DEUTSCHE–TANSANISCHE PARTNERSCHAFFT E.V. (DTP)

HAMBURG, GERMAN

FEASIBILITY STUDY FOR APPLICATION OF SOLAR PHOTOVOLTAIC SYSTEMS AT UZI ISLAND, ZANZIBAR-TANZANIA

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TANZANIA SOLAR ENERGY ASSOCIATION

TASEA

Lighting the way for Solar Energy

Dar es Salaam, July 2004

ACKNOWLEDGEMENTS

The research team would like to express their sincerely appreciation to all who in one way or the other provided the necessary assistance, guidelines, supports, suggestions, encouragements and contributions leading to the accomplishment of this report.

We are obliged to mention Ms Andrea Karsten, on behalf of German Tanzania Partnership (DTP), for her distinguished directive instructions, advices and supports. And so Nilles and Yonas, DTP Solar Project Kizimkazi-Zanzibar volunteers for their hospitality and assistance during field study visit in Zanzibar.

Solar Home System equipment suppliers, dealers and professionals deserve special appreciation for their encouragements and supportive provision of necessary information based on technical, social, safety and cost effective suggestions towards this study. These include TASEA, Umeme Jua, BP Solar, REX Investment, ENSOL (T) Ltd, local inverter manufacturers etc.

We would like to mention Mwl Said Uzi School Headmaster on behalf the Uzi School teachers and so Village Leaders (Shekha) of Uzi and Ng'ambwa villages; these received us in our Uzi Island visits and assisted us to meet the villagers with effective success. Lastly, but not least, sincere thanks should go to Uzi and Ng'ambwa villagers; who attended the meetings and provided us with the necessary information on energy crisis they face and suggested how can they contribute to the proposed project start up and operation.

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ABSTRACT

This report describes the study on the solar photovoltaic systems application at Uzi Island in Zanzibar, Tanzania. The study was conducted under the Tanzania Solar Energy Association (TASEA) on request of the German and Tanzania Partnership (DTP) that runs an awareness campaign for solar technology in Zanzibar. It follows the request by the Director of Energy Department, Zanzibar to DTP for support of electrification of Uzi, Tumbatu and Kojani Islands using solar energy, during the workshop 'How to Built a Solar Home System' March 2003. DTP, Department of Energy and Haile Selassie Secondary School organized the workshop. During the workshop, presenters of theoretical and practical part of solar technology; Dr. C. Z. M. Kimambo of University of Dar es Salaam and Eng. Richard Magembe, an engineer from Dar es Salaam used Swahili language for better understanding of the participants.

Procedures undertaken in the research include visit of the UZI Island from January 29th to January 31st, for the purpose of pointing out the actual energy demand, desire of electricity, economical (financial) abilities of the UZI Island residents, meetings with the villagers to expose them to project goals, model and time schedule, participation required and so earlier socio-economical acceptability of the project. Ressources of the project start up fund from DTP members donations plus project operating and expansion fund raising which is basically upon users, solar battery charging station analysis, household system planning to include inverters or not, correlation of energy harvest and consumption and socio-economical operation of the project are discussed.

Also financial analysis of the project that includes capital investment, operating cost and hence generation of fund raising for maintenances, replacements and expansion of the project are contained and we have recommended how to achieve self-driving project. Environmental Impact Assessment of the project as a crucial part of our study shows that the project shall not pose serious environmental risks to the site. Above that we realised the project is sustainable if the villagers shall intend and purposely take donor's objectives and recommendations contained herein.

LIST OF SYMBOLS AND ABBREVIATIONS

Symbol	Descriptions	Units
Ah	System Charge / Battery Capacity	Ampere-hour (Ah)
AC	Alternating Current	
CFL	Compact Fluorescent Lamp	
DC	Direct Current	
DOD	Depth of Discharge	
HH	Household	
I	Current	Ampere (A)
LVD	Low Voltage Disconnect	Volts (V)
NOCT	Nominal Cell Operating Temperature	^0C
PV	Solar Photovoltaic Panel/System	
SBCS	Solar Battery Charging Station	
SHS	Solar Home System	
SOC	State of Charge	Volts (V)
VAC	AC Voltage	Volts (V)
VDC	DC Voltage	Volts (V)
Wh	System Energy Demand	Watt-hour (Wh)
Wp	Peak Watts of the Solar Panel	Watts (W)

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1.0 INTRODUCTION TO UZI ISLAND AND THE PROJECT

1.1 UZI ISLAND

Uzi Island is among the two small islands surrounding Unguja Island and which are large enough to facilitate social lives of the people residing on them. The other island is Tumbatu. Kojani Island in Pemba, is also occupied by people for normal social lives. All these small islands are not connected to the national grid power supply, the connection that calls for submarine cables, something that is not expected to be done in the foreseeable future. After the Workshop on building of `Solar Home Systems', which was organized by the Deutsche–Tansanische Partnerschaft e.V. (DTP), in March 2003, Director of the Zanzibar Energy Department requested DTP to support the electrification of Uzi Island (as well as Tumbatu Island).

Figure 1: Map of Zanzibar Showing Uzi Island

Uzi Island is in the South-West part of Unguja Island and it has a total of 3,200 residents. There are two villages on the island, Uzi village with 2,200 residents and Ng'ambwa village having 1000 residents. The access to this island from Unguja Ukuu village, which is the border village on the Unguja Island side, is by two and half kilometers stone built road, which is passable only in low tide i.e. only some hours of the day. Otherwise the alternative access is by ferryboat on request.

Figure 2: Teachers of Uzi School Detailing Access to Uzi Island by Boat at the Seashore

The Western part of Uzi Island is a conserved area of Menai Bay and Pete Inlet on the East. The two villages share a school that has 733 pupils, 21 teachers, 12 classrooms, headmaster office, teachers' room and a library. Also the villages share a dispensary that has one doctor and four other medical staff. The dispensary attends 16 patients per day on average, it has two beds for patients however it has neither lights nor cooler for medicines and there is shortage of medicines.

Figure 3: A Photograph Taken in front of Uzi Dispensary During a Field Visit

There are three mosques within the island, which have neither lights nor loudspeakers and Koran School that has no lights despite the fact that it operates in the evening and sometimes in the night because its pupils go for formal school education in the morning to afternoon. Uzi is has very fertile land and its residences get income thorough agricultural activities for instance vegetable and fruits, which are sold in Zanzibar town and also by fishing, growing seaweed (mwani) for export, selling firewood and charcoal.

1.2 THE PROJECT

Background of the project can be traced as far as during the workshop 'How to Built a Solar Home System' March 2003, organized by DTP, Department of Energy and Haile Selassie Secondary School.in which the Director of the Zanzibar Energy Department requested DTP to support the electrification of Uzi Island (as well as Tumbatu Island). In response to the request by the Director of the Department of Energy in Zanzibar, DTP plans to start supplying solar photovoltaic systems through provision of financial support and material donation. In order for this to be possible, DTP required a study to be conducted to determine the electricity demand, examine the technical and economical viability as well as social acceptability of this alternative energy solution and to propose the modality on which the proposed solution will be implemented.

Preparation for the study included a visit to Uzi Island, from 29th to 31st January 2004, by Mrs. Andrea Karsten (Mama Ana), the DTP Chairperson, Dr. Christian Karsten (Member of DTP), Mr. Joseph Kihedu of the University of Dar es Salaam, Mr. Jonas Oberbeck (Volunteer from Germany), Mr. Nils Hanik (Volunteer from Germany) and Mr. Saidi Mustafa (Student of the Solar Workshop in Kizimkazi). The objective of the visit was to assess the energy need of the island. This was achieved through two meetings for the project descriptions and discussions. The first meeting was conducted on 29th January, and a total of twelve people attended. The second meeting took place on 30th of January and was attended by over sixty people from both villages i.e. Uzi and Ng'ambwa.

1.3 ABOUT TASEA AND ZASEA

Tanzania Solar Energy Association (TASEA) is a non-governmental organization that promotes the usage of solar energy technology through mobilizing capacities and resources of the individuals, groups and organizations dealing with technology through out the country. Zanzibar Solar Energy Association (ZASEA) was formed in March 2003 following the encouragement by TASEA and DTP. It has similar objectives as those of TASEA, however with the particular focus on the part of the Republic Union, covering Zanzibar and Pemba Islands. Since solar technology awareness is low throughout the country, and especially in Zanzibar and Pemba it is obvious that ZASEA face competitive challenge and so its collaboration with TASEA is of vital importance.

2.0 PROBLEM STATEMENTS AND PROPOSED SOLUTION

2.1 PROBLEM STATEMENT

The residents of Uzi Island face an unattended energy crisis due to the fact that it is not connected to the grid power supply and in addition not expected to be included in electrification programs in the near future. Radio and torch users use single use batteries sold from shops within the village at a price of TSh. 100 and 250 per piece for size AA and D batteries respectively. Three houses use car batteries to power televisions, radios and lamps. The batteries are charged at Fuoni (24 km away) or at Unguja Ukuu (2.5 km away) at a cost of TSh. 500.00 as a single charging fee. Among the three Televisions, one is color and it is powered by generator set that consumes four litres of petrol in six hours.

Figure 4: An Interview on Automotive Battery Usage at Uzi Village

The battery capacity used for black and white televisions in Uzi and Ng'ambwa villages are 50 Ah or 70 Ah, and users say that about 18 days of use are available for a black and white television while for a radio the battery lasts for about a month. The normal lamps (incandescent lamps) are known to consume more energy although the villagers could not specify this. There are two coolers supplied the Coca Cola Company in two shops within the villages. These use two to seven litres of fuel per week. Mobile telephone users have to travel to Unguja Ukuu to recharge the batteries for their mobile set. Cooking and warming water are done by firewood in traditional three stone cookers or using charcoal. Firewood supplies are abundant in the island and so the environmental impact related to excessive cutting down of trees for firewood is low.

Since October 2003 Uzi School got a donation of solar lamp renting station, including one 40-Watt panel and 15 lanterns from DTP. School teachers applied for such a station after having seen it working in Kizimkazi-Mkunguni where the SOLUX I lamps are assembled by German volunteers together with Tanzanian pupils and spread around 11 villages around Zanzibar. The school collects fees for renting the lamps as an income, which is spent on teaching materials or for buying more lanterns. One month later Uzi School Committee decided to buy a second renting station. All the lanterns are rented to the teachers and villagers of Uzi and Ng'ambwa who pay a monthly fee of TSh. 2,000.00. Uzi island residents are aware of solar energy usage to that extent.

In response to the request by the Director of the Department of Energy in Zanzibar to DTP to support the electrification of Uzi and Tumbatu Islands, the DTP plans to start supplying solar photovoltaic systems. This will be done through provision of financial support and material donation. In order for this to be possible, DTP requires a study to be conducted to determine the electricity demand, examine the technical and economical viability as well as social acceptability of this alternative energy solution and to propose the modality on which the proposed solution will be implemented.

2.2 ALTERNATIVE SOLUTIONS

2.2.1 Grid Extension

Electrical grid is the common busbar in which various electrical power plants are connected at the same voltage and frequency and so deliver power to scattered customers provided they are connected to such transmission and hence distribution lines. Tanzanian grid mainly gets power from Kidatu, Mtera and Kihansi Hydropower plants as well as Ubungo and IPTL power plants. Maimland grid is connected to Unguja Island grid thorough a marine cable that extends from Kunduchi in the Mainland to Fumba in Unguja. Electrification of Uzi Island can be achieved through extending national electrical grid power supply lines that has reached Unguja Ukuu i.e. 3 km from Uzi Island.

Advantages of Grid Extension

- Grid can respond to changing loads without extraordinary difficulties and its standby losses are minimal.
- Uzi Island will be connected to reliable governmental administered power supply line and so bringing the sense of nationality of the island sharing with the other Tanzanians.
- Possibility of unlimited electrical power utilization for residential needs, i.e. households and public needs, and so for possible small-scale industries.

Disadvantages of Grid Extension

- Connection to the national electricity grid supply requires the use of marine cable that calls for large capital investment due to high cost of transmission lines, not planned in the near future.
- The distant power supply that is out of user control.

2.2.2 Wind Energy

The propulsive power of wind can be used to drive multi bladed turbine wheel. The use of wind as source of power is not extensive but in places where direction of wind is constant for a sufficiently long period of the year and where high winds are a common feature, it is cheap and common source of power. Wind is air in motion caused by the rotation of the earth and the uneven heating of the atmosphere by the sun. Air rises as its particles spread out from being heated (making the air less dense and thus lighter.) Unheated or cool air comes in to take the place of the rising heated air. This process is called convection. Wind patterns vary according to seasonal, diurnal, and landscape variability and due to changing wind patterns, physical obstacles, in the area, slope, etc. So wind is thermal power that has already been converted to mechanical power.

Advantages of Wind Energy

- Wind is a renewable resource where as conventional methods such as coal, natural gas, and oil are limited (they have finite lifetimes).
- Wind Power can bring energy to remote areas outside the electrical grid.
- It is cheaper in to start a wind power system than to bring in power lines or other types of fuel, which are hard to transport.
- Wind Power does not produce the greenhouse (carbon) emissions of conventional energy methods and thus will reduce these if used in their place.

- The price of installation, implementation, and maintenance has dramatically dropped in the past two decades making wind a more viable economic option even in developing countries.

Disadvantages of Wind Energy

- There is some concern over the noise produced by the rotor blades, aesthetic (visual) impacts, and occasional avian (pertaining to birds) mortality.
- The technology requires a higher initial investment than fossil-fueled generators.
- Also wind energy is limited with geographical location of the site.

2.2.3 Solar Energy (PV Applications)

Solar thermal power, however, refers specifically to the production of electricity using high temperatures obtained through the concentration of solar radiation. *Solar thermal* technology for electricity generation is quite distinct from *solar photovoltaic (PV)* technology. Unlike solar thermal, PV does not use the "intermediary" of steam or gas turbines but exploits the photovoltaic effect whereby photons striking a specially designed solar cell force the movements of electrons. Thus while both solar thermal power and solar PV can be classed as "solar electricity" and ultimately offer the same service but technologically they are quite different.

Photovoltaic energy is the conversion of sunlight into electricity through a photovoltaic (PVs) cell, commonly called a solar cell. A photovoltaic cell is a non-mechanical device usually made from silicon alloys. Sunlight is composed of photons, or particles of solar energy. These photons contain various amounts of energy corresponding to the different wavelengths of the solar spectrum. When photons strike a photovoltaic cell, they may be reflected, pass right through, or be absorbed. Only the absorbed photons provide energy to generate electricity. When enough sunlight (energy) is absorbed by the material (a semiconductor), electrons are dislodged from the material's atoms. Special treatment of the material surface during manufacturing makes the front surface of the cell more receptive to free electrons, so the electrons naturally migrate to the surface.

Advantages of Solar Energy

- Available in abundance
- Gives minimum impact to the environment

- Running costs are low
- Power production is quiet

Disadvantages of Solar Energy

- It's inconsistent as can be affected by clouds.
- Large initial set up costs.

2.2.4 Tidal and Wave Energies

These are well-developed ocean energies; other ocean energies include ocean thermal energy conversion, ocean currents and salinity gradients.

Wave energy conversion takes advantage of the ocean waves caused primarily by interaction of winds with the ocean surface. Waves, particularly those of large amplitude, contain large amounts of energy. Wave energy is in effect a stored and concentrated form of solar energy, since the winds that produce waves are caused by pressure differences in the atmosphere arising from solar heating. Many research and development goals remain to be accomplished, including cost reduction, efficiency and reliability improvements, identification of suitable sites, interconnection with the utility grid, better understanding of the impacts of the technology on marine life and the shoreline. Also essential is a demonstration of the ability of the equipment to survive the salinity and pressure environments of the ocean as well as weather effects over the life of the facility.

Otherwise, tides are caused by the gravitational attraction of the moon and the sun acting upon the oceans of the rotating earth. The relative motions of these bodies cause the surface of the oceans to be raised and lowered periodically, according to a number of interacting cycles. These include:

- A half day cycle, due to the rotation of the earth within the gravitational field of the moon

- A 14 day cycle, resulting from the gravitational field of the moon combining with that of the sun to give alternating spring (maximum) and neap (minimum) tides

- A half year cycle, due to the inclination of the moon's orbit to that of the earth, giving rise to maxima in the spring tides in March and September
- Other cycles, such as those over 19 years and 1,600 years, arising from further complex gravitational interactions.

Figure 5: **Gravitational effect of the Sun and the Moon on tidal range**

Advantages of Tidal and Wave Energies

- Tidal energy is highly predictable in both amount and timing.
- The generation of electricity from tides is very similar to hydroelectric generation, except that water is able to flow in both directions and this must be taken into account in the development of the generators.
- The amount of energy obtainable from a tidal energy scheme therefore varies with location and time. Output changes as the tide ebbs and floods each day; it can also vary by a factor of about four over a spring-neap cycle.
- Has improved transportation due to the development of traffic or rail bridges across estuaries and reduced greenhouse gas emissions by utilizing non-polluting tidal power in place of fossil fuels.
- Both energies are abundant for the case of Uzi as an island.

Disadvantages of Tidal and Wave Energies

- **Tidal Changes;** The construction of a tidal barrage in an estuary will change the tidal level in the basin, which is difficult to predict.

- **Ecological Changes;** The effect a tidal station has on the plants and animals, which live within the estuary. As very few tidal barrages have been built, very little is understood about the full impact of tidal power systems on the local environment.

- Technologies of both energies are not popular, inefficient, unreliable, expensive and affects marine life.

2.3 DISCUSSION AND COMPARISON OF THE ALTERNATIVES

2.3.1 Grid Power Extension

Resource: Ready made however not reachable.
Technology: Very basic, readily available and moderately stable.
Initial Costs: Extra high.
Operation and Maintenance Costs: Moderate.
Maintenance: Difficult to implement.
Practicability: Practicable with enough capital.
Sustainability: Sustainable
Environmental Impact: Ecological may costs during installation and in operating faulty
Acceptability: Better provided that intensive care is taken.
Efficiency: Sufficient.
Reliability: Reliable.
***Recommendation**:* Feasible.
***Why the Recommendation**:* This technology has been used to connect Zanzibar into national electrical power grid from the mainland Tanzania. It is also efficient, reliable and cost of electricity be clearly forecasted and thus payback period can be established. However the main drawback of such project is that it requires large capital investments.

2.3.2 Wind Energy

Resource: Abundant.
Technology: Very basic yet so advanced making it very stable and dependable.

Initial Costs: High.

Operation and Maintenance Costs: Low.

Maintenance: Easy to implement.

Practicability: Very practicable.

Sustainability: Sustainable.

Environmental Impact: No emission but birds are effected with the turbines and concerns about noise generation.

Acceptability: Doesn’t pose a threat of being rejected as they occupy little space.

Efficiency: Very efficient.

Reliability: Very reliable as long as the wind blows.

Recommendation: Feasible.

Why the Recommendation: The only major problem is the costs involved in establishing wind power plants and the study needed to establish them costing more money and time. Another problem is the unsteady power as a result of wind fluctuation.

2.3.3 Solar Energy (PV Applications)

Resource: Abundant.

Technology: Readily available and moderately stable.

Initial Costs: Comparative high calling for donors aids.

Operation and Maintenance Costs: Low.

Maintenance: Easy to implement.

Practicability: Very practical.

Sustainability: Sustainable.

Environmental Impact: Low in terms of emissions

Acceptability: Shows positive signs especially with the current promotion of awareness.

Efficiency: Has good efficiency.

Reliability: Reliable in the sunny days.

Recommendation: Feasible.

Why the Recommendation: Solar power can produce small amount of electricity that can meet the current needs of the Uzi residents’ households’ energy needs. With appropriate and sufficient power storage and purposeful reduced energy consumption, problem of cloudy days can be solved. Cost of electricity cannot be clearly forecasted and thus payback period cannot be established.

2.3.4 Tidal and Wave Energies

Resource: Abundant since Uzi Island is surrounded by Indian Ocean.

Technology: It is a relatively new technology.

Initial Costs: Very high.

Operation and Maintenance Costs: Moderate.

Maintenance: Difficult to implement.

Practicability: Not practicable in less developed countries.

Sustainability: Sustainable

Environmental Impact: Low in terms of emission however disturbs greatly marine life.

Acceptability: Difficult as it crowds the beach useful for fishery etc.

Efficiency: Not very efficient.

Reliability: Not reliable.

Recommendation: Not feasible.

Why the Recommendation: It is a very expensive investment and the production of electricity is difficult to estimate, this results in high tariffs. The technology is unpopular and the unreliability of the system both adds into disadvantages if not complications. Also, cost of electricity cannot be clearly forecasted and thus payback period cannot be established.

2.4 DESCRIPTION OF THE ADOPTED SOLUTION

From the above analysis of the energy alternative for Uzi Island electrification applications of solar photovoltaic systems was adopted based on the factors as detailed under part 2.3 of this report. DTP plans to start solar electricity programmed for Uzi Island with support of financial aid and material donation. The idea is to have the first input of the project that includes 10 PV panels 120 Wp each and electrical installation fittings for 50 households as a donation. The batteries to be used with the systems will be bought by or belonging to the user. This will have the impact of creating responsibility of the villagers to the project so that they run it sufficiently and effectively for the future prosperity and expansion of its services to other villagers not included in the initial 50 households plan. This project is to be run as a private enterprise hence battery-charging fees must be paid to cover costs for replacing bulbs and damaged fittings as well as for the progress of the project.

Among 50 households, panels shall be installed in 10 houses, which must not be concentrated in one area thus charging stations are to be scattered within the villages to avoid long distances to carry the batteries for charging. A panel will then be dedicated for recharging 5 batteries (including that of the house on which it is installed), i.e. one battery per day. The villagers also agreed, based on population distribution that the distribution of the 10 panels should be such that Uzi village gets 6 panels for 30 households and Ng'ambwa village gets 4 panels for 20 households. Also it is desirable that all the people running the charging stations must be educated in taking measurements and charging of the batteries. It is also important that the users of the systems get introduction to battery use and maintenance of the systems. Lucky enough there is an electrician who lives in Uzi Island and who can be helpful in providing technical support to the project.

This study is aimed at determining the electricity demand, examining the technical and economical viability as well as social acceptability of this alternative energy solution and then propose the modality on which the proposed solution will be implemented. Zanzibar Solar Energy Association (ZASEA) members can take opportunity for practical training as participants of the workshop "How to built a Solar Home System" in the installation of the solar fittings of this project. Also creation of UZIesco (UZI electricity supply committee-company) by training of the villagers in regard of installation and maintenance of the solar technology; training of economical structures and business plans to increase the number of customers once the project is started, will provide important input to the installation and means of operation of the project in future.

3.0 PROJECT OUTLINE

3.1 AIM OF THE PROJECT

This project was aimed at examining the technical and economical viability as well as social acceptability of the proposed the modality on alternative energy solution on basis of the laid project goals. The goal is to have the first input from DTP that include 10 PV panels of 120 Wp each and electrical installation fittings for 50 households as a donation. The batteries to be used with the systems will be bought by or belonging to the user. This will have the impact of creating responsibility of the villagers to the project so that they run it sufficiently and effectively for the future prosperity and expansion of its services to other villagers not included in the initial 50 households plan. Thus during the study researchers shopped around for the availability and prices of solar photovoltaic systems devices including bulbs, wires, voltage regulators, charge controllers, inverters solar modules/panels and seek for technical advices on installation information, performance and maintenance of solar photovoltaic systems

3.2 METHODOLOGY USED

In order to come-up with the facts embedded in the proposed solution, the following steps were taken:

3.2.1 Literature Reviews and Internet Surfing

During the study various literatures and websites were searched for references and knowledge expansion to meet various study requirements. Also `Solar Battery Charging Stations Analysis of Viability and Best Practices' case studies for Brazil, Morocco, Philippines and Thailand shall be an important reference for performance and experience of the solar photovoltaic systems solution ahead.

3.2.2 Field Study Visit and Interviews

A total of three visits were paid by the donor and researchers for dialogues, meetings and interviewing villagers for:

(i) Familiarization of the island socio-economical lives of the residents;

(ii) Confirmation of the current energy crisis faced by the villagers and so establishing daily system energy requirement;

(iii) Establishing the desire for electricity and build-up electrical demand data;

(iv) Coming-up with villagers' proposal on how to run the project, including charging costs, village committees and cooperation with other governmental and non-governmental organization.

3.2.3 Market Surveys

Suppliers and dealers of solar photovoltaic systems were visited in order to:

(i) Examine available technical information about performance of the solar photovoltaic systems installed and comments if any;

(ii) Shopping around for the availability and prices of solar photovoltaic systems devices including bulbs, wires, voltage regulators, charge controllers, inverters solar modules/panels; and

(iii) To get technical advices on installation information and maintenance of solar photovoltaic systems.

3.2.4 Laboratory Testing

Laboratory testing of some components to be used in the project are to be performed to be certain of their performance prior project implementation phase. The crucial important foreseen at this stage include locally manufactured inverters which are to be used in the project. The tests shall include determination of efficiency, quality of the output i.e. the waveform and crest factor and reliability of the inverter in usage and especially on its effect on the appliances, if any.

3.3 TIME SCHEDULE

The time required to complete the project is three months, however the study was extended to clarify design of the systems, prepare reliable sourcing schemes for the equipments and propose agreements between the related parties. The project commenced on the end of April 2004. The detailed time plan is shown in Table 1.

Table 1: Detailed Time Plan

Month/Week Activities	April 2004				May 2004				June 2004				July 2004				August 2004			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Literature Reviews and Internet Surfing																				
Market Surveys and Interviews																				
Field Study Visit (Uzi Island)																				
Report Writing																				

3.4 PROJECT IMPLEMENTATION

3.4.1 Project Financing

German Tanzania Partnership (DTP) will be the main sponsor of the project mobilizing the financial aids and material for the project.

- Through Juwi, DTP shall provide ten 120 Wp panels made by Kyocera or Sharp.
- DTP through its members contributions shall cover costs for electrical household fittings, transportation of materials to the site, installation costs, demonstration phase and also it has contracted Tanzania Solar Energy Association (TASEA) to undertake feasibility study for the project.

3.4.2 Installation, Operation and Maintenance

- Zanzibar Solar Energy Association (ZASEA) members who will take opportunity for as a practical training camp for their participation on the workshop “How to built a Solar Home System” will do installation of the household electrical fittings.
- Also creation of UZIESCO (UZI Electricity Supply Committee) by training of the villagers in regard of installation and maintenance of the solar technology; training of economical structures and business plans to increase the number of customers once the

project is started, will provide important input to the installation and means of operation of the project in future.

- And so actual operation and maintenance requirements of the project calls for a village project committee for each village, Uzi and N'gambwa, as discussed under part 4.4.2 of this report (Details of Model SBCS; Maintenance and Operation).

4.0 THEORETICAL BASICS OF SOLAR PHOTOVOLTAICS

4.1 INTRODUCTION

Photovoltaic energy is the conversion of sunlight into electricity through a photovoltaic (PVs) cell, commonly called a solar cell. A photovoltaic cell is a non-mechanical device usually made from silicon alloys. Sunlight is composed of photons, or particles of solar energy. These photons contain various amounts of energy corresponding to the different wavelengths of the solar spectrum. When photons strike a photovoltaic cell, they may be reflected, pass right through, or be absorbed. Only the absorbed photons provide energy to generate electricity.

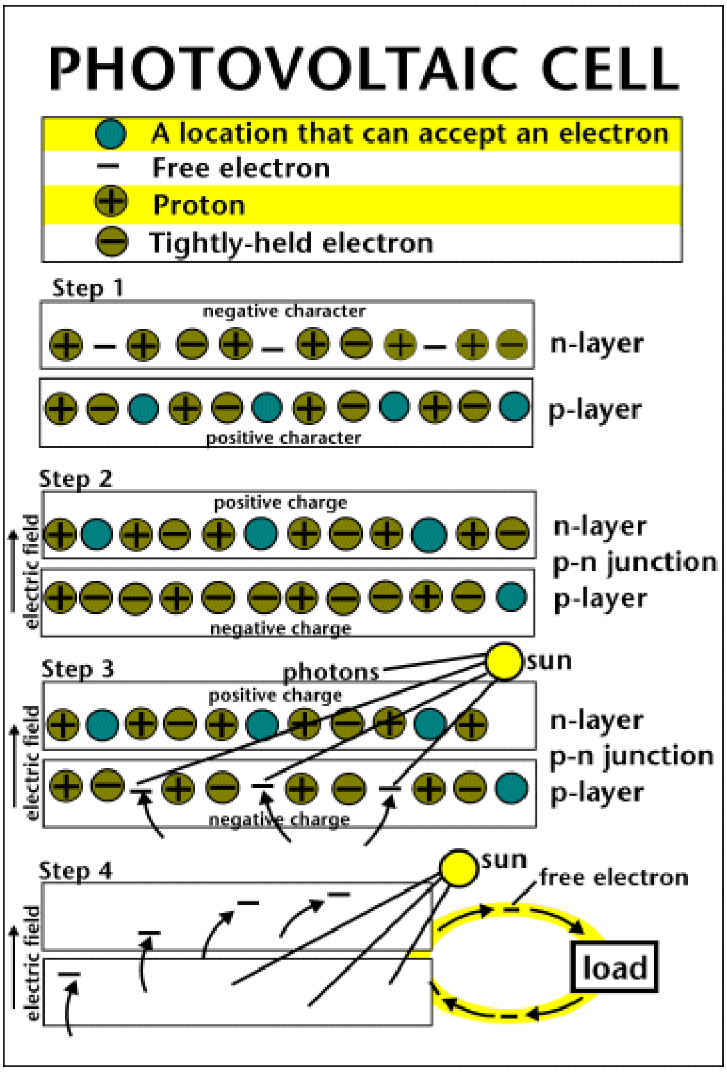

Figure 6: Photovoltaic Cell Principal of Operation

Electricity generated then can be used in two different modes in regard with the Uzi Island Electrification Project i.e. Solar Home Systems (SHS) and Solar Battery Charging Stations (SBCS). The following discussions on part 4.2 to 4.3 shall elaborate them in full.

4.2 SOLAR HOME SYSTEMS (SHS)

Solar electric systems applications include; rural electrification, small industries and institutions lighting, water pumping, health and vaccine refrigeration and telecommunication. Their advantages are: consume no fuel, they are environmental friendly, no or less maintenance is required, solar electricity is cheap and can be expanded with growing need. Disadvantages: high initial cost of solar system equipments, batteries are required as storage devices and lack of trained technicians.

Solar electric home system, which can either be utility interactive or stand alone, basically includes major components shown in figure 3.1 below. Basically it includes a solar panel that converts sunlight into DC electricity to charge the battery. This DC electricity is fed to the battery via a charge controller, which ensures the battery is charged properly and not damaged. DC appliances can be powered directly from the battery, but AC appliances require an inverter to convert the DC electricity into 240 Volt AC power.

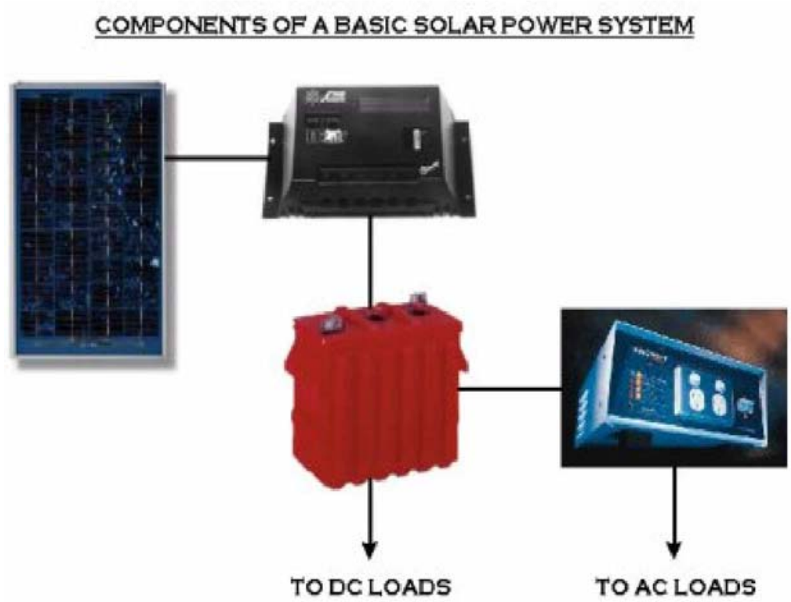

Figure 7: Components of a Solar Photovoltaic System

4.2.1 Solar Panels

Solar panels are classified according to their rated power output in Watts. Peak Watt (Wp) is the power that a PV can produce at noon (with 1,000 W/m) on cold day (25^0 C) and clear day under full bright sun. This rating is the amount of power the solar panel would be expected to produce in 1 peak sun hour. Solar panels can be wired in series or in parallel to increase voltage or current respectively. The open circuit terminal voltage of a solar panel is usually around 17.0 volts, but when connected to the load, this voltage is reduced to around 13 or 14 volts as required for battery charging. The cell operating temperature affects solar panel output. Panels are rated at a nominal temperature of 25^0 C. The open circuit output voltage of a solar panel declines by 0.5% per ^{0}C (degrees Centigrade) raise in temperature. Nominal operating cell temperature (NOCT) is influenced by insolation levels i.e. different of infrared gain and variation of heat dissipated especially on module mounting.

Solar panels are made of solar cells that capture the sun's energy and change it to electricity. Inside a solar panel, each cell contains silicon; an element found in sand that absorbs sunlight. The energy in this absorbed light produces a small electrical current. Metal grids around the solar cells direct the currents into wires that lead to the power controls. And hence a solar array is comprised of one or more solar PV modules (solar panels), which convert sunlight into clean solar electricity. PV is the short for Photovoltaic, which means electricity from light. The solar modules need to be mounted facing the sun and avoiding shade for best results. Solar panels generate DC power.

Blocking diode is often built in positive module conductor with its anode on the array side and cathode in the load side. These avoid reverse flow that can drain batteries and damage the array by allowing the current to flow only in one direction. Lightning protection has also to be installed between non-grounded conductors and a direct earth ground.

4.2.2 Charge Controllers

The purpose of charge controllers, or solar regulators as they are also called, is to regulate the current from the solar panels to prevent the batteries from overcharging. Overcharging causes gassing and loss of electrolyte resulting in damage to the batteries. A charge controller is used to sense when the batteries are fully charged and to stop, or decrease, the amount of current flowing to the battery. Most solar regulators also include a Low Voltage Disconnect (LVD) feature, which will switch off the supply to the load if the battery voltage falls below the cutoff voltage. This prevents the battery from permanent damage and reduced life expectancy. A charge controller also prevents the battery from back feeding into the solar panel at night and, hence, flattening the battery. Charge controllers are rated by the amount of current they can receive from the solar panels and so its amp rating must be greater than the total system amperage.

A charge controller must be able to handle the maximum current that can be produced by the solar panels. Reflected sunlight and specific temperature conditions can increase the output current of a solar panel by as much as 25% above it's rated output current. They often short the solar panel input when regulating. This does not damage the solar panel, but it does mean that the solar regulator must be sized to handle 125% of the solar panel's rated short circuit current. Hence the main function of a charge controller is to prevent over charging which results in out-gassing of the batteries, as well as keeping electrical storage in the batteries from discharging to the solar modules at night. The basic criteria for selecting a controller include the operating voltage and the PV array current. Controllers are critical components in stand-alone PV systems because a controller failure can damage the batteries or load. The controller must be sized to handle the maximum current produced by the PV array. There are two types of controllers: series and shunt. Series controllers stop the flow of current by opening the circuit between the battery and the PV array. Shunt controllers divert the PV array current from the battery.

4.2.3 Inverters

An inverter is a device, which converts the DC power in a battery to 230 or 240V AC electricity which is the most common type used by most household appliances and lighting. Inverters come in two basic output designs, square wave and modified sine wave. Pure sine wave inverters may be found and they can operate almost anything that can be operated on utility power however they are very expensive. Most AC devices also will work fine on the modified sine wave inverter, but there are some exceptions. Devices such as laser printers can be damaged when run on modified sine wave power. Motors and power supplies usually run warmer and less efficiently, and some things, like fans, amplifiers, and cheap fluorescent lights, give off an audible buzz on modified sine wave power. However, locally manufactured square wave inverters make the conversion from DC to AC a little inefficiently compared to imported modified wave, and they are relatively cheaper. In addition to that inefficient running, buzzing and risk of damaging the appliances is higher compared to the modified sine wave case.

Inverters are generally rated by the amount of AC power they can supply continuously. Manufacturers generally also provide 5 second and 1/2 hour surge figures. The surge figures give an idea of how much power can be supplied by the inverter for 5 seconds and 1/2 an hour before the inverter's overload protection trips and cuts the power. Televisions usually draws larger amount of power when started compared with not operation there after. If the power supply to the particular television is through an inverter, which is usually the case with 12V DC supply from the battery, then the inverter used must allow such peak power consumptions for short period of time calling for a proper crest factor representing peak current handling capacity of the inverter.

In the course of applications, inverters can be found to be stand-alone and synchronous inverters. Stand-Alone inverters can be used to convert DC from a battery to AC to run electronic equipment, motors, appliances, etc. Synchronous Inverters can be used to convert the DC output of a photovoltaic module, a wind generator or a fuel cell to AC power to be connected to the utility grid. Multifunction inverters perform both functions.

4.2.4 Batteries

Battery is basically an electrochemical cell that gets discharged by converting chemical energy into electrical and vice versa during charging. It is composed of two electrodes sometimes referred to as plates immersed in an electrolyte solution to produce an electric current when a circuit is formed between the electrodes. Batteries fall under two main categories namely deep discharge and shallow discharge cycle batteries. Deep discharge batteries from which more energy can be taken out without causing damage to the cells are preferred for solar electric systems. Shallow discharge batteries designed to supply large amount of power for a short duration e.g. automotive batteries, taking too much energy out of them results in damage of the plates. Battery capacity (Q) is measured in ampere-hours (Ah) indicating amount of energy that can be drawn from it. Hydrometer or voltmeter can be used to state of charge (SOC) of the battery telling the energy remaining in the battery while depth of discharge (DOD) referrers to how much the battery is discharged.

The batteries store the solar power generated and discharge the power as needed. The battery bank consists of one or more solar deep-cycle type batteries. Depending on the current and voltages for certain applications the batteries are wired in series and/or parallel. To ensure long battery life, deep cycle batteries should not be discharged beyond 80% of their capacity. i.e. 20 % capacity remaining. Discharging beyond this level will significantly reduce the life of the batteries. Deep cycle batteries are rated in Ampere Hours (Ah). This rating specifies the amount of current in Amps that the battery can supply over the specified number of hours. Batteries are used to provide direct current (DC) [which may also be converted into alternating current (AC) using an inverter] for lighting and entertainment in the home.

4.2.5 Wiring

Selecting the correct size and type of wire will enhance the performance and reliability of your PV system. The size of the wire must be large enough to carry the maximum current expected without undue voltage losses.

4.2.6 Loads

Loads are the appliances and devices (such as TV's, lamps, computers, lights, water pumps etc.) that consume electrical power.

4.3 SOLAR BATTERY CHARGING STATION (SBCS)

Battery charging is usually carried out at a charging station, four options of the battery charging stations include;

(a) Solar Battery Charging Stations (SBCS): Can be expanded or reduced in size depending on market demand. Module capacity sizing and number of charge outlets at the station is based on average daily insolation of the minimum or average month, battery size, demand characteristics of HHs and the community size. The modules are sized to allow each charge outlet to charge one battery per day at the daily average insolation. SBCSs can be of two designs,

(i) Charging outlets come from a common busbar, each outlet having a charge controller to prevent battery over-charging and a blocking diode to prevent battery current reversal.

(ii) One array of modules dedicated to one charge outlet making a charge controller and blocking diode optional.

(b) Diesel Generator Set Battery Charging (DGBC): A small diesel genset can power a multiple outlet battery charger. This is done by converting AC power from the generator to DC and regulated for battery charging. The number of batteries that can be charged simultaneously depends on the capacity of the charger, otherwise may be calculated assuming a single battery charge of 8 Amp, 13.5 V and a service that provides for all the assumed HHs in the service area.

(c) Solar Home Systems (SHS): Roof-mounted photovoltaic modules charge a rechargeable battery daily for each home. Charge controllers protect the battery from overcharging and conversely deep discharge and the energy delivery is limited by the size of the panel and available sunlight. Battery specifications and HH demand is assumed identical to other options and module capacity is calculated on the basis of daily demand and average daily insolation for the minimum or average month.

(d) Grid Battery Charging Station (GBCS): Similar to Diesel Genset Charging however number of batteries that can be charged is not limited by the capacity of the source i.e. the grid. GBCS is often far from the community it serves, and owners transport the batteries to and from the charge service; also pay fees for the service. A GBCS capacity is designed based on the number of batteries charged and is calculated assuming a single charge battery of 8 Amp and 13.5 V.

4.4 ADOPTED MODE

4.4.1 The Proposed Model

- One house is fitted with one 120Watt Panel and a battery charging station with a charge controller.
- Around this house four other houses take part at the charging station in the middle. The panel will be large enough to charge one battery in one day.
- Five houses will be fitted for one charging unit.
- Every house gets fitting for three bulbs, radio and TV (two plugs) and one inverter of 250 Watt (Model local production: Ennea Electronic Arts, P. O. Box 60549 Mwenge, Dar es Salaam). Normal saving bulbs can be used.

4.4.2 Details of Model SBCS

Activity: SBCSs to be used at Uzi Island, South-West of Zanzibar Island where average insolation is five peak sun hours with about 1,000 W/m^2. Ten solar panels each 120 Wp are to be used for ten SBCSs, i.e. one panel for each SBCS. Each SBCS is dedicated to serve five households. DTP shall organize the fund for material donation that include panels and electrical fittings for the project. Users to be served by the project shall have to by the batteries for their own uses. ZASEA shall engage in the project during the installation phase as well as monitoring technical prospects of the project. Village committee shall run the project through contributions from users to maintain and expand the project service to the users and villagers in general.

Technical Design: 10 panels each 120 Wp will be used for the project. Each SBCS shall serve five HHs in two alternative options whose performances are detailed under appendices B1 to B4:

(i) One battery from one HH is charge daily i.e. one charging outlet and one charge controller for each SBCS. This shall result in five days between recharging for each HH battery.

(ii) Two batteries from two different households are charged per day i.e. two charging outlets with one charge controllers for each SBCS. This shall result in to three days between recharging for each HH battery in a SBCS.

The head of the HH in which SBCS is attached, shall be SBCS operator, taking the responsibility of maintaining charging chance or round for each HH battery and checking battery SOC for proper remarks to the owners. Also the operator shall be responsible for village committee instructions on project prospects. Each HH fitting shall include three lamps, sockets for radio and TV. Inverters shall also be included if donors are capable and especially if locally manufactured inverters have satisfactory qualities. Battery over discharge controllers, SOC indicators are here by preferred than LVD, shall be installed to enable users and battery owners in particular to decide on the effective use of their batteries. Users need be given instructions or directives on the electrical systems provided to them and especially on battery basics, usages and maintenances.

Operation and Maintenance: Village committees have to be elected or appointed to oversee operation of the systems, set and collect charging fees for charging, maintenance and pay back of the installations, for future expansion of the project service. The committees shall include village leaders, schoolteachers and others, as villagers may prefer not forgetting SBCS operators. Batteries shall be given to SBCS operator in the morning in the day of recharging and collected in the evening or a little earlier if it is fully charged. Average distance of the battery transportation between a home and SBCS shall not exceed 300 to 500 meters. The range is due to the fact that houses at Uzi Village are scattered around while houses at Ng'ambwa village are along one village road. Charging or payback return fee may be based on each charge or monthly payments.

4.5 SUMMARY OF ANALYSIS OF VIABILITY AND BEST PRACTICES ON SBCS

SBCS are appropriate when they:

(i) Serve a community remote from grid with difficult accessibility and high diesel fuel costs;

(ii) Serve a household market with limited electrical energy needs. As needs and demand grow to regular daily use SEHS become least cost; and

(iii) Are designed to keep capital costs low and operating costs low. Such a design incorporate the following;

- ⇒ Panels dedicated to individual battery charging outlets rather than to a common bus
- ⇒ Self-regulating systems which offer low cost method should be preferred than the use of high voltage disconnect or a charge controller. However that calls for adequately trained SBCS operators equipped with meters to observe open-circuit voltage (VOC) and charge current and hence determine battery SOC.
- ⇒ Panel sizing should allow a typical discharged battery to be charged in average solar condition in one day.
- ⇒ Lead-Acid battery of 50 to 100 Ah capacity are optimum size and 80 to 100% DOD can be assumed in the design.

⇒ Large mating plugs should be used on battery to ensure the correct terminal connections at home and at the SBCS to prevent cross wiring. Also colour coding of the leads and terminals is a lower-cost option.

⇒ Allow users to own batteries to promote best maintenance practices of the batteries and avoid the costs of monitoring battery use.

⇒ SBCS should be developed to provide the infrastructure and prepare the market for SEHS services

⇒ Battery maintenance practices should be taught to users and especially to SBCS operators.

(iv) Technically unsophisticated system are used, this simply implies that;

⇒ Minimal initial, maintenance and replacement costs.

⇒ SBCS System control shall be upon an operator rather than electrical control.

⇒ High capacity utilization of the SBCS that permit battery to be fully charged in a day.

(v) One charging battery charging outlet assures that battery will be fully charged in a day however the risk of under capacity utilization is high. Multi charging outlets fully utilizes SBCS capacity but the system is usually not modular.

4.6 THE USE OF INVERTERS: A CRITICAL ANALYSIS

Inverter usage will make users feel more or less being connected to the grid like power, that they can exploit diversity and low priced AC appliances. Thus compared to DC power that shall limit them on low efficient DC appliances which are usually expensive, AC power shall make them free of such appliances although system energy or charge limitations still holds in both DC and AC powers. Range of low AC power colored TVs and normal energy saving lights can be used, also mobile phones batteries can be charged. Also, wire sizes and voltage drops in AC systems are minimal leading to reduced acquisition costs.

However we can also argue that since Uzi is not connected to grid, and that because a variety of DC powered appliances compatible with PV systems which are suitable for isolated homesteads are nowadays developed, AC should not dictate our mission. Also inverter efficiency is a draw back as its losses consumes precious energy in the conversion process and so affecting energy harvest and consumption relations. For example the single charging outlet SBCS model total daily system energy demand raised simply by the introduction of the inverter, refer appendices B1 and B2, and the same trend can be seen by comparing two models on appendices B3 and B4. This situation then calls for a larger battery capacity or DOD that complicates the project vision to the user.

The rise of the likeness of being connected to the grid may also lead into increase in appliance usage in terms of number, range (variety) and so time. We mentioned range of TVs, mobile phone batteries charging and others in the users horizon that in future may be used against system energy capacity at which we have designed. This will tend to overload HH fittings and hence SBCS to result into claims by the users that the project fails to meet their expectations.

Also we expect to use inverters from local manufacturers, such inverter have outputs which are obviously not sinusoidal and so the issue of interferences on TVs need special attention. For the time being what we can do is to get exact qualities of the inverters and also convincing the manufacturer to improve his products.

Inverter Qualities and Interferences

The electronic circuitry in inverters may, in some cases, cause problems with radio and television reception, noise on telephones and buzz in audio equipment. Actually these are electro-magnetic interference (EMI) that affects TV and radio (especially AM) reception, telephone conversation and computer operations. Inverter internal filtering circuits can be employed to filter these interferences out. Sine wave inverters cause the least amount of interference. If the waveform of the input power to the television is other than sine wave i.e. modified sine or square waves which are common for inverter output, then interference might be experienced and seen as many faint lines across the screen and sometimes hum sound may be heard through speakers. Also whenever AC input power has some harmonic content, television tends to buzz. Inverters by them selves make audible sound during operation, which is usually proportional to the load.

It is impossible to avoid such interference except with pure sine waves. However interference can be minimized by locating the inverter away from appliances that are susceptible to interference e.g. a TV, twisting together cables that connect the inverter to the battery locating the inverter very close to the batteries wrapping inverter in an alminium foil (caution should be taken not to affect heat dissipation to surroundings).

The positive impacts of inverter usage in the above discussion has obviously out way the negative impacts and so inverter usage is recommended keeping in mind the issues discussed earlier.

4.7 SIZING, SELECTION AND SOURCING OF SYSTEM COMPONENTS

4.7.1 Procedure for Sizing of the PV System Components

Sizing of the components to be used in the project implementation was done using Excel Sheets, available at TaTEDO as seen in appendices B1 to B4. With this program, different alternative models of SBCS were tested in terms of technical performance and project costs based on one SBCS and five household electrical fittings that will be powered by the SBCS. The SBCS models analyzed include those which shall serve households charge demand while the inverters are used or not for each household installation. Modeling went further on the options of SBCS charging one or two batteries per day for either household systems that include or not inverters.

4.7.2 Load Specification

During our field study at Uzi, residents who were interested on the project services wrote their names and provided us with the information on their expected appliances that need to be powered against their names as shown on appendices A1 and A2, taking into account preset project goals and objectives. All the users need to have three lamps, a radio and a television. The researchers from technical perspectives fixed lamps specifications, available in the market at Dar es Salaam. However radio and TV specifications are expected to be of various ranges that depend on users selection. The specifications as used on planning, refer appendices B1 to B4, are then as follows:

Table 2: Load Specification.

HH Systems with out Inverters (DC Loads)	Lamps	Three, each 7 W
	Radio 8 W	B/W or Coloured TV 14 to 20 W
HH Systems with Inverters (AC Loads)	Lamps	Three, each 7 W
	Radio 8 W	Coloured TV 40 W

4.7.3 Solar Panels

Sizing; Panel capacity must correlate energy harvest and demand per day hence,

Module Power Rating (Wp) = Total Daily System Charge Demand (Wh) / Peak Sun Hours (h)

In this project 120 Wp solar PV panels will be supplied by the project sponsor (DTP), donated by a Juwi and made by Kyocera or Sharp. Specifications[1] are as per the table 3 below, and it can be noticed panel specifications below provided the basis of the sizing carried out, refer appendices B1 to B4.

Table 3: 120 Wp Panel Specifications

Kyocera KC120-1 Specifications

General characteristics:

The Kyocera KC-120 is a multi crystal solar electric panel with 36 cells. It is laminated with glass in an aluminum frame. 4" x 4" junction box with conduit knockouts and terminal strips on back. Suitable for all applications in all climates.

Electrical Characteristics:		
Power Rating (Watts)	120	
Current at rated power (amps)	7.10	
Voltage at rated power (volts)	16.9	
Short circuit current (amps)	7.45	
Open circuit voltage (volts)	21.5	
Physical Characteristics:		
Length	56.1"	1425 mm
Width	25.7"	652 mm
Depth (including junction box)	2.0"	52 mm
Weight	26.2 pounds	11.9 kg
Warranty	25 Years	

4.7.4 Batteries

Sizing; Battery capacity must correlate energy harvest and demand per day hence,

Daily Charge Requirement (Ah) = Total Daily Energy Demand (Wh) / System Voltage (V)

Battery Capacity (Ah) = Daily Charge Requirement (Ah) x Days of Autonomy / Battery Discharge Limit

[1] Source: www.altenergstore.com/cart/1027.html

In this project batteries will be purchased and so owned by the users. This is meant to promote best maintenance practices of the batteries and avoid the costs of monitoring battery use as per section 4.5 of the report. Users can purchase solar or automobile batteries from local suppliers. Although solar batteries are significantly expensive compared to automobile batteries of the same Ah capacity, yet they can sufficiently serve larger household loads. This is due to the fact that they have larger DOD and designed to deliver energy in the longer period compared short time loading of the automobile batteries.

The sizing of batteries was done using solar PV sizing programme and the specifications are contained in the relevant data sheets (Appendices B1 to B4), summary of the battery sizing is shown on table 4 below. It is here by important to recommend the Ah capacity of the batteries that can meet users' energy needs, also the importance of sensitization and education of the users in regards to elementary battery basics, usage and maintenance prior the decision to buy or purchase a battery. Electricity is the premium form of energy however not well understood to most of the people targeted by this project.

Table 4: Battery Sizing Results

SBCS Model	HH Electrical Systems	Battery Specifications	Remarks
One Battery Charging Outlet	Without Inverters	150 Ah Automobile Battery (25% DOD)	Battery capacity is a crisis.
		60 Ah Solar Battery (80% DOD)	Better performance that meets project goals. **Satisfactory Performance.**
	With Inverters	75 Ah Solar Battery (80% DOD)	Better performance that meets project goals. **Selected Model.**
Two Batteries Charging Outlets	Without Inverters	40 Ah Solar Battery (80% DOD)	Panel (SBCS) capacity exceeded. **Not practical**.
	With Inverters	45 Ah Solar Battery (80% DOD)	Panel (SBCS) capacity exceeded. **Not practical**.

4.7.5 Inverters

Sizing; Inverter capacity must exceed total energy demand of the connected load and allow for short time overload (the surge) hence,

Total AC connected Loads (W) + Estimated Surge (W) = Total Power Needed

Inverter Rating (W) = Total Power Needed x 1.25

Household electrical fittings are expected and so designed for three lamps, a radio and a TV. These in total are around 150 to 200 W as shown on appendices B1 to B4, and so at least 250 W inverters are recommended. Inverters were proposed to be sourced from Ennea Electronics Art, Mwenge. The said inverter local manufacturer in the course of improving performance of his products, sold us one 350 W inverter which under laboratory tests proved the its starting difficulty and the worst case is the higher no load voltage output that blown a voltmeter. Hence the tests could not proceed and so improvement of such inverters is recommended before adoption to the project if time allows. For the time being imported 500 W inverters is the choice.

4.7.6 Charge Controllers

Sizing; Controller Amp Rating must exceed system current, also LVD and SOC indicator features are necessary as per user or designer conceptual attitudes hence,

Charge Controller Amp Rating = Total System Amps x 1.25

The sizing of charge controllers was done using solar PV sizing programme and the specifications are contained in the relevant data sheets (Appendices B1 to B4), summary of the charge controller sizing is shown on table 5 below. Charge controllers will be sourced from local suppliers; however LVD or SOC indicator devices which are important for the battery life and energy monitoring for each household, are not available within Tanzanian market. Possibility of using such devices developed at Physics Department of the University of Dar es Salaam is under way; otherwise charge controllers must be used for each HH electrical system.

Table 5: Charge controller Sizing Results

SBCS Model	HH Electrical Systems	Charge Controller Specifications	Remarks
One Battery Charging Outlet	Without Inverters	8.33 A	**12A Selected Based on Table 4 Results**
	With Inverters	10.33 A	
Two Batteries Charging Outlets	Without Inverters	11.03 A	
	With Inverters	12.03 A	

4.7.7 Wires, Cables, Fuses and Fixtures

All to be sourced locally and financed by sponsor. Replacements should be financed by users through collections to a central fund monitored by the village project committee as detailed under part 4.4.2 of this report (Details of Model SBCS; Maintenance and Operation).

4.8 SUMMARY OF SPECIFICATIONS OF SYSTEM COMPONENTS

Table 6: Specifications of System Components

System Component	Specifications
Solar Panel	120 Wp, 7.1 A rated power current
Battery	75 Ah solar battery
Inverter	500 W
Charge Controllers	12 Amps
Lamps	7 W Compact Fluorescent lamps

5.0 FIELD VISITS AND MARKET SURVEYS

5.1 VISITS TO UZI ISLAND AND MEETINGS WITH ITS RESIDENTS

Two visits at Uzi Island have been made regarding the project:

(i) **First Visit**; January 29th to January 31st 2004. **Participants**; Mwalimu Mkuu Saidi (Skuli ya Kizimkazi), Ana Karsten, Dr. Karsten (DTP), Joseph Kihedu (University of Dar es Salaam), Jonas Oberbeck (DTP), Nils Hanik (DTP) and Saidi Mustafa (Student of the Solar Workshop Kizimkazi Mkunguni). **Goals**; Point out the desire of electricity (Energy Crisis of the Residents) and Preparation for the feasibility study.

(ii) **Second Visit**; June 19th 2004. **Participants**; Dr. Kimambo (University of Dar es Salaam), Joseph Kihedu (University of Dar es Salaam), Hamad Bakari (Department of Energy, Zanzibar) and Mwalimu Musa (Haile Selassie School, Zanzibar). **Goals**; Meeting with village leaders to exchange views and information on progress of the project.

(iii) **Third Visit**; August 8th 2004. **Participants**; Joseph Kihedu (University of Dar es Salaam) and Hamad Bakari (Department of Energy, Zanzibar). **Goals**; Preparing villagers for project implementation phases, building awareness on how to run the project and particularly discuss with them with regard to project running costs and proposed agreement schemes between users and village project committee.

Figure 8: Meeting with Uzi Residents in a Field Visit

In the first visit, first meetings January 29th 2004, 4 to 6 pm, twelve peoples called by the teachers attended this meeting in school. The idea of the project described and discussed and questions about how many users, recharging fees, costs of fitting and panel, battery capacity beginning of the project and people to be connected to the project were answered. The participants suggested that the criteria for selection of the people for the first project services should not be based on special groups of inhabitants like teachers or relatives.

The second meeting January 30th 2004, 4 to 6 pm, was participated by more than sixty people of both villages Uzi and Ng'ambwa. A painting at the blackboard showed a structure of the first project step. A SBCS shall be attached to one house so that such a particular HH and the other four houses (around this house) can share the SBCS service avoiding long distances to carry the batteries for charging. It was agreed that Uzi village should have 6 SBCSs for 30 households and Ng'ambwa 4 SBCSs for 20 households.

The first donation shall cover panels and the fitting of the houses while batteries are to be bought and owned by the households and charging fees have to be paid be the. The charging fees which must include the renewal and replacement of the damaged electrical systems fitting components and for general maintenance and progress of the project. The project has to be run as a private enterprise by the villagers under supervision of the elected committee. SBCS operators have to be educated in measurements and charging of the batteries, users be given an introduction on use and maintenance battery and the systems. It was noted that one electrician lives in the village and so he can be assistive in future of the project.

June 19th 2004, 5 am to 2 pm meeting, it was agreed that researchers should prepare contractual proposal of agreement between a user and project village committee, proposal of committee structure and a seminar material on battery basics that would assist users to know how they should select appropriate batteries, criteria of selection and why important.

During another meeting that was held on August 8th 2004, villagers discussed on how the can run the project and asked the researcher assistant to help them get the picture. The villagers told the researchers that they have already elected members the village project committee and agreed on TShs 200/= charging fee. They were told the importance of satisfactory charging fee that can handle their requirements to run the project, to meet maintenance and replacement costs, expanding the project service to other villagers and hence meet donors' expectations. Minutes of the meeting are available on appendices E2.

5.2 SURVEY OF LOCAL SUPPLIERS AND PRICES EQUIPMENT

Most of SEHS equipment is available locally in the Tanzanian market. However, such availability is limited in specifications and type. For example, available solar panels do not exceed 75 Wp, independent LVD devices and SOC indicators are not available. Appendix … shows price lists from suppliers of solar energy systems within Dar es Salaam. The required SHS equipment and hence their prices was selected and specified from the list.

With regard to the LVD devices and SOC indicators, there is a possibility of developing them and manufacturing them locally at the Physics Department of the University of Dar es Salaam in time for application in the Uzi project. Alternatively, they could be sourced from outside the country, possibly from Germany.

5.3 INTERVIEWS WITH LOCAL DEALERS SOLAR PHOTOVOLTAIC SYSTEMS

A range of SHS Equipments dealers, suppliers, technicians, experts and organizations were visited. The following is the summary of their remarks, recommendations and technical experiences on the issues related to the project.

5.3.1 Ennea Electronics Art

- Inverters made by them are used by many customers, who recommend that the inverters are good. Oscillators or multvibrators for inverters are made by Chief Technical Officer of Department of Physics, Faculty of Science, University of Dar es Salaam, Mr Sewando, Customer feedback assures them so since no claims are built on the use of inverters. AC output from inverters can successfully run TV and even motors if expected usages are reported prior manufacturing of the inverter.
- Manufacturer tested his inverter using 120 Ah 12 V Yuasa battery to light two 200 W lamps each, i.e. 400 W in total. On loaded voltage of the inverter output was 215 V however he hesitated to measure no load (open circuit) voltage output of his inverter as he expected that it can exceed 600 V of his voltmeter. Starting of the inverters is not strict, a two to three trials are needed since sensitivity of the equipment is not high as it doesn't

use drivers and it supply lines are 9 to 12 V while in high starting sensitive inverters 6 V is used.

5.3.2 REX, RESCO and Umeme Jua

- We don’t have or sell independent LVD or SOC indicators.
- Five days between recharging may not be practical with such system energy demand, otherwise larger batteries should be used.

5.3.3 TASEA

- We promote the use of local manufactured SHS devices and so we prefer the use of Mwenge inverter in this project, if their quality allows so.
- You may need/use charge controllers in place of unavailable LVD or SOC indicators.
- Five days between recharging may not be practical with such system energy demand, otherwise larger and so, expensive batteries should be used.

5.3.4 ENSOL (T) Ltd

- With your system you can use one charge controller connected to all batteries which may be placed at the charging station or at each house, then cables can be used to connect a charging station and the household fitting.
- We usually don’t use local manufactured inverters since their performance are not such good that they can result into misunderstanding with our customers. Also we are not sure of their surge capacity, which is important specification.

5.3.5 BP SOLAR

For safety purposes batteries to be used in a such project;

- Need to be sealed ones, although they can be more expensive still they will solve maintenance requirements, which is usually difficulty for many villagers who cannot correctly do it. Also the sealed batteries shall avoid spillage of the battery acids on the soil in the process of transportation to and from the SBCSs.
- Can be covered with plastic caps for the terminals to avoid short-circuiting in the course of regular battery transportation between a house and a SBCS, bearing in mind that bicycles that are made of metallic frames may be used in transportation.

Review the energy harvest and consumption, they might not match and so provide risk for project technical performance.

6.0 LABORATORY TESTING OF LOCALLY MADE INVERTER

Inverter testing was performed at Physics Department Laboratory, University of Dar es Salaam, refer appendix C for the report on the test. As per its specification by the manufacturer i.e. 12 VDC input, 240 VAC and 350 W output, the following is the summarized initial observations made;

- Inverter was checked in physical appearance externally including; metal casing, weight as expected largely due to its transformer structure and a switch socket outlet were visualized.
- Internally; proper layout of the components, locally wound transformer on old laminations and heat sinks seen.
- Starting needed a number of trials and that a voltmeter set at 750 V range was blown signifying that no load output voltage exceeded the range.
- Output waveform and efficiency could not be determined due to the problem of excessively high starting voltage.
- **Recommendation**s; Inverters should not be accepted for the project until electrical, starting, efficiency and physical features are improved.

Refer to inverter testing report undertaken at Physics Department Laboratory, University of Dar es Salaam at appendix C.

7.0 TECHNICAL DESIGN OF THE SYSTEM

7.1 SYSTEM PLANNING

The following systems were analyzed based on the inverter use or not. In the analysis we have also considered the idea whether to charge one or two batteries per day.

7.1.1 System without inverter (12V DC Lights)

Consider the following simplified diagram that consists of two systems;

• Solar Battery Charging Station i.e. components between and including module to battery in the diagram below.

• Households electrical fittings (system without inverter) i.e. components between and including battery to appliances.

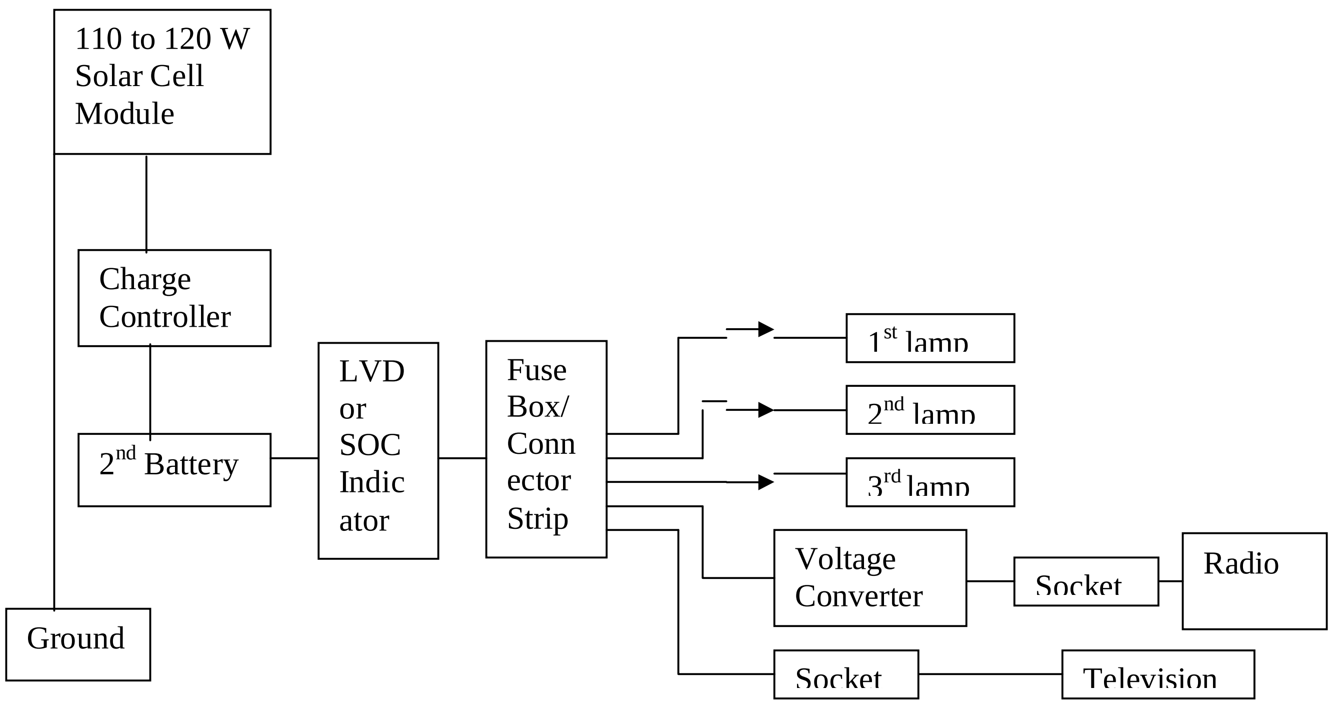

Figure 9: System without inverter (12V DC Lights)

7.1.2 System with inverter (with normal energy saving lights)

Consider the following simplified household installation diagram, which does not include the solar battery charging station.

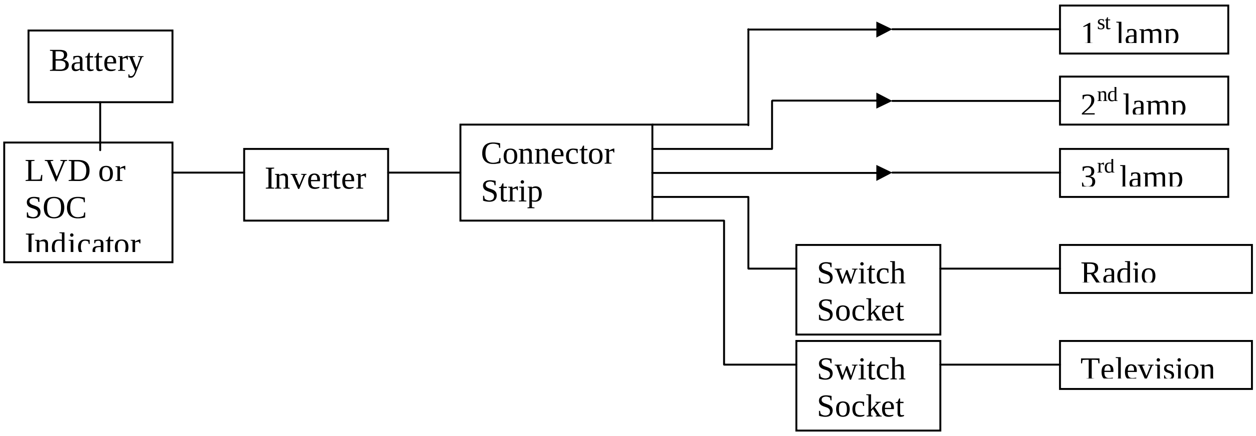

Figure 10: System with inverter (with normal energy saving lights)

NOTE: Arrows represent switches in figures, 7.1 and 7.2 above.

7.2 ENERGY HARVEST AND CONSUMPTION ANALYSIS

7.2.1 Calculating Total Daily System Energy Requirement/Demand

Daily energy demand measured in watt-hours is calculated by totaling the energy that all appliances use on average day. Thus for a particular load; power and average daily use hours are multiplied and the products for each load (DC and AC loads) are then added to get the daily system energy demand. However an amount of energy is usually lost within the system, the losses are around 10% and the other 10 to 20% if inverter is used, and so they must be added to get total daily system energy demand. Because battery capacity is measured in Ah, then in solar electric system total daily energy demand in watt-hour (Wh) are converted into Ah (total daily charge demand) by dividing energy in watt-hours by the system voltage.

Mean daily insolation data in peak sun hours was estimated from available insolation contour map. Design month referrers to the month with lowest daily insolation, usually this insolation value is used to size the module however excess energy in sunny months will be produced. To utilize the of the module, annual mean daily insolation was used, however shortage of energy or charge in cloudy months may be experienced and so users have to reduce usage duration of their appliances. Tracking can increase energy harvest up to 25% compared to modules not attached to trackers. The module stands to be used can be made with such vision.

Module must be chosen so that their energy output matches the energy requirement of the load.

Energy Demand Calculations

The following general formula were used in calculating energy demand, refer appendices B1 to B4.

Daily Energy Demand (Wh) = Power Rating of the Appliance (W) x Usage per Day (h)
= AC + DC Daily Loads Energy Demand (Wh)
Energy losses = 20% Daily Energy Demand (without including inverter losses)
Total Daily Energy Demand = Energy losses + Daily Energy Demand (Wh)

7.2.2 Energy Demand and Consumption Modeling

Appendices B1 to B4, shows Excel sheet results of energy demand and consumption analysis based the following assumptions:

(i) Users shall only use appliances listed on them not exceeding the given number of hours of use shown on Excel sheets on appendices B1 to B2 accordingly. The use of three lamps, a radio and at TV was suggested by the users themselves during a meeting in our field visit at Uzi.
(ii) Two models are checked, having or not (including or excluding) the inverters each of them with the options of single and double battery charging outlet models.
(iii) 10% energy losses of the systems and 10% energy losses of the imported inverters if used. Also Average insolation of five peak hours are used, not the minimum insolation that is around four and a half hours in March.
(iv) When Ahrs sizing is used voltage fluctuations are negligible and so preferred in battery sizing since battery capacity is expressed in Ahrs also.
(v) In Whrs sizing open circuit voltage drop of 0.4% per ^{0}C rise taken to be included in system losses.

7.3 MODEL SBCS PERFORMANCE AND SELECTION

Excel Sheets on Appendices B1 to B4 were used to predict performance of the four SBCS models.

First SBCS model found on appendix B1 is aimed to charge one automotive battery in a day that is to be used for a household fitting in which an inverter is not used. The results show that 92.6% of the panel capacity will be utilized and a charge controller of 8.22 Amps needed. Battery capacity of 150Ah to allow only 25% DOD will be needed which is expensive to most of Uzi people. Similar SBCS however using solar battery of 60Ah at 80% DOD is shown under appendix B1.1 as alternative model to avoid battery capacity crisis. The second SBCS model to charge one solar battery per day with the use of inverters is shown under appendix B2. A solar battery capacity 75Ah shall be needed, panel capacity shall be full utilized and a charge controller of 10.03 Amps needed.

The third SBCS model to charge two solar batteries owned by two independent homesteads per day without the use of inverters in household fittings is shown under appendix B3. Each household can use a solar battery of 40Ah however panel capacity is exceeded by 24.3% and a charge controller of 11.03Amps needed. The fourth SBCS model to charge two solar batteries per day with the use of inverters in each of the two household fittings is shown under appendix B3. Each household can use a solar battery of 45Ah however panel capacity is exceeded by 35.6% and a charge controller of 12.03 Amps needed.

The above discussion shows that the third and fourth SBCS models aimed to charge two batteries are totally impractical with the use of the same available solar panels. This is due to the fact SBCS capacity cannot satisfy the energy demand although reduced battery capacity requirement can be achieved. Hence the idea of charging two batteries is here by grounded.

The remaining models are practically possible with the stated daily average use of indicated appliances and usage time. Also panel capacity exceeding values can be tolerated with the actual panel output in operation in the field as well as energy demand calculations that took into account larger margin of safety that include 10% system losses and 10% inverter losses whenever included.

7.4 INSTALLATION OF THE SYSTEMS

After the planning exercise, solar system should be made available at the site before starting the installation phase commences. That means, equipments should be bought and transported to Uzi. The following instructions should be noted, studied and hence followed, prior and during the installation exercise.

7.4.1 Installation Diagrams

Four types of installation diagrams i.e. block, circuit, wiring and cable diagrams are covered. Each diagram shows two separate systems i.e. solar battery charging station and a separate household electric system.

7.4.1.1 Block Diagrams

These are diagrams showing all equipment connections.

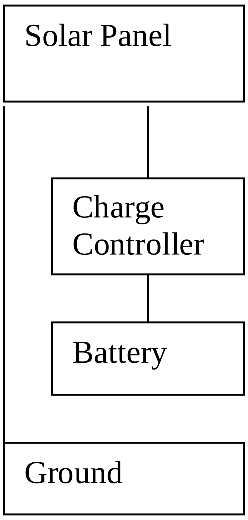

Figure 11.1: SBCS

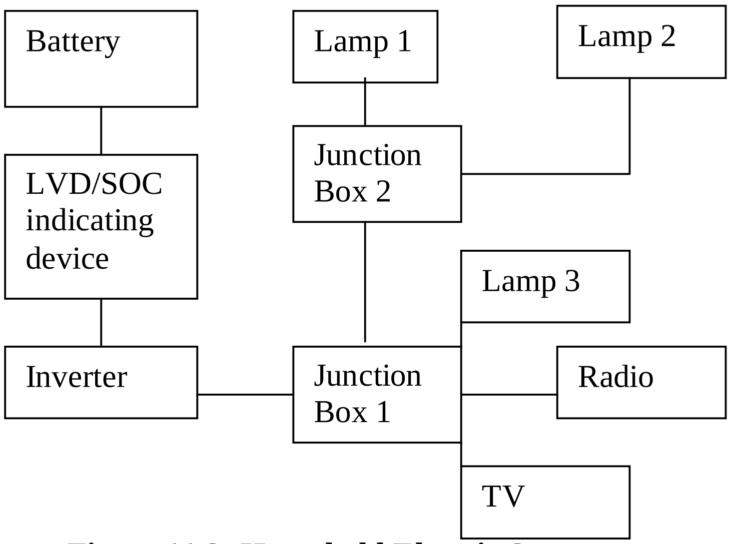

Figure 11.2: Household Electric System

7.4.1.2 Circuit Diagram

These are diagrams drawn using electrical symbols.

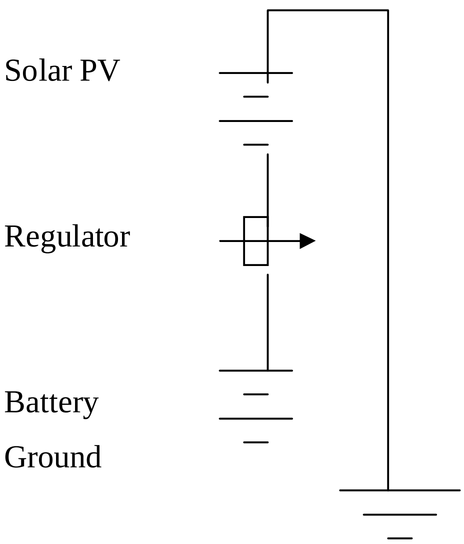

Figure 12.1: SBCS

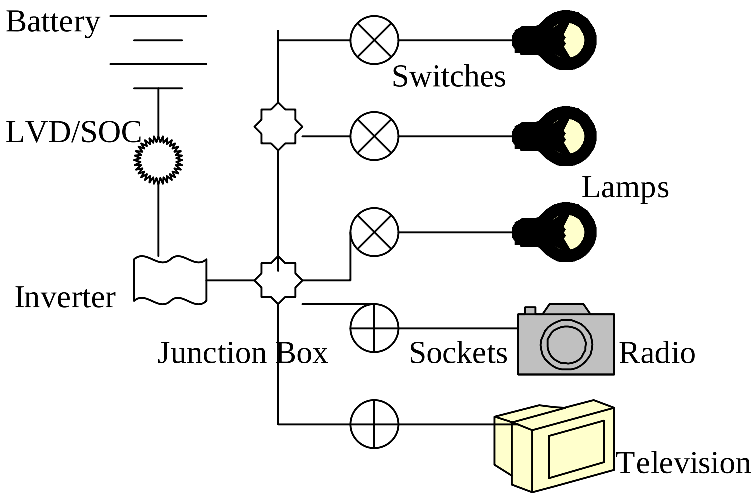

Figure 12.2: Household Electric System

7.4.1.3 Circuit Diagrams

These are diagrams showing how wires are connected.

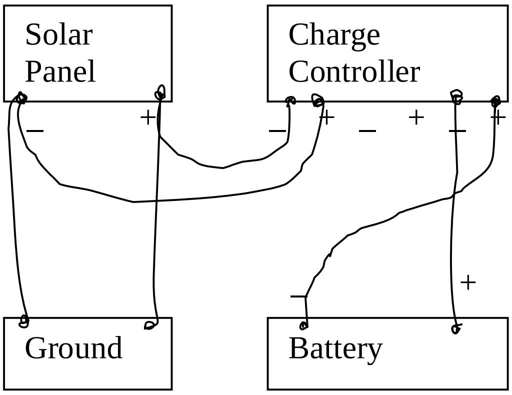

Figure 13.1: SBCS

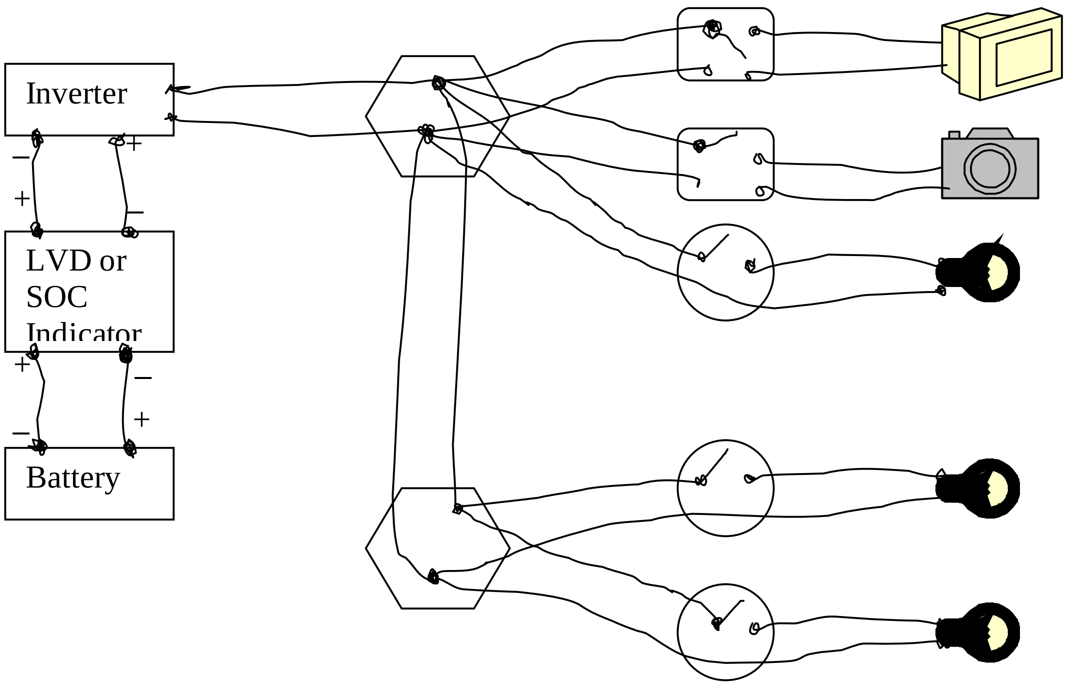

Figure 13.2: Household Electric System

7.2.2 Installation Precautions

(1) Installations must be made in accordance to safety regulations and manufacturers instructions.

(2) Panels: must be covered during the installation, directed to the equator at around 15^0 angle of inclination, should not be obstructed from sunlight by permanent shadow, installed at a safe place with the necessary security and reachable for cleaning purposes.

(3) Cables should have only the necessary length to reduce losses, connections must be covered, sharp corners must be avoided and include means of disconnecting parts of the circuit for maintenance and replacement purposes.

(4) Inverters and charge controllers: must be installed indoor, away from human, animals and dirty interferences, ventilated and that inverters can only be put on when all appliances are off.

(5) All components must be grounded for security purposes, e.g. in case of lightning and voltage surges.

7.2.3 After Installation Notes

The following tests must be done to prove that the circuit works:

- Infinity resistance test,
- Continuity test, for switch functionality and wire open circuitry.
- Positive and negative terminals of the module and other equipments.
- Visual test of the whole system for proper installation and operation.

Also users and SBCS operators in particular must be taught to check that:

- Shadow does not fall on the panel.
- Panel is cleaned (without using any soap).
- Panel safety.
- Batteries are always clean and dry.

SBCS operators must have spare battery acids and fusses.

8.0 FINANCIAL ANALYSIS

8.1 CAPITAL INVESTMENT

8.1.1 Feasibility Study Costs

COST ITEM	QUANTITY	UNIT COST (TSH)	COST IN TSHS	SOURCE
Feasibility study	1	1,400,000.00	1,400,000.00	DTP
Sample Inverter	1	50,000.00	50,000.00	DTP
SUBTOTAL			***1,450,000.00***	***DTP***

8.1.2 Equipment and Acquisition Costs

COST ITEM	QUANTITY	UNIT COST (TSH)	COST IN TSHS	SOURCE
Solar panels (approx.)	10 pieces	1,000,000.00	10,000,000.00	DTP Donor
VAT for Solar Panels	20%	10,000,000.00	2,000,000.00	DTP
Inverters	50 pieces	320,000.00	5,000,000.00	DTP
Batteries	50 pieces	110,000.00	4,750,000.00	Users
Battery box	50 pieces	25,000.00	1,250,000.00	DTP
Battery wires - 10 mm^2	100 metre	2,000.00	200,000.00	DTP
Battery terminals	120 pieces	500.00	60,000.00	DTP
Charge Controllers	10 pieces	55,000.00	500,000.00	DTP
Discharging Control	50 pieces	30,000.00	1,500,000.00	DTP
Panel Stand	10 pieces	30,000.00	300,000.00	DTP
Lamp holders	150 pieces	1,000.00	150,000.00	DTP
Lamps	150 pieces	3,000.00	450,000.00	DTP
On and Off Switches	150 pieces	1,200.00	180,000.00	DTP
Switch Sockets	50 pieces	2,500.00	125,000.00	DTP
2.5 mm sq cables	1,200 metres	400.00	480,000.00	DTP
6 mm sq cables	100 metres	1,200.00	120,000.00	DTP
Junction boxes	100 pieces	1,000.00	25,000.00	DTP
Connector strips	10 packs	6,500.00	65,000.00	DTP
Clips	10 packs	1,500.00	15,000.00	DTP
Nails	3 box	3,000.00	6,000.00	DTP
Screws	2 box	5,000.00	10,000.00	DTP
Insulation tapes	5 pieces	700.00	3,500.00	DTP
Earth rods	50 sets	2,000.00	100,000.00	DTP
Earth wire	450 metres	200.00	90,000.00	DTP
Fuses	10 pieces	5,000.00	50,000.00	DTP
Installation, maintenance and repair tools	1 set	250,000.00	250,000.00	DTP
Port clearing costs	Lump sum		200,000.00	DTP
Contingency	Percentage	Approx. 10%	3,000.00	
SUBTOTAL	*30,834,500.00*		*16,084,500.00*	*DTP*
			10,000,000.00	*DTP Donor*
			4,750,000.00	*User*

8.1.3 Transportation Costs

COST ITEM	SOURCE-DESTINATION	COST IN TSHS	SOURCE
Fitting Components	Suppliers-Dar Port	30,000.00	DTP
Fitting Components	Dar-Zanzibar	120,000.00	DTP
Wharfage	----	40,000.00	DTP
Solar Panels and Fitting Components	Zanzibar-Uzi	50,000.00	DTP
ZASEA Members	Zanzibar-Uzi-Zanzibar	100,000.00	DTP
Emergence Trips	Uzi-Zanzibar-Uzi	10,000.00	DTP
SUBTOTAL		*350,000.00*	***DTP***

8.1.4 Installation, Commissioning and Training Costs

COST ITEM	UNIT COST	NO. OF UNITS	COST IN TSHS	SOURCE
Installation Labour Costs	20,000.00	10	200,000.00	DTP
Camping Costs	10,000.00	10	100,000.00	DTP
Supervision and training (TASEA)	50,000.00	7 days	350,000.00	DTP
Subsistence costs	20,000.00	57 days	1,140,000.00	DTP
Transport costs in Zanzibar - Uzi	10,000.00	10 trips	100,000.00	DTP
Transport costs from to Dar es Salaam	25,000.00	2 trips	50,000.00	DTP
Materials	Lump sum		100,000.00	DTP
SUBTOTAL			***2,040,000.00***	***DTP***

8.1.5 Inauguration and Publicity

COST ITEM	COST IN TSHS	SOURCE
Materials	50,000.00	DTP
Media coverage	50,000.00	DTP
SUBTOTAL	***100,000.00***	***DTP***

8.1.6 Total Capital Cost

Total Capital Cost for the Uzi Solar Photovoltaic Project	**TSh. 34,774,500.00**
Through DTP	***TSh. 20,024,500.00***
Through DTP Donor	***TSh. 10,000,000.00***
Through Users	***TSh. 4,750,000.00***

8.2 OPERATING EXPENDITURE (PER ANNUM)

8.2.1 Payments and Allowances

COST ITEM	No. OF UNITS	UNIT COST (TSH)	COST IN TSHS	SOURCE
Station Operators Allowances	12 months for 10 operators	500.00	60,000.00	Village Committee
Labour Cost for Maintenance	Lump sum		120,000.00	Village Committee
SUBTOTAL			180,000.00	Village Committee

8.2.2 Consumables

COST ITEM	COST IN TSHS	SOURCE
Battery acid	25,000.00	Users
Lamps replacements	100,000.00	Users
Battery Terminals	10,000.00	Users
Fuses replacements	20,000.00	Village Committee
SUBTOTAL	***20,000.00***	***Village Committee***
250,000.00	***135,000.00***	***Users***

8.2.3 Budget for Village Committee

COST ITEM	COST IN TSHS	SOURCE
Committee Meetings and Executive Activities	15,000.00	Village Comm.
Office Rent (To be llocated at school)	-----	Village Comm.
Project Documentation	10,000.00	Village Comm.
Traveling Costs	8,000.00	Village Comm.
	33,000.00	Village Comm.

8.2.4 Total Operating Budget (Per Annum)

Total operating cost for the Uzi Solar Photovoltaic Project	TShs 368,000/=
Through Village Committee	TShs 233,000/=
Through Users	TShs 135,000/=

8.3 OPERATING INCOME (PER ANNUM)

Project income shall be through users' contributions throughout service life of the equipments and especially solar panels, which is around twenty years of service.

YEAR	NUMBER OF UNITS	RATE (TSH)	AMOUNT (TSH)
1	600	3,000.00	1,800,000.00
2	600	3,000.00	1,800,000.00
3	600	3,000.00	1,800,000.00
4	600	4,000.00	2,400,000.00
5	600	4,000.00	2,400,000.00
6	600	4,000.00	2,400,000.00
7	600	5.500.00	3,300,000.00
8	600	5.500.00	3,300,000.00
9	600	5.500.00	3,300,000.00
10	600	7,300.00	4,380,000.00
11	600	7,300.00	4,380,000.00
12	600	7,300.00	4,380,000.00
13	600	9,700.00	5,820,000.00
14	600	9,700.00	5,820,000.00
15	600	9,700.00	5,820,000.00
16	600	13,000.00	7,800,000.00
17	600	13,000.00	7,800,000.00
18	600	13,000.00	7,800,000.00
19	600	13,000.00	7,800,000.00
20	600	13,000.00	7,800,000.00
TOTAL			***82,100,000.00***

8.4 DESCRIPTION AND COMMENTS

8.4.1 MATERIAL AND INSTALLATION COSTS

Appendices B1 to B4 show Excel sheet also shows total costs of the two SBCS models in two different options of using or not using inverters. The prices used are VAT inclusive and based on suppliers pricelists. However prices of the LVDs or SOC indicators are not included since they are not available in the market. Battery prices and maintenance costs are included for future users' information. Financial Analysis elaborates the costs and is meant to foresee project future.

Installation costs are expected to include labour and camping costs, with which ZASEA members shall undertake installation activities at the site as a practical training opportunity after their attendance on the workshop on ‘How to Build Solar Home System”. Supervision during the installations of the systems also shall require to be funded as well as commissioning or demonstration phase.

Alternative acquisition costs for the selected components used in the Financial Analysis under part 8.1.2, from different suppliers around Dar es Salaam are as follows:

Table 7: Availability and Prices of Selected Equipments within Dar es Salaam Market

System Component	Specifications	Suppliers	Product Name/Code	Unit Prices (TShs)
Solar Panel	120 Wp 7.1 A	Donated by Juwi	Kyocera/Sharp 120	1,100,000.00
		Ensol (T) Ltd	120W, SX & H	836,000.00
Battery	75 Ah Solar Battery	Umeme Jua Ltd	Chloride Exide 75Ah	61,200.00
		Chloride Exide (T) Ltd	075SOLAR	51,500.00
			80 Sealed	80,000.00
		REX Investment Ltd	Solar Battery 80AH	120,000.00
		Ensol (T) Ltd	N75, Chloride	79,000.00
	60 Ah Solar Battery	Umeme Jua Ltd	Atlas (Sealed) 65Ah	84,000.00
		Chloride Exide (T) Ltd	067SOLAR	46,000.00
			65 Sealed	70,000.00
Inverter	500 W	Umeme Jua Ltd	XTX 500	180,000.00
		BP Solar	UX512E, INVETER	650,000.00
		REX Investment Ltd	Inverter 600Watt	485,000.00
		Ensol (T) Ltd	XANTREX-500	190,000.00
Charge Controllers	12 Amps	Umeme Jua Ltd	Steca, 12A, SOC	98,400.00
		REX Investment Ltd	Solar Regulator 12A	118,000.00
		Ensol (T) Ltd	Steca 12A	120,000.00
		Chloride Exide (T) Ltd	15 Amps Prostar	150,000.00
Lamps	7 W Compact Fluorescent Lamps		Energy Savers	3,000.00
		Umeme Jua Ltd	Steca CFL, 7W	26,400.00
		Chloride Exide (T) Ltd	Multi Light 7 Watts	20,000.00
		Ensol (T) Ltd	Lumina 7W	28,620.00
			Solsum 7W	32,330.00
			External Bulkhead 7W	47,700.00

8.4.2 CHARGING FEES AND USERS CONTRIBUTIONS

Charging fees and payback calculations taken are based on the material and installation costs above without including interest figures as the amount may also depend on donors, village committees and users agreement. Total capital costs for the project implementation is TShs. 34,774,500.00 including DTP and users’ costs. However if we exclude user costs i.e. taking into considerations only DTP and other collaborative donors’ costs towards the project, total capital invested is TShs. 30,024,500.00. Assuming averagely fixed annual operating costs of

TShs. 368,000.00 for twenty years service life of the solar panels, that sum to TShs. 7,360,000.00 then total project costs is TShs. 37,384,500.00. This cost calls for TShs. 3,000.00 per month as a total charging fee and payback contributions for each user is can be used if no interest is to be gained. It should be remembered that villagers them selves estimated charging fee of only TShs. 200/= (Two hundreds only) during their meeting, refer appendices E3. Although researchers managed to convince them to review their estimates based on project operating costs, this socio-economical capacity of the villagers should not be left aside.

Six charges a month, each TShs. 500.00 after every five days, shall add up to TShs. 3,000.00 per month. However, the charging fee can be reviewed after every three years as shown on part 8.3 to include inflation rate of about 10% a year lumped into 30% in three years time. Under the stated assumptions, pay back period of the capital investment by the donors covering TShs. 30,024,500.00 is thirteen years while the total project costs that include capital investment; users' cost on batteries maintenances and replacements is fifteen years. After 20 years a sum of TShs. 82,100,000.00 is expected to have been collected under the same assumptions.

9.0 ENVIRONMENTAL IMPACT ASSESSMENT

9.1 IMPORTANT ENVIRONMENTAL ISSUES

Environmental issues can be viewed in different levels as follows:

9.1.1 International Issues

Climate change is a global problem requiring action from the entire international community. Countries from around the world are working together to share technologies, experience, resources and talent to lower net greenhouse gas emissions and reduce the threat of global climate change. Many countries participate in and supports several international efforts designed to help countries to address climate changes.

One important strategy for reducing global greenhouse gas emissions is developing and sharing climate-friendly technologies, commonly referred to as Technology Cooperation. These efforts can occur between nations, private entities, and organizations around the world. The countries also participates in various bilateral and multilateral technology cooperation initiatives that aim to encourage the use of technologies that will reduce greenhouse gases. Countries have been encouraged to implement projects that reduce, avoid, or sequester greenhouse gas emissions. In the past, the U.S. Countries Studies Program provided developing countries and countries with economies in transition with funding and technical assistance to support greenhouse gas inventories, mitigation assessments, vulnerability and adaptation assessments and national action plans for addressing climate change. Finally, international efforts establish guidelines for Land Use, Land Use Change, and Forestry practices that reduce greenhouse gas emissions and increase carbon sinks.

As countries continue to grow and develop, international cooperation will become increasingly important as the global community searches for ways to meet the climate change challenge efficiently and effectively. The key to successful cooperation is finding activities that will help all countries achieve their economic, environmental, and developmental goals in a climate-friendly manner.

9.1.2 National Level

In response to mounting concern over the potential risks posed by global warming, the Framework Convention on Climate Change was opened for signature in Rio di Janeiro at the United Nations Conference on Environment and Development (also referred to as the "Earth Summit") in June 1992. More than 150 nations, including many of the Eastern and Southern African countries signed the treaty, which entered into force less than two years later, on March 21, 1994. It has now been ratified by more than 155 nations.

Under this treaty, the world's industrialized nations pledged to establish policies and measures that reduce emissions of the greenhouse gases that are changing the Earth's climate. World countries are strongly committed to addressing the challenge of climate change with cost-effective policies that are good both for the environment and the economy. The approach has three pillars. First, contribution to a necessary foundation in science through extensive research effort on climate change of any nation in the world. Second, policies are based on win-win partnerships with the private sector, states, localities, and non-governmental organizations. Finally, commitment to strengthening international responses to the risks of climate change - global warming will require global solutions.

9.1.3 Regional/State Level

Action at the state level is a key component of the response to the potential impacts posed by climate change. This section – State Actions – focuses on state level activities, programs, technologies, and policies to reduce greenhouse gas (GHG) emissions across the nation. In the United States of America many of these actions were initiated and/or have received assistance from the US Environmental Protection Agency’s (EPA's) State and Local Climate Change Program, a capacity-building program that provides technical and financial assistance to state (and local) officials and organizations that support state functions. As of November 1999, over 34 states and Puerto Rico had become partners in the Program. State partners are involved in a variety of activities including the preparation of state GHG emission inventories, action plans, demonstration projects, and informational and educational programs.

The goal of the State Actions section of the Global Warming website is to share results that state climate program developers may find useful in the adoption and transfer of innovative technologies and policies that reduce GHG emissions. State Actions is divided into the following three subsections:

(i) State Action Plans – 25 states and Puerto Rico are working on, or have completed, action plans that identify cost-effective options for reducing GHG emissions or enhancing GHG sequestration. This subsection features summaries of, and links to, selected State Action Plans.

(ii) Case Studies – Many states have begun to implement programs, technologies, and policies that are resulting in real GHG emission reductions. This subsection provides background information and results (in terms of GHG reductions, energy savings, and costs, where available) for a number of state and local programs. The case studies illustrate a cross-section of the vast experience states and localities are accumulating as they implement policies that reduce GHGs.

(iii) State Actions List – This subsection provides access to an EPA-compiled database on state actions so that state decision-makers can obtain information on the types of policies that are under consideration or being implemented by their colleagues. Query options are available to make it easy to select and sort information from the database.

(iv) Legislative Initiatives – Public decision-makers are addressing global climate change through their policy-making decisions, bills, joint resolutions, and memorials. The Legislative Initiatives subsection provides a listing of state legislation and public sector initiatives specifically addressing climate change or greenhouse gases.

In addition to the material in these subsections, several other tools are available to assist states, including:

(i) Inside the Greenhouse – An electronic newsletter for state and local governments and other stakeholders that includes information on successful GHG mitigation efforts at the state and local level, information on impacts, upcoming conferences, and other features.

(ii) EPA's State & Local Climate Change Outreach Kit – Provides a one-stop source for the outreach material that state and local leaders need to inform the public about global warming. The kit focuses on voluntary greenhouse gas reduction strategies that help states and communities save money, improve air quality, and lower risks to human health.

(iii) States Guidance Document: Policy Planning to Reduce Greenhouse Gas Emissions, Second Edition – This document provides guidance for developing state action plans and GHG mitigation strategies.

(iv) Climate Change Program Contacts – A list of climate change program contacts and relevant contact information at both the regional and state levels.

9.1.4 Local Level

Cities and towns across the world are on the front lines of climate change and feel the effects of changes such as in precipitation, temperature, sea-level rise, and air quality. Cities and towns are also in the position to take a variety of energy efficiency and renewable energy actions that can have multiple benefits including saving money, creating jobs, promoting sustainable growth, and reducing critical pollutants.

"Smart Savings: Climate Solutions for Cities" identifies twenty actions that local officials can take to save money, save energy, clean the air, reduce congestion, curb sprawl, and reduce greenhouse gas emissions. The actions range from building improvements to transportation, waste management and urban design. While the list of actions is not comprehensive, it provides good examples of actions that cities in the world have voluntarily taken and that make a contribution to improving our environment.

See EPA's State and Local Climate Change Outreach Kit, for additional material. It provides a one-stop source for the outreach material that state and local leaders need to inform the public about global warming. The kit focuses on voluntary greenhouse gas reduction strategies that help states and communities save money, improve air quality, and lower risks to human health.

EPA's Heat Island Reduction Initiative provides communities with information resources and technical assistance to address the impacts of increasing urban temperatures, which can be up to 10 degrees F hotter than rural surroundings. Not to be confused with global warming, the urban heat island effect results from a high concentration of construction materials that absorb, rather than reflect, the sun's heat. By planting trees, and installing reflective roofs and pavements, communities can achieve the benefits of lower ambient air temperatures, improved air quality, and energy savings.

9.1.5 Individual Level

What difference can I make? When faced with this question, individuals should recognize that collectively they could make a difference. Think back to the days before recycling became popular – when everyone threw everything out in the trash. In less than 20 years, most households have gone from recycling little to nothing to recycling newspapers, plastics, glass and metal. Many businesses recycle paper and buy recycled products and many industries practice source reduction in their packaging efforts. An entire mindset has changed in one generation!

Taking action on global warming (or climate change) is similar. In some cases, it only takes a little change in lifestyle and behavior to make some big changes in greenhouse gas reductions. For other types of actions, the changes are more significant. When 30 million people in Tanzania or the 6 billion people worldwide multiply that action, the savings are significant.

"Individuals Can Make A Difference" identifies actions that many households can take that reduce greenhouse gas emissions in addition to other benefits, including saving you money! The actions range from changes in the house, in the yard, in the car, and in the store. Everyone's contribution counts so why don't you do your share?

9.2 POSITIVE ENVIRONMENTAL ASPECTS OF SOLAR PHOTOVOLTAICS

With regard to PV, its use for our everyday electricity needs has distinct advantages. We avoid consuming resources and degrading the environment through polluting emissions, oil spills, and toxic by-products. Participants of the Regional Solar Electric Training and Awareness Workshop (6) made the following recommendations with regard to the environmental aspects of PV technology:

"PV technology is recommended on the basis of being relatively environmentally friendly:

(i) Enhances good health as it has no smoke emissions and therefore produces no eye ailment.

(ii) Conservation of the environment by not contributing to deforestation, erosion and desertification.

(iii) *Does not contribute to global hazards such as the green house effect, ozone layer depletion, acid rains and air, water and noise pollution and global warming.*

(iv) *Saves on dry cells batteries use and favours lead-acid battery recycling.*

(v) *Disposal of fluorescent lights could be a problem but may be slowed by use of PL*[2] *lights."*

9.2.1 Smoke Emissions

PV operations does not result into smoke emissions since no fuel is used hence no any combustion process takes place during the act of solar energy conversion into electrical energy. PV applications then does not contribute into health hazards that include eyes ailment, difficulty and insufficient oxygen breath that can extend to lungs damage due to high air impurities content from combustion products. By avoiding such health hazards, PV applications can be considered to enhance good health in comparison to other energy or light sources e.g. generators, kerosene lamps and firewood, which emit smoke.

9.2.2 Deforestation, Erosion and Desertification

The project has not been focused to serve energy for cooking or related usages so that significant amount of firewood utilization can be avoided or at least reduced. Also there has been no particular evidence of Uzi villagers using firewood for lighting purposes however that is the trend for most of the villagers in the region. In general wood fuel needs can result into deforestation in the course of satisfying energy needs. If the energy needs are left to grow up and either no alternative energy sources are introduced or deforestation is not controlled then the situation shall obviously lead into erosion and hence deforestation. PV applications at Uzi Islands shall reduce the use of firewood by provision of quality lights.

9.2.3 Green House Effect and Global Warming

Green House Effect is caused by human made layer of gasses in the atmosphere around the earth which are the results of combustion processes or otherwise. Such gasses avoid short wave sun radiations and allow long wave radiations leading to increase of overall temperature around the earth. This temperature rise simply is referred to as Global Warming and its

[2] PL is a code used by Philips Company for energy saver light

effects include change of climates. PV application shall not contribute to gaseous emissions and hence its wide usage shall reduce the effects of green house and global warming.

9.2.4 Acid Rains, Air, Water Pollution

Gaseous emissions to the atmosphere that include various chemicals e.g. sulphur dioxide pollute air. Whenever it rains, such pollution is converted into acidic components, which are then washed to the earth as acid rains that can pollute water in the rivers, lakes and oceans. Acid rain pollutes soil, affects plants and the living organisms. Water pollution affects water Ph values, organisms that live in water and thorough the food chains that are thorough to fishes, animals and hence human beings will be affected.

9.2.5 Noise Pollution

While PV operation is silent, other sources of energy e.g. generator produce audible sound and sometime uncomfortable noise. Noise usually affects immediate fields, however depending on the sizes of the energy sources, means of energy conversion and presence of moving parts, noise can also be wide spread. When the situation has reached that stage, the community around the site faces noise pollution.

9.2.6 Battery Recycling

PV systems are purposely meant to charge batteries of wide range capacities. These batteries being rechargeable reduce the environmental problems associated by dry non-rechargeable cells i.e. uncontrolled disposal. Improper battery disposal leaves piles of used up batteries that contains heavy metals and toxic chemicals scattered around and so posing health hazards. The major issue over such a problem is that currently there is no safe methods of disposal of used up batteries within the region where by the safe methods, which include recycling, and neutralization requires heavy capital and the technologies are not disseminated.

9.2.7 Use of Energy Saving Lights

PV system utilization calls for efficient solar lights, which are nothing, but efficient lamps, which can properly utilize precious energy collected. These lamps in turn have an added advantage of having longer service life the fact by which these energy savers are superior compared with normal fluorescent lights. Hence disposal problems associated with the use of normal fluorescent lights may be slowed by use of energy savers lights.

9.3 NEGATIVE ENVIRONMENTAL ASPECTS OF SOLAR PHOTOVOLTAICS

9.3.1 Acid, Fumes and Electric Current from Batteries

Lead acid batteries contain corrosive sulphuric acid. If spilled, sulphuric acid will burn the skin or eyes, it will burn holes through clothes and furniture, and it will damage cement floors. If acid is splashed into the eyes, rinse the eye continuously for ten minutes with clean water. Then take the affected person to hospital for further treatment. If acid gets splashed on skin, wash immediately with plenty of water. If acid spills on the floor, rinse the floor with water and pour an alkaline such as bicarbonate of soda on the acid.

Batteries give off explosive hydrogen gas when they are being charges. This gas must be vented away from the battery to prevent explosions. Open flames or lit cigarettes should not be carried in battery storage rooms. Batteries contain a large amount of energy. Care should be taken not to put any metal (conducting material) across the battery terminals. If the terminals are shorted, they could cause a bad electric shock or fire.

9.3.2 Disposal of Batteries

Disposal of batteries is one of the big environmental concerns, especially in Developing Countries. Many of the Developing Countries have not yet instituted environmental legislation that prevents environmentally unfriendly ways of disposing batteries including the acid. In many of these countries batteries are disposed by simply damping them in rubbish collection points, where they end up being burnt. The acid is poured onto the ground and in many cases ends up polluting the soil and water. Where the above situation does not happen, piles of batteries are seen. This by itself is a form of environmental pollution.

Safe and environmentally friendly means of disposing and recycling batteries have been developed in the developed world. However, these are yet to be applied in most of the Developing Countries, particularly in eastern and Southern African region.

Apart from PV the other source of used batteries is the car industry. In fact at the moment this is by far the biggest. With the long life of solar batteries (5 to 10 times that of car batteries), the problem of used battery pollution from PV becomes less. However, as the level of application of PV technology increases, there is a need of putting in place effective environmentally friendly systems of disposing and recycling batteries. As we have seen in Section 8.2 solar PV has many environmental advantages compared to the conventional energy alternatives. We should therefore not allow these advantages to be outweighed by the negative aspects.

9.3.3 Recycling and Disposal of Panels

Similarly as with batteries, there is a potential for environmental problem resulting from used PV panels. The life of PV panels is long (over 20 years). However, the fact that for the same power output, the amount of material for panels is bigger e.g. compared to that used in internal combustion engine. The problem is compounded by the fact that as of present, there is no safe disposal method existing at least in most of the Developing Countries. With the other energy options e.g. internal combustion engines, windmills, water turbines etc., the used equipment can easily be recycled even in the Developing Countries.

9.3.4 Other Environmental Considerations Relating to Manufacturing of PV Panels and Accessories

Environmental issues related to the production of solar panels and accessories covers the processes by which they are made. Such processes may cause degradation of our environment through the process and energy used. Widely industrial processes used depend on the available energy for machinery and equipments operations, which obviously call for usage of widely, used energies from environmental unfriendly sources. Although such processes provide us with the environmentally friendly solar panels, they may contribute to air, water and noise pollution, global warming, ozone layer depletion, greenhouse effect and acid rains.

It is important to note that similar consideration needs to be made with regard to the other pieces of equipment forming a PV power plant such as inverters, charge controllers, and appliances used with the PV power plants etc.

9.4 ENVIRONMENTAL JUSTIFICATION FOR SOLAR PHOTOVOLTAICS

Based on previous discussions under part 9.2 and 9.3, positive environmental impact of the solar photovoltaic systems applications by far has out way its negative impacts. PV systems shall not contribute to smoke emissions, green house effects and global warming, acid rains, air and water pollution and noise pollution in addition to that it will reduce battery and fluorescent lamps disposal problems. Acids, fumes and electricity from the battery are dangerous but with proper system design, installations, instructions to the users and hence their readiness to take care of such issues, their effects can be minimized if not avoided.

10. SOCIAL ASPECTS AND EXPECTEDECONOMIC IMPACT

10.1 SOCIO-ECONOMICAL VALUES OF THE PROJECT

Economically Uzi Island people live moderate African life since the island is fertile and fishery is common to its residents. However this does not guarantee or mean good life especially on the need for electricity to satisfy or at least reduce their demand on lights, education and home entertainments. That is to say SBCS project cannot facilitate them with worldwide technological development in day-to-day usages but at least they can do with home lights, communication and entertainments. DTP with collaborating donors taking cover of the project capita investment would be a significant aid in capacity building for the Uzi Island people in the course of energy demand.

Above details shows how much the project will be valued by Uzi Island residents. During our field visits at the island, many of the villagers told us their deeply rooted interest, that turned into need with the current energy demand for electricity by any means they could afford with their little capacity. Others thought or were worried that the project can get channeled into certain class of the people e.g. teachers and village leaders.

10.2 THEFT AND VANDALISM

Uzi Island as part of Unguja Island, a part of Tanzania which is normally known for undisturbed African cultural values that include people respecting one another and particular people being strict followers of religious teachings, its is expected that theft and vandalism issues would not much affect the project. However such behaviors are usually internal to individuals and sometimes catalyzed by life experiences, referring on how patterns of behaviors are built on different individuals. Hence it is important to take it into considerations earlier before such issues affect the project.

It is here by recommended that users inter into a contract to village project committee that they will take care of the SBCS and electrical fittings given to them on the sense that they will use them as per instructions of the donors and maintain their performance. Research team has proposed such a contract to the villagers, refer appendix D1, and so villagers can take it as a basis of the agreement to take care of the project resources. Appendix D2 shows a proposed agreement between the donor and village committee, that can handle interactions between the two parties on this project related issues.

11.0 SUSTAINABILITY OF THE PROJECT

The project after taking the course of the feasibility study, that included selection of the best solution among various alternatives that were considered to be viable, technical performance predictions, field visits and meetings with the Uzi people, financial analysis that detailed cost effectiveness of the project and broadly explored financial analysis, in each item the project was found to be promising. That is to say the project is sustainable as far as the scope of this feasibility study in terms of the following important observations;

- Initial costs cover by DTP (the donor) covers crucial part of the project that Uzi Island residents could not afford.
- Residents of Uzi Island can economically run the project using on hand resources for the betterments of their life and so reducing the scale of the energy crisis they are currently facing.
- Technical performance of SBCSs has been proven to be sufficient to meet charge demand of the households
- Environmental impact assessment conducted proved that project is environmental friendly.
- Financial Analysis of the project can show that project capitalization is within ordinary range.
- Socio-Economic Impact Assessment suggests that the project is of vital importance to villagers and so they have positively accepted the project.

Uzi people are willing to pay the charging fee, which is important for project systems equipments replacements, maintenance and expansion of its services to other villagers. Researchers have tried to expose the villagers to the important issues concerned with project running costs and systems technical performance through the meetings, refer appendices E. Donors are then assured that their investment on the project shall serve the objective and that the project can be run and hence expanded by the villagers as it’s the running costs are within their capabilities, what is important is actually strengthening the awareness to them about the project operations issues.

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APPENDICES

Appendix A: List of Uzi Island Residents to be Included in the First SBCSs Usage and Household Fittings

Names in bold: Village Project Committee Member (SBCS operator except Shekha and Headmaster plus Assistant Headmaster).

Blank Row: Differentiates Households to share a SBCS.

APPENDIX A1: Uzi Village (Shehia ya Uzi)

S/N	Name	Set of Appliances		
		Lamps	Redio	TV
1	Juma Khamis Juma	3	Yes	Yes
2	Hamad Suleiman Hamad	3	Yes	Yes
3	Fadhili Khamis Juma	3	Yes	Yes
4	**Abeid Hemed Sleyum**	3	Yes	Yes
5	Mwalimu Suleiman Hamad	3	Yes	Yes
6	**Hassan Shomar Khamis**	3	Yes	Yes
7	Hamad Ali Juma	3	Yes	Yes
8	Madiana Abubakar Haroub	3	Yes	Yes
9	Hassan Juma Simai	3	Yes	Yes
10	Kudura Azizi Ali	3	Yes	Yes
11	Hamad Khamis Ronga	3	Yes	Yes
12	Zulfa Abdulla Abdulla	3	Yes	Yes
13	TwahaYussuf Mrisho	3	Yes	Yes
14	**Salehe Mrisho Abdulla**	3	Yes	Yes
15	Rashadi Mohamed Mrisho	3	Yes	Yes
16	**Shehe Shaya Mohamed**	3	Yes	Yes
17	Ahmed Yassin Ali	3	Yes	Yes

S/N	Name	Set of Appliances		
		Lamps	**Redio**	**TV**
18	Amali Shaya Mohamed	3	Yes	Yes
19	**Zubeir Mtumweni Khatib** (Headmaster)	3	Yes	Yes
20	Mtumweni Abass Mtumweni	3	Yes	Yes
21	Haji Shomari Khamis	3	Yes	Yes
22	**Hamad Ramadhan Mdura** (Shekha)	3	Yes	Yes
23	Mohamed Mahazi Ali	3	Yes	Yes
24	**Maruhumi Suleiman Hemed**	3	Yes	Yes
25	Shafii HusseinAbdulla	3	Yes	Yes
26	Said Ali Omar	3	Yes	Yes
27	Ramadhani Haidar Khamis	3	Yes	Yes
28	Omar Khamis Ali	3	Yes	Yes
29	**Badru Aboud Salum**	3	Yes	Yes
30	Salmini Khamis Ali	3	Yes	Yes

APPENDIX A2 Ng'ambwa Village (Shehia ya Ng'ambwa)

S/N	Name	Set of Appliances		
		Lamps	Redio	TV
1	**Ali Makame Khamis**	3	Yes	Yes
2	Sofia Mwinyi Bali	3	Yes	Yes
3	Hassan Mrisho Ali	3	Yes	Yes
4	**Yussuf Mwinyi Mfaume** (Shekha)	3	Yes	Yes
5	Abubakar Ali Makame	3	Yes	Yes
6	Ramadhani Hija Hussein	3	Yes	Yes
7	**Hassuni Mwalim Suleiman**	3	Yes	Yes
8	Khatib Abdulla Abdulla	3	Yes	Yes
9	Hassan Ame Hassan	3	Yes	Yes
10	**Said Jecha Hamad** (Assistant Headmaster)	3	Yes	Yes
11	Aboud Hija Hussein	3	Yes	Yes
12	**Abdu Mohamed Khamis**	3	Yes	Yes
13	Kibiga Amir Mkadam	3	Yes	Yes
14	Khatib Mussa Khatib	3	Yes	Yes
15	Said Omar Hija	3	Yes	Yes
16	Bimkubwa Khamis Hamad	3	Yes	Yes
17	Bilali Issa Mussa	3	Yes	Yes
18	**Badru Hija Hussein**	3	Yes	Yes
19	Humudi Amour Khamis	3	Yes	Yes
20	Ali Mohamed Khamis	3	Yes	Yes

APPENDIX B: SBCS MODELING

APPENDIX B1: SINGLE BATTERY CHARGING SBCS (Automotive Battery, Without Inverter)

Project: Uzi
Electrificationt: Uzi Electrification

SINGLE CHARGING OUTLET MODEL SBCS

Sizing and Cost Estimates for a Solar Battery Charging Station and Five Household Systems without Inverter

1.10 daily energy use

	Appliance		**Voltage [V]**	**Power [W]**	**Daily Use [Hrs]**	**Energy Use [WHrs]**	**Units**
	Compact F lamp	1	12	7	3	21	
	Compact F lamp	1	12	7	2	14	
	Compact F lamp	1	12	7	2	14	
	Radio/Cassette Player	1	9	8	3	24	
	DC Colour TV 14"	1	12	14	2	28	
	Subtotal					101	
	Total			**43**	**12**	**101**	**WHrs**
	Estimated losses since the system is new:				10%	10.1	**WHrs**
	Estimated losses since an inverter will be used to power AC appl.					0	**WHrs**

1.11	Total Daily System Energy Demand	**111.1**	**WHrs**
	5 Days System Energy Requirement	**555.5**	**WHrs**
1.12	System Voltage:	12	VDC
1.13	Daily System Charge Requirement	9.3	**AHrs**
	5 Days System Charge Requirement	46.3	**Ahrs**
1.14	Location of the site	South West Zanzibar	
1.15	PSH design month	April	
1.16	Estimated Insolation Value of the site:	5	Hours
1.17	System Design Charging Current	9.3	A
1.18	**Solar Modules Selection**		
1.19	Type	120	Wp
1.20	Charging current: A	**7.100**	A
1.21	No. of panels needed	**0.926**	**WHrs Sizing**
1.22	**Battery Selection**		
1.23	Number of batterry storage days	5	days
1.30	Maximum allowable depth of discharge of batteries:	25%	fraction
1.31	Required system battery capacity:	185.2	Ah
1.32	Battery size: Ah	150	Ah
1.33	No. of batteries needed	**1.234**	**Ahrs Sizing**
1.34	**Charge Controller Selection**		
1.35	Module side input current A to be rated more than:	8.22	A
1.40	Load side output current A to be rated more than:	4.48	A

APPENDIX B1.1: SINGLE BATTERY CHARGING SBCS (Solar Battery, Without Inverter)

Project: Uzi
Electrificationt: Uzi Electrification **SINGLE CHARGING OUTLET MODEL SBCS**

Sizing and Cost Estimates for a Solar Battery Charging Station and Five Household Systems without Inverter

1.10 daily energy use

	Appliance		**Voltage [V]**	**Power [W]**	**Daily Use [Hrs]**	**Energy Use [WHrs]**	**Units**
	Fluorescent lamp	1	12	7	3	21	
	Compact F lamp	1	12	7	2	14	
	Compact F lamp	1	12	7	2	14	
	Radio/Cassette Player	1	9	8	3	24	
	DC Colour TV 14"	1	12	14	2	28	
						101	
	Total			**43**	**12**	**101**	**WHrs**

	Estimated losses since the system is new:	10%	10.1	**WHrs**
	Estimated losses since an inverter will be used to power AC appl.		0	**WHrs**
1.11	Total Daily System Energy Demand		**111.1**	**WHrs**
	5 Days System Energy Requirement		**555.5**	**WHrs**
1.12	System Voltage:		12	VDC
1.13	Daily System Charge Requirement		9.3	**AHrs**
	5 Days System Charge Requirement		46.3	**AHrs**
1.14	Location of the site		South West Zanzibar	
1.15	PSH design month		April	
1.16	Estimated Insolation Value of the site:		5	Hours
1.17	System Design Charging Current		9.3	A
1.18	**Solar Modules Selection**			
1.19	Type		120	Wp
1.20	Charging current: A		**7.100**	A
1.21	No. of panels needed		**0.926**	**WHrs Sizing**
1.22	**Battery Selection**			
1.23	Number of baterry storage days		5	days
1.30	Maximum allowable depth of discharge of batteries:		80%	fraction
1.31	Required system battery capacity:		57.9	Ah
1.32	Battery size: Ah		60	Ah
1.33	No. of batteries needed		**0.964**	**Ahrs Sizing**
1.34	**Charge Controller Selection**			
1.35	Module side input current A to be rated more than:		8.22	A
1.40	Load side output current A to be rated more than:		4.48	A

APPENDIX B2: SINGLE BATTERY CHARGING SBCS (Solar Battery, With Inverter)

Project:Uzi
Electrification t: Uzi Electrification

SINGLE CHARGING OUTLET MODEL SBCS

Sizing and Cost Estimates for a Solar Battery Charging Station and Five Houseshold Systems with Inverters

1.10 daily energy use

	Appliance		Voltage [V]	Power [W]	Daily Use [Hrs]	Energy Use [WHrs]	Units
	CFL Energy Saver	1	230	7	3	21	
	CFL Energy Saver	1	230	7	2	14	
	CFL Energy Saver	1	230	7	2	14	
	Radio/Cassette Player	1	230	8	3	24	
	AC Colour TV 14"	1	230	40	1	40	
						113	
	Total			**69**	**11**	**113**	**WHrs**
	Estimated losses since the system is new:				10%	11.3	**WHrs**
	Estimated losses since an inverter will be used to power AC appl.				10%	11.3	**WHrs**

1.11	Total Daily System Energy Requirement	**135.6**	**WHrs**
	5 Days System Energy Requirement	**678**	**WHrs**
1.12	System Voltage:	12	VDC
1.13	Daily System Charge Requirement	11.3	**AHrs**
	5 Days System Charge Requirement	56.5	**Ahrs**
1.14	Location of the site	South West Zanzibar	
1.15	PSH design month	April	
1.16	Estimated Insolation Value of the site:	5	Hours
1.17	System Design Charging Current	11.3	A
1.18	**Solar Modules Selection**		
1.19	Type	120	Wp
1.20	Charging current: A	**7.100**	A
1.21	No. of panels needed	**1.130**	**WHrs Sizing**
1.22	**Battery Selection**		
1.23	Number of batterry storage days	5	days
1.30	Maximum allowable depth of discharge of batteries:	80%	fraction
1.31	Required system battery capacity:	70.6	Ah
1.32	Battery size: Ah	75	Ah
1.33	No. of batteries needed	**0.942**	**Ahrs Sizing**
1.34	**Charge Controller Selection**		
1.35	Module side input current A to be rated more than:	10.03	A
1.40	Load side output current A to be rated more than:	7.19	A

APPENDIX B3: TWO CHARGING OUTLETS SBCS (Solar Battery, Without Inverter)

Project: Uzi
Electrificationt: Uzi Electrification

TWO CHARGING OUTLETS MODEL SBCS

Sizing and Cost Estimates for a Solar Battery Charging Station and Five Household Systems without Inverter

1.10 daily energy use

	Appliance		Voltage [V]	Power [W]	Daily Use [Hrs]	Energy Use [WHrs]	Units
	Compact F lamp	1	12	7	3	21	
	Compact F lamp	1	12	7	2	14	
	Compact F lamp	1	12	7	2	14	
	Radio/Cassette Player	1	9	8	3	24	
	DC Colour TV 14"	1	12	20	2	40	
						113	
	Total			**49**	**12**	**226**	**WHrs**
	Estimated losses since the system is new:				10%	22.6	**WHrs**
	Estimated losses since an inverter will be used to power AC appl.					0	**WHrs**

1.11	Total Daily System Energy Demand for 2 HH	**248.6**	**WHrs**
	3 Days System Energy Requirement for 2 HH	**745.8**	**WHrs**
1.12	System Voltage:	12	VDC
1.13	Daily System Charge Requirement	20.7	**AHrs**
	3 Days System Charge Requirement	62.2	**Ahrs**
1.14	Location of the site	South West Zanzibar	
1.15	PSH design month	April	
1.16	Estimated Insolation Value of the site:	5	Hours
1.17	System Design Charging Current	12.4	A
1.18	**Solar Modules Selection**		
1.19	Type	120	Wp
1.20	Charging current: A	**7.100**	A
1.21	No. of panels needed	**1.243**	**WHrs Sizing**
1.22	**Battery Selection**		
1.23	Number of batterry storage days	3	days
1.30	Maximum allowable depth of discharge of batteries:	80%	fraction
1.31	Required system battery capacity:	77.7	Ah
1.32	Battery size: Ah	40	Ah
1.33	No. of batteries needed	**1.942**	
	No.of batteriesfor each HH	**0.971**	**Ahrs Sizing**
1.34	**Charge Controller Selection**		
1.35	Module side input current A to be rated more than:	11.03	A
1.40	Load side output current A to be rated more than:	5.10	A

APPENDIX B4: TWO CHARGING OUTLETS SBCS (Solar Battery, With Inverter)

Project:Uzi
Electrificationt: Uzi Electrification

TWO CHARGING OUTLETS MODEL SBCS

Sizing and Cost Estimates for a Solar Battery Charging Station and Five Houeshold Systems with Inverters

1.10 daily energy use

	Appliance		Voltage [V]	Power [W]	Daily Use [Hrs]	Energy Use [WHrs]	Units
	CFL Energy Saver	1	230	7	3	21	
	CFL Energy Saver	1	230	7	2	14	
	CFL Energy Saver	1	230	7	2	14	
	Radio/Cassette Player	1	230	8	3	24	
	AC Colour TV 14"	1	230	40	1	40	
						113	
	Total			**69**	**11**	**226**	**WHrs**
	Estimated losses since the system is new:				10%	22.6	**WHrs**
	Estimated losses since an inverter will be used to power AC appl.				10%	22.6	**WHrs**

1.11	Total Daily System Energy Demand for 2 HH	**271.2**	**WHrs**
	3 Days System Energy Demand for 2 HH	**813.6**	**WHrs**
1.12	System Voltage:	12	VDC
1.13	Daily System Charge Requirement	22.6	**AHrs**
	3 Days System Charge Requirement	67.8	**AHrs**
1.14	Location of the site	South West Zanzibar	
1.15	PSH design month	April	
1.16	Estimated Insolation Value of the site:	5	Hours
1.17	System Design Charging Current	13.6	A
1.18	**Solar Modules Selection**		
1.19	Type	120	Wp
1.20	Charging current: A	**7.100**	A
1.21	No. of panels needed	**1.356**	**WHrs Sizing**
1.22	**Battery Selection**		
1.23	Number of batterry storage days	3	days
1.30	Maximum allowable depth of discharge of batteries:	80%	fraction
1.31	Required system battery capacity:	84.8	Ah
1.32	Battery size: Ah	45	Ah
1.33	No. of batteries needed	**1.883**	
	No. of batteries for each HH	**0.942**	**Ahrs Sizing**
1.34	**Two Charge Controllers Selection for a SBCS**		
1.35	Module side input current A to be rated more than:	12.03	A
1.40	Load side output current A to be rated more than:	7.19	A

APPENDIX C: COPY OF LABORATORY TESTING REPORT FOR ENNEA ELECTRONICS ART INVERTER

UNIVERSITY OF DAR ES SALAAM

DEPARTMENT OF PHYSICS

REPORT ON A 12 VDC INPUT, 240 VAC 350 W OUTPUT PROTOTYPE INVERTER

INTRODUCTION

This is a report on a locally (Tanzanian) made inverter to be used in a battery supported solar electricity supply system. Some of the objectives of making this solar inverter locally are as follows:

b) To enable solar-based electricity to be used as an inexpensive alternative to the high cost electricity supplied by TANESCO, the sole feeder and distributor to national grid in Tanzania,
c) To capitalize on the abundant solar energy in Tanzania,
d) The inverter to be used in set-ups in villages in which batteries for different households are charged by a central solar energy based charging system
e) Each inverter to be used in conjunction with a single battery for a single household to supply electricity for radio, television and lighting application.

SPECIFICATIONS

The specification on the prototype inverter were:

a) 12 Volts DC input.
b) 240 Volts AC, 350 Watt output.

PHYSICAL APPEARANCE

External

The prototype inverter was housed in a locally made metal casing, on the sides of which were cooling fins for the inside components. The structure of the inverter casing was not properly done, the finishing was not good, and the painting was poorly done. The inverter was heavy due to the transformer as expected, and a handle was built on the casing for lifting/carrying.

The leads from the batteries were of a gauge that can support the current needed (approx 30 Amps at 350Watts) but the terminals were unsuitable for fitting to a battery. The output was a single UK style switch-socket, to which a similar style plug can be inserted.

Internal

Internally, the layout of the components was properly done, except the leads were not properly terminated. The main component was the step-up transformer, which seems to have been locally wound using laminations from another transformer. The transistors were well fitted to the heat sinks, but the heat dissipation could not be determined experimentally because as explained below, the inverter failed the electrical test.

ELECTRICAL PERFORMANCE

The plan was to test the inverter using a fully charged battery and various loads in order to establish its efficiency. A new and fully charged battery was therefore used for this. The results of the electrical tests were as follows:

a) The inverter failed to operate when switched on, and only functioned erratically as observed from the transformer vibrations. It needed several trials of switching on and off before it would operate. Although not measured, the current drawn from the battery at no load did not appear to be excessive.

b) The first attempt to record the no-load output voltage by a DMM indicated a voltage exceeding 750 VAC. The second attempt to verify this observation resulted in the DMM being burnt.

It therefore became necessary to discontinue further electrical testing.

CONCLUSION AND RECOMMENDATIONS

The conclusion which can be drawn from this prototype inverter are as follows. The maker has made a bold attempt, but the inverter should not be accepted until the following modifications have been effected.

a) The electrical/electronics of the inverter should be improved, to ensure that its performance is not erratic but reliable, and it meets the required or indicated electrical specifications.

b) The inverter should be made as efficient as possible, otherwise it may turn out to be more expensive if it requires too frequent charging.

c) The safety and electrical interference features should be improved.

d) It seems that the inverter was not subjected to electrical tests by the maker in the presence of the client. In future, the inverter should be tested by the maker in the presence of the client, and with caution of voltage.

e) The physical features should be improved.

Name: Prof H. N. Kundaeli Signature: *Signed*

Date: 27 - 7 - 2004

APPENDIX D: PROPOSED AGREEMENTS

APPENDIX D1: DRAFT AGREEMENT BETWEEN USER AND VILLAGE COMMITTEE

MAKUBALIANO YA MATUMIZI YA HUDUMA YA UMEME WA JUA KATIKA MRADI ULIOFADHILIWA NA USHIRIKIANO BAINA YA UJERUMANI NA TANZANIA

BAINA YA

MTUMIAJI HUDUMA YA UMEME WA JUA

NA

KAMATI YA UENDESHAJI MRADI WA UMEME WA JUA YA KIJIJI CHA UZI / NG'AMBWA, ZANZIBAR-TANZANIA

Makubaliano yameandaliwa na:
Tanzania Solar Energy Association (TASEA),
Dar es Salaam.

August, 2004

MAKUBALIANO NA MAKABIDHIANO

VIFAA VYA MFUMO NA HUDUMA YA UMEME WA JUA

Makabidhiano na makubaliano yanafanyika leo tarehe _____________ kati ya kamati ya kijiji cha ___________ inayoendesha mradi wa wa umeme wa jua uliofadiliwa na ushirikiano wa Ujerumani na Tanzania (ambayo ndani ya taarifa hii itaitwa KAMATI) na mtumiaji huduma ya umeme wa jua na kuchaji betri kwa umeme wa jua ambaye pia anakabidhiwa vifaa vya mfumo wa umeme wa jua (ambaye ndani ya taarifa hii ataitwa MTUMIAJI). Mfumo wa umeme na huduma ya ya kuchaji betri, vitamuwezesha MTUMIAJI kutumia taa tatu, redio na luninga.

1. **TUNASHUHUDIA IFUATAVYO:**

   Huduma ya umeme, inayojumuisha vifaa vya umeme wa jua na kuchaji betri kwa umeme wa jua, itatolewa na KAMATI kwa MTUMIAJI kuanzia leo tarehe ________________.

2. **KAMATI INAKUBALI KUWAJIBIKA KWA MTUMIAJI KAMA IFUATAVYO:**

   (a) KAMATI inamkabidhi MTUMIAJI vifaa vya mfumo wa umemewa jua na kuvifunga nyumbani mwa MTUMIAJI, mfumo mzima ukiwa tayari kw matumizi, baada ya MTUMIAJI kupata maelekezo ya matumizi ya mfumo huo wa umeme wa jua na kuridhishwa na maelekezo hayo.

   (b) Kamati itahakikisha kwamba mfumo wa umeme wa jua uliokabidhiwa kwa MTUMIAJI unaendelea kufanya kazi na kwamba MTUMIAJI anapata huduma ya kuchaji betri mara moja katika siku tano na kugharamia marekebisho katika mfumo au kituo cha kuchajia betri hitilafu zitakapojitokeza. Jukumu la marekebisho kwa KAMATI hatitajumuisha hitilafu za betri, ambayo ni mali ya MTUMIAJI na hivyo utendaji wake wa kazi hauihusu KAMATI.

   (c) KAMATI itamtoza MTUMIAJI kiasi cha shilingi (tarakimu)/= za Tanzania (kwa maneno) kila tarehe ____ ya mwezi, kila mwezi kwa ajili ya kugharamia uendeshaji wa mradi, marekebisho ya mfumo wa umeme na kituo cha kuchajia betri na hatimaye upanuzi wa huduma za mradi (kusambaza umeme wa jua) kwa wanakijiji wengine.

(d) KAMATI itakuwa na haki ya kumsimamishia MTUMIAJI huduma ya kuchaji betri iwapo atashindwa kulipia michango ya uendeshaji mradi kwa miezi miwili mfululizo au kwa limbikizo.

(e) KAMATI inayo haki ya kuvifungua na kuvichukua vifaa vya mfumo wa umeme ilivyovikabidhi kwa MTUMIAJI na kumkabidhi mwanakijiji mwingine iwapo itathibitika kwamba;

   (i) MTUMIAJI ameshindwa kulipia michango kwa KAMATI kama ilivyoelezwa katika kifungu namba 2.(c) hapo juu kwa miezi mitatu mfululizo au kwa limbikizo.

   (ii) MTUMIAJI ameshindwa kutunza kwa uaminifu vifaa vya mfumo wa umeme alivyokabidhiwa, ikijumuisha uharibifu au upotevu wa vifaa hivyo.

3. MTUMIAJI ANAKUBALI KUWAJIBIKA KWA KAMATI KAMA IFUATAVYO:

(a) MTUMIAJI atakuwa na haki ya kupatiwa huduma na KAMATI, ya kuchaji betri yake katika kituo cha kituo cha kuchajia betri siku moja kila baada ya siku tano na kwamba marekebisho katika mfumo wa umeme aliokabidhiwa yatagharamiwa na KAMATI.

(b) Mtumiaji wa umeme baada ya kupata maelekezo ya utumiaji wa umeme kwa hiari yake ataendelea kutumia umeme kwa uangalifu na kwamba hatari au ajali yoyote itakayosababishwa na umeme itakuwa ni juu yake.

(c) MTUMIAJI atalazimika kuchangia gharama za uendeshaji mradi kama zilivyoainishwa katika kifungu 2. (c) hapo juu.

(d) KAMATI itakuwa na haki ya kumsimamishia huduma ya kuchaji betri MTUMIAJI kulingana na kifungu 2. (d) hapo juu.

(e) KAMATI itakuwa na haki ya kumnyang'anya MTUMIAJI vifaa vya mfumo wa umeme kwa mujibu wa kifungu 2. (e) hapo juu.

4. KAMATI NA MTUMIAJI WANAKUBALIANA IFUATAVYO:

(a) Uvunjwaji wa kipengele chochote katika makubaliano haya utakaofanywa na upande wowote KAMATI au MTUMIAJI, unatoa haki ya kisheria kwa upande mwingine wa kutekeleza hatua zilizoelekezwa katika makubaliano haya.

(b) Notisi kwa maandishi itatolewa siku tatu kabla ya kabla ya kutekelezwa kwa hatua yoyote kwa mujibu wa kipengele 4. (a) hapo juu. Mtoa notisi atalazimika kupata ushahidi wa utoaji notisi kwa watu wawili mbele ya mtolewa notisi.

Tushuhudia na kuazimia kutekeleza makubaliano haya kama yalivyoanishwa hapo juu:

MTUMIAJI :

Jina Kamili ________________________________ Sahihi ____________ Tarehe ____________

SHAHIDI WA KWANZA:

Jina Kamili ________________________________ Sahihi ____________ Tarehe ____________

SHAHIDI WA PILI:

Jina Kamili ________________________________ Sahihi ____________ Tarehe ____________

KATIBU WA KAMATI KIJIJI CHA ________________:

Jina Kamili ________________________________ Sahihi ____________ Tarehe ____________

MWENYEKITI WA KAMATI KIJIJI CHA_________________:

Jina Kamili ________________________________ Sahihi ____________ Tarehe ____________

APPENDICES D2: DRAFT AGREEMENT BETWEEN VILLAGE PROJECT COMMITTEE AND GERMAN-TANZANIA PARTNERSHIP (DTP)

PROJECT AGREEMENT DOCUMENT

DATED THIS ___ DAY OF OCTOBER, 2004

BETWEEN

UZI/NG'AMBWA VILLAGE. PROJECT COMMITTEE

AND

GERMAN-TANZANIA PARTNERSHIP (DTP): Hamburg, German.

Prepared by:

Tanzania Solar Energy Association (TASEA),

Dar-es-Salaam.

August 2004.

PROJECT AGREEMENT DOCUMENT

PROJECT CAPITAL INVESTMENT AND OWNERSHIP

This agreement is made on ___ day of October, 2004 between German-Tanzania Partnership of Hamburg, German (hereinafter called DTP which expression shall where the context so admits its executor, administrator or successor in title) as one part and and the second part, Uzi/Ng'ambwa Village Project Committee (hereinafter called the COMMITTEE which expression shall where the context so admits its executor, administrators or successors in title).

1 WITNESS AS FOLLOWS

DTP as the donor and the sole owner of the project capital investment and the COMMITTEE is the immediate village organiser of the project to the users on behalf of the DTP.

2 THE COMMITTEE HERE BY COVENANTS WITH THE DTP AS FOLLOWS:

(a) Being elected by the villagers on the criteria laid by DTP, the COMMITTEE shall organise and execute daily issues of the project by ensuring fluent and availability of battery charging services and electrical energy utilization to the users.

(b) The COMMITTEE shall collect users' contributions and keep the records for the collections and expenses, hence submit the records (not the money) to DTP every 1st of September of the year. (The villagers also have the right to get these records from the COMMITTEE).

(c) Expenses by the COMMITTEE under part 2(b) above shall be the replacements of all electrical fittings for the battery charging stations and household systems excluding lamps (battery replacements and its consumables will be on users costs). In case of theft or vandalism over the systems, replacement shall not be the duty of the COMMITTEE and a particular station operator or user will be handled in accordance with the agreement between him/her with the COMMITTEE.

(d) The COMMITTEE will also spend some money from users' contributions for execution of its duties, which are COMMITTEE meetings, project documentation and systems troubleshooting.

(e) In case of the expenses that are not listed in this agreement, the COMMITTEE must seek for the permission from the DTP. Such circumstances include expansion of the project services by increasing the number of the users and new project installations.

3 THE DTP HERE BY COVENANTS WITH THE COMMITTEE AS FOLLOWS:

(a) DTP being the owner of the project hands over village project organisation and the execution of the daily project issues on the hands of the COMMITTEE, which shall have to submit the project progressive reports in each year as depicted on part 2(b) above.

(b) If the progressive report submitted by the COMMITTEE to DTP is incorrect or incomplete, then DTP may require the committee to correct or complete it accordingly and the failure to do so in three (3) months DTP may order the committee to resign.

(c) DTP shall continue to have the rights for the project ownership for the twenty (20) years of project in which the project capital investment is expected to have reached payback period. During the period, COMMITTEE shall handle all project funds allocating their usages and expenses as detailed under part 2(a) to 2(e) above with consent of DTP.

(d) DTP shall not take any money from the COMMITTEE and the project in general after handing over the project to the COMMITTEE on behalf of the villagers.

(f) COMMITTEE may solicit for the technical and financial assistant from DTP, however the assistant may only be given if the DTP proves that the situation is not within COMMITTEE capacities or may render the project ineffective.

4 DTP AND COMMITTEE HEREBY AGREE THAT:

(a) Breach of any duty in this agreement gives the other side of the agreement, DTP or COMMITTEE, the right to take actions detailed herein.

(b) In any case that actions are to be taken by any side of this agreement as detailed under part 4(a), one (1) month notice must be given in presence of two people.

We hereby agree towards project implementation as follows:

SECRETARY TO THE COMMITTEE

Full Name ______________________________ Signature ___________ Date ____________

COMMITTEE CHAIRMAN

Full Name ______________________________ Signature ___________ Date ____________

DTP EXECUTIVE

Full Name ______________________________ Signature ___________ Date ____________

DTP CHAIRMAN

Full Name ______________________________ Signature ___________ Date ____________

Prepared by:
Tanzania Solar Energy Association (TASEA),
Dar-es-Salaam.

August 2004.

APPENDICES E: UZI MEETINGS MINUTES.

APPENDICES E1: January 29th 2004

The meeting was opened at 4 o'clock pm and took about two hours. Twelve peoples called by the teachers attended this meeting in school. The idea of the project was described and discussed and related questions answered.

Main questions were:

- How many users are required for establishment on the project?
- What is the amount of money required for recharging fees?
- What is the cost of household electrical fitting?
- What is the cost of panel?
- What battery capacity needs to be used?
- Which are the criteria of the election of the first people to be connected to the project?

The participants suggested that the selection criteria should not be based on special groups of inhabitants like teachers or relatives.

Also it was asked to whom the charging fees collections belong?

- Are they for the villagers?
- For Deutsch Tansanische Partnerschaft e.V.?
- Or others?

If someone buys a battery and is ready to pay charging fee can he be assured that he will get the service?

When is the beginning of the project expected?

APPENDICES E2: January 30th 2004

The meeting was opened at 4 o'clock pm and took about three hours. The meeting was participated by more than sixty people of both villages Uzi and Ng'ambwa. A painting at the blackboard showed a structure of the first project steps, how the SBCS will be located around the village.

Project descriptions was laid out basically on the information that one house shall be fitted with a panel that charges one battery in one day. Around this house four other houses are able to charge their battery in the first house. Important was to avoid long distances to carry the batteries for charging. That means the houses with the panels have to be scattered around the both villages.

The villagers agreed that Uzi should have 6 panels and household electrical fitting for 30 households and Ng'ambwa 4 panels for 20 households.

The donors aimed at donating the panels and the fittings of the houses. Batteries are to be owned by the users and charging fees have to be paid by them. The charging fees must include the renewing of bulbs and broken things also for the progress of the project. They have to run it like a private enterprise.

During the meeting it was realized and agreed that it is important to expose the villagers to the introduction in battery use and maintenance of the systems. One electrician lives in the village. All the people who run a charging station has to be educated in measurements and charging of the batteries.

APPENDICES E3: August 8, 2004

The meeting was opened at 12:40 am by Shekha of Ng'ambwa, Mr. Yussuf Mwinyi, who admitted his selection to chair the meeting. Eighteen people attended including Shekha from Uzi and Ng'ambwa as well as Uzi School Headmaster and his Assistant.

Assistant Headmaster for the Uzi School detailed the vision of the project current information also provided decisions made by the expected users' meeting although the date was not remembered. The names of the selected members of one village project committee attaché at appendices F. It was also decided that charging fee is to be 200/= (two hundreds Tanzanian Shillings only).

Questions and Answers:

- Why did you decide to have one committee? To reduce project-running costs, join our capacities for the same goal directed manner and hence continue with our tradition to share services among the villages, just like how we sufficiently share a school and a dispensary.
- What is the progress in project preparation? Joseph provided how the project implementation preparations are going on.
- Can we get maintenance and measurements equipments also technical assistant from the donor after the project takeoff? Maintenances are upon village committee for the case of measuring equipments and technical assistant we will communicate with the donor.
- Can automotive batteries be used in the project? Of course automotive batteries can be used however they will need to be of the higher Ah capacities. Although we are still trying to analyze the situation, we expect at least 50 Ah and particularly 70 to 75 Ah capacities are satisfactory.
- What is the difference between solar and automotive batteries? Automotive batteries are designed and hence made to deliver large power in short period, e.g. during engine starting after which a battery is recharged by the engine systems. Note that other accessories i.e. radio, lamps and even the engine it self (for the case of petrol engines) all of them utilizes electrical power from the engine systems not the batteries whenever the engine is running. Solar battery is designed and made to deliver optimum power in longer periods, e.g. thorough out the night during which solar power is not available to recharge

the battery. Simply we can say that the recommended depth of discharge for the automotive batteries is 20% while for the solar batteries is 80%.

- Can you give us information on availability and prices of the solar batteries? Solar batteries are available at Dar es Salaam at wide range of prices. Hereby Umeme Jua Ltd, BP Solar and Chloride Exide (T) Ltd price lists were displayed to the villagers who really noticed the difference in the costs although the difference could not make the forget about batteries differentiations above.
- 200/= recharging fee is enough for the project? Thanks for such self drive motive towards the project. Earlier we said that costs for maintenance, replacements of the damaged components and technical troubleshooting issues related to the project are duties of village project committee and villagers in general. Also it is important to note that the donor expects you to run the project as a business meeting the entire running costs and so expanding project services to other villagers. These costs require significant funds allocations for them that in our analysis we found that 2,500/= to 3,000/= is the satisfactory user contribution to meet above needs. We ask you then to review your contribution or charging fees to be equal or at least approach 500/= per charge that you pay at Fuoni or Unguja Ukuu per charge.
- How much do you spend per month for your kerosene lamp? It is about TShs. 3,000.00, this excludes dry cells for radios and battery charging fees for TVs.
- During rainy season, will the charge still be satisfactory? It is true that energy harvest during such situation may be lower. In our design we are trying to include spare capacity to meet such demands. If weather is even worse in the day of your last charge, you might have to reduce your energy consumption by reduction of appliances and their number of hours in use.
- You selected members of project committee; did you select its chairperson, secretary and cashier? No, we said members of the committee have to select these among themselves.
- Why government notification on the project implementations? It is for the purpose of information to the governing organs. Note that the project is meant to reply the request of the Director of Energy Department, we must notify him then. Shekha said ‘We have simply informed the governmental officials at least by words of mouth”
- Which are the village committee costs? For current situation, we shall volunteer, as we need to learn how to run the project. Significantly committee shall need to record user contributions.

- In how many years will the committee serve before resigning? Resigning issues were not thought about, we should discuss its importance and how it fits with our situation.
- What are you going to do with a user who does not pay his fees accordingly? We shall take project equipments from him.
- We have proposed an agreement between a user and the committee so that you take actions among yourselves. The agreement was briefly discussed and the villagers wanted the committee to discuss in details and come up with the acceptable terms.

Shekha of Uzi closed the meeting at 14:30, by saying, “On behalf of the villagers, we humbly wait for the project implementation phase, and may the Almighty God enable our dreams become true. Other wise send our greetings to Mama Anna, we wish her all the best and the good safari to Uzi”

APPENDIX F: MEMBERS OF VILLAGE PROJECT COMMITTEE

The meeting of the expected users, as detailed under appendix E2, elected fellows to be project committee members, members selected were as follows:

1. Hamadi Ramadhan Mdura - Shekha (Uzi)
2. Yussuf Mwinyi Mfaume - Shekha (Ng’ambwa)
3. Zubeir Mtumweni Khatib - Headmaster (Uzi)
4. Said Jecha Hamad - Assistant Headmaster (Ng’ambwa)
5. Abeid Hemed Sleyum - (Uzi)
6. Hassan Shomari Hamis - (Uzi)
7. Salehe Mrisho Abdulla - (Uzi)
8. Shehe Shaya Mohamed - (Uzi)
9. Maruhumi Suleiman Hemed - (Uzi)
10. Badru Aboud Salum - (Uzi)
11. Ali Makame Khamis - (Ng’ambwa)
12. Hassuni Mwalim Suleiman - (Ng’ambwa)
13. Abdu Mohamed Khamis - (Ng’ambwa)
14. Badru Hija Hussein - (Ng’ambwa)