **3**(4): 420-432.

Kihwele, S., et al. (2012). "Visions, scenarios and action plans towards next generation Tanzania power system." Energies **5**(10): 3908-3927.

Kirai, I. E. S. I. M. H. A. S. P. (2009). "Target Market Analysis Tanzania's Solar Energy Market." 1-26.

Kweka, A., et al. (2012). Practical approach for sustainable solar eletrification of remote rural communities in eastern Africa: the case of Tanzania, CCIAM.

Leach, G. (1992). "The energy transition." Energy Policy **20**(2): 116-123.

Malik, K. (2013). "Human development report 2013. The rise of the South: Human progress in a diverse world."

Map (2014
). "Map of Tanzania ". Retrieved December, 2014, from http://upload.wikimedia.org/wikipedia/commons/thumb/2/2a/Tanzania_map-fr.svg/1000px-Tanzania_map-fr.svg.png.

MEM (2013). Scaling Up Renewable Energy Programme (SREP). Investment Plan For Tanzania United Republic Of Tanzania, Ministry of Energy and Mineral**:** 1-145.

Modi, V., et al. (2005). "Energy services for the millennium development goals." Energy services for the Millennium Development Goals.

Moner-Girona, M., et al. (2006). "Decreasing PV costs in Africa: Opportunities for rural electrification using solar PV in sub-Saharan Africa." Refocus **7**(1): 40-45.

Mwampamba, T. H. (2007). "Has the woodfuel crisis returned? Urban charcoal consumption in Tanzania and its implications to present and future forest availability." Energy Policy **35**(8): 4221-4234.

NBS, N. B. o. S. (2013). Population Distribution by Age and Sex. Population Distribution by Age and Sex. Dar es Salaam, National Bureau of Statistics, Ministry of Finance**:** 1-499.

Ngwenya, B. (2013). "Stakeholders Perception of Socio-Economic Benefits of Rural Electrification Programme in Zimbabwe: A Case of Umzingwane District." American Journal of Rural Development **1**(3): 33-39.

Oluka, W. (2010). Perceptions and uptake of solar lighting systems in siha district, Tanzania. Noragric. Norway, NUMB. **Masters:** 1-87.

Ondraczek, J. (2013). "The sun rises in the east (of Africa): A comparison of the development and status of solar energy markets in Kenya and Tanzania." Energy Policy **56**: 407-417.

Rogers Everett, M. (1995). "Diffusion of innovations." New York.

Ruud, C. (2013). "Why not go green?: an analysis of the viability of solar PV mini-grids in Tanzania."

Statistics, N. N. B. o. (2012). 2012 POPULATION AND HOUSING CENSUS. Ministry of Finance Dar es Salaam, Ministry of Finance Dar es Salaam.

TAREA (2012). "
Tanzanian Renewable Energy Association." Retrieved December 10, 2014, from http://www.tarea-tz.org/index.php/contact.

UCLA, C. F. H. P. R. (2014). "Section 4: Key Informant Interviews." 1-10.

UN (2002). Report of the World Summit on Sustainable Development Johannesburg, South Africa United Nations 1-176.

UN-ICC (2005). "AN INVESTMENT GUIDE TO TANZANIA." International Chamber of Commerce The world business organization: 1-82.

UNCF (1987). Our Common Future. **Report of the World Commission on Environment and Development:** 1-247.

Vatn, A. (2005). Institutions and the Environment. Edward Elgar Pubishing Limited the Lypiatts 15 Landsown road Cheltenham Glos UK, Edward Elgar Publishing, inc.

Villavicencio, A. (2001). "Sustainable energy development- the case of photovoltaic home system." UCCEE Risoe National Laboratory, Denmark **Draft UCCEE working paper, Denmark**.

Wamukonya, N. (2007). "Solar home system electrification as a viable technology option for Africa's development." Energy Policy **35**(1): 6-14.

Ward, J., et al. (2009). "Catalysing low-carbon growth in developing economies." Public finance mechanisms to scale up private sector investment in climate solutions. Geneva: United Nations Environment Programme.

Wilk, R. R. (1997). "A critique of desire: distaste and dislike in consumer behavior." Consumption, Markets and Culture **1**(2): 175-196.

Appendix

Section A: Preliminary Information

Date: :________________ Questionnaire NO:___________________

Village:____________________ Solar or No Solar ______________

1. Name of the Interviewee

Section B: Household Characteristics

2. Sex
   1. Male ( )
   2. Female ( )

3. Age _________

4. Main source of livelihood
   a. Farming ( )
   b. Officially employed ( ) Mention…..
   c. Causal laborer ( )
   d. Business (specify) ( )
   e. Other (specify) ( )

5. Education level of the respondent
   a. No formal education ( )
   b. Adult education ( )
   c. Primary education ( )
   d. Secondary education ( )
   e. Other (specify) ( )

6. Number of people in the household and how many go to school?

Residence in he HH	Number that Go to school

Section B: Household assets and endowments

7. What assets does the household possess? (Indicate the amount in each area)

Type	Car/ motorbike	gen. set	bicycle	cart	radio	TV	lamp	mobile	solar units	Hoes/ panga	Others-Specify
#											

8. What type of dwelling do you have?

   (Brick, mud, straw, etc.)___________________

9. How much land do you own (acres)?

a. 5≤
b. 5 – 10
c. 10 – 15
d. 15≥

Section B: Economic Status of the household

10. What do you use energy for? How much do you pay for it?
Who collects the resource? Where does it come from?

Energy source	Use	Collector of the resource Male / female	Amount spent on the energy per day (Tshs)	Amount spent on the energy per week (Tshs)	Amount spent on the energy per month (Tshs)	Location of Resource
• Firewood						
• Charcoal						
• Kerosene						
• Solar						
• Candles						
• Torches						
• Batteries						
• Other						

11. What type of energy do you use for each activity both inside and outside the household?

Activity	Type of energy	Source	Responsible M/F	Monthly cost
Cooking				
Heating				
Lighting				
Others (specify)				

12. Were there any problems that you faced with these sources of energy?

Sources of Energy	Problems you face	How bad, Rating 1-3
Kerosene		
Coal		
Firewood		
Gas		
Solar		
Grid Electricity		

13. How much do you earn per month? Both farm and off farm earnings.

a. 10 000≤
b. 10 001 – 20 000
c. 20 001 – 30 000
d. 30 000- 40 000
e. ≤40 000/ other (specify)_____________

Crops	Cost per Kilo	Amount Sold per day (Tshs)	Amount Sold per week (Tshs)	Amount Sold per month (Tshs)
• Maize				
• Cotton				
• Millet				
• Ground nuts				
• Sweet potatoes				
• Sugar cane				

** How much do you earn per season and year? Amount ___________________tsh?

14. Do you grow crops and if so, what kind?

15. Previous crop season how much did you make from each crop per annum, 2012?

Amount ____________________tsh

16. Do you get any remittances from other family members?

• Other				

17. Do you have any livestock and if so what kind?

Crops	Cost per Animal	Animals sold per day (Tshs)	Animals sold per week (Tshs)	Animals sold per month (Tshs)
• Goat				
• Fish				
• Cow				
• Chicken				
• Sheep				
• Pig				
• Other				

18. How much do you make per annum from your livestock, 2012?

Amount ____________________tsh

19 .Do you make local brew, if so what?

Brew	Cost per liter	Liters Sold per day (Tshs)	Liters sold per week (Tshs)	Liters sold per month (Tshs)

Remittances	Amount per month	Which family member
Livestock		
Money		
Crops		
Other		

• Beer				
• Coconut wine				
• Gongo				
• Other				

20. How much do you make from it per annum from your brew, 2012?

Amount ____________________tsh

21. What is your max you would pay to have solar energy installed in your home?
Amount____________________tsh

22. On a payment card circles the largest amount that you would be willing to pay for solar energy in your home.

a. 2000 ( )	g. 50,000 ( )
b. 3000 ( )	h. 100,000 ( )
c. 5000 ( )	I. 150,000 ( )
d. 7000 ( )	J. 200,000 ( )
e. 10,000 ( )	
f. 20,000 ( )	

23. How would you be willing to pay for solar energy, daily, weekly, monthly? Which do you prefer the most 1-3 highest to lowest, 3 being the highest?

a. Daily ( )
b. Weekly ( )
c. Monthly ( )
d. Year ( )

24. Would you be willing to pay for solar energy for 5 years on a monthly basis and what is the maximum you would be willing to pay?

Monthly payments
a. 2000 ( )
b. 3000 ( )
c. 4000 ( )
d. 5000 ( )
e. Other_______

25. Would you be willing to pay for solar energy for 10 years on a monthly basis and what is the maximum you would be willing to pay?

Monthly payments
a. 2000 ( )
b. 3000 ( )
c. 4000 ( )
d. 5000 ( )
e. Other_______

26. Do you want solar energy? Yes or no and if so what for? ________

a. Lighting ( )
b. Security ( )
c. TV ( )
d. Radio ( )
e. Lanterns ( )
f. Cost ( )
g. Efficiency ( )
h. Health ( )
i. Other (specify) ( )

27. Why should the solar mini grid be extended to your home?

a. Willing to pay for electricity ( )
b. Want solar grid electricity ( )
c. Other (specify) ( )

Benefits of solar

28. How long have you been connected to the solar mini grid?

a. Weeks ( )
b. Months ( )
c. Years ( )
d. Other (specify) ( )

29. What made you decide to connect yourself to the solar grid?
a. Household lighting ( )
b. Safety ( )
c. Education ( )
d. Business opportunity ( )
e. Other (specify) ( )

30. Are you satisfied with solar PV mini grid connection, on a scale of 1-3, 3 being the highest?
( )

31. How much did solar grid connection cost?

a. $2000 \leq$ ( )
b. $5000 \leq$ ( )
c. $8000 \leq$ ( )
d. $10,000\geq$ ( )
e. $20,000\geq$ ( )
f. Other (specify) ( )

32. How many accessories that use solar electricity do you use per day?

a. Bulbs ( )
b. Lanterns ( )
c. Radios ( )
d. TV ( )
e. Cellphones ( )
f. Other (specify)

33. How many hours a day do you use solar mini grid?

a. 3$\leq$ ( )
b. 6$\leq$ ( )
c. 9$\leq$ ( )
d. 12$\geq$ ( )

34. Do you think solar mini grid energy is adequate for your daily activities? Scale of 1-3, 3 being the highest.
( )

35. What are the most important benefits of having (mini grid) solar? Scale 1-3

a. Light ( )
b. Studying ( )
c. Security ( )
d. Efficiency ( )
e. Increased business opportunities ( )
f. Increased capital ( )
g. Other (specify)

36. Can you describe life in your households before you started using solar energy? Scale yes/ no the same

Various sectors	Increased / result of solar	Decreased / result of solar	Remained the same / result of solar
Business opportunities			
Ability to study			
Security			
Buying Kerosene Consumption			
Flashlights Usage			
Torches consumption			

Batteries consumption			

37. Where did you hear about solar energy?
    a. Newspaper ( )
    b. Radio ( )
    c. Village meeting ( )
    d. TV ( )
    e. Friends ( )
    f. Investors ( )
    g. Other (specify)

38. Have you ever used any other solar products before solar mini grid?
    a. Solar pump ( )
    b. Single solar panel ( )
    c. Solar lantern ( )
    d. Other (Specify) ( )

39. What kind of energy do you use on a daily basis (check all that apply)?
    a. Firewood ( )
    b. Charcoal ( )
    c. Kerosene ( )
    d. Electricity ( )
    e. Electric generator ( )
    f. Solar energy ( )
    g. Other (mention)… ( )

40. How do you rate the cost of solar units with the other sources of energy?
    1. Very low 2. Low 3. Moderate 4. High 5. Very high

41. If you were given chance to choose among several sources of energy for lighting, what will be the chance for solar energy to be selected?

	1st choice	2nd choice	3rd choice	4th choice	5th choice
Choice rank					

42. What would be the reasons for your choice from the above question?
    a. Dependability ( )
    b. Health issues ( )
    c. Cost ( )
    d. Access ( )
    e. Only option for modern energy ( )
    f. Other (specify) ( )

43. How often do you purchase energy per week?

a. 2≤ ( )
b. 4≤ ( )
c. 6≤ ( )
d. 10≤ ( )
e. 10≥ ( )

44. What is the average that you pay for energy Monthly?

a. 2000≤ ( )
b. 5000≤ ( )
c. 8000≤ ( )
d. 10,000≤( )
e. 10,000≥( )

45. What is the cost of kerosene per ¼ liter?

a. 1000 ( )
b. 2000 ( )
c. 3000 ( )
d. 4000 ( )
e. 5000 ( )

46. How often did you buy kerosene before solar mini grid investment, weekly?

0 ( )
1 ( )
2 ( )
3 ( )
4 ( )
5< ( )

47. How often do you buy kerosene after solar investment, weekly?

0 ( )
1 ( )
2 ( )
3 ( )
4 ( )
5< ( )

48. Did you have any knowledge of solar before this project?
Yes or no

49. How many time has your solar mini grid shut down, weekly?

0 ( )
1 ( )
2 ( )
3 ( )
4 ( )
5> ( )

50. How would you gauge solar grid electricity 1-3, 3 being the highest?

1 ( )
2 ( )
3 ( )

51. Is this the first time you have been connected to grid electricity?
Yes or no

52. Who repairs the grid?

a. You ( )
b. Village engineer ( )
c. Town Engineer ( )
d. Investors ( )
e. Terea NGO ( )

53. If it is not you who has to repair, the grid, how does that make you feel that you don't have to repair the grid?

a. Relieved ( )
b. Secure ( )
c. Insecure ( )
d. Indifferent ( )
e. Confident ( )
f. Bad ( )

54. What changes do you see in your household and village as a result of the solar mini grid? Gauge each from 1-3, 3 being the highest

a. Men work less ( )
b. Women work less ( )
c. Everyone feels secure ( )
d. Everyone feels safe ( )
e. Children have more opportunities ( )

55. Do you feel that electricity is a benefit to the household and the community?
Yes or no

56. In what way does electricity benefit the and community? Gauge each from 1-3, 3 being the highest

a. People organizing ( )
b. Children feeling secure ( )
c. Women feeling secure ( )
d. Education ( )
e. More opportunities for business ( )
f. More active ( )
g. Others (specify) ( )

57. Are these prices feasible for you to pay for solar grid electricity? 1-3, 3 being the highest.

a. 50,000
b. 100,000
c. 150,000
d. 200,000

58. Out of your closest neighbors house, how far is the closest house?

a. 5 meters
b. 10 meters
c. 15 meters
d. 20 meters
e. other (specify)

How far is the furthest house?

a. 5 meters
b. 10 meters
c. 15 meters
d. 20 meters
e. other (specify)

59. How much do you spend on solar energy per month?

a. 2000 ( )
b. 3000 ( )
c. 5000 ( )
d. 7000 ( )
e. 10,000 ( )
f. 20,000 ( )
g. 50,000 ( )
h. 100,000 ( )
I. 150,000 ( )
J. 200,000 ( )

Pay close attention to questions 23, 28, 29, 32

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