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Drivers and barriers to renewable energy systems in Tanzania

- perceptions of systems' workability among key stakeholders

Master of Science Thesis in the Master Degree Programme, Industrial Ecology – for a sustainable future

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This study is conducted within the research program Socio-Technical-Ecological Evaluation of Potential Renewable Energy Sources (STEEP-RES) at Chalmers University of Technology and Göteborg University, Sweden. STEEP-RES is a multidisciplinary research project on opportunities and barriers for increased utilization of renewable energy sources in East Africa. The program is coordinated by Prof. Sverker Molander, Environmental Systems Analysis, Chalmers University of Technology.

Abstract

The country of Tanzania located in east Africa has an overall electrification level of about 14 % and the rural electrification level is only about 2-3 % (MEM 2009). Renewable energy sources are abundant in sub-Saharan Africa (Karekezi 2002) and their role in increasing the electrification rate in these countries can therefore be of great importance. To understand when local stakeholders view these technologies as working solutions is interesting to better understand what factors that are driving or acting as a barriers to their diffusion. Material was collected by semi-structured interviews with key stakeholders such as governmental agencies, technical consultants, NGO:s etc. By using theoretical concepts from SCOT methodology outlined by Bijker (1995) the stakeholders' views of the technologies' workability is analysed. The study hereby contributes to a deeper understanding of the potential for solar PV and small-scale hydropower to increase access to electricity in Tanzania today and in the future.

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It would not have been easy to perform this study without the fantastic support that I have received from a great number of people. I would therefore like to seize the opportunity to express my gratitude to some of them. First I would like to thank my supervisor Helene Ahlborg for her guidance and not the least patience. This has been of great importance for me not only during the field study itself but also both in the preparations before going to Tanzania and in the subsequent period of writing. I have learned a lot during these months and your efforts were of greatest importance. I want to thank Hans Fogelberg for his insightful advices and knowledge in the use of the SCOT-methodology. I want to thank Lennart Bångens for his support before and during the field study. I want to thank Dr Cuthbert Kimambo for his guidance and help in Dar es Salaam. I would also like to thank all the respondents who willingly shared their time, experience and views in the interviews which have been of the greatest importance for this work. Finally I would like to thank Christine, you are the best.

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1. Introduction

Tanzania has an overall electrification level of about 14 % and the rural electrification level is only about 2-3 % (MEM 2009). Earlier research has shown that successful installations of electricity in rural societies result in improvement in health, education, and living standards (Zomers 2001, World Bank 2008, chp 2.6). Increased access to electricity is also seen as an important driver of growth in Tanzania (REPOA 2010, Odhiambo 2009). Renewable energy sources are abundant in sub-Saharan Africa and are considered to have a large potential to supply the rural society with energy. Renewable energy systems that can be used decentralised could for example be a cheaper alternative than grid extension (Karekezi 2002). At the same time the world's fossil energy consumption is playing a substantial part in the causing of a global warming. Shifting away from fossil fuel to renewable energy sources is difficult since today's energy system is built up around fossil fuels in such a way that it can be described as a carbon lock in (Unruh 2001). To increase the availability of modern energy to rural societies in Tanzania by using renewable energy technologies is of key interest not only for the local inhabitants but also for the global progress of shifting away from a dependence on fossil fuels. Therefore increased knowledge about the diffusion and use of renewable energy systems for electricity production is needed.

In the field of diffusion of innovation a common way to better understand the diffusion of a certain technology or innovation is to look at how people view its properties. If individuals perceive an innovation to have greater relative advantage, compatibility, trialability, observability and to be less complex it will diffuse at a higher rate than other innovations (Rogers 1995 p. 15-16). Increasing the spread of renewable energy technologies could also be viewed from the technology transfer literature. Also in this tradition it is important to consider the main actors. Wilkins (2002) states that to successfully transfer renewable energy technologies it is important to take the main stakeholders into account. In the case of Tanzania there are several renewable energy systems that could be suitable for electricity production, for example: solar PV, small-scale hydropower, biomass and wind power (Ahlborg and Hammar 2011). Due to lack of time this work will concentrate on solar PV and small-scale hydropower.

1.1 Aim of study

Stakeholders and their views of the technologies are of importance for the diffusion and development of a technology and are therefore interesting to analyse more deeply. This has not been done for the case of solar PV and small-scale hydropower for electricity production in Tanzania and the aim of the analysis is therefore:

To describe and analyse, when solar PV and small-scale hydropower are seen as working or non-working and how the stakeholders' perceptions influence the diffusion of the technologies.

According to Bijker (1995 p. 50) it is fruitful to look upon the problems and solutions connected to the artefacts when analysing stakeholders' view of a technologies workability. The stakeholders might not share the views about the technologies possibilities to serve as a solution or what problems that needs to be solved. To reach this aim the following research questions are considered:

-What are, according to the stakeholders, the main problems that are solved with the technologies?

-What are, according to the stakeholders, the main problems connected to the technologies?

-To what extent do stakeholders share the same views of the technologies?

This knowledge is valuable to better understand the potential to use solar PV and small-scale hydropower to increase access to electricity in Tanzania, both today and in the future. The study is part of the STEEP-RES1 project where earlier studies have concerned drivers and barriers to renewable energy systems in general; it is therefore also useful within the project to add information of specific technologies. It could also

1 Socio-Technical-Ecological Evaluation of Potential Renewable Energy Sources (STEEP-RES) is a multidisciplinary research project at Chalmers University of Technology and Göteborg University, Sweden. Studies are undertaken regarding opportunities and barriers for increased utilization of renewable energy sources in East Africa. Prof. Sverker Molander, Environmental Systems Analysis, Chalmers University of Technology coordinates the program.

be valuable for donors and governmental agencies that are working with increased access to electricity in Tanzania.

1.2 Limitations of the study

This study will focus on solar PV and small scale hydro power for increased electrification both incorporated in the main grid and in off grid solutions in Tanzania. Other renewable energy that could be used for electricity production is out of the scope of this study.

1.3 Disposition of thesis

The *background* provides information to better understand the context in which the thesis is situated. In the subsequent chapter *theory* a description of the theoretical background is presented. Then the *method* describes how the material was collected and analysed. The *result* will present the major findings from the interviews and in the *analysis* the collected material is used to answer the research questions and thereby also bring light to how stakeholders view the technologies. In the *discussion* some strengths and weaknesses with this thesis are described and this chapter is followed by the *conclusion* including a short summary of the main results.

2. Background

In the following chapter follows a short presentation of the Tanzanian energy sector and energy use together with some known benefits of electrification and a short summary of earlier described drivers and barriers to renewable energy system.

2.1 The Tanzanian electricity sector

The total power generation capacity is around 1100 MW (MEM 2009) and the majority is produced with hydropower. Other important resources used are domestic natural gas and imported oil. The main electricity grid covers a small part of the country excluding many areas especially in the southern and western regions (Ahlborg and Hammar 2011). It is estimated that 14% of the households in Tanzania have access to electricity while in the rural areas the number is probably as low as 2 % (MEM 2009). Today a very low share of the electricity production comes from renewables other than hydro, but there is an outspoken intention to take advantage of the available renewable energy in particular to increase the rate of rural electrification (MEM 2009).

Tanesco (Tanzania Electric Supply Company) is dominating the production and distribution of electricity in Tanzania and is a public agency under the Ministry of Energy and Minerals. The electricity act in 2008 opened up for the private sector to increase their activity in the electricity production. Today the most notable power producer except for Tanesco is the Songas gas plant with 180 MW installed capacity (MEM 2009). Formed in 2006 EWURA (Energy and Water Utilities Regulatory Authority) is responsible for technical and economic regulation of the electricity sector and reviews for example the electricity tariffs (EWURA 2011). The Rural Energy Agency (REA), which became operational in 2007, carries the responsibility to increase rural electrification by working in partnership and collaboration with private sector, NGOs, public authorities and government agencies. This is done through for example capacity building, providing technical assistance and financial support (REA 2011). Other important stakeholders are among others donors, NGO:s, international consultants, users, etc.

In 2010 the fee to connect to the main grid was 380 000 Tsh per household which is a large investment compared to the average income which at the time were 50-60 000 Tsh per month and household. The tariffs are differentiated in price where the users of electricity who consume less than 50 kWh per month are subsidised by having a lower tariff. The difference is substantial and the users who consume more than 50 kWh per month have a tariff three times as high. The production cost is however is not covered in this tariff system and Tanesco thereby sells electricity at constant loss (Ahlborg and Hammar 2011).

2.2 Energy use in Tanzania

Common applications in rural electrification include: radio/TV; lighting; fans and refrigerators; ironing; clinics, schools, shops, streetlights; workshops; and crop processing (Holland 2001). Electricity is rarely used for cooking (Holland 2001, World Bank 2008). 95% of the Tanzanians use biomass for cooking according to the Tanzanian household budget survey from 2007; firewood and charcoal are the most common types (HBS 2007). Kerosene is the most common source of lighting in households with 83 % of the household using it. Only in Dar es Salaam electricity was a more common source for lighting. 2007 around 66 % of the households owned a radio and the percentage of households owning a phone had increased from 1% in 2001 to 25% in 2007. According to the Poverty and Human Development Report 2007 the industrial share of the electricity consumption was 48% (REPOA 2007).

2.3 Benefits of modern energy

Successful installation of electricity has resulted in improvements in health, education, quality of life and productivity. The quality of electric light is substantially higher than the light from the commonly used kerosene lamps. When kerosene lamps are replaced the air quality is also improved since smoke from kerosene lamps emits particles, which are damaging to ones health. Increased use of television and radio improves people's awareness about for example health issues. Lighting provides possibility for more time for children to do homework, extended working hours and in home business. Electricity also improves the quality of institutions like schools, health facilities by for example extending opening hours and allowing use of electric equipment (World Bank 2008).

Increased electrification is seen as an important driver of growth in Tanzania (REPOA 2010, Odhiambo 2008). However earlier finding show that electricity might not be enough to spur economic growth by itself in a rural community but it has the potential to enhance the development already taking place (Holland et. al. 2001, World Bank 2008 p. 78).

2.4 Drivers and barriers

According to a review of the drivers and barriers to rural electrification performed by Ahlborg and Hammar (2010) “the main goal and motivation for rural electrification is related to individual and social development”. They then divide some of the more important benefits of electricity into direct, potential and long-term benefits. The direct benefits include improved living standards by lighting, better health care and education, entertainment and communication. Potential benefits include increased income generation from productive activities, access to water pumps and mills, reducing work burden on women and reduced household expenditure. Long-term benefits include returns from improved education improved education, health and production efficiency.

According to Kammen and Kirubi (2008) the key socioeconomic drivers for solar PV systems in rural Africa are the possibility to use it for lighting, TV, radio and cellular phones.

The barriers found in the review of Ahlborg and Hammar (2010) was extracted from Africa related literature on rural electrification are divided into: *Institutions and stakeholder performance:* low institutional quality, inadequate planning, organizational structures and inadequate strategies, lack of co-investment, and lack of private sector involvement. *Economy and finance:* high capital costs compared to urban electrification, fees and tariff system, subsidies, insufficient rural financial institutions, poor rural markets and limited productive use, and disproportionally high administrative costs in off-grid electrification with small systems. *Social dimensions:* poverty and low affordability, gender relations, as women are key energy users and suppliers, and problems of local participation such as mismanagement, local resistance and theft. *The technical system and its management:* lack of access to knowledgeable personnel, bad maintenance, and the low capacity of some RES systems. *Technology diffusion and adoption:* inappropriate technology, unwillingness of behavioural change, and weak local awareness of technology usefulness. However, local cultural and social settings can work both as drivers and barriers to technology adoption. *Rural infrastructure:* refer to low population density, and limited basic infrastructure.

Ahlborg and Hammar (2011) later made a closer study of drivers and barriers to rural electrification in Tanzania and Mozambique. Here they found some additional drivers and barriers not previously discussed in length in the literature. The new drivers found in the Tanzanian case were: donors and individuals in governmental agencies pushing to introduce renewable energy technology, churches who are involved in electrification projects, the existing promotion of renewable energy and off-grid projects of rural electrification creates demand for grid extension. The new barriers found were: incompatible donor policies, problems of top-down management in the energy sector, conflicts over compensation in land acquisition, lack of consistency between rural electrification projects, high costs of diesel, donor dependency, lack of local engagement, low generation capacity of renewable energy systems, lack of local entrepreneurship, long distances of transmission, protection of nature reserves and national parks.

Another review of barriers to technology transfer of renewable energy systems is done by Wilkins (2002): *Political, institutional and legislative:* lack of clear government plans and targets, lack of appropriate support mechanisms, lack of good communication between involved institutions *Intellectual property and standards:* weak or unclear law on intellectual property rights, lack of supporting legal institutions, lack of technical standards and quality control. *Local capacity: infrastructure and knowledge:* low access to information, lack of skilled local labour and capabilities, lack of exchange in ideas and experience. *Financing:* lack of access to capital, lack of investment, inappropriate subsidies, dispersed nature of the projects *Social:* local culture, religion, superstition, gender aspects and/or low community and end-user involvement in planning might lead to low social acceptance.

3. Theory

In this chapter the major theoretical background for this thesis will be described and motivated and the components that later are used in the analysis will be described.

A common way to analyse the diffusion process of a certain technology is to look at the properties of the technology. One example is in the theory of Diffusion of Innovation where Rogers (1995) suggests that an innovation should be analysed by examining: *Relative advantage* compared to other innovations (could be in economic terms, social prestige, convenience, etc.). C*ompatibility,* which is how well the innovation, fits existing values, past experience and the needs. *Complexity*, is the innovation perceived as difficult to understand and use? *Trialability*, does the adopter have an opportunity to try the innovation before going to a full-scale adoption? *Observability* for others, how easy is it to see and understand the results of the innovation? If individuals perceive the innovation as having greater relative advantage, compatibility, trialability, observability and less complex it will diffuse at a higher rate than other innovations (Rogers 1995 p. 15-16). Also in the theory of Technology Transfer it is mentioned that the technology's affordability, accessibility, sustainability, relevance and acceptability are important for a successful transfer of technology (Wilkins 2002 p. 43-44). Studies in Social Construction Of Technology (SCOT) are concerned with how the perceptions of an artefact among stakeholders influence development and diffusion of the same artefact. According to Bijker (1995) technology does not have any properties in itself instead the properties are socially constructed and in need of analysis (Bijker 1995 p. 270). Not only that engineers are designing them, but also consumers who by buying or not buying can modify and shape the development of a technology into new directions different from the originally idea of the designer (Bijker p. 3-4). Bijker states: "if we want to understand the development of technology as a social process, it is crucial to take the artefacts as they are viewed by the relevant social groups." (Bijker 1995 p. 49). The stakeholders in connection to a technology are with their view of the technology important and influencing the development of the technology (Bijker 1995 p. 49). One part of this is to analyse how the artefact becomes seen as working or non-working (Fogelberg 2000 p. 37). Differences in views of an artefact are allowed and called *interpretative flexibility.* A property of a technological artefact could be seen as a positive feature for one social group but could at the same time be seen as a downside for another. When the air inflated tyre was introduced in the late 19th century to bicycles some saw it as a vibrational decreasing device, others found it negative for the bicycle aesthetics, while racing bicyclists found it useful to reach higher speeds (Bijker 1995 p. 77-84). The views of an artefact can vary a lot among stakeholders or groups of stakeholders. This can possibly be explained by the stakeholders having different goals and thereby different problems to solve and look for different solutions (Bijker 1995 p. 124-125). Stakeholders who share the same view about an artefact are called a *relevant social group*. There might be several variants of the artefact but also several ways of viewing each artefact. In SCOT-methodology it is called a *stabilisation* if the artefacts develops in such a way that one artefact becomes the dominating option. This is by Bijker exemplified by the safety bike that after a turbulent time with many different variants of bicycles, tricycles, and highwheelers became the dominating solution in the end of the 19th century. If the views of an artefact becomes unified among the stakeholders this is called a *closure*. To better understand how the relevant social groups perceive the artefact it is fruitful to look at the *problems* and *solutions* connected to the artefact (Bijker 1995 p. 50).

Another way to understand the diffusion of a technology is by looking at what factors that are acting as drivers or as barriers to the diffusion of the technology. This has been done within the STEEP-RES project for the case of rural electrification in Tanzania and Mozambique by interviewing important local stakeholders (Ahlborg and Hammar 2011).[2] Wilkins (2002) also uses the concept of barriers when studying technology transfer of renewable energy technology. He further mentions the following stakeholders to be of importance for a successful technology transfer of renewable energy technology: policy-makers, legal and regulatory bodies, development agencies, financiers, utilities, manufacturers, suppliers, developers, installers, consultants, academic institutions, NGOs, community groups, recipients and users of the technology (Wilkins 2002 p. 56).

Literature from both diffusion of innovation and technological transfer describe the stakeholders and their views of a technology as important for its diffusion. SCOT then provides methodological tools for analysis of the stakeholders' opinions about the

2 See background

technologies in a way that makes it possible to reach deeper understanding about the role of the stakeholders and their views in the diffusion of these technologies in Tanzania. The SCOT methodology has mostly been put forward as a tool to analyse the history of development and diffusion of an artefact. In this thesis however I want to use SCOT methodology in real time to understand the diffusion process and the future potential for solar PV and small-scale hydropower to increase access to electricity in Tanzania. SCOT has been used in real time before by for example Elle et. al. (2009). The methodology was then used in a forward looking way to analyse what different relevant social groups saw as key indicators for a building to be seen as environmentally friendly. This was then used to lead the groups to a closure about what was seen as working indicators. I will in this study however not actively try to influence the stakeholders' views. This study will take advantage of the following concepts from the SCOT tradition:

-workability
-interpretative flexibility
-stabilisation and closure
-problems and solutions
-relevant social groups
-stakeholders' goals

The use of SCOT in real time can increase understanding in what actions that might be needed to increase the rate of diffusion of the technologies. It should then be valuable to combine the SCOT-approach with the concept of "drivers" and "barriers" to better point out what problems that needs to be solved to allow the speed of diffusion to increase. These concepts called "drivers" and "barriers", "inducement-" and "blocking-mechanisms" or alike are used with various definitions in the literature. I choose to follow Wilkins (2002) definition of barrier and thus the term is used in this thesis to refer to any technical, economic, institutional, legal, political, social or environmental factor impeding the deployment of solar PV and/or small-scale hydropower. Wilkins (2002) further stress that barriers tend to be interrelated and therefore it is difficult to isolate the impact from one single barrier. I then define driver based on the definition of barrier that is any technical, economic, institutional, legal, political, social or environmental factor enabling the deployment of the solar PV and/or small scale hydro.

To link the SCOT-theory to the concept of drivers and barriers the properties that make a technology being viewed as a working solution to different problems can be seen as technology specific drivers for the technology's further diffusion in Tanzania. While the properties that make a technology being viewed as less of a solution or even unworkable can be seen as a technology specific barriers. These technology specific drivers and barriers might amplify or weaken the effect from the drivers and barriers found on system level. The material is not large enough to perform a full description of all the relevant social groups for the technologies in Tanzania. Some of the concepts will however be used to discuss the different views of the stakeholders.

4. Method

Here the method used during the collection of the material and the analysis will be described. That is the interview method, how the respondents were chosen, how the theory was used with the material. Finally the strength and weaknesses with the fieldwork and analysis method are described.

4.1 Method for collection of material

In this qualitative study data were collected through interviews with key stakeholders in Tanzania during February-April 2011. The respondents were found by using reports, articles and Internet to find stakeholders relevant to the spread of the two technologies in Tanzania. The work of the STEEP-RES project has provided many valuable contacts with stakeholders and also the interviewed themselves provided new contacts. In some organisations two or three people were interviewed at the same time. In total 21 interviews were conducted with governmental agencies, development agencies, NGOs, private companies, financial institutions, academia, utilities, consultants and users of the technology.[3] The interviews were ranging from 30 minutes to 1h and 30 minutes, were in all cases but one held in English (which was held in Swedish) and were in most cases recorded as audio files.[4] The recorded interviews were later transcribed and quotes were used as a meaning unit divided in subcategories (e.g. diesel generators have high running costs), which are part of categories (advantages with solar PV and small scale hydro compared to diesel generators) (Graneheim 2003). The categories are related to the questions prepared on beforehand (deductive analysis), but new categories were also allowed to emerge from the material (inductive analysis) (Mikkelsen 2005). The interviews where semi-structured, i.e. asking open-ended questions, using a prepared set of questions which were slightly modified to suit the respondents background (Mikkelsen 2005). Follow-up questions were used to get a more complete picture. The following topics where discussed in the interviews:

-What are the general advantages and disadvantages with the technology?
-What are the advantages and disadvantages compared to electricity from the main grid?

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3 A more thorough description of the stakeholders is found in the Appendix

4 Retailer A, REA, User 2, User 1 notes were taken. Since the audio recording was prohibited or not suitable.

-What are the advantages and disadvantages compared to electricity from diesel generator?

-What are the advantages and disadvantages with solar PV compared to small-scale hydropower?[5]

-When is the technology applicable?

-What are the main drivers and barriers to the technology?

-What are the future potential of the technology?

The topics have been discussed directly or indirectly in most of the interviews. Discussed directly means that the interviewer asked the question directly (e.g. what are the advantages with solar PV?). Indirectly means that the topic was discussed on the interviewed's own incentive or in connection to another question. It is likely that other answers had been put forward if the stakeholders who discussed a topic indirectly got a direct question and this is therefore a weakness to the material. The reason for this approach still was taken is that many of the questions are overlapping (e.g. while speaking about general advantages of solar PV the interviewed sometimes did by themselves start comparing with other technologies while sometimes they did not and they were then asked directly) and there would be less flow in the interviews if all questions had to be asked even though the interviewed already had been into that area. When a question asked during the interview got an answer that according to my methodological framework were better suited as an answer to another question, the quotes were moved to the appropriate category in the result section.

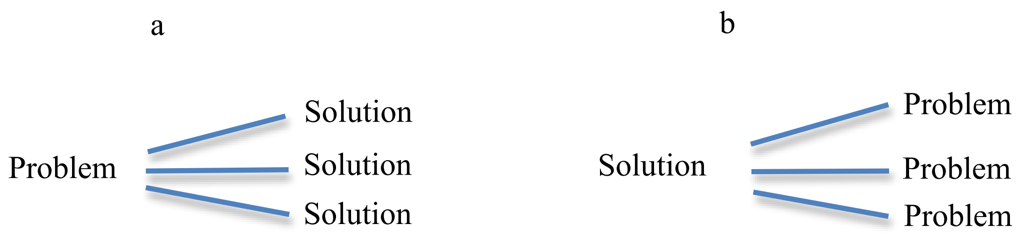

Figure 1: ***Problems and Solutions.*** Case (a) shows the described method from Bijker (1995 p. 50-60) which is used when analysing what problems that the stakeholders see in connection with the technologies, case (b) shows the method used to analyse when a technology is seen as a solution.

5 Only the stakeholders who were knowledgeable in small-scale hydropower were asked to compare solar PV with small-scale hydropower.

4.2 Method for analysis

The stakeholders' opinion about what problems that they want to solve, and what a technology should full fill to be seen as working is influencing what technologies they use, sell and promote. Bijker presents an example with a high-wheeled bicycle called the ordinary, which had a problem of being unsafe. This rendered a number of alternative solutions that all were trying to solve the problem of safety. This will be used in this thesis when discussing the problems or disadvantages that the stakeholders see with the technologies (case a in figure 1). This will be analysed by looking at the by stakeholders mentioned system barriers and the disadvantages with the technologies both in general and in comparison to grid connection and diesel generators. A similar approach will also be used to understand when and to what problem a specific technology can be used as a solution (case b in figure 1). This case could again be illustrated by the safety bike which from the start where seen as a solution to the safety problem but also turned out to be a solution to reach higher speeds in racing grounds. Thus it was a solution to several problems at the same time. This method will be used when analysing the system drivers and the technologies applicability in combination with the perceived advantages of solar PV and small-scale hydro against grid connection and diesel generators. A discussion regarding when and why the different stakeholders shared or did not share the same view of the technologies will be held. This will to some extent be done by analysing the stakeholders' goals in some of the cases of controversy. The overall question about how the stakeholders perceive the technologies workability in Tanzania is discussed through the analysis of the problems and solutions connected to the artefact.

4.3 Strengths and weaknesses

There are some known weaknesses, which are good to keep in mind. The situation in Tanzania and technologies themselves are not static. It is therefore important to remember that this study is a snapshot in time. The interviews conducted are limited in number and length. That is more information to analyse could be gathered if more respondents were interviewed, the respondents could have explained more if the interviews were longer or more interviews with the same respondent were made. In the material there is an overweight of stakeholders with connection to solar PV. The simple explanation to this is that it was easier to find stakeholders dealing with solar PV. Another possible problem with the study could be that only one interview with each respondent where held. This might make the respondents hesitate to reveal their opinions fully if they feel insecure or do not trust the interviewer fully. This could for example lead to a more positive attitude towards renewable energy in general since it might be more politically correct to favour environmentally friendly technologies.

If respondents are misinformed about for example a certain technology's characteristics it should not be a problem for the analysis since they are forming their opinion on what they know, even if it is a misunderstanding. Questions prepared beforehand might lead to that important information is missed if it is not covered by the questions. The method of using open-ended questions however allows the respondent to lift own reflections that she/he thinks are important even if they are not covered by the questions. There is also a risk for misunderstanding because of lacking language skills. My work as an interviewer is limited to this study and this lack of routine might also be a weakness to bear in mind. Another weakness is the limited geographical spread of the respondents. Almost all interviewed live and work in Dar es Salaam (except one user and one retailer from Iringa town and the small scale hydro project in Bulongwa). This is partly explained by the fact that many of the agencies, NGOs, donors and consultants are situated there but the retailers and users of solar PV and villages with small-scale hydro are present in many regions of Tanzania and it would of course be more interesting to have a more differentiated material.

A major strength with the SCOT methodology is that besides describing what advantages and disadvantages there are to these technologies in Tanzania, one can better understand why the stakeholders perceive them as drivers and barriers. This knowledge should be of importance to understand the future development of these technologies in Tanzania.

5. Result

Here follows a compilation of the results from the interviews that are lifted in the discussion. It does not fully follow the structure held in the interviews but is instead ordered to suit the analysis. The following topics will be presented: the applicability of the technologies, the general advantages and disadvantages, the advantages and disadvantages compared to grid connection, compared to diesel generators, solar PV compared to small scale hydro power and system drivers and barriers to the technologies. The most frequent answers are presented in tables while answers found among few stakeholders are found as comments below the text describing the table. First however there is an explanation of how the different stakeholders will be referred to in the results and also a description of the different variants of systems that were brought to discussion by the stakeholders. The stakeholders interviewed will be referred to in tables and text by using the following abbreviations: *Retailer 1-3* are retailers dealing with solar PV systems. *Finance 1-2* are financial institutes. *Academia 1-2* are academic institutions. *MEM, EWURA, REA* are the used abbreviations of corresponding governmental agency. That is Ministry of Energy and Minerals, Energy and Water Utilities Regulatory Authority and Rural Energy Agency. *Tanesco 1-2* are the largest Tanzanian utility company Tanesco. *Consultant 1-2* are consultants working with renewable energy in Tanzania. *NGO 1-2* are non-governmental organisations working with renewable energy solutions in Tanzania. *User 1-2* are users of solar PV systems. *Donor 1-2* are international donors. *Bulongwa* is a village project using hydropower to supply a hospital and surrounding village with electricity.[6]

5.1 Variants of the technologies

During the interviews the questions asked were about solar PV and small-scale hydro in general and it was up to the stakeholders interviewed to define and discuss the properties of different specific systems. Below follows a short description of the different variants of solar PV systems and small-scale hydro systems that have been discussed in the interviews.

6 A more thorough description of the stakeholders is found in the Appendix.

Solar PV

Stand-alone systems or solar home systems (SHS): These are smaller systems with one or more solar panels, battery, wiring for the building. *Solar back-up system*: A back-up system is simply a panel and battery used when there is a black out or rationing in the main grid. It is often of smaller power than the user normally takes out from the main grid. *Solar lantern:* A solar lantern is commonly a small lamp with an integrated solar PV panel. No wiring needed and there are models that can charge mobile phones. One could argue that the solar back-up systems and the solar lanterns are subgroups to the stand-alone systems. Therefore the advantages and disadvantages with stand-alone systems (presented later in this chapter) will be assumed to be advantages and disadvantages for solar back-up systems and solar lanterns if not otherwise specified. *A village system with a local grid:* A local grid or mini grid with solar PV as source for its power normally consists of a number of panels and batteries, a transmission grid to the users and in house wiring. *A village system with battery charging station:* Instead of building transmission lines to make a local grid/mini grid a battery charging station can be used to let the villagers come and charge batteries that can be used as an energy source in their homes. The system consists of a number of solar panels connected to charging stations, batteries and in house wiring. *Grid connected solar farm:* A grid connected solar farm consists of a number of panels connected to the main grid.

Small-scale hydropower

Off grid systems: A hydro station located in an area without access to the main grid with a local grid to provide the nearby society. *Or* a hydro station located in an area without access to the main grid that primarily provides electricity to industry, hospital or alike with potential to sell the rest to the nearby society. *Grid connected:* A hydro station is built primarily for own use but excess electricity is sold to the grid. *Or* a hydro station built primarily for supplying electricity to the grid.

5.2 Applicability of solar PV and small-scale hydropower

	User 1	User 2	Ret 1	Ret 2	Ret 3	Fin 1	Aca 1	Aca 2	MEM	EWURA	REA	TAN 1	TAN 2	NGO 1	NGO 2	Don 1	Don 2	Cons 1	Cons 2	Bulw	Fin 2	Total
Rural areas (solar)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
Rural areas (hydro)								1	1	1	1	1	1	1	1	1	1	1	1	1	1	14
Gridconnection is the final goal	0,1			1				1	1	1	1	1	1		1	1	1	1	1		1	13,1
Hydro is preferred before solar								1	1	1	1	1	1	1	1	1	1		1		1	12

Table 1: ***Applicability of solar PV and small-scale hydropower.*** (1) Corresponds to that the stakeholder agreed to the statement. (0,1) Corresponds to that the stakeholder disagreed to the statement. The total number of stakeholders who agrees or disagrees to a statement is then found in the rightmost column, where the agreements adds up in integers while the disagreements adds up in the decimals. An empty cell means that the topic was not discussed in the interviews.

Both solar PV and small scale hydro is commonly seen as applicable in *rural areas,* or areas without access to grid. In the case of solar PV it might be enough to be living 2-3 km away from the grid to find it more economical to buy a solar panel (MEM). It has also been mentioned by many stakeholders that a *grid connection is the final goal.* Many also points out that *hydro is preferred before solar*. That is if you have the possibility of choosing a grid connection you will not choose a solar PV system. This was however challenged by User 1 who claimed solar PV to be a better solution than grid connection since it is cheaper and easier to get. Also Academia 1 agrees that it is easier to get a solar PV system than a grid connection.

	User 1	User 2	Ret 1	Ret 2	Ret 3	Fin 1	Ac 1	Ac 2	MEM	EWURA	REA	TAN 1	TAN 2	NGO 1	NGO 2	Don 1	Don 2	Cons 1	Cons 2	Bulw	Fin 2	total
Applicable:																						
Small loads			1	1		1	1	1	1	1			1	1	1	1	1	1	1	1	1	16
Households	1	1	1			1	1	1	1	1				1	1		1	1	1		1	14
Institutions			1	1	1		1		1	1	1		1	1	1		1	1	1		1	14
Small scale business			1	1				1	1	1			1	1	1	1		1	1			11
As backup power	1	1	1	0,1	1	1	1	1	1			1			1	0,1		0,1	1	1		12,3
Not applicable:																						
Heating devices			1	1		1		1	1	1					1	1	1			1	1	11
Milling				1				1	1				1									4
For the poor	0,1		1		0,1		0,1		1					1	1,1	1		1	1		1,1	8,5
Village system (local grid)			1	1				1	1	1				1	1	1		1	1	1		11
Village system (charging stations)								1,1							1,1	1,1					0,1	3,4
Feeding electricity to the grid				1				1		1					1						1	5

Table 2: ***Applicability of solar PV.*** (1) Corresponds to that the stakeholder agreed to the statement. (0,1) Corresponds to that the stakeholder disagreed to the statement. The total number of stakeholders who agrees or disagrees to a statement is then found in the rightmost column, where the agreements adds up in integers while the disagreements adds up in the decimals. An empty cell means that the topic was not discussed in the interviews.

<u>Applicability of solar PV</u>

Solar PV in general is applicable for *small loads, which* in turn makes stand-alone system useful *in households, in institutions* and *in small-scale business.* In households the most commonly mentioned use is lighting, phone charging, watching television and listening to radio. Mentioned institutions that can benefit from solar PV are for example: schools, health centres, police departments. The uses are commonly for lighting but also for it-equipment, fridges (health centres). Small-scale businesses mentioned in connection to solar PV are mainly phone charging, hair cutting saloons and showing TV in bars. It is not seen as applicable for *heating devices* such as ironing or cooking or for *milling*. Solar PV is by some argued to not be applicable *for the poor* while some other stakeholders disagree (User 1, Retailer 3, Academia 1). Some stakeholders mention the solar lanterns as a solution for the poor both for people who cannot afford bigger solar systems (Retailer 3, Academia 1, MEM, NGO 2, Finance 2) but also for poor in town who cannot afford a grid connection (MEM). Solar PV is also seen as applicable to use in town *as backup power* in case of black outs or rationing. This is however opposed by some stakeholders who say that it is better to use only batteries for this purpose (Retailer B, Donor 1, Consultant 1). Academia 2 explain that this could be done by charging the batteries from the grid but then all the batteries are together using a lot of power in a grid with already too low generation. Solar PV is not seen as suitable in a *village system with a local grid*. Some stakeholders did not want to say that it was not applicable they were instead open for the possibility to use solar in a village with a local grid (Academia 1, REA, Donor 2, Finance 2). Some stakeholders mention that if one is to use solar in a village system it is better to use a *village system with battery charging stations*. This since the costs of transmission lines are high (Academia 2, NGO 2) and that it is easier to handle the payments for use (Donor 1, Finance 2). But both Academia 2 and NGO 2 think it's better to use smaller decentralised household systems rather than charging stations and Donor 1 does not believe in solar PV as a total solution for a rural community at all. *Feeding electricity to the grid* is not seen as applicable for this technology because of the high cost. But two stakeholders suggest that a differentiated tariff system could be introduced under the Standardised Power Purchase Agreements[7] (Academia 2, NGO 2).

7 The Tanzanian government is enhancing the development of renewable energy sources by letting private sector participate in the power sector through Small Power Projects (SPPs). By entering an agreement a project will be promised a certain tariff for its produced electricity. The tariffs called Standardized Power Purchase Tariffs (SPPT) are given to projects, which are connected and selling

Applicability of small-scale hydropower

	Aca 2	MEM	EWURA	REA	TAN 1	TAN 2	NGO 1	NGO 2	Don 1	Don 2	Cons 1	Cons 2	Bulw	Fin 1	Total
Applicable															
All loads	1	1	1	1	1	1	1	1		1	1	1	1	1	13
Milling machines	1			1		1					1	1	1		6
For a community	1	1	1	1	1	1	1	1	1	1		1	1		12
To use in a company	1			1	1		1			1		1	1	1	8
Grid connected	1	1	1	1		1	1	1	1	1		1		1	11
To be managed by companies or organisations	1			1	1					1		1		1	6

Table 3: ***Applicability small-scale hydropower*****.** (1) Corresponds to that the stakeholder agreed to the statement. (0,1) Corresponds to that the stakeholder disagreed to the statement. The total number of stakeholders who agrees or disagrees to a statement is then found in the rightmost column, where the agreements adds up in integers while the disagreements adds up in the decimals. An empty cell means that the topic was not discussed in the interviews.

A small-scale hydro station is applicable for *all kind of loads.* This makes it possible to be used for *milling machines*. It could be used in an off grid area to *supply a community,* or even a whole region with power. It is however difficult to sell electricity to villages (Donor 2, NGO 1, Academia 2) and it is according to them more applicable to sell to a company. It is applicable *to use in a company* (with a possibility to sell the excess power). It is also suitable to use it *grid connected* and sell to the main grid. This is also preferred over selling in to villages (Donor 2, Finance 2). The reasons mentioned for why it is preferred to sell to grid and use in a company are for example that there is no need to worry about transmission and distribution (only generation), no need to build a local grid, better security in payments. It is suitable to be *managed by a company, organisation. S*ome stakeholders even say that it is not suitable for individuals (NGO 1, NGO 2, Donor 2) and difficult for villages to run them themselves since they are complicated projects (REA, Consultant 2).

power to the main grid or local grids in Tanzania. The tariffs are revised annually and are higher for local grids (EWURA 2010).

5.3 Advantages with solar PV

	User 1	User 2	Ret 1	Ret 2	Ret 3	Fin 1	Aca 1	Aca 2	MEM	EWURA	REA	TAN 1	TAN 2	NGO 1	NGO 2	Don 1	Don 2	Cons 1	Cons 2	Bulw	Fin 2	totalt
In general																						
Not site specific	1	1	1	1	1	1	1	1	1		1		1	1	1		1		1	0,1	1	16,1
Works in stand alone system		1		1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	18
Reliable						1	1	1				1		1	1	1	1					8
Cheap running cost	1	1		1	1	1	1	1	1	1		1	1	1	1		1	1	1	1	1	18
Long lifespan		1		1					1						1		1					5
Stand alone systems																						
Simple technology	1		1,1	1	1	1	1	1,1		1	1	1	1,1	1			1	1	1	1	1	17,3
No distribution system				1				1		1			1		1		1		1		1	8
Short start up time	1						1	1		1	1			1			1	1	1		1	10
Modular				1	1	1	1	1	1	1	1			1	1		1		1			12
Solar lanterns																						
Cheaper					1		1		1						1						1	5

Table 4: ***Advantages with solar PV.*** (1) Corresponds to that the stakeholder agreed to the statement. (0,1) Corresponds to that the stakeholder disagreed to the statement. The total number of stakeholders who agrees or disagrees to a statement is then found in the rightmost column, where the agreements adds up in integers while the disagreements adds up in the decimals. An empty cell means that the topic was not discussed in the interviews.

In general it is seen as an advantage that: *Solar PV is not site specific* since the sun is an available resource in Tanzania. The systems can be used in a decentralised manner since they *work in stand-alone systems*. Solar PV systems is a *reliable* way of producing electricity, the sun is always there and low frequency of breakdowns. Two stakeholders mentioned that 12-volt systems are more reliable than the systems with inverter since the later are more complicated (Retailer 3, Donor 1). A solar PV system has *cheap running costs*; even if you are out of money you can have electricity (User 2, MEM, Finance 2). Solar PV systems are seen as having a *long lifespan* as User 2 mentioned "*when you have it, you have it forever".*

<u>Advantages specific for stand-alone systems:</u>

Simple, they are easy to install and manage. Tanesco 2 and Academia 2 partly disagree with this since the management of the batteries is complicated. Retailer 1 mentions that to have a system where the owner can work with it himself is both good and bad. Good in the sense that maintaining or upgrading the system is a possible task for the owner to succeed with. Bad in the sense that it is also possible that the owner might tamper too much with the equipment and then end up with a non-working system. *No distribution* *system* is needed which are expensive. Another mentioned aspect connected to the simpleness of the systems is the *short start up time.* You can go to the shop and buy a system and have power the same day. They are *modular,* one can therefore adapt the size of the system to the need, or to the wallet, and it is also an advantage that you can add parts as you either get a higher power need or when you can afford.

Advantages specific for solar lanterns:

Cheap. The lanterns are more suitable for the poor than ordinary stand-alone systems (Retailer 3, Academia 1, MEM, NGO 2, Finance 2).

Advantages mentioned by one or a few stakeholders:

The stand-alone systems have a short payback period (User 1, Retailer 3). The lanterns are also mentioned to be portable (Retailer 3, Finance 2). Finance 2 mentions that in a small stand-alone system with fixed lamps it is unusual to install lamps in the kitchen where much of the household work is done. With a portable system women are able to at least part of the day use it in the kitchen. Solar PV can be a way of educating people on how to use electricity and what benefits it carries (Academia 2, REA, Consultant 2). According to Consultant 2 it could in some sense be seen as a driver for increased demand for electricity.

5.4 Disadvantages with solar PV

	User 1	User 2	Ret 1	Ret 2	Ret 3	Fin 1	Aca 1	Aca 2	MEM	EWURA	REA	TAN 1	TAN 2	NGO 1	NGO 2	Don 1	Don 2	Cons 1	Cons 2	Bulw	Fin 2	Total
In general																						
High Investment cost	0,1	1	1	1	1	1			1	1		1	1	1	1	1	1	1	1		1	16,1
Limited output				1	1	1		1	1	1			1	1	1	1	1		1	1	1	14
Fake products on the market			1			1			1		1				1	1	1					7
Village system (local grid)																						
Distribution system are expensive				1				1							1		1		1		1	6
Difficult to finance				1				1						1	1							4

Table 5: ***Disadvantages with solar PV.*** (1) corresponds to that the stakeholder agreed to the statement. (0,1) Corresponds to that the stakeholder disagreed to the statement. The total number of stakeholders who agrees or disagrees to a statement is then found in the rightmost column, where the agreements adds up in integers while the disagreements adds up in the decimals. An empty cell means that the topic was not discussed in the interviews.

Solar PV systems have a *high investment cost*. Two stakeholders agree that the cost is high but they claim that since the payback period for a stand-alone system is short many people can afford it if they want to (Retailer 3, User 1). According to User 1 a 5 watt system costs about as much as a sack of onions and most people can afford that.[8] Other stakeholders mention the solar lanterns as a possibility for the ones who cannot afford the stand-alone systems (Academia 1, Retailer 3, MEM, NGO 2, Finance 2). The *limited output* of a solar PV system. It is technically possible however not economically feasible to use it for ironing, cooking or larger machines such as milling machines (Retailer 2, Academia 2, MEM, Tanesco 2). Some stakeholders also question the usefulness of solar for economic development because of its low output (Donor 2, Consultant 2, Donor 1, Tanesco 2). The low output is indirectly connected to the high initial cost (since a lower cost per installed watt would lead to better possibilities to use larger systems) and three stakeholders states that if it gets cheaper per watt it can become very useful since then you increase the possibility to use it for heavier loads as well (Tanesco 2, Donor 2, Consultant 2). The limited output is however by many not seen as a problem for the people in rural areas since their consumption levels are very small (Retailer 2, Academia 1, Academia 2, MEM, EWURA, Tanesco 1, NGO 1, Donor 2). Donor 2 and Academia 2 question the importance of people not being able to cook food with a solar PV system since electricity is not commonly used for cooking by those who have grid connection. *There are low quality products on the market.* Low quality

8 The particular system the user was referring to could power 4 LED lamps and charge mobile phones

solar PV panels easily break down after a short time (Retailer 1, Financial 1, MEM, REA, NGO 2, Donor 1, Donor 2). These products are discouraging the whole market for solar PV. This problem is however seen as taken care of by imposing importation standards (MEM, REA, Consultant 1, Donor 2).

Disadvantages specific for village systems with a local grid:

Distribution systems are expensive. Which is one reason why these projects are *difficult to finance*.

Disadvantages mentioned by one or few stakeholders:

Solar PV systems are *not a complete solution for a society* (Donor 1, Tanesco 2, Consultant 2). *The equipment is imported* and money is therefore leaving the country (NGO 1), *the equipment does not always look like real electricity* (Retailer 3). *The stand-alone systems can be stolen* (User 1, Retailer 3). *The systems can be misused* and stop working (Consultant 2, Retailer 2, Retailer 1, Retailer 3). The system might be *troublesome to repair* if broken (Academia 1). *Village systems with a local grid are difficult to manage* (Academia 2, NGO 1, Consultant 2), it can for example be *difficult to collect money* (Donor 1, Finance 2). There is also a *risk of low cooperation* by misuse (Retailer 2) or low maintenance (Academia 2). *If you own your own system you tend to take better care* (Academia 2). *A decentralised system is better adapted to the need in each household* (Academia 2). Another disadvantage with village systems is that f*or bigger power needs a diesel system becomes cheaper* (Retailer 2). There is also a problem with *lack of recycling facilities* to take care of the future waste from batteries and panels (NGO 2).

5.5 Advantages with small-scale hydropower

	Aca 2	MEM	EWURA	REA	TAN 1	TAN 2	NGO 1	NGO 2	Don 1	Don 2	Cons 1	Cons 2	Bulw	Fin 2	Total
Large potential In tanzania	1	1		1			1	1		1	1			1	8
Cheap way to produce electricity	1	1		1	0,1	1	1	1	1	1	1	1	1	1	12,1
A possibility to earn money			1	1	0,1	0,1		1		1	1		1		6,2
Can supply a community	1	1	1	1		1	1	1	1	1		1	1		11
Not limited in output	1	1	1	1	1	1,1	1	1		1	1	1,1	1	1	13,2
Can be used for productive use	1	1	1	1	1	1	1			1	1	1		1	11
Leads to development of the comr	1					1		1				1			4
Simple technology		1				1	1		1		1				5

Table 6: ***Advantages with small-scale hydropower.*** (1) Corresponds to that the stakeholder agreed to the statement. (0,1) Corresponds to that the stakeholder disagreed to the statement. The total number of stakeholders who agrees or disagrees to a statement is then found in the rightmost column, where the agreements adds up in integers while the disagreements adds up in the decimals. An empty cell means that the topic was not discussed in the interviews.

There is a *large potential,* meaning that there are still many unused sites with good hydro potential in Tanzania. It is a *cheap way to produce electricity.* Investors see hydro projects as *a possibility to earn money* by selling electricity or using it in an industry. Tanesco 1 and Tanesco 2 however say that hydro projects are seldom economically viable for Tanesco. Tanesco 2 mentions that churches more than investors are going for hydro since they are not interested in fast returns. It can provide enough power to *supply a community.* Which means that it can provide power to large machines and large amount of users and is in this sense *not limited in output.* This makes electricity from hydropower the same as electricity from the grid (MEM). It is to be remembered that sooner or later off-grid system reaches the roof of possible power supplied by the hydro station (Tanesco 2 Consultant 2). Since it can be used for a higher power output it *can be used for productive uses*. An installation of small-scale hydro *leads to development of the community.* It is also a *simple technology, which is easy to run and maintain,* and a *reliable* way of producing electricity.

Advantages mentioned by one or few stakeholders:

Small-scale hydro stations have a long life span (Tanesco 2, NGO 2, Donor 2) and *the re-installation cost is low* (Tanesco 2 Donor 2). This later is explained by that the engineering does not need to be done again and it is often possible to reuse facilities (Tanesco 2). *Clean Development Mechanisms*[9] *(CDMs) can be used to get funding* (MEM, Donor 2). This has not yet been working very well (Donor 2). To own and run a

9 Clean development mechanisms is a tool within the Kyoto protocol.

small-scale hydro power plant creates ownership and responsibility in the village (Tanesco 2, Donor 1) and give a reason for the local people to better take care of the local environment (REA). It is also an advantage to own your resource, because you can use cheap power (Bulongwa). It is an advantage for grid-connected systems compared to off grid systems that they are surer of knowing how much income they will get (Donor 2, Consultant 2, Finance 2). According to Tanesco 2 it is though more important to support a local community since this will bring electricity to a new community while the grid connected only will bring higher security in main grid. According to NGO 2 and EWURA small scale hydro project can be suitable to combine with the Standardised Power Purchase Agreements (SPPA).[10]

5.6 Disadvantages with small-scale hydropower

	Aca 2	MEM	EWURA	REA	TAN 1	TAN 2	NGO 1	NGO 2	Don 1	Don 2	Cons 1	Cons 2	Bulw	Fin 2	Total
Site specific	1	1	1		1	1	1	1		1	1	1		1	11
Rely on water supply	1	1	1	1	1	0,1	1		1	1		1			9,1
High investment cost	1	1	0,1	1	1	1	1						1	1,1	8,2
Takes long time finish		1	1	1		1		1				1		1	7
Slow rate of return on investment		1	1	1		1		1				1			6
Complicated projects	1			1		1	1	1	1	1	1	1,1		1	10,1

Table 7: ***Disadvantages with small-scale hydropower.*** (1) Corresponds to that the stakeholder agreed to the statement. (0,1) Corresponds to that the stakeholder disagreed to the statement. The total number of stakeholders who agrees or disagrees to a statement is then found in the rightmost column, where the agreements adds up in integers while the disagreements adds up in the decimals. An empty cell means that the topic was not discussed in the interviews.

Small-scale hydropower is *site specific* and only a possible option where there are good streams. Donor 2 points out that it is also site specific in the sense that you have to have someone to sell the electricity to. Which means that streams with good potential that lies in remote areas or areas with poor villages might not be economically feasible. NGO 1 also discusses this by mentioning that it is difficult to match the local resource with the local demand. While Consultant 1 stresses the problem that much of the small-scale hydro potential is in the south of Tanzania while the need is in the north. It *relies on the water supply, which* means that there is a risk of seasonal or permanent changes in the

10 The Tanzanian government is enhancing the development of renewable energy sources by letting private sector participate in the power sector through Small Power Projects (SPPs). By entering an agreement a project will be promised a certain tariff for its produced electricity. The tariffs called Standardized Power Purchase Tariffs (SPPT) are given to projects, which are connected and selling power to the main grid or local grids in Tanzania. The tariffs are revised annually and are higher for local grids (EWURA 2010).

water flow. This is not seen as a big problem by Tanesco 2 who explains that you can use it for seasonal production or combine the hydro power station with a diesel generator. *High investment cost.* Some however say that the high cost is not the problem but to find the investors (EWURA, Finance 2). The projects *takes long time to finish,* this is related to another disadvantage, which is the *slow rate of return of the investment*. Tanesco 2 concludes that it is a good investment for the country but not for a company. The projects are *complicated* and the mentioned complications are several. For example the heavy bureaucracy before start (REA, Donor 2, Consultant 2, Finance 2) where some of the applications run the risk of turning out to be negative and then you have lost your money (REA). Another example is the need of proper water management since others might use the water resource in the community (Donor 1, Donor 2, Consultant 2). There is also a need of experts to handle geological and hydrological engineering (Consultant 2, Tanesco 2). There is often a lack of hydrological data, which means that you need experienced personnel to do the assessment properly (Tanesco 2, Donor 1). There might be problems to regulate and handle peak power in an isolated system (Consultant 2). Skilled people are needed to do maintenance (Donor 1, Consultant 2) but are not a problem according to Tanesco 2 and NGO 1 since they can be trained locally. To solve the problem that hydro projects are complicated some stakeholders mention that increased training is needed (Consultant 2, NGO 2, Tanesco 2). Tanesco 2 further mention that Tanesco have a lot of competence in hydropower that is not fully utilised. The projects are *risky.* Environmental assessments could turn out negative (REA), the geology or hydrology might not be suitable or might not be affordable to examine fully (Tanesco 2, Consultant 2), the hydrology might change over time because of the climate change (Donor 2, REA) or because of changes in the surrounding environment (NGO 2). When doing the technical groundwork it is according to Tanesco 2 very difficult to balance cost and risk. The more engineering you do the safer project but also more expensive. Some of these problems are partly solved by the work of EWURA (Academia 1, NGO 1, Academia 2, Tanesco 2, NGO 2, Donor 2) and REA (Academia 1, MEM, NGO 2, Tanesco 1, Donor 2, Finance 2). Financial risk is lowered by the SPPA from EWURA and the subsidies from REA, the later also helps to lower the investment costs. REA further offers technical assistance to projects that cannot afford expensive consulting. Some mention that these incentives are fairly new and they ought to show good results (MEM, Finance 2, Tanesco 2).

Disadvantages mentioned by one or few stakeholders:

You cannot choose freely what size you want to install (Donor 2, Academia 2).

5.7 Solar PV's advantages compared to grid connection

	User 1	User 2	Ret 1	Ret 2	Ret 3	Fin 1	Aca 1	Aca 2	MEM	EWURA	REA	TAN 1	TAN 2	NGO 1	NGO 2	Don 1	Don 2	Cons 1	Cons 2	Bulw	Fin 2	Total
Can be used in stand alone systems		1		1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	17
Lower running costs	1	1		1	1	1	1		0,1			1					0,1	1			1	9,2
Small investment	1	1			1				1					1	1							6
Reliable	1	1	1			1	1								1		1	1	1			9

Table 8: ***Solar PV's advantages compared to grid connection.*** (1) Corresponds to that the stakeholder agreed to the statement. (0,1) Corresponds to that the stakeholder disagreed to the statement. The total number of stakeholders who agrees or disagrees to a statement is then found in the rightmost column, where the agreements adds up in integers while the disagreements adds up in the decimals. An empty cell means that the topic was not discussed in the interviews.

The most mentioned advantage over grid connection is that solar PV *can be used in stand-alone systems*, which can be used in areas where there is no grid. The general coverage of the main grid is low (EWURA, REA, NGO 2, Donor 2, Consultant 1, Finance 2) and according to several stakeholders it will take a long[11] time before the main grid is widespread in Tanzania (Retailer 2, Finance 1, Academia 1, Academia 2, MEM, REA, NGO 2, Donor 1, Donor 2, Consultant 1, Consultant 2, Bulongwa), and some locations will according to Consultant 1 never get grid. *Lower running costs*. As before mentioned you can if you own a solar PV system afford electricity even if you do not have any money at the moment (User 2, MEM, Finance 2). You can combine grid connection and a solar PV system to lower you electricity bill (Retailer 3). MEM and Donor 2 doubt that the low running costs are reason enough to choose solar PV instead of grid. One reason is that the users with low consumption have a lower tariff in the main grid. A stand-alone solar PV system is a *small investment* compared to connecting to the grid. This is only true for low power uses (MEM, NGO 2, Finance 1). Solar is also more *reliable*, you are sure to have electricity even there is black outs or rationing in the main grid. According to Consultant 2 and User 1 the market for solar PV increases in connection to periods with rationing of electricity in the main grid. Solar PV can be a way for people to be more independent and not rely on others for electricity supply (Donor 2, Consultant 1). There might also be problems with spikes in the main

11 The answers ranging from 10-100 years

grid, which can damage appliances while this cannot happen with solar PV system (User 2).

Advantages mentioned by one or few stakeholders:

It takes a long time to apply for grid connection (User 1, Academia 1), and you might need to bribe people to actually get it (User 1). Solar is *safer to handle,* nobody gets electrocuted by a solar PV system (User 1, User 2, Finance 1). Another problem for grid connection as alternative is that people have *no faith in Tanesco*, whether you talk about the speed of grid extension or the reliability of electricity supply (NGO 2, Consultant 1 Consultant 2). It is also mentioned as an advantage to own and control your own power (Academia 2, Donor 2, Consultant 1).

5.8 Solar PV's disadvantages compared to grid connection

	User 1	User 2	Ret 1	Ret 2	Ret 3	Fin 1	Aca 1	Aca 2	MEM	EWURA	REA	TAN 1	TAN 2	NGO 1	NGO 2	Don 1	Don 2	Cons 1	Cons 2	Bulw	Fin 2	Total
Limited output				1	1	1		1	1	1	1		1	1	1		1	1	1		1	14
The responsibility for generation and maintenance								1									1	1		1		4
Expensive per kw				1				1		1			1	1		1	1		1			8

Table 9: ***Solar PV's disadvantages compared to grid connection.*** (1) Corresponds to that the stakeholder agreed to the statement. (0,1) Corresponds to that the stakeholder disagreed to the statement. The total number of stakeholders who agrees or disagrees to a statement is then found in the rightmost column, where the agreements adds up in integers while the disagreements adds up in the decimals. An empty cell means that the topic was not discussed in the interviews.

The most commonly mentioned disadvantage is that the solar PV system has a *limited output.* People want to be able to use as much power as they feel like and whatever appliances they want (Academia 2). As earlier mentioned many stakeholders see the limited output as less of a problem in rural areas were the consumption levels are very small (Retailer 2, Academia 1, Academia 2, MEM, EWURA, Tanesco 1, NGO 1, Donor 2). You cannot use it for much productive use (Donor 2, Consultant 2, Donor 1), a grid connection is therefore encouraging more investment in the area (EWURA, Consultant 2). *The responsibility of generation and maintenance.* With a grid connection one do not worry about that since the provider of electricity will do it. Solar PV is more *expensive per kWh.*

Disadvantages mentioned by one or few stakeholders:

When buying a solar you *have to pay a lot at once* but grid connection is more like a loan where you pay back slowly with the electricity tariff (Retailer 2). *The main grid is subsidised*, why should not the solar PV systems also be subsidised? (Academia 2).

5.9 Small-scale hydropower compared to grid connection

According to some stakeholders a connection to a small-scale hydropower system is the same as having a connection to the main grid (MEM, NGO 2, Consultant 2).

	Aca 2	MEM	EWURA	REA	TAN 1	TAN 2	NGO 1	NGO 2	Don 1	Don 2	Cons 1	Cons 2	Bulw	Fin 2	Total
Advantages															
Works in areas without access to grid	1		1	1				1	1	1	1		1	1	9
Reliable		1		1				1				0,1	1		4,1
Cheaper than grid extension	1		1			0,1	0,1	1	1						4,2
Disadvantage															
Troublesome to regulate and manage	1					0,1			1	1		1			4,1

Table 10: ***Small-scale hydropower compared to grid connection.*** (1) Corresponds to that the stakeholder agreed to the statement. (0,1) Corresponds to that the stakeholder disagreed to the statement. The total number of stakeholders who agrees or disagrees to a statement is then found in the rightmost column, where the agreements adds up in integers while the disagreements adds up in the decimals. An empty cell means that the topic was not discussed in the interviews.

Advantages

As in the case with solar PV systems the most commonly mentioned advantage for small-scale hydropower compared to grid connection is that it *works in areas without grid connection.* To repeat the reasons the general coverage of the main grid is low (EWURA, REA, NGO 2, Donor 2, Consultant 1, Finance 2) and the grid extension will according to several stakeholders take a long[12] time (Retailer 2, Finance 1, Academia 1, Academia 2, MEM, REA, NGO 2, Donor 1, Donor 2, Consultant 1, Consultant 2, Bulongwa) and some locations will according to Consultant 1 never get grid. Another possible reason to why the possibility to use small scale hydro in off grid areas is an advantage is that in some cases a small-scale hydro is *cheaper than grid extension* to remote locations. According to Tanesco 2 this is unfortunately not true in most cases and sometimes even diesel generator systems is a cheaper option. NGO 1 does not say that grid is always cheaper but emphasize that small-scale hydro projects are expensive. It is discussed whether being connected to an off grid system with a small-scale hydro is

12 The answers ranging from 10-100 years

more reliable than being connected to the main grid. Some claim that a hydro system is more *reliable* Consultant 2 claims the opposite while NGO 1 and Donor 1 say that the main grid should be more reliable since it depends on many sources of generation but in Tanzania this is not a definite case since the stability of the main grid is very low.

Advantages mentioned by one or few stakeholders:

An advantage in small off grid systems is that you can decide your own tariff (Consultant 2, Bulongwa). This to make the projects economically viable (Consultant 2). Or to lower the connection fee and price for electricity as a service to the community (Bulongwa).

Disadvantages

The small-scale hydro could be troublesome to regulate and manage. For example it might be difficult to handle peak power in an isolated system (Consultant 2) and you will need local personnel (NGO 1). Tanesco 2 on the other hand claim it to be quite easy to manage and that the locals can be trained.

Disadvantages mentioned by one or few stakeholders:

The electricity is cheaper per kWh in the main grid (NGO 1 EWURA, Donor 1). *You are more flexible with the main grid* since local resources have a roof in power output and this might be a hinder for people to connect or use as much power as they want (Consultant 2, Academia 2). *Grid extension takes shorter time* (REA). Tanesco have done grid extensions for a long time and know how to do it (REA, Tanesco 1). If a village owns a local system it is responsible for managing it and maintain it while if you have a grid connection they do not have to bother (Donor 1, Consultant 2). MEM and Bulongwa puts it in another way and say that it might be advantage to take care of the system yourself and not be bothered by problems elsewhere.

5.10 Solar PV and small-scale hydropower compared to diesel generator

Many of the advantages for solar PV and small-scale hydro are the same compared to diesel generators. I choose therefore to present them together. When asking about the advantages and disadvantages compared to diesel there has to a large extent been few or no answers about the disadvantages with solar PV or small-scale hydro compared to diesel. The interviewer should have seen this during the interviews and asked again for the disadvantages. This is a weakness to this material.

Disadvantages Diesel	User 1	User 2	Ret 1	Ret 2	Ret 3	Fin 1	Aca 1	Aca 2	MEM	EWURA	REA	TAN 1	TAN 2	NGO 1	NGO 2	Don 1	Don 2	Cons 1	Cons 2	Bulw	Fin 2	Total
High running costs	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
Low access to fuel								1	1	1	1		1	1	1						1	8
Not environmentally friendly		1	1	0,1		1		1	1	1	1		1	1	0,1	1	1		1			12,2
Diesel produces a lot of smoke and noice	1	1	1	1	1	1		1	1	1					1	1			1		1	13
Needs more maintenance than solar	1	1	1	1				1	1				1					1				8
Needs more maintenance than hydro									1				1			1				1		4
Solar is easier to manage		1		1	1	1						1				1		1	1		1	9
Advantages Diesel																						
Solar has a limited output			1		1			1	1				1	1	1	1			1			9

Table 11: ***Solar PV and small-scale hydropower compared to diesel generator.*** (1) Corresponds to that the stakeholder agreed to the statement. (0,1) Corresponds to that the stakeholder disagreed to the statement. The total number of stakeholders who agrees or disagrees to a statement is then found in the rightmost column, where the agreements adds up in integers while the disagreements adds up in the decimals. An empty cell means that the topic was not discussed in the interviews.

Disadvantages with diesel generators:

High running costs. Diesel must be bought and the machine must be maintained. Both solar PV systems and small-scale hydro have free energy supply. The expensive running costs might lead to that you only use it part of the day (EWURA, Bulongwa, Finance 2). *Insecure fuel supply*. To reach remote areas, long transport is needed and this might be difficult during rains, it might also be more expensive because of the long transport and the few amounts of dealers in remote areas (NGO 2). The price of diesel is fluctuating and the supply itself might be insecure because of the political unrest in delivering countries (NGO 2, Tanesco 2). Diesel generators are *not environmentally friendly.* Two stakeholders claim that environmentally friendliness is not an advantage that makes any difference for the buyers (NGO 2, Retailer 2). Others mention that renewable energy sources are important from a resource security perspective (Tanesco 2, User 2). Diesel generators *produce a lot of smoke and noise*. The smoke and noise is something that people should be worried about but they do not seem to care (NGO 2). Diesel generators are seen as less durable, they are mentioned to *need more maintenance* than a solar PV system but also compared to a hydro system. Some claim that they often are more complicated to repair than a hydro station (Donor 1, Bulongwa, Finance 2). When repaired they need skilled personnel which might be hard to find in rural areas (Bulongwa). A generator generally has a shorter lifespan than both solar- (User 1, Retailer 2) and hydro-systems (Tanesco 2, NGO 1). It is *easier to manage* a solar system compared to a diesel generator. This is however something that many people who are using diesel generator have not realised (Consultant 2).

Disadvantages mentioned by one or few stakeholders:

Tanzania as a country loses money when importing diesel (Donor 2). A diesel generator might be difficult to start (User 2, Finance 2)

Advantages with diesel generators:

Solar PV systems have a limited output. Diesel generators can be used for heavier loads and can thereby be used for productive uses. When you use diesel in a business you can pass on the cost to the customer (Academia 2, Retailer 3). To buy a diesel generator is a *cheap investment* (Academia 2, Tanesco 1, NGO 2, Consultant 2) and an easy investment decision (Consultant 2)

Advantages mentioned by one or few stakeholders:

One advantage with diesel generators is that they are well known. Solar is a new technology and is therefore often not considered as an option (Tanesco 1, NGO 2, Consultant 2). Compared to hydro a diesel generator is not site specific (NGO 1, Finance 2). For a village system a diesel generator might actually be cheaper even if one account for many years of use (Tanesco 2).

5.11 Solar PV compared to small-scale hydropower

	Aca 1	MEM	EWURA	REA	TAN 1	TAN 2	NGO 1	NGO 2	Don 1	Don 2	Cons 1	Cons 2	Bulw	Fin 2	Total
Advantages with solar PV															
Less of a project	1		1		1			1		1	1	1	1	1	9
Not site specific	1	1					1							1	4
More reliable	0,1	1	1		1	1	1	0,1							5,2
Disadvantages with solar PV															
More expensive per kwh	1				1	1		1		1		1	1	1	8
Limited output	1	1	1	1	1	1	1	1	1	1		1	1	1	13

Table 12: ***Solar PV compared to small-scale hydropower.*** (1) Corresponds to that the stakeholder agreed to the statement. (0,1) Corresponds to that the stakeholder disagreed to the statement. The total number of stakeholders who agrees or disagrees to a statement is then found in the rightmost column, where the agreements adds up in integers while the disagreements adds up in the decimals. An empty cell means that the topic was not discussed in the interviews.

Five stakeholders answered that these two technologies are not really comparable (Tanesco 2, Donor 1, Donor 2, Consultant 2, Bulongwa). As before mentioned many stakeholders said that a grid connection is the final goal but if you cannot get a connection to the grid a connection to a local grid with hydro is better (Academia 2, MEM, EWURA, REA, Tanesco 2,NGO 1, NGO 2, Donor 1,Donor 2, Consultant 2 and Finance 2).

Stand-alone systems of solar are *less of a project*. Some stakeholders mention that the investment cost is considerably higher for small-scale hydropower (Academia 2, Donor 2, Tanesco 1, Finance 2). The installation itself is quick with solar and take normally days instead of years. Donor 2 disagrees that the size of a hydro projects is a disadvantage; they are not comparable since small-scale hydro projects have investors and are not for single households. Solar PV is *not site specific,* hydro projects are only viable in connection to streams while sun is everywhere. Solar PV systems are *more reliable* since sun is always there while the water flow is changing. This is opposed by NGO 2 and Academia 2 who mention that solar is intermittent while hydro has continuous power. Electricity produced with solar PV systems is *more expensive per kWh*. Solar PV systems have *limited output.* Which makes solar PV systems *less useful for economic development.*

<u>Advantages and disadvantages mentioned by one or a few stakeholders:</u>

The larger power output of small-scale hydropower makes it also more suitable in serving the main grid (Academia 2, EWURA, NGO 2), and is also more suitable to use in a local grid (EWURA, NGO 2) Solar PV is difficult to use together with CDMs since the project size is often small (Donor 2, MEM). Stand-alone systems of solar are standardised and easy to install (Academia 2, Consultant 2). Less maintenance with solar PV (Consultant 2). A village system with solar PV is more complicated than a similar hydro system (NGO 1).

5.12 System drivers

The interviews did in general not include a topic about main system drivers to electricity. It was however commonly discussed in other words during the interviews. The interviews where the term 'driver' was used was: User 2, NGO 2, REA, EWURA, Consultant 1, Consultant 2, Finance 1, Retailer 2, MEM, Finance 2.

	User 1	User 2	Ret 1	Ret 2	Ret 3	Fin 1	Aca 1	Aca 2	MEM	EWURA	REA	TAN 1	TAN 2	NGO 1	NGO 2	Don 1	Don 2	Cons 1	Cons 2	Bulw	Fin 2	Total
People want electricity				1	1	1		1	1	1	1	1		1	1		1	1		1		13
Enhanced service in public institutions			1	1	1		1		1	1	1		1	1	1		1	1	1		1	14
Economic development	1	1	1		1			1	1		1	1	1	1	1	1	1	1	1	1		16

Table 13: ***System drivers to the spread of solar PV and small-scale hydropower.*** (1) Corresponds to that the stakeholder agreed to the statement. (0,1) Corresponds to that the stakeholder disagreed to the statement. The total number of stakeholders who agrees or disagrees to a statement is then found in the rightmost column, where the agreements adds up in integers while the disagreements adds up in the decimals. An empty cell means that the topic was not discussed in the interviews.

People want to use applications that need electricity. People want electricity to get light and to use different appliances such as TV and mobile phones. Many people already have mobile phones, which shows that there is a need of electricity (Retailer 2, Retailer 3, Finance 1, Academia 2, MEM, Tanesco 1, NGO 1, Donor 2). People also want electricity to save money from not buying kerosene, batteries or charging mobile phones (User 2, Retailer 3). According to Consultant 2 it is probably modern appliances like TV and mobile phones rather than access to light driving the demand. Also other stakeholders mention TV and possibility to charge phones to be the most important driver for solar PV systems (Retailer 2, Finance 1, MEM). Electrification can also result *in enhanced service in public institutions.* Schools, health centres, police stations can operate after dark and might be able to use it- equipment.

People want to use electricity to earn money and people want economic development. Several stakeholders mention economic activities as important for the spread of these technologies. Some mention that hydro has potential to develop rural communities through increased economic activity (NGO 2, Academia 2, Tanesco 2 REA, Donor 2, Consultant 2). Others mention that investors are interested in hydro as a possibility to earn money (EWURA, REA, NGO 2, Donor 2, Consultant 1, Bulongwa). Solar PV is by some stakeholders seen as less important for economic development because of the low possibilities to productive use (Donor 2, Donor 1, Consultant 2). MEM however sees solar PV as a possibility to prevent rural areas from becoming marginalised. Although the economic activities are mostly small scale (e.g. phone charging or barber shop or earning extra money in a household by charging the neighbour's phone) they are seen as important for the spread (User 1, User 2, Retailer 1, Retailer 3, MEM, Tanesco 1 NGO 1, Donor 2). Consultant 2 sees the possibility to earn money on phone charging as a temporary possibility before the systems are too common and the prices thereby goes down. Instead Consultant 2 sees the better possibilities for communication in the country as more important for the economic development.

5.13 System barriers

	User 1	User 2	Ret 1	Ret 2	Ret 3	Fin 1	Aca 1	Aca 2	MEM	EWURA	REA	TAN 1	TAN 2	NGO 1	NGO 2	Don 2	Don 2	Cons 1	Cons 2	Bulw	Fin 2	Total
People are poor				1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1		16
Lack of credit					1	1		1	1	1					1	1	1	1	1	1	1	12
Lack of skills						1			1		1			1	1	1	1	1	1		1	10

Table 14: ***System barriers to the spread of solar PV and small-scale hydropower.*** (1) Corresponds to that the stakeholder agreed to the statement. (0,1) Corresponds to that the stakeholder disagreed to the statement. The total number of stakeholders who agrees or disagrees to a statement is then found in the rightmost column, where the agreements adds up in integers while the disagreements adds up in the decimals. An empty cell means that the topic was not discussed in the interviews.

People are poor. As earlier mentioned many stakeholders see the initial cost for solar PV systems as high and some stakeholders say that most people cannot afford a system. For small-scale hydro this is problematic since it is not economically feasible to sell electricity to poor villagers.

Lack of credit. For individuals this is a problem when they need to borrow money to buy a solar PV system (Retailer 2, Retailer 3, Finance 1, Academia 2, MEM, NGO 2, Donor 2,Consultant 1). Some stakeholders described SACCOs[13] as a possible way of increasing the availability of credit for individuals (Finance 1, MEM, Donor 2 Academia 2). Another option mentioned was micro finance institutes (NGO 2, Finance 1, Finance 2, Academia 2). Consultant 2 does not share the view of lacking credit for individuals. They are most probably not creditworthy anyway so increasing the availability of credit will not solve the problem. Another problem mentioned by MEM is that people avoid financial institutions since they are afraid of not being able to pay the rents. Also companies and investors in both solar PV and small-scale hydro have problems to find credit (EWURA, Donor 1, Donor 2, Consultant 2, Bulongwa, Finance 2). In the case of hydro this is seen as risky by banks (REA, NGO 2, Donor 1, Bulongwa). Some banks require that repayments should start within 6 months, but a small-scale hydro project takes longer time to finish (NGO 2).

Lack of skills. Many companies are not skilled in book keeping (Finance 2). Regarding solar PV some stakeholders say that there is a lack of technicians (Retailer 1, Finance 1, Academia 1, NGO 1, NGO 2, Consultant 1) according to NGO 2 there is a general lack of skilled people not only technicians but also at higher levels. REA on the other hand sees the market as working with enough skilled people. Small-scale hydro projects are complicated to manage and needs skilled people, which are hard to find in the rural areas (REA, NGO 1, Donor 1, Consultant 1, Consultant 2). The solution is to train more people (Consultant 2, NGO 2).

<u>Mentioned by one or a few stakeholders:</u>

Troublesome to import. The technologies and their spare parts are imported which often is a troublesome task (Retailer 3, Bulongwa). This also makes the equipment expensive (NGO 1 Bulongwa) and the country is losing money (NGO 1). The spare parts to small-scale hydro found inside the country are often of low quality (Bulongwa). *Bad governance.* With better governance the country's renewable resources could be used to a larger extent (NGO 2, Finance 2). *Tanzania relies on and is controlled by donors,* “it is not enough to have good ideas, you also need to have money” (REA). *The transaction*

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13 SACCOs stands for Savings and Credit Cooperative Societies (SACCOs) and are grass-roots financial institutions which offering members a home for their savings and an access point for loans. For many people, membership of their SACCO is an invaluable safeguard against unexpected illness, accident or family death. Workers in the informal economy have increasingly looked to SACCOs in recent years to meet their needs (Bibby 2006).

costs are high when you are working with rural areas (Finance 1). *People are used to invest in other areas.* They rather invest in something that gives quicker returns (REA, Tanesco 2) or in areas where they have invested before since renewable energy is quite new (REA). This is opposed by Donor 1, Donor 2 and Consultant 1 who say that investors are interested but they have problems to access credit.

6. Analysis

As described in the method chapter, it is interesting to understand what stakeholders see as problems and solutions connected to the technologies and from this analyse the technologies' workability in Tanzania. The perceived properties that makes a technology to be seen as a working solution are as earlier mentioned seen as technology specific drivers while the perceived properties that prevents it from being a solution is seen as technology specific barriers. From Rogers, Wilkins and Bijker we understand that the perceptions of a technology is important for it's spread but exactly how important they are is more difficult to understand. It should be of importance how many of the stakeholders who state the same opinion and/or which stakeholders that are stating the opinions. What stakeholders who are not present in the material to express their opinion is also of importance. If the phenomenon were described in scientific literature this would also be a way to confirm it as important.

6.1 What are the main problems that are solved with the technologies?

According to the results people in Tanzania want and/or need electricity. To access electricity is however as we have seen a problem with several possible solutions. Both solar PV and small-scale hydropower are possible ways of solving this problem but according to many of the interviewed stakeholders the most preferred solution is a grid connection.

To get access to grid electricity is however problematic. Low coverage of the main grid, high frequency of black outs and rationing, high connection and running costs, slow application process to get a grid connection, not enough power in the main grid are some mentioned disadvantages with the main grid. These are problems that possibly can be solved by different variants of solar PV and small-scale hydropower. The most commonly mentioned disadvantage with the main grid is the low coverage, which makes the possibility to use solar PV and small-scale hydro in off grid areas an important driver for both technologies. That renewable energy systems that can be used decentralised could be a cheaper alternative than grid extension has support in the literature (Karekezi 2002) and it is by the stakeholders viewed to be of importance also in the future since the grid extension is believed to take a long time and might not even reach all areas.

If we now take a closer look at what the will or need to access electricity means at household level then stakeholders mention lighting, phone charging and TV as important drivers for solar PV. Some mention TV and mobile as more important than lighting (Retailer 2, Finance 1, MEM, Consultant 2). The fact that you can use a solar PV system for these applications is probably of great importance for the spread of solar PV systems. If for example the will to access electricity in a household had been connected to cooking rather than phone charging then solar PV had not been an option at all. In this case it is the household user's perception that phone charging and TV is important rather than cooking that makes this technology a workable option in a household.

As earlier discussed the technologies are however not without problems themselves limiting their possibilities to work as solutions to the problems of the grid. There where many different views regarding how severe the problems were. Some stakeholders questioned the usefulness of solar PV for economic development because of the low output which makes it less useful for productive uses (Donor 2, Consultant 2, Donor 1, Tanesco 2) while at the same time the small possibility of economic activities with solar PV was seen important for the spread (User 1, User 2, Retailer 1, Retailer 3, MEM, Tanesco 1 NGO 1, Donor 2). Donor 1 saw a solar PV system as a last option when no other possibilities were available. Others saw the limited output as less important since the power demand is low in rural areas. User 1 not only saw it as a solution for the ones without access to grid but as a better alternative than grid connection. Some mentioned the cost to be limiting the use of solar on large scale since most people are poor. While others did not see this as a problem as they meant that people already could afford it. To conclude there is an interpretative flexibility to what extent solar PV is solving the problem of low coverage. From Donor 1 who sees it as a last option to User 1 who thinks that it is better than a grid connection.

Places with access to grid connection still have some problem. The unreliability of the main grid is by several stakeholders seen to be solved by a solar PV back-up system. It is interesting that the intermittency of solar PV systems, which is mentioned as a possible barrier by Wilkins (2002) is not mentioned by many of the interviewed stakeholders but instead the reliability of the system is seen as an important advantage. The future importance of this driver for solar PV systems is however unclear since it is probably of high priority to fix the unreliability of the main grid. Small-scale hydro can be used to solve some of the problems of the unreliable grid by being grid connected and thereby reducing the need of rationing but this is not mentioned as a driver.

Many stakeholders mention that if you live in an area with possibility of getting grid access you will probably go for that instead of buying a solar PV system. Some stakeholders however mention that there are some problems to get a grid connection. The application process for a grid connection is mentioned to be very time consuming process while a solar system can be bought and installed the same day. In this case the driver is the view that stand-alone systems of solar are simple and have a short start up time. But it is difficult from this material to say that this is a driver of large importance since only two stakeholders mentioned it.

There is a possibility to buy the solar PV systems in modules and in that way spread the costs over time. A smaller and thereby cheaper solar PV system is mentioned to be a possibility for poor people that live close to the grid but cannot afford the grid connection (or the later electricity bills). It is interesting that the initial cost for a solar PV system is described as a solution in this case while it in general is described as a problem. The modularity of a solar PV system has been discussed as a possibility to a lower initial cost for installing an electricity system and could thereby be an advantage over grid connection in cases of low power demand (Wamukonya 2007).

Another possibility is to use diesel generators to solve the problems of the main grid. It can for example be used in areas without grid or as a backup system. There are of course as we have seen in the interviews problems connected to use of diesel generators as well and some of them that can be solved with solar or hydro systems (e.g. the high operational cost, insecurity of supply of the diesel, not environmentally friendly etc.). It would also be interesting to analyse what problems of solar and hydro systems that are perceived to be solved by diesel generators. This is however more difficult since this was seldom discussed during the interviews, which is a weakness to the material. Mentioned was however that a diesel generator is a cheap investment and an easy investment decision. Compared to a solar PV system it can be used for productive use, and an advantage compared to hydro is that it is not site specific. This is a subject for further studies both among the stakeholders interviewed but it would also be interesting to collect the views of retailers and users of diesel generators to get a better understanding of when and in that case why diesel generators are a preferred option.

In the comparison between solar PV and small-scale hydropower we also see that there are problems with solar PV that can be solved with small-scale hydropower and vice versa. The major problems discussed with solar PV that can be solved with hydropower are connected with the limited output. Solar PV is more expensive per kWh which and is because of this limited in output and thereby less useful for productive uses. Solar PV however is not site specific and can thereby be used in areas without possibilities to use hydropower as a source for electricity. It is also much less of a project and can therefore be a quicker and easier way to access electricity even if it is more limited. It is also by some stakeholders discussed if solar PV or small-scale hydro is to be seen as a more reliable source of electricity.

In some of the interviews the advantages of solar was compared with having a kerosene lamp. This shows that the option to solar PV was not only other types of electricity. The problem that solar PV was solving in this case was not accessing electricity but more specifically access to light, which could be solved by using a kerosene lamp or candles. It would have been interesting to also compare solar PV to kerosene lamps or candles. This was not foreseen before performing the study and is therefore a possibility for future research.

6.2 What are the main problems connected to the technologies?

As was shown in the results the most commonly mentioned disadvantages with solar PV were the high initial cost and the limited power output. These two disadvantages are also used as arguments to why stakeholders do not see solar PV as a workable option for the poor, for productive uses, for a community or for a person who have the choice to choose the main grid. Solving these problems would thereby increase the chances of for the technology to be used in the before mentioned applications. That people are poor and the lack of credit are two mentioned system barriers that further confirm the problem of high initial cost of solar PV systems. But it also shows a possible solution in increasing the access to credit. One could argue that the only problem is the high initial cost since the possibility to use larger power out takes would increase if the price per watt decreased. The connection between high initial cost and low output is also seen when smaller systems were suggested as a solution to the problem of high initial cost. The high initial cost and low output of solar PV are mentioned by many of the interviewed stakeholders and from many different groups of stakeholders (governmental agencies, NGOs, donors etc.). The high cost of solar systems and its low output is also described in the literature (see for example Kammen and Kirubi 2008). That people are poor and the general lack of credit is also described as potential barriers in the works of Ahlborg and Hammar (2011) and of Wilkins (2002). Another mentioned system barrier was the lack of people skilled in the technology. In total the high initial cost, the low output, the low affordability among people and the general lack of credit are likely to be important barriers to the diffusion of solar PV in Tanzania.

The most commonly mentioned disadvantage with small-scale hydro is that it is site specific which of course is limiting the possibilities to use it in Tanzania. Many stakeholders mention the high unused potential in the country as a advantage and it is therefore a bit confusing to understand how important the "site specificness" is as limitation today. Some stakeholders however mentioned that the demand often is not found close to the streams and that this is also part of the site problem. Solutions to this problem are not discussed during the interviews. The perception of small scale hydro projects as risky sounds understandable since they are said to: rely on water supply, have high investment cost, take long time to finish, have a slow rate of return on the investment and are complicated. These problems are also connected to the mentioned system barriers. That the projects are complicated are connected to the lack of skilled people and the slow return on investment is in the case of village system connected to that people are poor. On the whole these disadvantages also might explain the low access to credit or investors since the projects can be seen as risky investments. The described problems have support from many of the stakeholders both from governmental agencies, donors, consultants and a financing institution. Some of the problems are also described as barriers by Ahlborg and Hammar (2011) and Wilkins (2002), (for example high capital costs, low access to credit and lack of knowledgeable personnel). These problems are therefore likely to be important barriers for small-scale hydro's diffusion in Tanzania. Some stakeholders however mention that they believe that the market is changing for the better because of the recent work of REA[14] and the

14 e.g. supply a subsidy to bring down investment cost and make the return on investment higher, providing consulting services to solve lack of local skill and make the project less complicated.

SPPA from EWURA[15], which is making the hydro projects more economically feasible. It is however to be remembered that no investors, except for a not-for-profit finance institute, were interviewed in this study and it would of course be interesting to know how these actions are perceived among the ones whose interest one tries to wake. It is therefore difficult, using this material, to say that these problems are solved by these actions. Increased education and training is also mentioned as possible solutions to the complicated projects.

As discussed in the results, a hydro station that serves the main grid or a local company is preferred over a system that serves a local community. This might be explained by that this set-up is partly solving several of the commonly mentioned disadvantages. No transmission and distribution means smaller and easier projects to manage, no local grid means smaller investment (which could be offset by long transmission lines to reach the main grid or a company) and higher security in payments means reduced economical risks. This shows that even if the small-scale hydro was by several stated as suitable for a community the problems surrounding it are at least to some extent making it less of an option.

The usefulness of solar PV seems to be limited by problems of high initial cost and the low output. While the initial cost is troublesome for both technologies the output is not seen as a problem in the case of small-scale hydro (which by some stakeholders are comparable to a grid connection). Instead it is more accessing the water and organisational aspects in the surrounding the technology that is problematic.

6.3 To what extent do stakeholders share the same view of the technologies?

To find groups of stakeholders who share the same view one could start to look at the different user groups of these technologies. Stakeholders who use the technology for the same purpose should be more likely to share views of the technology. It is however difficult to say if they actually share views since I have not interviewed many stakeholders from the groups of users. From the results we can differentiate a couple of user groups of solar PV and small-scale hydro. In the case of solar PV we have stand-alone systems of solar that for example are used in households, institutions, small-scale

15 EWURA helps small power producers to agreements with Tanesco using a standardised tariff, which makes it easier to know how much money the project, will generate.

business without access to grid, poor households in areas with grid and urban households who are using it as back up. In case of small-scale hydro the main users are companies who need electricity and have access to a stream with hydro potential, companies who wants to earn money by selling electricity, NGOs who supplies villages, hospitals, churches and/or schools. These mentioned groups of users are probably not homogeneous, for example in households male and female users might have different views about the technology, and thereby constitute subgroups. One way to deepen the study would be to include a number of stakeholders from all the user groups. In this material only two household users of solar and one NGO producing electricity with hydropower are interviewed.

The different stakeholders interviewed are in general not users but are still connected to these technologies. Even if they can be grouped after their role (e.g. NGOs, retailers, governmental agencies, donors etc.) it has been difficult to see opinions to belong to a certain group. It should however be remembered that the views in this material is not necessarily the general views of the organisation interviewed.

Even if the stakeholders use the same variant of the technology the goals behind the usage might differ. This may lead to different stakeholders having different criteria for perceiving the technology as working. That is a relevant social group is not necessarily the same as the group of users. One reason for diverging views about a technology's workability might be that they have different goals and thereby different problems they want to solve with the technology. As before mentioned some users of stand-alone systems of solar might use it as permanent electrification while others use a similar system as back up. The goal of the stakeholders was not asked for during the interviews because of the limited time during interviews but also the limited time for analysis of the results. Apart from asking the stakeholders of their goals one could also think of questions about their view of what criteria that is needed for a solution to be valid. This is possibly a subject for further studies.

When looking at the interpretative flexibility in the case of the solar back-up systems (if the solar PV systems are working as back-up system or not) we can see a difference in stakeholders' goals. According to some stakeholders the solar panel is not needed since you can charge the battery by connecting it to the grid while (Academia 2) mention decreased load in the main grid (from reduced use of back-up system charged by the grid) as the major reason for the solar system to be a preferred solution. In this case we see that the first stakeholders see the benefits of the individual as the goal, while (Academia 2) see the benefits of the whole system.

As earlier mentioned the will to access electricity can be seen as a major driver where solar PV and small scale hydro power sometimes can be suitable means to reach this objective. One could however differentiate this objective into the two system drivers mentioned in the result. The first driver being the will to benefit from appliances that needs electricity (lighting, TV, etc.). The second driver to reach economic development of the society or to earn money by selling electricity or products/services where electricity is used in the process. These two drivers could be seen as two different goals to why different stakeholders want increased access to electrification. This could for example explain why some questioned the usefulness of solar PV since it did not have a large effect on economic development while another saw a solar PV system as better than a grid connection. The former states the economic development as their goal while the later probably had benefits of applications in his home as his goal.

According to this separation of goals one could say that to benefit from applications using electricity is a driver for solar PV mainly used in households and institutions, and a driver for hydro systems to be used for communities and large institutions. When it comes to earning money on selling electricity hydro systems can be used to sell electricity both to grid, to villages or to companies while solar PV's suitability for charging phones is a driver. In the case of selling products or services using electricity a driver for hydro is that it can be used in bigger companies and smaller industries that are using machines in the production (e.g. carpentry shops, milling machines). Solar PV systems applicability in small-scale businesses is also a driver (hair cutting, TV shows, etc.). The use of solar PV to power TV and mobile phones is described as a driver by Kammen and Kirubi (2008) and the use of solar PV in small scale businesses are described as important for the spread of solar PV systems by (Farina and Svensson 2010). From this division we see that the will to benefit from electrical appliances and the will to develop the society and/or to earn money are important system barriers. We also see that with these as goals certain properties of solar PV and small scale hydro

becomes important technology specific drivers, as the technologies, because of their properties, becomes means to reach these higher goals.
In these cases we see that the differences in goals might explain differences in views among the stakeholders. When solar PV systems' workability for the poor is discussed it seems as if the different stakeholders have based their perception on the same goal and criteria, namely that poor people should be able to afford a solar PV system. What differs is their view whether the poor really do afford it or not. This controversy might be explained by different knowledge among the stakeholders about the cost of a solar PV system or the income of the poor, but it could also be a difference in view of what capacity a solar PV system should have to be seen as working. Some mention the lanterns as suitable for the poor since they are cheap but some of the stakeholders who saw the solar PV systems as too expensive might have thought of a bigger and thereby more expensive system.

It is also mentioned by Bijker (1995 p. 126) that even if stakeholders share the same goal they might have different strategies to reach that goal. In one case I stumbled across one of the goals that Tanesco 1 and Bulongwa had in common. They both stated that one of their aims was to serve as many people as possible with electricity. Bulongwa therefore prioritised households before economic activities since this would allow more connected users in total. Tanesco chose to electrify areas with economic activity first. Their argument was that a milling machine for example is used by many people in the society and the benefit of electricity is therefore reaching as many as possible. They share the same goal but they use directly opposite strategies to reach the goal.

6.4 The workability of solar PV and small-scale hydropower

As described in the theory section there might be several variants of a technology but also several ways of viewing each variant. A *stabilisation* is a situation where the technology develops in such a way that one variant of the technology becomes the dominating option. If instead the views of one certain variant becomes unified among the stakeholders this is called a *closure*. When the stakeholders have different opinions this is called a case of *interpretative flexibility*.

In the case of solar PV, village and grid connected systems are in general not seen as working among the interviewed stakeholders. Solar PV seems therefore to have reached some degree of stabilisation in that it is stand-alone system of solar which is the model seen as workable. I say degree of stabilisation since stand-alone systems in itself can be divided into household systems, back-up systems and lanterns. Closure seems to be reached in that solar PV systems are workable for small loads and as a solution in areas without access to grid. But there is still interpretative flexibility in if it is a solution for the poor, as back-up systems in town and how useful it is in the rural areas since it has low output (some saw it as less useful since it is not leading to economic growth while others saw it as suitable for the low demand in the rural areas). These controversies might be explained by differences in goals among the interviewed stakeholders but further investigation is needed to actually understand these cases of interpretative flexibility.

All the variants of hydro systems are seen as working but the systems where electricity is sold to the grid or is used in companies are said to be preferred by investors. This does not however seem to be a stabilisation in one variant dominating the others from the scene but rather a matter of prioritising. The stakeholders seem to have reached a closure about the good performance of a hydro system and are pretty much coherent about the problems surrounding the projects.

In general small-scale hydro was seen as a better solution than solar PV since it is more of a total solution and is more important for the development of the community. Both of the technologies are however seen as being needed for a long time since the grid extension is believed to take a long time and might not even reach all areas.

7. Discussion

In this section I will compare some of the results with existing literature, discuss the usefulness of the results and method.

No extensive works that are collecting and describing stakeholders' views about solar PV or small-scale hydro's performance or suitability for Tanzania have been found. The drivers and barriers mentioned in this material are however described in general terms in the existing literature described in the background to this thesis. Also the described uses of electricity are coherent with what is mentioned to be common uses in newly electrified rural areas (World Bank 2008).

Everything is changing, the technologies, the users, and the surrounding society. Also very small changes in for example price for diesel or solar panels might lead to drastic changes in the perception of these technologies. It is therefore difficult to say how long this thesis' descriptions of today's stakeholders' views will remain accurate. They are to be seen primarily as a snapshot of today but it will however still be valuable in a historical perspective. The preceding work of deciding what stakeholders to interview missed many of the later found user groups. It had of course been valuable to include them and their views in this analysis. Also deeper interviews that could reveal more about the different stakeholders' goals and their criteria for when a solution was to be seen as valid would have made the SCOT-analysis more interesting.

The SCOT-methodology gave a good overview of the Tanzanian situation and it gave good focus to the will and need of the local stakeholders rather than just the diffusion process as such. The value of this is great since it put focus on what problems they see as important to solve and why. Then it is less relevant exactly which technology to use as long it brings a solution. Thereby this work has not only become a collection and description of drivers and barriers to solar PV and small scale hydro but also a help to understand these drivers and barriers by the increased knowledge about when and why the technologies are seen as working in Tanzania. In many cases the stakeholders' views were rather coherent, this was of course interesting in itself but it was even more interesting in the cases of interpretative flexibility. These were also the cases where I found the SCOT methodology most useful.

The results from this thesis can hopefully be useful for the local stakeholders themselves to better understand the market for these technologies and maybe make own assumptions about the future. Tanzania is heavily depending on foreign aid and this thesis might be used to better understand what kind of electrification projects that are wanted and most likely to succeed. It might also be interesting from a methodological point of view since it adds to the few users of SCOT in real time.

That solar PV in some cases is compared with kerosene lamps and candles rather than other types of electricity was missed during the preparations of the study. This would be very interesting to include in a future study concerning solar PV among household users.

8. Conclusion

Solar PV and small-scale hydro are two interesting technologies for increasing the access of electricity in Tanzania. Increased knowledge about the perceived workability of these technologies has been gained through analysis made with concepts from SCOT-methodology on interviews made with stakeholders who are important for the diffusion of these technologies in Tanzania.

The purpose of this thesis was to analyse the drivers and barriers to solar PV and small-scale hydro to better understand their potential to increase the electrification level in Tanzania. The controversies surrounding solar PV systems low output and the discussion of its usefulness points out that it is not self-evident what is to be counted as having access to electricity. Is it necessary to have an access to grid electricity or to options fully equivalent to a grid connection to count? Or are the benefits from a 5-watt solar PV system enough? This is a subject for further discussion since
Governmental institutions and donors are probably going to face this problem of definition when policies for electrification are outlined.

Stand-alone systems of solar PV are the model seen as workable rather than larger village systems. The main areas where the technology is seen as suitable are for small loads, mainly households, institutions and small-scale business. Some interpretative flexibility was found in how important the solar PV is for the rural areas, where some saw it as very suitable because the power demand was thought to be low while others saw it as less useful because they did not see it lead to much economic development. It was also discussed if the poor could afford the technology and if it was suitable to use instead of grid or as backup systems in electrified areas. The most commonly discussed technology specific barriers to its diffusion were the high initial cost and the low output. The most important barriers on system level were that people are poor and the low access to credit among buyers and retailers. The most discussed drivers were the possibility to use it in areas without grid (specifically for lighting phone charging and watching TV in households), its reliability, its modularity and the possibilities to earn money in small-scale businesses.

Small-scale hydro was in general seen as having a more useful output and was thereby seen as a better total solution suitable for a whole community and therefore useful in for example local grids serving villages in areas without access to grid. The systems were it was possible to sell electricity to the grid or to use in companies were however thought to be preferred by investors. The main technology specific barriers concerned site specificness, reliance on water supply, high investment cost, long project times, slow rates of return on the investment, complicated and risky projects. The system barriers further complicating the situation were that potential costumers are poor, the lack of skilled personnel and the low access to credit. The main drivers are the possibility to use it in areas without grid, the possibility to use large power loads that makes small-scale hydropower useful in productive use and the possibility to earn money.

Many stakeholders pointed out that in the long run grid connection was the main goal and in that sense these technologies can be seen as temporary solutions. Both of the technologies are however seen as important for many years to come because of the slow expansion of the main grid.

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Appendix

The organisations/users interviewed:

Bangens consulting
Description from homepage (Bangens 2011): "The company focuses on development issues with a particular interest in energy and environment for development. Though work that promotes sustainable development is undertaken in other fields such as value chains and agro-processing, diffusion of academic knowledge, ICT4D, innovation systems. Most clients are within the donor community".

Camco
Description from homepage (Camco 2011): "Camco is a global developer of greenhouse gas emission reductions and clean energy projects. We have been providing our clients with project development expertise, technical delivery capabilities and policy advice for over 20 years."

COSTECH
Description from homepage (COSTECH 2011): "Tanzania Commission for Science and Technology (COSTECH) is a parastatal organization with the responsibility of co-ordinating and promoting research and technology development activities in the country. It is the chief advisor to the Government on all matters pertaining to science and technology and their application to the socio-economic development of the country. ". The interviewed is a senior research officer

E+Co
E+Co is a finance institute who invests in local entrepreneurs dealing with clean energy services in developing countries. The investments range from US$25,000 to US$1,000,000 (E+CO 2011).

Ensol Tanzania Limited
Description from homepage (ENSOL 2011): ENSOL (T) LTD specializes in supply, installation and maintenance of solar energy systems for residential, commercial and public institutional use.

EWURA

Description from homepage (EWURA 2011): “The Energy and Water Utilities Regulatory Authority (EWURA) is an autonomous multi-sectorial regulatory authority... It is responsible for technical and economic regulation of the electricity, petroleum, natural gas and water sectors in Tanzania.... The functions of EWURA include among others, licensing, tariff review, monitoring performance and standards with regards to quality, safety, health and environment. EWURA is also responsible for promoting effective competition and economic efficiency, protecting the interests of consumers and promoting the availability of regulated services to all consumers including low income, rural and disadvantaged consumers in the regulated sectors.“ Two people were interviewed at the same occasion.

MEM

Description from homepage (MEM 2011): The ministry energy and minerals (MEM) is one of the eighteen Government of Tanzania’s ministries. MEM is charged with the mandate to manage and administer the energy and mineral sectors through the energy policy of 2003 and minerals policy of 1997. Mission Statement: Set and monitor implementation of policies, strategies and laws for sustainability of energy and mineral resources to enhance growth and development of the economy. Two people were interviewed at the same occasion.

REA

Description from homepage (REA 2011): “Rural Energy Agency (REA) is an autonomous body under the Ministry of Energy and Minerals of the United Republic of Tanzania. Its main role is to promote and facilitate improved access to modern energy services in rural areas of Mainland Tanzania. REA became operational in October 2007.”

Resco Tanzania Limited

Is a private company providing renewable energy solutions. They design, integrate, supply and install solar energy systems for various applications (Resco 2011).

SIDA/The embassy of Sweden, Dar es salaam

The embassy of Sweden has a development corporation with support from the Swedish International Development Cooperation Agency (SIDA). SIDA is a government department of the Swedish ministry of foreign affairs and is responsible for organising development assistance to developing countries (SIDA 2011). Two people were interviewed at the same occasion.

Tanesco

Description from homepage (Tanesco 2011): Tanzania Electric Supply Company Limited (Tanesco) is a parastatal organization under the Ministry of Energy and Minerals. The Company generates, transmits, distributes and sells electricity to Tanzania Mainland and sells bulk power to the Zanzibar Electricity Corporation (ZECO). Tanesco's generation system consists mainly of Hydro and Thermal based generation. Hydro contributes the largest share of Tanesco's power generation (Tanesco 2011). Two people were interviewed in different occasions.

TAREA

Description from homepage (TAREA 2011): Tanzania Renewable Energy Association (TAREA), formerly TASEA (Tanzania Solar Energy Association) is a non-profit making, non-government Organisation that brings together 250 actors in the renewable energy sectors to promote the accessibility and use of renewable energies in Tanzania.

TaTEDO

Tanzania Traditional Energy Development and Environment Organisation (TaTEDO) is a NGO whose mission is: "To advance popular access to sustainable modern energy technologies in marginalized communities in Tanzania through technological adaptations, community mobilization, capacity building and advocacy for increased access to sustainable energy services, poverty reduction, environmental conservation and self-reliance." (TaTEDO 2011). Three people were interviewed at the same occasion.

Tujijenge Tanzania

Is one of two micro finance institutes (MFIs) operating by Tujijenge Africa in Tanzania. As of January 1st 2010 the total portfolio for these two MFI:s was TZS 3.08 billion, with 13,260 clients. Some of their activities include business loans, agricultural loans, health insurance loans and solar lantern loans (Tujijenge 2011).

UNIDO

Description from homepage (UNIDO 2011): “UNIDO is the specialized agency of the United Nations that promotes industrial development for poverty reduction, inclusive globalization and environmental sustainability”. The activities in Tanzania are focused under three main priorities namely: Poverty reduction through productive activities, trade capacity building and energy and environment.

University of Dar es salaam

Tanzania's largest public university with around 6000 students (2007-2008). The university of Dar es Salaam offer a Master of Science in Renewable Energy Engineering (UDSM 2011).

User 1

Lives in Iringa town, have possibility to connect to the main electricity grid but choose not to. Is instead owner of a solar PV system that used for electricity in the household.

User 2

Lives in Dar es Salaam. Is connected to the main electricity grid and is owner of a solar PV system that used as back up. He had also bought a system for his mother who lived in a village without access to electricity.

Watu na nuru

Anglican Church in the diocese of Iringa works as a retailer and import solar PV kit and sells to the local communities (Watu na nuru 2011).