Drivers and barriers to rural electrification in Tanzania and Mozambique – grid extension, off-grid and renewable energy sources

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Abstract: Mozambique and Tanzania are countries with very low rural electrification rates – far below 5 % percent of the rural population use electricity. The pace of rural grid electrification is slow and for most remote areas access to the national electricity grids will not occur within a foreseeable future. Off-grid (decentralized) electricity grids are seen as a complement and fore-runner to the national grid, making electricity available many years in advance and creating demand and a customer base. Most off-grid systems are supplied by diesel generators which entail unreliable and costly electricity. Alternative off-grid energy sources exist in the region, such as biofuels, wind, micro-hydro and solar PV; but there are significant barriers to adoption, adaptation and diffusion of such RE-based technologies. In this study, the specific drivers and barriers for rural electrification and off-grid solutions in both countries are explored across a stakeholder spectrum. It is part of a larger research effort, undertaken in collaboration between Swedish and African researchers from natural, engineering and social sciences, aiming at an interdisciplinary assessment of the potential for an enhanced utilization of available renewable sources in off-grid solutions. By qualitative methodology, data was collected in semi-structured stakeholder interviews carried out with ten national level energy sector actors. Findings illustrate country-specific institutional, financial and poverty-related drivers and barriers to grid and off-grid electrification, as perceived by different energy sector stakeholders.

Keywords: *Rural Electrification, Off-grid Systems, Renewable Energy, Africa, Drivers and Barriers*

1. Introduction

There is little doubt that access to and use of electricity is a benefit to people, not only in the current electricity-dependent world but also in developing rural areas. While electricity may not bring development on its own it is a highly desired commodity and a prerequisite to rural development in long term perspective [1] [2]. In the first industrial countries massive electrification was initiated in the 1880's, to be completed only decades after the World War II; a huge effort backed by powerful institutions. The challenge is now to spread the same technologies in emerging economies with often very different institutional, cultural and financial conditions. One such region is sub-Saharan Africa where the electrification level is minute – especially in rural areas.

In this study, the current and future prospects for rural electrification (RE) in Mozambique and Tanzania are assessed in terms of drivers and barriers for RE through grid extension and off-grid solutions; based on interviews with key stakeholders from government, international donors, private sector and civil society in both countries carried out during 2010. The aim is to conduct a cross-sector analysis of country specific drivers and barriers to successful RE and use of renewable energy sources (RES) in off-grid systems, as perceived by stakeholders influencing the development in each country. Both countries have very low RE levels and there is a long history of Swedish bilateral partnership within the energy sectors. The analysis reveals important drivers and barriers at national and local level, some of which are not addressed in literature reviewed. The paper starts with a description of current conditions for RE in sub-Saharan Africa. Thereafter, the electricity sub-sectors of Tanzania and Mozambique are outlined followed by a section on method. The results for each country are presented and discussed, followed by conclusions.

1.1. Prerequisites for rural electrification in sub-Saharan Africa

In any country the construction of electric grids to distribute power in rural areas is an infrastructure assignment carrying huge expenses, not less so in most African countries where existing infrastructure is rudimentary. In Africa and elsewhere, RE has largely been the responsibility of the public sector, which in the African context generally implies a large influence from donors. In comparison with industrial countries and own ambitions, RE in Africa has been progressing at a slow pace. In order to speed up the process and involve the private sector as encouraged by the World Bank, many African countries have in later years taken on energy sector reforms, strategies which have yet not shown intended results [3]. The large distances and low incomes make distribution expensive and rural customers financially unattractive to private sector investors.

Expenses associated with vast distance could be met by decentralized grids in wait of full grid coverage. Such off-grid approaches for supplying electricity in remote areas are frequently powered by diesel generators which are dependent on fuel transports for operation, and generate a comparatively higher running cost. An alternative to diesel powered off-grid are available renewable energy sources (RES). In sub-Saharan Africa the potential of RES is high [4] and particularly micro hydro power and solar photovoltaic (PV) have been utilized so far. Due to the low population density and geographical distances, RES are often the least-cost alternative and financing instruments like the Clean Development Mechanism can become an important driver for RES in both countries [4, 5].The extensive pan-African literature covers progress and constraints of such RES based off-grid implementations [6] [7] [8]. Moreover, development programs have addressed the use of PV systems, solar home systems (SHS), in rural households which have resulted in an internal market for these technologies in some countries. The SHS trend is accompanied by a substantial impact assessment literature. Rural area energy transition is not unproblematic and several barriers have been identified – both regarding RE in general and regarding the use of RES in off-grid in particular. An earlier literature review [9] identified barriers within the following areas: institutions and stakeholders performance; economy- and finance; social dimensions; technical system and its management; technology diffusion and adaption; and rural infrastructure.

1.2. Rural electrification in Tanzania

Tanzania's current electricity generation relies heavily on hydropower; secondary sources are domestic natural gas and imported oil. In 2008 the total power generation capacity was 1100 MW. The transmission grid covers a minor part of the country leaving out most areas, particularly western and southern regions. District capitals and other important centers are supplied by diesel generators. The RE level is currently 2% (2009). There is an outspoken intention to utilize the prominent availability of RES, in particular for enhancing RE [10]. Still, there is little use of RES for electricity generation and only 13 % of the disbursed budget 2008/2009 was used for RE and RES altogether (corresponding to 1/3 of what was used for the gas and petroleum sector).

The Tanzanian power subsector, under the Ministry of Energy and Minerals, is dominated by the public agency Tanesco (Tanzania Electric Supply Company). An energy sector reform has taken place during the last decade, leading to the enactment of the Electricity Act in 2008 [10]; private sector is now encouraged to take an active role within the sector and a regulatory oversight of the tariff system is ensured by the EWURA (Energy and Water Utilities Regulatory Authority), established in 2006. The responsibility of RE has been transferred from TANESCO to the Rural Energy Agency, REA, which became operational in 2007. REA is responsible for facilitating RE which is done by supporting applicants (public, NGO or

private) with grants for organizational learning and for capital investment (normally covering up to 30% of the project). Other important actors are donors, who provide major parts of the energy budget, NGO's (primarily TaTEDO) and international consultants.

1.3. Rural electrification in Mozambique

In Mozambique the electricity generation is heavily dominated by the 2075 MW hydro power station Cahora Bassa, situated in the north western part of the country. Cahora Bassa, a few smaller hydropower stations and a back-up coal power station supply all electricity to the national grid. The lion share of electricity from Cahora Bassa is exported to neighboring countries but transmission lines reach the largest cities and some towns. Since the country is stretching over enormous distances transmission losses are significant and the power supply becomes fragile in the outskirts of the grid. Numerous diesel generators have been allocated to supply smaller and remote districts. In difference to Tanzania the country has endured a long lasting civil war, ended in 1992. Since then the efforts in grid extension have been significant; still the RE level was below 2% in 2007.

EdM (Electricidade de Moçambique) is the governmental utility responsible for electrification (generation, transmission and distribution) in Mozambique, but a restructure is considered. EdM buys most of its distributed electricity from the Cahora Bassa dam to low costs which somewhat complicates competition and introduction of other energy sources. The private sector, however, are free to contribute. EdM carries out RE by extending the national grid and the tariff is regulated by the Ministry of Energy. Another public institution is FUNAE (National Fund for Rural Electrification), founded in 1997 and strongly supported by donors, in practice responsible for rural off-grid electrification mainly using diesel generators and solar PV systems. Like in Tanzania, foreign consultants play an important role both in development of national strategies and project specific planning. In Mozambique very few NGO's are involved in RE.

2. Method

The study was conducted during eight weeks of field work in Tanzania and Mozambique in January-March 2010. By qualitative methodology data were collected through interviews with stakeholders. The interviews addressed six themes: (1) current state of the electricity infrastructure in rural areas; (2) institutional and socioeconomic drivers and barriers to RE; (3) productive uses of electricity; (4) potential for off-grid and renewable energy systems; (5) local participation in electrification processes; and (6) impact from electricity on people's lives. The themes were based on a review [9] of mostly African-related peer-reviewed literature (results presented in Table 2 alongside interview results). The interviews were recorded (unless circumstances made this impossible) as sound files. The interviews were semi-structured, i.e. asking open-ended questions, using an interview guide, and considering the professional experience of the respondent [11]. This paper presents the findings from 17 interviews carried out with government staff, donors, consultants and NGOs. The respondents were selected based on their influence in and experience of RE processes. Some interviews are with two or three respondents at the time. Our analytical strategy is based on theoretical propositions [12] and the concepts of 'drivers' and 'barriers', which are commonly found in the management literature, but are also commonly used by stakeholders in the field, as to signify factors that enhance or hinder the wished-for development.

The interviews have been transcribed and then analysed using the Atlas.ti software for qualitative data analysis. Each interview is read through and then all meaning units

(quotations) are sorted into subcategories (e.g. "communication problems"), that are part of categories (e.g. "barriers for RE") which are in turn related to the themes. This type of analysis combines a deductive analysis (categories are based on the themes of interest) with inductive analysis (subcategories emerge from the material) in an iterative process [11]. The software then allows for analysis of e.g. specific categories, subcategories and Boolean queries. The result is a cross-sector mapping allowing for comparison between various perspectives, organizations and between countries.

Some methodological weaknesses should be pointed out. First and foremost, the analysis is limited in scope both in terms of number of respondents and time allocated in each interview. The respondents are in general very knowledgeable in their area and much more can be learnt from each stakeholder. For practical reasons, only one interview was held with each respondent, implying that the analysis reflects what stakeholders found relevant at a specific point in time. However, the format of semi-structured interviews allows for respondents to reflect on their own answers and bring up additional aspects even if not asked for. Second, there is always a risk of misunderstandings, due to lacking language skills. Interviews were held in English and translated by local interpreter when necessary. Further, information given must be assessed critically as respondents may lack knowledge or hold subjective perceptions that are inaccurate in some areas. Such weaknesses are addressed through triangulation of findings. It also matters if there are sensitive issues to which respondents are unwilling to answer. The question of biases in interviews, the concepts of reliability and validity (coming from quantitative science) are discussed in length in literature and take on a slightly different meaning for this type of analysis [11]. In this study, trustworthiness of results is sought by two researchers searching for inconsistencies and comparing findings to existing literature.

3. Results

3.1. Indicated drivers and barriers for rural electrification

Results of identified barriers and drivers are shown in Table 1 and 2 respectively, and discussed in section 4. The respondents' reflections regarding the potential for renewable energies are not included in the tables but presented in the following section (3.2.).

3.2. Respondents' reflections regarding the potential of renewable energy sources

Among the renewable energy sources known to be available in the region micro/pico hydro power were evidently the source most appreciated among respondents. In Mozambique most respondents and in particular the EdM were very enthusiastic about the potential of micro scale hydro for off-grid applications (notably, no larger expansion of hydro power have been undertaken since colonial time in the country). Apart from hydro power EdM showed little interest for renewable sources. In Tanzania the potential exploitation of new hydro power resources, including micro scale, was greatly advocated by Consultant A who also stated that hydro power expansion in Tanzania are being successfully counteracted by the gas lobby. Hydro power has the strong benefit of higher capacity than e.g. solar PV while the flipside of the coin are the seasonal droughts that in particular have affected Tanzania. Regarding wind power there were little support in both countries, with skepticism related to costs and fluctuations. However, wind power got some support from Tanesco's research division. Solar PV is used for off-grid electrification in both countries still it was referred to as generally expensive and of low productive use. Regarding geothermal energy conversion Consultant A reported that a previous assessment has indicated good resources but low political interest.

Table 1. Identified barriers or constraints to successful RE in general (B) and to off-grid electrification in particular (b) extracted from stakeholder interviews and Africa-related literature (L). Tanzania: 1=Tanesco, 2=REA, 3=TaTEDO, 4=Donor, 5=Consultant A. Mozambique: 6=EdM, 7=FUNAE, 8=Donor, 9=Consultant B, 10=Consultant C. Number of interviews: i-iii.

Identified barrier	Source										
	L	**1** *iii*	**2** *ii*	**3** *i*	**4** *ii*	**5** *i*	**6** *iii*	**7** *ii*	**8** *i*	**9** *i*	**10** *i*
Institutions and stakeholder performance											
Low institutional quality	B				B	B	B				B
Inadequate planning capacity	B	B			B	B			B		
Organizational structure and strategies	B					B					
Lack of co-investments (rural develop.)	B					B					
Lack of private sector involvement	B		b		B						
Incompatible donor policies						b					
Top-down management in energy sector				b	B	B	B				
Economy and finance											
Tariff system and connection fees	B		b		B	B					
Subsidies	B		b		B						
Insufficient rural financial institutions	B		b		B						
Poor rural market and low productive use	B	B	b		b		B		B	B	B
Admin. costs in small off-grid systems	B									B	
Compensation (in land acquisition)		B									
Lack of consistency between RE projects		B									
High costs of diesel		B		b			b	b		B	b
Donor dependency					B	B	B		B	B	
Social dimensions											
Poverty and low household affordability	B	b	b	b	b	B	B				
Gender issues	B			b							
Problems in local participation and theft	B								B		B
Lack of local engagement						b		b			
Change of mind among costumers								b	B	B	
Technical system and local management											
Lack of access to skilled personnel	B		b							B	b
Weak maintenance culture	B			b		B				B	b
Low capacity of solar PV systems	B					b		b			
Low access to required components	B	B					B	b			
Low generation capacity						B	B		B		B
Technology diffusion and adaption											
Unwillingness of behavioral change	B		b	b							
Users' low awareness of techn. potential	B										
Lack of local entrepreneurship						B	B				
Rural infrastructure											
Scattered population	B	B				B	B	b	B		
Limited rural infrastructure (roads etc.)	B					B					
Long distance transmission							B				B
Traditional houses (electricity prohibited)					b	B					
Devastating cyclones										B	
Nature reserves and national parks					B	B	B				

Table 2. Identified drivers to RE in general (D) and to off-grid electrification in particular (d) extracted from stakeholder interviews. Tanzania: 1=Tanesco, 2=REA, 3=TaTEDO, 4=Donor, 5=Consultant A. Mozambique: 6=EdM, 7=FUNAE, 8=Donor, 9=Consultant B, 10=Consultant C. Number of interviews with each organization: i-iii.

Identified driver	Source									
	1 *iii*	**2** *ii*	**3** *i*	**4** *ii*	**5** *i*	**6** *iii*	**7** *ii*	**8** *i*	**9** *i*	**10** *i*
Policy and poverty mitigation ambitions										
Governmental policies and subsidies	D	d	d	D	D	D	d	D		D
Political campaigning	D					D			D	
Donor push / support			d	D	D			D	D	
Pushing from individuals in gov. agencies					D					D
Private sector involvement										
Market incentives	D	d							D	
Churches		d			d					
Social responsibility in private sector						D				
Niche market for certain energy systems								D		
Local demand										
Increasing demand (industry, households)	D	d	d			D	d	D		D
Grass-root organizing				D		D	d			
Off-grid RE creates demand for grid ext.					D					D
Other										
Need of increased sustainability in grid						D		D		
Promotion of renewable energy / CDM				d					d	

4. Discussion and conclusions

According to stakeholders, the main drivers for RE in Tanzania are political priorities. Tanzania confronts challenges both at the national and local levels, while no references are made to important actors at the intermediate level. Tanesco is considered the main actor but with major financial and organizational problems. According to donors and consultants, lack a of planning at government level is a main issue, causing inefficient implementation and financing problems – in fact only a minor part (14%) of available funds for energy projects in 2008-2009 were disbursed on time. The opening up for private sector involvement is considered a driver but so far little private investment is taking place in RE. Low return rates, political setting of tariffs and a weak customer base in rural areas makes RE unattractive. Tanesco and REA both use economical potential and productive energy use as indicators for RE planning, still, much would be gained if RE projects would also be accompanied with complementary infrastructural investments according to experienced consultants. Among local barriers, most stakeholders mention poverty and low population density – the latter having huge impact on both distribution and transmission costs. Despite low tariffs (that are financially unviable), rural customers find it difficult to afford connection and subsidies are often used to overcome this barrier. To find a level appropriate both for satisfying consumers and encouraging private sector incentives in the energy sector is difficult. For off-grid, all stakeholders agree that diesel generators are costly and unreliable, but where grid extension is not economically feasible, off-grid solutions are necessary for political goals to be attained.

Also in Mozambique, political ambitions are considered the main driver for RE, for social and economical reasons. EdM regard RE as means to slow urbanization, providing better health care and education, and lower birth rates in rural areas. The lack of industry poses a barrier as

RE is not commercially viable and in comparison to Tanzanian agencies the emphasis on prevalent economical potential and productive use are seemingly not used as a strong indicator of where to direct RE. New generation is needed; Mozambique is depending on the large hydro plant Cahora Bassa and long distances leave most of the country without power. Another recognized barrier is that private actors find it hard to compete with Cahora Bassa's cheap electricity. The energy sector is top-down oriented and donor dependency creates problems in budgeting; the budget becomes more of a wish-list than a planning instrument. Diesel generators are very common for small-town electrification and rural off-grid systems but very costly and unappreciated. There is a good hydro potential but virtually no expansion have been implemented since colonial times. FUNAE has a major mission carrying out off-grid throughout the country but is still a rather limited and new organization. Off-grid barriers are high costs of diesel, logistics (incl. spare-parts), and communication with costumers due to bad infrastructure. For sustainable off-grid solutions, a technical support system is needed to facilitate maintenance, and most probably there are huge benefits waiting in micro hydro power. Local people's engagement is important but variable, according to FUNAE, impacting off-grid system sustainability. Along the coast, the occurrence of cyclones destroys infrastructure and impedes investments.

In comparison, the two countries face similar challenges with low population densities, weak customer bases, large distances and inadequate infrastructure. While domestic actors regard social demand as an important driver for RE this view is less pronounced by the foreign actors who rather regard the (lack of) economic demand as a barrier. At the national level, both countries rely on external funding for RE, but low institutional capacity and quality – both countries suffer from corruption and politically motivated but economically unviable plans– hinder efficient implementation and use of funds. There is political recognition that grid extension needs to be complemented by off-grid solutions, but the responsible agencies are yet to become fully operational.

The drivers and barriers identified in this study are largely corresponding to those in the literature, as can be seen in Table 2. However, the problems associated with donor dependency and how this impacts budgeting and implementation comes out as important constraints for both countries, which is not discussed in any detail in the RE literature. Institutional weaknesses are often discussed in terms of bad governance, but in Tanzania the lack of correspondence between local realities and donor criteria for RE projects also create institutional barriers. In this study it further found that traditional building techniques (using mud and grass) in rural areas slow down connection rates; a barrier not previously emphasized. All stakeholders turned out to share a view on diesel generators as expensive and unreliable. Here, appropriate RES could assist but the interest among stakeholders is weak. A barrier with certain relevance for the region is the reported lack of complementary services and co-investments to accompany RE. Here, Tanzania seems to have taken more account of recognizing other rural development when carrying out RE. In sum, our results support earlier findings but complement with country-specific drivers and barriers. To be remembered, importantly, RE takes decades to implement even in the wealthiest country; due to strong political ambitions, donor support and an accumulating experience among stakeholders the rate of electrification is keeping up in both studied counties.

The methodological weaknesses are primarily due to time constraints and a follow up on sector development over the coming years would improve credibility of finding. This study provides an assessment of drivers and barriers to RE that is broader in scope and more detailed than earlier writings, and provides an excellent basis for cross-country comparison

and in-depth studies for each country. It is also valuable for stakeholders, such as donors, consultants and policy makers, to gain overview of challenges to address.

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