Tampere University of Applied Sciences
Degree programme in Environmental Engineering
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Final thesis

POTENTIAL OF SOLAR POWER IN ELECTRICITY PRODUCTION IN DAR ES SALAAM, TANZANIA

FOCUS ON HOUSEHOLDS AND PAYBACKS

Supervisor Senior Lecturer Eeva–Liisa Viskari
Commissioned by TaTEDO Development Organization
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ABSTRACT

The purpose of this work was to study the opportunities and challenges of using solar power by solar photovoltaic (PV) in production of electricity for households in Dar es Salaam, Tanzania. Dar es Salaam has plenty of sunshine throughout the year making it a perfect candidate for solar PV electrification.

Data collected for this work was done mainly by conducting interviews with different levels of households, private and government institutes, literature from books, web pages and previous reports on similar works were used as well. A questionnaire was used to collect people's opinion and understanding towards solar PV, the Ministry, Nongovernmental institutes and organizations dealing with solar energy were interviewed.

The results of estimated electricity consumption in different levels of households were used to calculate the amount paid in a year for electricity from the grid and comparing the amount with that of solar PV systems the paybacks were calculated.

As a result I found out that in the long run it is beneficial for all household levels to invest on PV systems for electricity production as it will ensure reliable supply of electricity.

Keywords: Dar es Salaam, solar power, Photovoltaic cells, electricity, households

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TIIVISTELMÄ

Tämän työn tarkoituksena on tutkia aurinkoenergian käyttöä ja haasteita PV-sähköntuotannossa kotitalouksille Dar es Salaamissa Tansaniassa. Dar es Salaamissa aurinko paistaa paljon ympäri vuoden, joten se on mainio paikka PV-aurinkosähkön tuotantoon.

Tiedot työhön on kerätty pääasiassa haastatteluin erilaisissa kotitalouksissa sekä yksityisissä ja valtion laitoksissa: kirjallisuudetta, verkkosivuja ja aiemmin aiheesta laadittuja raportteja on myös käytetty lähteinä. Mielipiteiden kokoamiseen käytettiin kyselylomaketta, jossa kartoitettiin asukkaiden tietämystä PV-aurinkoenergiasta. Ministeriön sekä alan eri järjestöjen edustajia haastateltiin.

Kotitalouksen arvioitua sähkönkulutusta erilaisissa kotitalouksissa käytettiin perustana laskelmassa, jossa vertailtiin perinteisesti tuotetun ja PV-aurinkosähkön hintaa. Tuloksena oli, että tulotasosta riippumatta, kaikkien kotitalouksien kannattaisi investoida PV-sähköjärjestelmään pidemmällä aikavälillä mitattuna.

Hakusanat: Dar es Salaam, aurinkovoima, aurinkopaneeli, sähkö, kotitalous

FOREWORD

I would like to express my sincere gratitude to my supervisor Eeva-Liisa Viskari for backing up my thesis topic and supervision of my thesis, also for helping me get funded for my trip to Dar es Salaam. To Marjukka Dyer, the head of Environmental Engineering degree programme for the opportunity to be a part of the programme.

Thanks to TaTEDO for offering me valuable information which helped me to understand about solar PV and introducing me to solar PV users in Dar es Salaam.

Thanks to Maa-ja Vesitekniikan Tuki ry (MVTT) for funding my trip to Dar es Salaam.

Thanks to God for all his blessings, Special thanks to my parents, Dr & Mrs. Kibbassa who have always believed in me and never stopped encouraging and supporting me through every step, my mother especially, I don't know what I would do without her.

Lots of thanks to my family and friends for the prayers and encouragement, to my fellow 06IENVE who made the past four years memorable to Yoav Magen for the company and endless help and Blandina Kirumbi for her support and friendship.

And to MEM, REA, TASEA, TANESCO, TMA and the people who took time to answer my questionnaire, thank you for all the help and information.

Tampere April 2010

Mwilumbwa Kibbassa

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ABBREVIATIONS

HEP- hydroelectric power

PV- Photovoltaic

REA- Rural energy agency

SHS- Solar home system

TANESCO – Tanzania Electric Supply Company

TASEA- Tanzania Solar Energy Association

TaTEDO- Tanzania Traditional Energy Development Organization

Tsh- Tanzanian shilling

USD- United States Dollar

VETA- Vocational Education and Training Authority

Wp- Watt peak

Currency

1USD approximate 1320Tsh

1€ is approximately 1800Tsh

Contents

1Introduction

Dar es Salaam, the largest city in Tanzania has had to deal with long hours without electricity in the recent years due to power rationing taking place throughout the country. Electricity produced by the only national power utility, Tanzania Electric Supply Company (TANESCO) has not been enough for the whole country.

Most of the electricity supply for Dar es Salaam and the country at large is from hydropower stations within the country. However, due to decreasing volumes of water in all the Hydro Electric Power (HEP) dams, as a result of the scarcity of rains, electricity supplied from hydroelectric power plants is no longer reliable. In order to address this problem the power company has been trying to compensate the gap by producing electricity from diesel and natural gas generators. In this age where fossil fuels have been contributed so much to global warming it is wise to look for alternative ways and method of producing power.

This thesis looked into production of electricity for Dar es Salaam city by solar power and solar PV to be more specific, the thesis concentrated on the households' electrification.

In my opinion solar power by using photovoltaic cells is one of the most effective and quick ways of producing electricity especially in a city like Dar es Salaam which has plenty of sunshine throughout the year.

1.1 Dar es Salaam

Dar es Salaam is the commercial capital of Tanzania and its located close to the equator (6°48'S 39°18'E) /22/. Its advantageous location within the tropics ensures reception of sufficient sunshine throughout the year

Dar es Salaam has an area of about 1,393km2 with a population of 2,487,288 according to the 2002 statistics /20/. About 59% of all households in Dar es Salaam are connected to the national electricity grid. Most of the households, which do not have access to electricity, are found in the outskirts of the city. These are the areas where most of the unplanned settlements are found, connection to the grid for these areas is and expensive and challenging since they are unplanned. The majority of these areas have low energy demand and in some cases are located far from each other making electrification by the grid even more expensive./3/

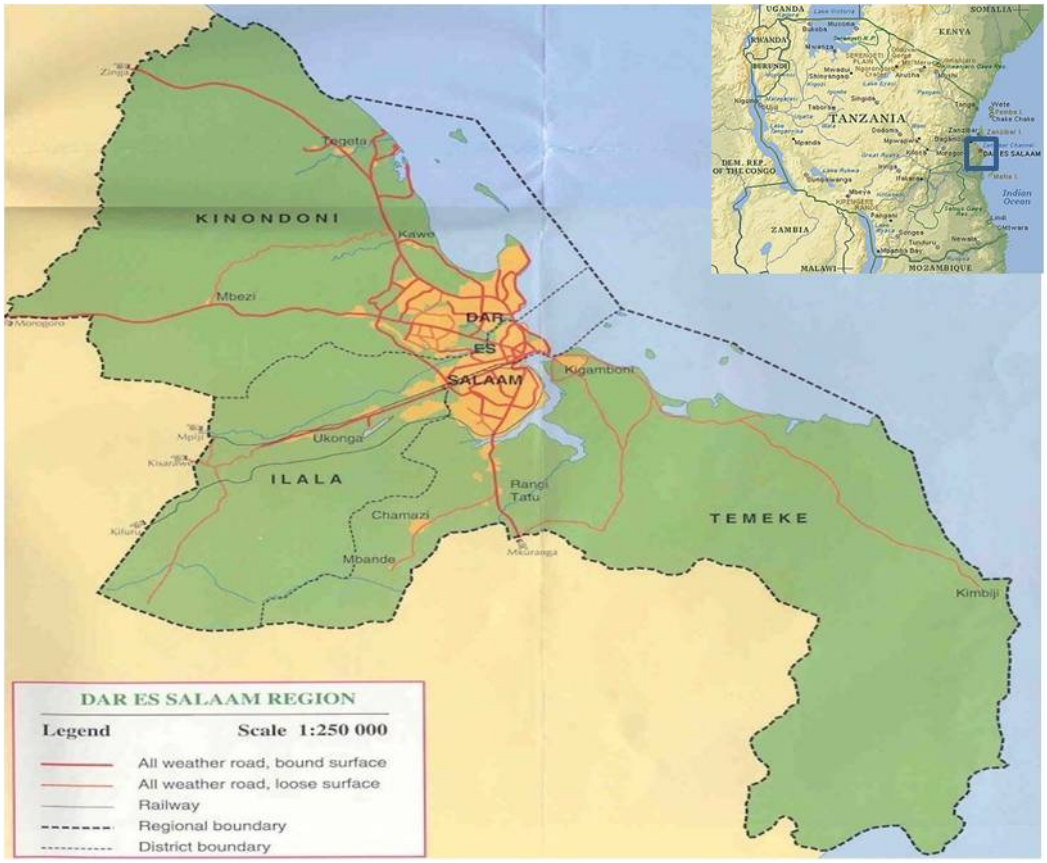

Figure 1: A map of Dar es Salaam, Tanzania /12,13/

1.2 Solar power

Solar power is the energy that comes from the sun. The sun as the source of life to earth it supplies light and heat to earth, plants use the suns energy in the process of making its food, and we as human being eat plants and animals which feed on plants as well. The fossil fuels we use today are from a long process of decomposition which was aided by the heat from the sun.

The use of fossil fuels has increasingly led to global warming which has made the need for use of alternative fuels more pressing than before. Solar power is among the promising alternatives for the future of energy production, it is clean, simple to use and can be accessed from many parts of the world.

Solar power in the simplest form gives heat and light to the earth, but the suns energy can be harnessed for electricity production. Electricity is the simplest form of energy available; it comes from different sources, these can be renewable energy such as hydroelectric power, wind and solar power and fossil fuels such as petroleum, coal and natural gas.

Electricity production by using solar power is available in two main forms; by use of photovoltaic panels (solar PV) and also by use of concentrated solar power (CSP), the latter is by concentrating the sun’s rays and obtaining a high temperature, the high temperatures produces heat which is then used to power plants for electricity production./1/

In this work I will concentrate on solar PV as it is more applicable to households.

1.3 Solar PV

Solar PV is the production of electricity from the sunlight by the use of photovoltaic cells. The cells are made from semiconductor material which is mainly silicon and other semiconductor materials.

There are three types of the semiconductors, these are: crystalline, multi crystalline and amorphous. These three types are categorized according to their layout, the crystalline semiconductors have an ordered crystal formation and they are more effective because their layout allows ready application, but they are the most expensive to manufacture /6/

Multi crystalline or poly crystalline production is less complicated compared to the crystalline ones, it is made up of many crystalline which are laid in different directions, and it is much more used for making PV cells. Amorphous is non crystalline, it is much cheaper compared to the crystalline silicon

The semiconductors are made up of two layers the negative (n-layer) and the positive (p-layer) which are sandwiched to give pn junction. The n-layer has an excess of electrons while the p layer has excess holes.

The sun’s rays contain pockets of energy known as photons, when the photons hit the surface of the semiconductor they excite the electrons and cause them to move to a higher state after gaining the energy from the photons. The excited electrons occupy the empty holes and at the same time they live holes from their original position, this movement creates a current which produces electricity /6,15/

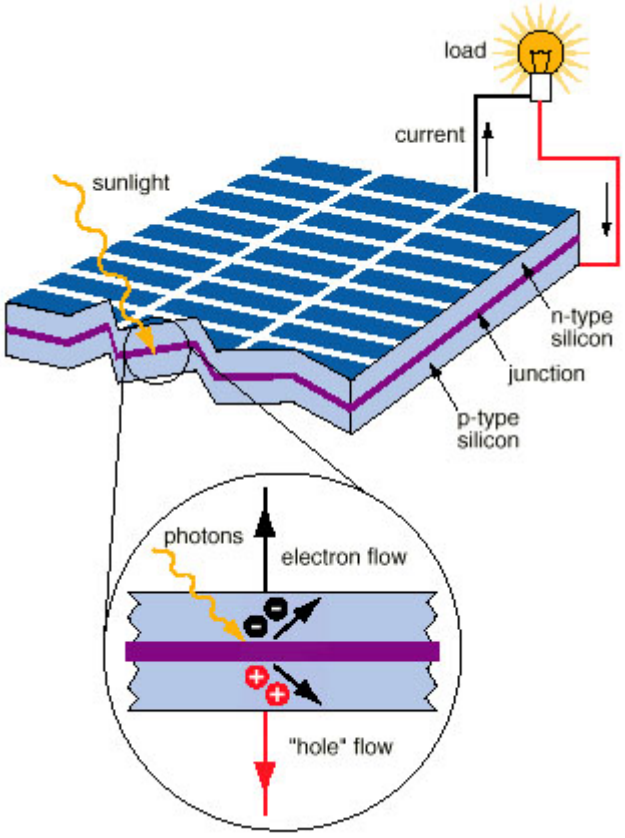

Figure 2: A Close-up image of a PV cell showing how current is generated /20/

1.3.1 Advantages of solar PV Technology

- There is no fuel cost involved since it is powered by the sun which is readily available in most parts of the world and after the initial cost of the system have been paid off, free electricity can be used without the worry of an electricity bill.
- It requires low maintenance cost especially because they are no moving parts to make it wear off easily.
- It is safe to use as it does not involve combustible fuels and if they are installed correctly
- It is a clean source of energy; it does not cause pollution, so in turn reduces the impact of global warming

- The modules are very durable; most will produce power for 25 years or more if they are well kept. /4/
- It is an independent system making it applicable even in remote areas as it does not have to connected to the grid
- The technology is a source of job creation and it creates opportunity for small businesses in remote areas with no access to electricity

1.3.2 Disadvantages of solar PV technology

- The initial costs for the whole system are very high, making it hard for people to use the technology, the cost for the installation of the conventional electricity system is usually low compared to solar PV at the beginning./4/
- In some areas there is variability in available solar radiation which inhibits the system to function at its best.
- Lack of awareness to this relatively new technology slows down its technology and market growth/4/

1.4 Solar home system

These are independent solar systems which are used to power households demands; they have been most popularly used in remote areas in the past where they did not have access to the grid but they are becoming more popular in the urban areas because of frequent power shortages, more people want to turn to renewable energy to reduce the impact of global warming and some opt for solar power to cut the cost of the conventional electricity bills.

The load usually determines the size and the specification for the appliances needed for the house.

Figure 3; A house in Dar es Salaam which gets electricity completely from solar PV(Photo: Mwilumbwa Kibbassa)

1.4.1 Components of a photovoltaic system

1. Module: This is a setup of PV cells which generate voltage and current when In contact with the sunlight, a panel is one or more modules and when the panels are arranged and wired together it's called an array./4/
2. Battery: for storage of the direct current (DC) energy, this stored energy can be used at night time or when there isn't enough solar radiation. Deep cycle batteries are the best for this use as they can withstand being deeply discharged and then fully recharge when there is sunshine; convenient car batteries are not suitable for this use./4/

3. Charge controller: a machine that regulates the voltage of the battery, it is placed between the solar module and the battery, this device controls the charge that goes in the battery. It withholds excess charge from going into the battery./1/
4. Inventor: an electronic device which changes direct current to alternating current,

5. AC and DC loads: Appliances, motors and equipments such as radios, TV, lights, refrigerators powered by AC and DC respectively.

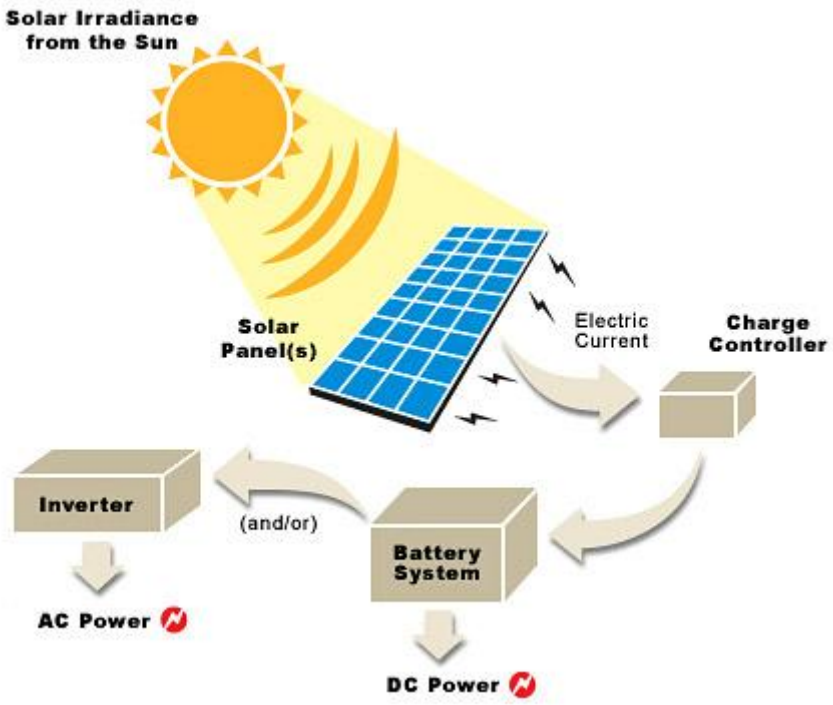

Figure 4: A schematic representation of a simple solar PV system /14/

1.5 TaTEDO

TaTEDO is a development NGO which works at promoting the use of sustainable energy. It was established 17 years ago and it operates in 10 regions of Tanzania. TaTEDO takes a community based integrated and entrepreneurship approach to reach people to disseminate information and knowledge about sustainable energy.

TaTEDO aims at making sustainable modern energy technologies accessible to people especially in the rural areas, they do this through community mobilization, energy technology adaptation and influencing policy to increase access to sustainable energy services and environmental conservation. By doing this they aim at poverty reduction, climate change mitigation, environmental protection and a sustainable development./19/

1.5.1 TaTEDOs Activities

- Promotion of sustainable modern energy services for production to Small and Medium Enterprises (SMEs) such as agricultural processing plants, households, small entrepreneurs and social service centers such as schools, and health facilities.
- Providing energy related consultancy services
- Reducing the impact of environmental degradation which is associated with energy use such as deforestation for charcoal.
- Conducting researches on energy related matters
- Lobbying and influencing policy making especially environmental and energy related, policy making and legislations.
- Provision of services to enterprises development and development of network and partnership with local and international organizations
- Manage and spread energy information to institution, education centers, communities and other stake holders./19/

1.5.2 TaTEDO and Solar Power

TaTEDO promotes the use of solar power for household electrification, solar phone charging systems as well as electrification of dispensaries and schools.

Awareness of solar PV has increased due to its promotion initiatives from TaTEDO, individuals have come to understand, appreciate and use Solar PVs, despite the fact that at the moment solar technology is too expensive for most people to afford. In order to address the issue of affordability, TaTEDO has been facilitating links between potential users and local microfinance institutions in order to get loans./19/

TaTEDO has been running workshops in communities as well as technical colleges to get the technology familiar to people and to help it get integrated to colleges syllabus especially in electrical studies./19/

TaTEDO has its own centre which is called sustainable energy development centre (SEDC), at this centre TaTEDO has a building which is electrified by solar power and apart from that it has an exhibition of a library, small hair cutting saloon, kitchen and an

office, both fitted with electrical appliances. This exhibition helps the people and other institutions to see how solar power can work practically

Figure 5: TaTEDO´s Sustainable Energy Enterprise Centre (SEECE) powered by solar PV (Photo: Mwilumbwa Kibbassa)

1.6 Aim of the work

The aim of this work was to investigate the potential of solar power by using PV panels for household's electricity production in Dar es Salaam. The paybacks are calculated for solar PV systems which are being used as back up or in hybrid with the grid.

2 Methodology

In order to achieve the aim of the study, different people, organization and institutes were interviewed. A questionnaire with the aim of knowing peoples perspective, understanding and use of solar power was prepared. A sample of 20 households was randomly selected, this sample group consisted of people who had solar systems for the households and those who didn't, focusing the sample group to one specific area would have resulted to most if not all households not having a solar PV thus the results lacking the opinions of households with solar PV systems. The questionnaire used can be seen from appendix 2.

The mean monthly radiations of ten years (1999-2008) were obtained from the Tanzania Meteorological Agency. The results are taken from the J.K. Nyerere International airport weather station in Dar es Salaam. The results were aimed to study the amount of sunshine that Dar es Salaam receives and see if it is enough for electricity production by solar PV.

A qualitative interview was conducted with the research and environmental manager from TANESCO, the purpose of the interview was to find out the present situation of electricity in Dar es Salaam. The electricity demand of the city, what are the sources of electricity supplied in Dar es Salaam, reasons for the recent power shortages, how they plan to resolve this problem. The interview also aimed at finding out TANESCOs take on solar PV and if they have plans to use it in the future for electrification of Dar es Salaams households.

The arm of the government which deals with energy matters, the Ministry of Energy and Minerals was also visited and a qualitative interview was conducted with the Assistant commissioner for renewable energy. The objective of this interview was to see what the government does to promote the use of solar PV and what are the government plans in relation to use of Solar PV. During the interview I found out about the ministry's free body, Rural Energy Agency. As a part of the research I also interviewed the agency, found out about its functions and activities towards solar PV development.

Another qualitative interview was carried out with the executive secretary of Tanzania Solar Energy Association (TASEA). The executive secretary told about the work of

TASEA, awareness and use of solar PV for households, how the association works together with the government and other institutes in matters regarding solar PV. With the help of the Association I was able to recognize some of the reliable and top suppliers and dealers of solar PV equipments.

At the end a comparison was made between the investment and price of electricity from the grid and from solar PV. The price of various PV systems were taken from TaTEDO who made the average price of various PV systems found in Dar es Salaam, the price of the solar PV systems can be seen from appendix 1. The price of electricity from the grid was taken from TANESCO.

3 Results

3.1 The results of the weather condition of Dar es Salaam

The mean monthly radiation of Dar es Salaam is presented in Table 1.

Table1: The mean monthly radiation (kWh/m^2) of Dar es Salaam year 1999-2008 from the J.K.Nyerere International airport weather station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1999	6,0	6,4	5,2	4,8	4,8	5,3	5,3	5,4	6,3	6,5	5,7	5,7	5,6
2000	6,9	7,0	5,5	6,0	5,9	5,8	5,6	6,1	6,4	6,7	6,5	5,9	6,2
2001	5,6	6,3	5,9	5,8	5,6	5,5	4,9	5,6	6,0	6,7	7,2	6,2	5,9
2002	5,6	6,6	5,2	4,3	6,1	5,5	5,4	5,2	5,5	6,1	6,3	5,9	5,6
2003	6,3	6,6	6,5	6,1	4,7	5,9	6,0	6,6	6,5	6,6	6,8	7,4	6,3
2004	6,3	5,8	5,6	5,2	6,2	6,0	6,0	6,6	6,8	6,7	6,5	6,0	6,1
2005	7,7	7,6	6,6	4,9	3,8	4,6	4,1	4,3	5,1	4,7	5,2	5,7	5,3
2006	5,5	5,5	4,5	4,2	4,2	3,8	4,8	4,8	5,2	5,1	4,7	4,8	4,8
2007	5,2	5,4	4,9	4,2	4,1	4,3	4,5	4,6	5,0	4,9	5,0	5,3	4,8
2008	4,9	4,8	4,8	3,3	4,2	3,9	3,9	4,2	4,7	5,0	m	5,0	4,4

m=missing data

3.2 Results of the questionnaire of the use of solar PV in households

The results presented here are from the questionnaire presented in appendix 2. A total 20 people were randomly selected participated in this questionnaire and the answers are as following:

1. Figure 6. Presents the share of households familiar with production of electricity by using solar power

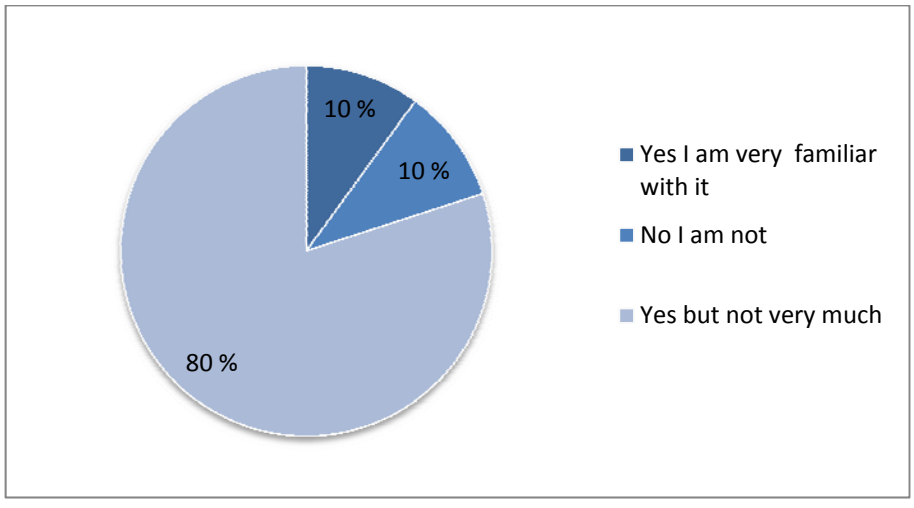

Figure 6: The share of households as a percentage to their familiarity to solar power

The 90% who had an idea of what solar power is and how it can produce electricity got their information from the media, friends and colleagues, and some had attended seminars and exhibitions on solar power. Only the 10% out of the 20 had formal knowledge on the subject from their previous studies or jobs.

2. Figure 7 shows the share of households using solar power

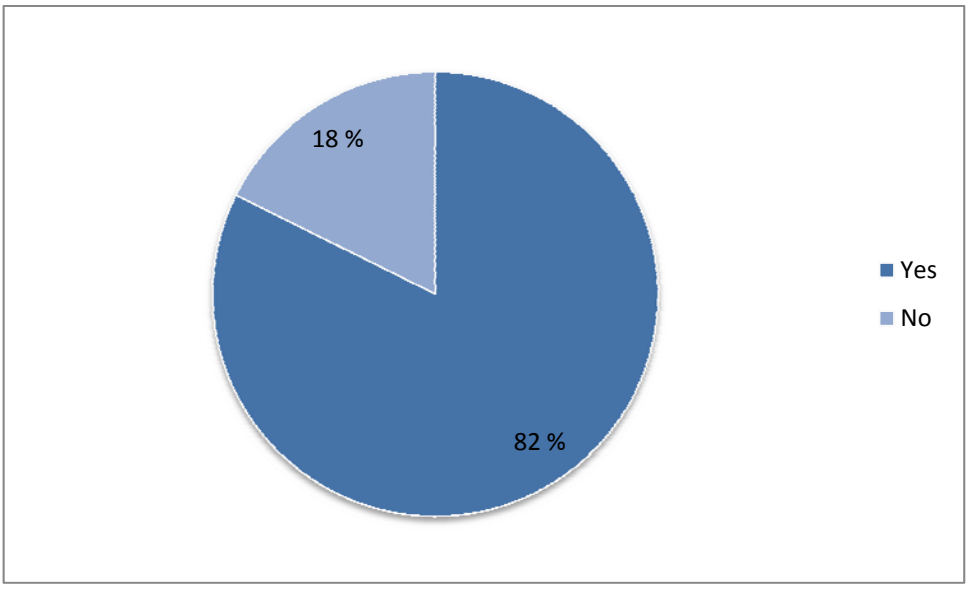

Figure 7: Percentage of households using solar power for electricity production

Only15% out of the 20 people were using solar power for electricity production for their homes, lack of knowledge, unreliability towards new technology, and most of all the initial high cost of the system hinders most people from using this new technology.

3. Figure 8 presents the willingness of people to use solar power if the prices are reduced

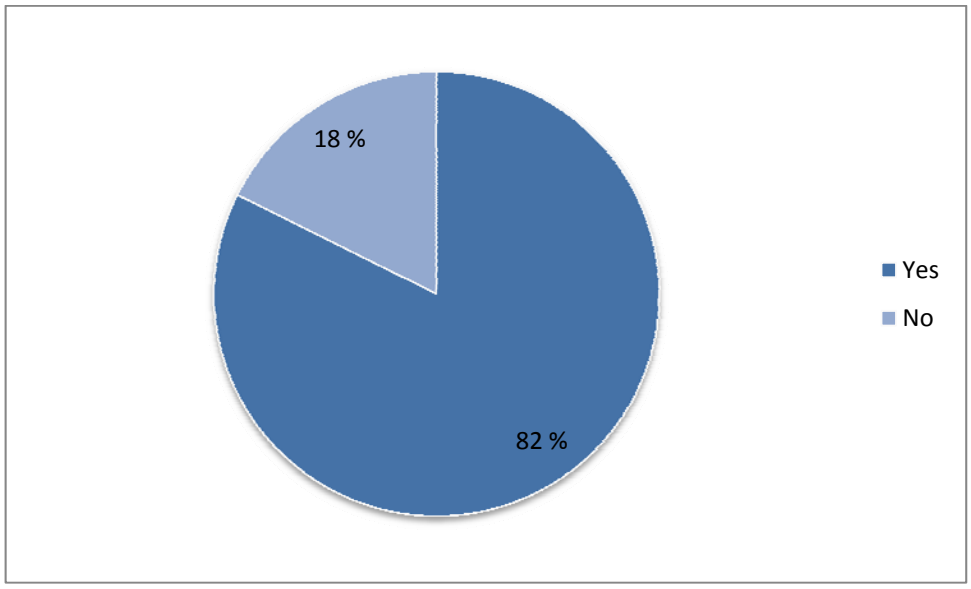

Figure 8: Willingness of people to use solar power for their households

Of the 17 who do not have solar systems for their homes, 82% were willing to use solar power for electricity production; the remaining 18% thought there was no need of changing or adding to their current system (electricity from the grid) as the current power rationing isn't going to last for long.

4. Power generated by the solar PV systems in Watt peak (Wp)

Of the three people who has solar power in their homes one had less than 20Wp, one had between 20-50Wp, none had 50-80Wp and one had more than 80Wp from their solar systems.

5. When asked if solar power is being used for all the electrical appliances in the house, the following answers were given

All households didn't use solar power to electrify all the electrical equipments, they used it for electrical equipments which didn't consume a lot of power, and these equipments were such as lights, phone charges, TV set and radio.

6. When asked how well their solar home systems worked

The answers were rated from very well,well, average, not well and poor. From the three people who used Solar power, one said the system worked well, one said average and one said not well.

7. To the question of giving advantages and disadvantages to the solar power electricity I got the following answers.

Advantages:

It provides electricity during power shortages from the grid
It is free after the initial costs
It's easy to use, requires very little maintenance
It is safe for the environment

Disadvantages

It is expensive at the beginning
If the load is bigger than the power of the panels the system doesn't work well
It does not produce electricity during night times or when there is cloud cover

8. When asking if the households had plans to increase the capacity of their solar power system I got following opinions.

Two people didn't want to increase the capacity of their system, this is because they use solar in hybrid with the power from the grid, which is used for powering big load equipments. Only one person prefers to fully use renewable energy, hence his plan is to increase his solar power capacity in hybrid with biogas.

3.3 Tanzania electric supply company (TANESCO)

TANESCO is a parastatal body under the Ministry of Energy and Minerals (MEM). It is responsible for the electricity generation, transmission and supplying of electricity to Tanzania, TANESCO is the first and almost the only electricity supplier in Tanzania together with the Independent power producers, who sells its electricity to TANESCO.

TANESCO power generation comes from hydro power and thermal power. In 2008 nearly 90% of its electricity came from hydropower sources. /18/ the maximum demand of whole of Tanzania as in January 2010 was 750MW of which about half went to Dar es Salaam alone. /24/

The drought season has made the capacity of the dams to produce electricity drop and this has led TANESCO to apply diesel engines and natural gas.

Despite the unreliable rains and power shedding, TANESCO does not see solar power to be competitive in electrification of towns such as Dar es Salaam; this is because Dar es Salaam, compared to other regions is well electrified by the national grid. The remaining parts, which are not supplied by the grid, are mostly found in the outskirts of Dar es Salaam and electrifying them is not financially viable. TANESCO however, is investing on wind energy with plans for seven stations in regions where there is enough wind capacity./24/

3.4 Ministry of Energy and Minerals

The ministry is the one in charge of the energy; it works together with other organizations such as TASEA and TaTEDO in policy making. The vision of the energy sector is to provide for energy that is efficient, safe, affordable and environmentally friendly to all sectors sustainably. The Government so far does not impose tax on renewable energy equipments. /10/

The ministry does not have separate plans for solar power it just refers to all renewable energy together without clear separation of the different types of renewable energy.

The Energy Act of 2003 states that one of the reasons that there has been such a poor development in the renewable energy sector is because there has been a low level of

awareness and understanding toward the technology so people are hesitant to utilize it. In order for renewable energy such as solar power to work a framework has to be designed for the planning, financing, coordinating and mobilizing its development./10/

3.5 Rural energy agency (REA)

REA is a free body of the ministry of energy and minerals, the main function of the agency is to promote, facilitate and support rural energy projects. REA doest own projects itself but it works to support projects from NGOs, institution, public as well as individuals./16/

Their mission is to promote and facilitate access to sustainable modern energy services in the rural areas for social and economic development. /16/

The majority of Tanzanians (85%) live in the rural and the government believes access of modern energy services such as solar PV will highly contribute to the development of rural Tanzania.

The agency offers grants for projects by private and public institutions and local community organizations, offers training and technical advice, it also offers technical assistance, provisions of financial assistance and capacity building for experts and qualified developers ./17/

REA also encourage technicians to work in rural areas, these technicians will be helping in installation and repairmen of the PV systems there

REA refers to the areas in the outskirts of Dar es Salaam to be rural areas, 59% of Dar es Salaam is connected to the national grid and the remaining 41% doesn’t have access to electricity and a big percentage is found in the outskirts of the city./23/

The population in the outskirts of Dar es Salaam lives on a very low income, many of them live in unplanned areas.

REA sees a big potential in solar PV for Dar es Salaam, this is because the technology itself is wide spreading and its costs are also decreasing.

3.6 Tanzania Solar Energy Association

Tanzania Solar Energy Agency is an international membership organization which was registered in 2001. Its members include of engineers, technicians and other people who are interested in the field of solar power and other renewable energy. One of TASEAs advantage is that it has an ability to bring together stakeholders for solar power to share ideas and experience as well as work together to make a frame work for renewable energy development. TASEAs work include training of technicians of solar power from grass roots such as villages, after training TASEA helps to equip these technicians with working tools so that they remain to work in their areas. There has been a trend that most technicians leave the village after being trained because they lack working tools so they move to towns to look for jobs and this creates a shortage in the rural areas./25/

TASEA is also involved in information dissemination by printing a renewable energy directory which is distributed for free, this helps people and institution to avoid dealing with distributers of fake devices.

There has been a big problem of fake products and TASEA has been working as a watch dog for controlling the product quality.

It also acts as a lobby for solar power, for instance it was involved on the tax reform for renewable energy equipment, and as a result Tanzania does not impose tax on renewable energy equipment which means things such as solar panels are exempted from tax. The association also works with international organization in making standard for renewable energy sources one of them being solar./25/

TASEA was involved in making of the curriculum for VETA instructors, this helps to make sure that future technicians also have the knowhow on dealing with solar systems./25/

TASEA organizes the National solar energy day every year with the purpose of getting the knowledge of solar power to the public; it also releases a magazine called Sunenergy four times a year. This magazine contains useful information such as recent

developments in the solar technology field, information about authentic solar PV equipment dealers within the country, recent solar PV projects, and other related news./25/

3.7 Solar PV equipments suppliers in Dar es Salaam

A large number of suppliers for solar PV equipments are located in Dar es Salaam even thought a lot of business they do is in the rural areas.

Most of the suppliers dealing with Solar PV equipments do not only sell the equipments, they also offer other services such as installation and maintenance of the systems.

The following are the top ten PV equipment suppliers according to TASEA

1. Rex Investment Ltd (www.rexsolarenergy.com)
2. ENSOL (T) Ltd (www.ensol.co.tz)
3. Aglex Company (www.aglexcompany.com)
4. Zara Solar
5. Dlight Design
6. Water Wells (waterwellstz.com)
7. Davis and Shirtliff
8. Locking Centre
9. Sollatek (www.sollatek.co.ke)
10. BP Solar

3.8 Cost comparison between grid electricity and Solar PV

Tables 2,3 and 4 showing the cost estimations of electricity consumption for low, medium and high income households are my own estimations with experience to various classes in Dar es Salaam as official data and figures could not be found.

The information in table 6 does not take into account possible maintenance for PV system and grid; it also does not take into account the cost of installation for the grid,

which can be seen from table 5. It does however include the investment for PV system and the monthly bill for grid electricity.

The following are the cost of electricity from the grid (TANESCO) for domestic users, for low electricity users (0-50 kWh) it is 49 Tsh (3,7c USD, 2,7c and 156Tsh (12c USD, 8,7c €) for more than 50kWh. /9/

3.8.1 Estimations of Households' electrical consumption per month

Table 2, 3 and 4 represent the estimations of monthly electricity consumption of low, medium and high income households respectively.

Table 2: Low income households electricity consumption and price per month

Appliance	Amount	Watts	Hours used per day	Consumption per month(kWh)
Phone charger	1	1	1	0,03
Incandescent Bulbs	3	60	5	27
Radio	1	15	7	3,2
TOTAL	5	76	13	30

Monthly bill +22% Tax **2,000 Tsh** (49Tsh/kWh)

Table 3: Medium income households' electricity consumption and price per month

Appliance	Amount	Watts	Hours used per day	Consumption per month(kWh)
Phone charger	2	1	2	0,06
Florescent tube light(60cm)	4	20	10	24
Incandescent Bulb	3	60	10	54
TV set(26"color)	1	150	5	22,5
Refrigerator	1	210	24	151,2
Radio	2	20	4	4,8
Water kettle	1		0,5	
Electrical fan	2	40	8	19,2
Iron	1	1000	0,5	15
TOTAL		1501	64	290

Monthly bill +22% Tax is **55,000 Tsh** (156Tsh/kWh)

Table 4: High income households' electricity consumption and price per month

Appliance	Pieces	Watts	Hours used per day	Consumption per month (kWh)
Phone charger	5	1	3	0,45
Radio	2	40	5	12
TV Set(40"colour)	2	98	7	41,16
Fluorescent light Bulbs	15	20	10	90
Fridge/freezer(sun frost)	2	112	24	81
Water kettle	1		1	
Microwave	1	1000	0,5	15
Hair dryer	2	1000	0,17	5,1
Washing machine	1	500	0,5	7,5
Dish washer	1	1200	2	72
Air condition	2	1000	6	360
Electrical fans	4	40	9	43,2
Blender	1	300	0,17	1,53
Vacuum cleaner	1	650	0,17	4
Computer(laptops)	2	35	6	12,6
Iron	1	1000	0,75	22,5
Hot plate	1	1200	4	144
TOTAL		8196	79,26	912

Monthly bill +22% Tax is **170,000 Tsh** (156Tsh/kWh)

Table 5: The price of getting connected to the National grid by TANESCO (single phase)/9/

Distance from the grid(meters)	Amount in Tsh
30	340,000 – 390,000
70	1,100,000 - 1,150,000
120	1,650,000 - 1,700,000

3.8.2 The Estimation of solar PV systems

Table 6 represents the calculation for paybacks of solar PV systems for different households which will use different proposed PV systems for households.

The estimations of various PV systems for households can be seen from Appendix 1; these estimations are made by TaTEDO and they are of systems which contain different kinds and amounts of loads (electrical appliances)

The paybacks calculated in table 6 are for households which are already connected with the grid. These households will adopt solar power as a hybrid working together with the electricity from the grid; solar power will also act as a back up during periods of power shortages

Table 6: Electricity bill for various households and paybacks after using solar PV systems

Type of household	Yearly electricity bill from the grid (Tsh)	Type of proposed solar PV system	Price of proposed solar PV system	years for the payback
Low	22,000	1 or 2	460,000 or 695,000	21 or 32
Medium	664,000	5 or 6	999,000 or 1,901,000	1,5 or 3
High	2,100,000	7 or 8	2,976,000 or 5,320,000	1,5 or 2,5

4. Discussion

Finding a household which uses solar power in Dar es Salaam is very difficult, this is because most people do not use it, solar PV is relatively a new technology which people are not familiar with, in the discussions with people I found out that even if they had an idea of how solar power produces electricity they did not know that it can work together with the grid, they thought in order to have a solar home system the grid connection had to be removed first. This kind of thinking is because many of solar systems that they have seen are those in rural areas where the grid has not reached.

Most people were interested in knowing more about solar PV and how they can get their own solar home systems but they do not know where or how to get this information, the biggest reason for people not having a solar home system is that the initial cost of purchasing the system are too high, at the moment there aren't many loaning schemes or programmes that would enable people in Dar es Salaam to purchase solar PV. Many projects and loans are located in the rural areas where there is virtually no access to electricity from the grid.

Table 1 shows the mean monthly radiation of Dar es Salaam from 1999 to 2008, from the table it can be seen that Dar es Salaam receives a lot of sunshine which is much more or less uniform throughout the year. This uniform distribution is not seasonal so daily storage is sufficient./6/ The daily storage here can be used during the night when the sun isn't shining.

Looking at the prices of getting connected to the grid (table 5) it can be seen that for low households depending on how far they are located from the grid, it is much cheaper to have a solar PV system, e.g. it costs about 1,100,000Tsh for a connection 70 meters from the grid while for a solar PV system including the price of installation it is only 874,000 for a simple system which powers four lights, phone charger and a radio. These systems are very beneficial especially in outskirt areas where the grid has not reached.

For a middle income solar home system 5 and 6 were proposed. It costs more than one million to get connected get electricity a distance of 70 and 120 meters from the grid, these connection expenses alone are enough to cover more than half of cost for home solar system 5 of 6 (Appendix 1) The prices are even higher for household much further

from the grid, in these cases it’s better to have a solar home system and increase the capacity of the system as the household power demand increases.

Solar home system 7 or 8 were proposed high income households because they had a lot of electrical appliances and were most likely to afford the system because of the income, a bigger system 7 and 8 is possible but also the price of it will be high as the they would require a much bigger system which is costly. The suggestion in this case would be to have both the grid and solar power for low load equipments. A high income household completely powered by solar isn’t impossible, it is just too expensive but in the long run it is beneficial.

The costs of electricity are still high in Tanzania, in order to reach all Tanzanians TANESCO could take into consideration solar PV in areas of Dar es Salaam that have no access to electricity, they could do this by installing solar PV home systems to areas not reached by the grid, then apply a monthly paying method to the customer, depending on the cost of the system the customer could freely own the SHS after finishing paying up, the dept could be paid off gradually.

The new National Energy Policy which is expected to be out this year (2010) should have clear goals and strategies of how much electricity produced is going to be from renewable energy, solar PV to be more specific. The current 2003 policy doesn’t indicate how much of the total electricity generated should come from solar PV. Having strategies and timeline will make the implementation of such plans effective.

To minimize the problem of fake products and incompetence dealers, the government has to put standards for both the equipments being shipped and sold in the country and providing identification cards to qualified dealers and technicians so that people can recognize the original products and qualified dealers. Doing this will help reduce the problem of fake products, wrong sizing and installations in households.

Education about solar PV should be disseminated to the public; this will help people get familiar with the technology and know that they have the option of getting electricity from solar PV as well, in many places people think the only way to get electricity in a household is by connecting to the grid.

6. Conclusion

Solar PV needs to be seen as an investment, an investment to a cleaner energy and a future with reliable electricity supply for households in Dar es Salaam. Solar PV has a bright future ahead of it, a lot of countries and companies are investing on research and development which aims to improve the efficiency of the panels and other solar PV components. The market for solar PV is also growing and due to competitions the prices will go down and the technology will be less expensive. Solar PV for households in Dar es Salaam means a great reduction or no electricity bills at all in the future.

It can be concluded that there is a clear future for solar PV in Dar es Salaam, this future might not be driven directly by the need to use sustainable renewable energies as means of reducing carbon footprint of fossil fuels but by the power cuts, people are going to look for an energy source that is available in plenty and does not run out.

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7 Appendices

7.1 Appendix 1 Estimation of various solar PV systems

TaTEDO, Off Shekilango Road, Near Institute of Social Work,
Kijitonyama, Dar es salaam.
P. o. Box 32794 Dar Es Salaam,
Tel: +255 22 2700438, Fax: +255 22 2774400

1. Two lights

Item	Quantity	Unit cost (Tsh)	Amount (Tsh)
Panel, 14 W_p	1	90,000	90,000
Charge controller, 5A	1	60,000	60,000
Battery, 32Ah	1	80,000	80,000
Lights, 10W	2	15,000	30,000
Wires and Accessories	1	80,000	80,000
Mounting Structure	1	20,000	20,000
Battery box	1	20,000	20,000
Labour charge	1	80,000	80,000
Total			460,000

2. Three lights, phone charging and Radio

Item	Quantity	Unit cost (Tsh)	Amount (Tsh)
Panel, 14W_p	2	90,000	180,000
Charge controller, 5A	1	60,000	60,000
Battery, 50Ah	1	110,000	110,000
Lights, 10W	3	15,000	45,000
Wires and Accessories	1	90,000	90,000
Phone charger adapter	3	9,000	27,000
Voltage converter	1	28,000	28,000
Mounting Structure	1	30,000	30,000
Battery box	1	25,000	25,000
Labour charge	1	100,000	100,000
Total			695,000

3. Four Lights, phone charging and Radio

Item	Quantity	Unit cost (Tsh)	Amount (Tsh)
Solar Modules, $14W_p$	3	90,000	270,000
Charge controller, 5A	1	60,000	60,000
Battery, 65Ah	1	125,000	125,000
Sundaya tube Lights, 10W	4	15,000	60,000
Wires and Accessories			200,000
Phone charger adapter	1	9,000	9,000
Mounting structure	1	30,000	30,000
Labour charges			120,000
Total			874,000

4. Five Lights and Radio

Item	Quantity	Unit cost(Tsh)	Amount (Tsh)
Solar Modules, $14W_p$	3	90,000	270,000
Charge controller, 5A	1	60,000	60,000
Battery, 67Ah	1	130,000	130,000
Sundaya tube Lights, 10W	5	15,000	75,000
Wires and Accessories		200,000	200,000
Phone charger adapter	1	9,000	9,000
Mounting structure	1	30,000	30,000
Labour charges			130,000
Total			904,000

5. Six Lights, Radio and phone charging

Item	Quantity	Unit cost(Tsh)	Amount(Tsh)
Panel, $14W_p$	3	90,000	270,000
Charge controller, 8A	1	78,000	78,000
Battery, 100Ah	1	170,000	170,000
Lights, 10W	6	15,000	90,000
Wires and Accessories	1	170,000	170,000
Phone charger adapter	2	9,000	18,000
Voltage converter	1	28,000	28,000
Mounting Structure	1	30,000	30,000
Battery box	1	25,000	25,000
Labour charge	1	120,000	120,000
Total			999,000

6. Two Lights, Radio and TV

Item	Quantity	Unit cost(Tsh)	Amount(Tsh)
Panel, 85W_p	1	755,000	755,000
Charge controller, 12A	1	105,000	105,000
Battery, 150Ah	1	210,000	210,000
Inverter, 350W	1	450,000	450,000
Lights, 10W	2	15,000	30,000
Wires and Accessories	1	150,000	150,000
Phone charger adapter	2	9,000	18,000
Voltage converter	1	28,000	28,000
Mounting Structure	1	30,000	30,000
Battery box	1	25,000	25,000
Labour charge	1	100,000	100,000
Total			1,901,000

7.Four – Six Lights, Phone charging, Radio and TV

Item	Quantity	Unit cost (Tsh)	Amount(Tsh)
Panel, $50W_p$	3	510,000	1,530,000
Charge controller, 20A	1	140,000	140,000
Battery, 200Ah	1	340,000	340,000
Inverter, 350W	1	450,000	450,000
Lights, 10W	6	15,000	90,000
Wires and Accessories	1	170,000	170,000
Phone charger adapter	2	9,000	18,000
Voltage converter	1	28,000	28,000
Mounting Structure	1	60,000	60,000
Battery box	1	30,000	30,000
Labour charge	1	120,000	120,000
Total			2,976,000

8.Four – Six Lights, Phone charging, Radio, TV and Refrigerator

Item	Quantity	Unit cost(Tsh)	Amount(Tsh)
Solar Modules, 85W_p	4	755,000	3,020,000
Charge controller, 30A	1	181,000	181,000
Battery, 200Ah	3	340,000	1,020,000
Inverter, 500W	1	605,000	605,000
Sundaya tube Lights, 10W	6	15,000	90,000
Wires and Accessories			200,000
Phone charger adapter	1	9,000	9,000
Mounting structure	1	55,000	55,000
Labour charges			140,000
Total			5,320,000

NOTE: The Systems are designed to operate equipment for an average duration of 5 hours/day
Terms and conditions
100% down payment
Guarantee period of 6 months from the date of commissioning for any problem related to installation workmanship and not abuse or misuse of the system
Guarantee on equipment is provided by supplier and manufacturers
Price of equipment may be modified without any time prior notice
Transport cost is to be met by the customer

7.2 Appendix 2: Questionnaire

Peoples take on solar power for household electricity production

1. Are you familiar with production of electricity by using solar power?

Yes I am familiar with it

Yes but not very much

No I am not

If you answer (a) or (b) say what you know and where you have learned about it'

Are you using solar power for electricity production at your house

Yes

No

If you are not using solar power please say the reason(s)_____

Are you willing to use solar power if the prices of the solar system are reduced?

Yes

No

Please explain if you answered no_____

4. How much power does your solar system produce?

<20Wp

20-50 Wp

50-80 Wp

>80 Wp

5. Does solar power all the appliances in the house?

Yes

No

If no please name the appliances powered by solar _____

6. How well does your solar system work?

Please rate on a scale of 1-5

(1=very well, 2=well, 3=average, 4=not well, 5=bad)

7. Please give a list of advantages and disadvantages that you have seen so far after starting to use solar powered electricity _____

8. Are you planning to increase on your systems capacity in the future?

Yes

No

If not please explain _____