CHALMERS

# Assessing the Potential for Directing Electrification Towards Productive Use in Rural Mozambique

*Master of Science Thesis in the Master Degree Programmes:*

*Technology, Society and the Environment*

*Industrial Ecology - for a Sustainable Society*

NIKLAS JAKOBSSON
CARL KARHEIDING

Department of Energy and Environment
*Division of Environmental Systems Analysis*
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden, 2012
Report No. 2012:2
ISSN: 1404:8167

# Assessing the Potential for Directing Electrification Towards Productive Use in Rural Mozambique

NIKLAS JAKOBSSON
CARL KARHEIDING

Environmental Systems Analysis
Department of Energy and Environment

CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden 2012

Assessing the Potential for Directing Electrification Towards Productive Use in Rural Mozambique
NIKLAS JAKOBSSON
CARL KARHEIDING



ESA report no 2012:2
ISSN: 1404:8167
Environmental Systems Analysis
Department of Energy and Environment
Chalmers University of Technology
SE-412 96 Göteborg
Sweden
Telephone + 46 (0)31-772 1000

Cover:
The top picture shows houses from a typical Cabo Delgado village, the electricity grid passes close by, yet the houses remain unconnected. The left picture shows a miller with his electrified mill. The right picture shows a sawmill in Diaca

Göteborg, Sweden 2012

"'Don't let them take your spare parts"'

-Nicoleta

## Acknowledgements

This thesis would not have been possible without the support we have received from a large number of people. We are thankful to SIDA, ÅF, Chalmers Vänner and Ingenjörer Utan Gränser (Gothenburg chapter) for supporting us economically. We are thankful to all our respondents for welcoming us and taking the time to answer our questions. We would like to extend special thanks to the following people for their friendship, help, and encouragement during our time in Mozambique: Erica Beuzer, Prof. Boaventura Cuamba, Rickard Ehnsiö, Kajsa Johansson, Gerhard "'Pelle"' Berger and Sergio Santimano. A person we are especially grateful to is Mr. Fernando Iahaia who spent many days traveling with us and supported us in our work during the field survey. We would like to thank Mariena Teixeira for her invaluable help and collaboration during the preparation of the project and the field work.

Finally we want to thank our supervisor Linus Hammar for his unwavering optimism and encouragement even when we seemed to have lost our way.

**Abstract**

It is generally accepted that electricity brings a number of social benefits such as better health-care, better education, increased security due to street lightning and lower household expenditure due to a cheaper light source. Electricity is also expected to bring economic benefits in the form of income-generating opportunities, this happens less regularly and it cannot be expected that production springs from the ground once electricity arrives to a region; a larger understanding of the connection between electrification and its effect on production is therefore needed.

Our Master of Science thesis describes the methodology behind, and the results of, an 8 week field survey on the connection between rural electrification and productive use carried out in the province of Cabo Delgado in northern Mozambique. The idea is to investigate if existing production can be utilized as an anchor for electrification in the sense that it can either provide a strong consumption basis to increase the economic viability for grid extension, or if it can be utilized for larger income-generation when electrified. The project springs from an idea in the scientific literature to identify productive activities in rural settings and utilize them as anchors in the described sense. Specifically an electrification project in Ribáuè district in northern Mozambique is frequently cited as a success story when utilizing productive use in electrification processes.

The results show that there are not enough, or large enough, production units on the country-side in northern Mozambique for any of them to be utilized as an anchor in the hoped sense and thereby that the example from Ribáuè is not reproducible generally. The only wide-spread type of production is milling, this activity is too small to generate any substantial incomes from the electric utility and its income-generating effect for a village is, compared to the number of inhabitants, limited; larger activities are limited to one cotton factory, two cashew nut processing factories, a couple of saw mills and a couple of salt production sites (excluding tourism). The cotton factory is the single most substantial electricity anchor, both from supplier perspective and due to its income generating effect on the local people.

Finally, to effectively utilize productive use for income generation, we give the recommendation for a multi-cooperative effort between the government, foreign aid institutions and NGOS to spur simultaneous creation of infrastructural, complementary service and additional business project expansion. In the light of this recommendation, the emphasis on existing production represents a shortcut that we do not feel is possible to take in northern Mozambique.

# Preface

This master thesis investigates the possibility to utilize productive use when performing rural electrification in a specific case study. The case in question is the electrification of the province Cabo Delgado in northern Mozambique. The presented results are based partly on literature reviews performed in Sweden and partly on the results from a field study in the Mozambican capital of Maputo and the countrys' northenmost province of Cabo Delgado. The field study has been performed under the framework 'Minor Field Studies' initiated and supported by the Swedish foreign aid agency (SIDA). The project has been developed in collaboration with the research group STEEP-RES based at the department of Energy Systems Analysis at Chalmers University of Technology, Gothenburg, Sweden; as well as the Faculty of Sciences, Universidade de Eduardo Mondlane, Maputo, Mozambique. The field work was performed in collaboration with Ms. Mariena Teixeira from the University of Tokyo, Japan.

All aspects of the field work has been performed collaboratively between the two authors of this report; report-wise, Niklas Jakobsson is the main author of the preface, introduction, background, method, discussion and conclusions chapters; Carl Karheiding is the main author of the theory and results chapters.

## Abbreviations

- EDM: Electricidade de Mozambique, National power utility.
- h: Hour
- Hp: Horse power, effect unit
- kVA: kilo Volt Ampère, effect unit
- kWh: kilo Watt hour, energy unit
- LPG: Liquified Petroleum Gas.
- MFI: Micro-financial institutions.
- Mt: Meticai, Mozambican currency. Exchange rate for the summer 2011: 1 Mt = 0.03 Euro. 1 Euro = 34 Mt
- NGO: Non-governmental organization
- SIDA: Swedish International Development Cooperation Agency
- USD: United States currency

# Contents

# 1 Introduction

Electricity is recognized as a necessary, although not sufficient, prerequisite for enabling social and economic development in the developing world. The use of electricity in rural areas of Mozambique is generally low; far below 5 % of the rural population have access to electricity and supply is lacking at many institutions such as schools and hospitals. Current electrification rates are low and some areas will not be electrified in a foreseeable future [3]. In relation to this, the World Bank has requested to include industry and the private sector in electrification processes throughout the developing world. The interest from these actors has however been low since rural electrification is perceived as a loss affair. Despite the recommendation from the World Bank, Mozambique has chosen to neglect suggested power sector reform mechanisms (structural unbundling of EdM) due to unfulfilled expectations in other Sub-Saharan African countries [1].

The rural electrification in Mozambique today occurs both through grid extension (to a large degree supported by Swedish foreign aid), and through local off-grid solutions such as diesel generators, and off-grid solar systems. The current electrification practice aims at evenly electrifying the countryside, with a major and almost fulfilled ambition to electrify all district capitals [2]. Still there have been problems with maintaining implemented systems, particularly regarding off-grid electrification. In many areas electricity consumption is low, disabling the electricity companies' ability to afford maintaining the grids and/or off-grid systems. Furthermore, the general effects of rural electrification over income is unclear at best. Nevertheless there are successful examples and in some cases electrification has been successfully directed towards areas with productive use, which means that there will be an increased economic output from electrification [3]. This induces further electricity use which will enable continuous maintenance of the electricity system and securing that electricity is available for the rest of society (e.g. schools, hospitals, homes) when they can afford it, even though population density might be low and the population poor.

Specifically Mulder and Tembe [3] describes the electrification of a cotton factory in Ribáuè district, Nampula province, Mozambique. The Ribáuè case has been put forth as a splendid example of when rural electrification has led to not only social benefits, but also economic ones, (direct) poverty reduction and income generation for the rural population [3, 4]. The authors suggest identifying similar existing production activities and utilizing these for reaching economic benefits when performing rural electrification in developing countries.

Productive use has widely been accepted as an important component for improving benefits of infra-structural development such as electrification [5]. Rural electrification in Brazil has taken a clear focus on productive use [6] and in Bangladesh a focus on productive use was key to achieve success of a rural electrification program [7]. However, in the scientific literature the actual potential for connecting rural electrification with productive use has not been thoroughly dissected with aspect on the low-capital sub-Sahara African countryside in general or Mozambique in particular. Mulder and Tembe perceive their example as generic, but such assumption might not be evident when taking the perceptions from local actors into consideration [8]. The aim of this study, is to understand if this example can be reproduced throughout rural Mozambique and if the involvement of industry and the private sector in rural electrification in the developing world is realistic in countries with low rural production.

Based on the above, the research question is defined as: *Would an emphasis on electrifying existing production activities lead to substantial*[1] *increases in direct*[2] *income generation in rural Mozambique?*

## 1.1 Scope

As in all societal studies, the delimitations necessary to make are substantial. The over-arching goal here is to enable development through a specific type of income generation by focusing on existing production when performing electrification. Thus, assessment of a number of (development) related issues have already been excluded from the study, these include:

- Formal institutions, such as a relevant and reliable legal framework that enables development and is stable across time in order to create trust and allow for long-term planning and agreements.
- Informal institutions, such as corruption, power division, inequalities, respect for the legal system, etc.
- Financial capabilities among the private sector and the state. Access to markets able to receive increased amounts of production.
- Education, knowledge-level and spirit of entrepreneurship of the general population.

[1] In the same order as the Ribáuè example.

[2] Indirect income generation would be the effects of increased education, safety and health care that comes with the social benefits of electrification, these are not assessed in this study.

It is important to keep these delimitations in mind in order to understand the theoretical context of this study. Furthermore, there are delimitations in the resolution of the assessment for productive use and how the investigation is carried out, these are further discussed in the methodology section.

# 2 Background

This section gives some background to Mozambique and its energy sector, it also outlines some arguments for and against the World Bank initiated power sector reform and describes some previously given advices in relation to Mozambican rural electrification.

## 2.1 The Energy system in Mozambique and its development

Geographically Mozambique is situated along the East African coast to the west of Madagascar and bordering South Africa in the south. The capital, Maputo, is situated in the far south of the country, in the north west lies the Tete province where the Cahora Bassa, a hydro power dam, which currently is the (more or less) only source for grid based electricity, is situated. For a map of the grid as it was in 2004 [9] see figure 1). Mozambique is divided in 16 provinces which in turn are divided in districts and at the lowest level administrative posts (posto de administrativo). Every district have their own district capital.

Mozambique was a Portuguese colony for a couple of hundred years, it gained independence in 1975 after a decade of independence struggle supported by Tanzania, it however quickly fell into a civil war which lasted until 1992. Today the official language of the country is Portuguese which is being taught in school for three years. In their homes, people in general speak one of the about a dozen local languages that exist in the country.

Most of Mozambique's power infra-structure (along with other infrastructure) were destroyed during the civil war. Since the end of the civil war, the infra-structure has continuously been re-built with foreign aid. Almost all of Mozambique's grid electricity is supplied by Cahora Bassa, a large hydro power dam commissioned by the Portuguese in 1975, the current output of the dam is in the order of 2 GW, about four times the power usage of Mozambique, the rest is being exported to South Africa. It should be noted therefore that Mozambique's electrification challenges are somewhat different compared to most other African countries where not enough power is being generated. Mozambique's challenges lies with transmission and distribution[3]. Another unique aspect of the Mozambican electricity sector is the, comparatively, very cheap electricity price due to Cahora Bassa[4], prices differ with

[3]Generation could also be improved in the sense of geographical diversity of different sources, it would be good with generation capability in the north, in case the grid backbone breaks in the middle of the country, the whole north goes black.

[4]Of course only for grid connected electricity.

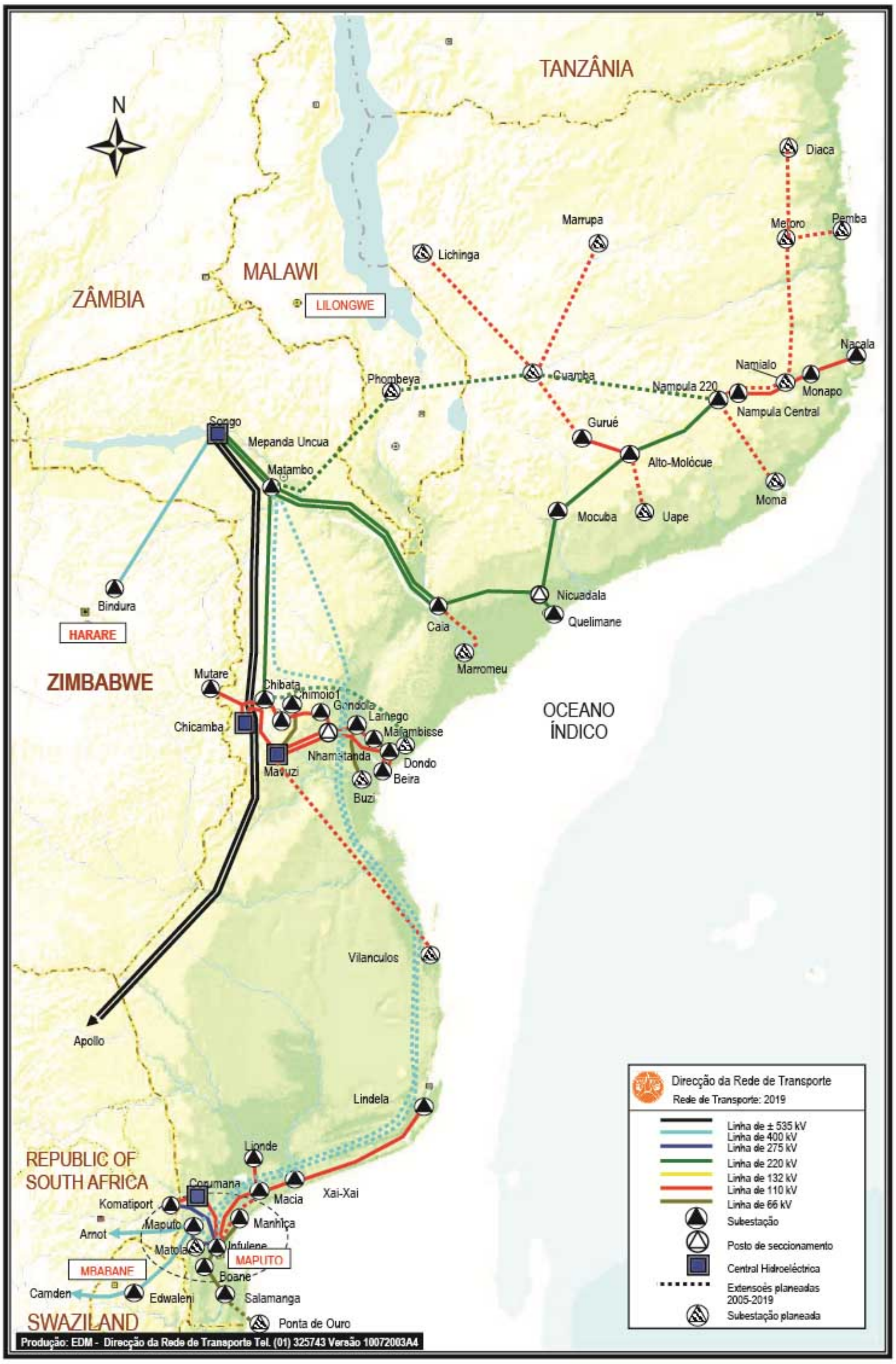


**Figure 1:** A map of the Mozambican backbone electricity grid of 2004. Source EdM

the type of tariff, but the domestic tariff lies on 2.5 Mt/kWh with the social tariff and high consumer tariff being less than half of that (prices are from 2011) [10].

Mozambique has a national power utility, EdM (Electricidade de Mozambique). This utility is responsible for all practical aspects in relation to the distribution of grid electricity. To their help, they have policies developed by the ministry of energy (often in collaboration with donor nations who fund all of the rural electrification in the country) and a group of foreign consultancies who help to develop plans for electrification.

While EdM only deals with grid connected electricity, there is another entity, Funae (Fundo de Energia) who is responsible for off-grid electrification solutions. There has been many diesel generators placed in remote locations (not reachable by grid) to supply electricity. These have received substantial criticism due to their expensive nature and, very often, unsuitable capacity for their operating area[5] [11]. Besides diesel generators, solar PVs has been in focus for Funae, whilst micro hydro has so far been pursued to a lesser extent. Various stakeholders in Mozambique has expressed a low interest in wind power [11].

The energy system in Mozambique, as well as many other aspects of the Mozambican society is affected by a number of factors related to its development status. Corruption levels are high resulting in a troublesome business climate, low enforcement of rules and regulations, and unreliable institutions (Mozambique was rated as the 120th country out of 182 on Transparency Internationals Corruption Perceptions Index 2011 [12]). Low knowledge levels combined with lack of business traditions and extremely low financial capabilities result in a low level of entrepreneurship in rural regions. Mozambique has a very skewed demographic pyramid with a median age of 16.8 years [13] which also yields a low work force compared to the total population. On top of this comes health problems with HIV and Malaria. HIV infection rates are 11.5% among the adult population [13].

## 2.2 Power Sector Reform

Power sector reform is a concept that was introduced in the 1970s by the World Bank and has since then spread widely and became in the 1990s a standard approach in power sector development [14]. The main reason for reforming the power sector was the reported bad performance the sector had due to (especially in developing countries) frequent government interventions

[5] Very often, the capacity installed is too big, so that too much energy is generated at a given time point compared to the amount of demand at the same time point.

[15]. Even though reform may be done in many different ways, the main and most prevailing one that has been used is privatization of the energy sector. Two common terms used in the privatization scheme is horizontal and vertical unbundling of the sector. Vertical unbundling refers to privatization as well as structural change in the sense that national power utilities are unbundled into separate generation, transmission and distribution entities. Horizontal unbundling refers to geographical subdivision of the national power utility into smaller provincial or district utilities [15].

The World Bank has actively promoted power sector reform in developing countries with the expectation that this will result in improved utilities, this argument has historically been well accepted among developing countries who has gone to various lengths for reforming their power sector. The direct changes the World Bank supports among governments in developing countries are stated as: [16]

- improve corporate governance and commercialization of state-owned energy companies;
- establish competition in energy markets through market-opening and gradual liberalization;
- strengthen utility management and operations to underpin efficiency, quality of service, and financial sustainability;
- increase private sector participation in the energy sector;
- strengthen and expand the electricity networks to maximize the benefits of electricity trading; and
- support generation, transmission, and distribution projects through its full range of financial instruments (loans, guarantees, equity investment, etc.)

Power sector reform has, however, received substantial criticism [14, 15, 17]. The critics argue that a reformed power sector will be unable to provide extended coverage since pure transmission utilities never can be economically viable. Further they argue that there is no society, rich or poor, in which rural electrification in the form of extending electricity coverage can be considered a win affair due to the long distances and few customers. This is especially true in developing countries where the rural inhabitants not only are few, but also, often, very poor. Since grid extension in many countries have low rural coverage (in rural Mozambique less than 5% of the inhabitants have access to electricity [8]), rural electrification is perceived as one of the major challenges of the energy sector. Furthermore critics argue that power sector reform may be the way forward for nations that are developed and have good electricity coverage, but that it is not a natural step for developing countries with low electrification rates, [17] states that: "‘Evidence from other developing countries indicates that high rural electrification levels have been achieved when rural electrification initiatives preceede major market-oriented reforms such as privatization"’, hinting at the need for complementary policies to the reforms. In the case of the developed countries it can be noted that they often had strong subsidies for grid extension in rural regions and reached a near 100 % coverage before any reform mechanisms were put into place.

In eastern Africa, power sector reform has progressed slower than in other regions [15]. In the case of Mozambique, the national utility EdM has a horizontally unbundled structure with a central office who (in collaboration with consultancies and the ministry of energy) makes a master plan for the country's electrification while the district offices puts this master plan into action by deciding more directly which areas should be electrified. EdM describes themselves as a "‘government-owned limited liability company"’ a transition to which they made from a "‘state entity"’ in 1995 [18], hinting at a degree of commercialization compared to earlier management forms. However, Mozambique has had plans to perform vertical unbundling of EdM and concessioning the distribution company to a private concessionaire, a plan which was abandoned in 2005 due to bad experiences from privatizations in other countries [1].

The rationale behind privatization requires that there is an existent, independent and sufficiently large market that can drive electrification from its different perspectives (generation, transmission and distribution). There is evidence that only the generation side has been successfully ran privately in developing countries [14, 15, 17]. If power sector reform to its fullest extent can be successfully implemented in Mozambique, it requires financial incentives in terms of customers with high buying capacity, a question is if the market in Mozambique is ready for this reform?

## 2.3 The Ribáuè electrification project

In the scientific literature it is well known that electricity on its own cannot generate development [19, 20, 21]. Specifically [21] states that:

*"‘Electricity can stimulate development that is already taking place. It will not initiate development"’*

As can be seen in the case of power sector reform, the world bank has a strong belief in utilizing production and market based mechanisms alongside electrification for promoting development. Also among local stakeholders in Mozambique it is frequently stated that productive use is a thing they prioritize when doing rural electrification [11].

In relation to this, Mulder and Tembe [3] has investigated the effects from the electrification in the Ribáuè district in Nampula province, Mozambique. They found that the benefits of the electrification project outweighed the costs within a few years and that the re-opening of a cotton factory in the region was key to the high benefits achieved[6]. One of the conclusions and a main recommendation of the study is that rural electrification can be commercially viable and that the government of Mozambique should impose policies to promote anchor projects and look for key customers as a key part in their rural electrification strategy. The authors perceive the electrification of Ribáuè district as a typical example of rural electrification in Mozambique. With experience from the Cabo Delgado province, it shall be shown here that the case is, in fact, atypical.

[6] Other benefits were mainly of social character transformed to monetary terms through various reasonings, some of these benefits lite decades into the future (increased salaries from education).

# 3 Theory

In this section will the definition of productive use, complementary services assisting electricity, the definitions of supplier anchor and social anchor be explained. It will further be described the effects of using grid or off-grid electricity and what effects it brings. The pre-paid Credelec system chapter shows in what way a pre-paid system can help the rural electrification for spatial users.

## 3.1 Productive use of electricity

In 1992 the Club of Rome defined productive use of energy as [22]:

> *In the context of providing modern energy services in rural areas, a productive use of energy is one that involves the application of energy derived mainly from renewable resources to create goods/or services either directly or indirectly for the production of income or value.*

In the context this study is interested in electricity in particular and its *direct* application to productive use, furthermore has the productive use aspect been separated from sources of electricity (renewables in Club of Rome case) and instead study the electricity source aspect separately from the productive use aspect.

From here on the following meaning of *productive use of electricity* is intended:

> *A productive use of electricity is one that involves the application of electricity to create goods/ or services for the direct production of income or value.*

Since the aim is to investigate productive electricity use which could anchor electrification in a region this study is only interested in types of productive use that increases the wealth of a village (bringing money into the village to pay for the electricity).

## 3.2 Type of productive use

Productive use of electricity in the sense of increasing production may essentially be broken down into three different types, these are:

- Increasing working hours: Happen primarily due to lightning, but possibility to store fish as well as stabilizing electricity supply may be considered to belong in this category.

- Reducing expenditure due to cheaper electricity source, note that this increases monetary income, but may not increase production per se (thus measures in both money and production quantity may prove necessary).

- Increasing *productivity* by utilizing electrical appliances.

For reference as well as understanding of the impact of electricity on production, an attempt to classify production (with aid of electricity) according to the above definition will be done.

## 3.3 Complementary Services for electricity

Complementary services can be defined as:

> *"'Services that accompany the same product or system and support its acquisition, installation, usage, maintenance, and disposal."'[23]*

and refer to the surrounding systems that is needed or could help the use of a specific product or service in a specific environment.

By introducing complementary services together with electricity in rural regions will latent demand develop and the use of the electricity can pay for it self according to Ranganathan [19]. Rangathan mentions access to credits, roads and communication as important complementary services and points out that electricity alone cannot create development if other complementary inputs are missing.

In this section will focus be put on complementary services enhancing the use of electricity in a direct matter, other services complementing the community in case of water, schools, hospitals etc will not be discussed.

It must be mentioned that in rural Mozambique are the preconditions weak and what could be taken as granted in the western world may not exist. The use of electricity is in many cases a new experience requiring additional information for consumers.

### 3.3.1 Micro-financial institutions

Many of the districts has no formal access to a banking system [24] which hinders potential customers to afford to connect to the grid. The connection fee can even with subsidies be high for households or small enterprises that they would requirer to save money for several months before they can afford the connection fee. With the ability to save or loan money would the impact of the investment be less significant at a specific time [5].

Micro-financial institution is one complementary service that must come along with the power distribution to give small enterprises the ability to connect to the grid and invest in machinery. From a survey performed in Benin it was found that even though the health centers had access to electricity their economical support where lacking and they had no ability to acquire electrical equipment [5]. This is one example showing the importance of both technical and financial support at the same time.

### 3.3.2 Information

Information is needed in all instances during the electrification process. The potential customers must understand how electricity can help them both technical and economical but also which new costs occur and must be paid for. There are critics against the information from EdM regarding costs at household level where customers not have understood that bills had to be paid [25].At the same time must the electricity supplier understand what the consumers need and how the electricity will be used.

For enterprises must the potential of electricity be enlightened to make the customers see why they should invest in electricity and how to use electricity in the best way [5]. For example enterprises changing energy source in a productive way could enhance their production or save money by switching to electrical appliances instead of using traditional sources of energy for lightning or power. This could also mean that changing from traditional fuels to other more advanced fuels could have the same effect as electricity. It could mean changing to LPG or charcoal instead of firewood for lightening or heating. Customers also lack information/knowledge of costs and can therefore not efficiently plan their economy. The costs of using traditional energy sources as candles or oil lamps for lightning are substantially higher compared to the use of electricity for the same purpose [26]. Studies have shown that in some cases has electricity not been efficiently utilized and old appliances have been in use even after grid connection has been installed. The customers are not aware of the costs of using a radio with dry cell batteries instead of using the radio with grid electricity or in some cases is an investment needed to connect the radio to the grid [5]. In a study performed in Benin the results shows that even after the introduction of electricity households consumes 3 liter of kerosene per month compared to 8 liter before electrification [5]. At household level have the lack of information for example where to install switches affected the use of electricity and customers continued to use traditional light sources that easily could be operated from the bed [5]. A sub-optimization that could have been avoided with better information to the worker installing electricity in a house that would have resulted in a greater electric usage and economic savings for the costumer.

### 3.3.3 Communication

Cabo Delgado suffer from bad roads connecting rural villages with the main road. That hinders transportation and the ability to interact with other villages and markets. By enabling transportation between villages and share information on prices in close by regions could the market horizon be extended and interconnection between villages could increase the trade. Roads do not only effect export from the village but also offers the possibility to receive spare parts/equipment and other goods from surrounding villages [5]. Road constructions are common in combination with distributing electricity but roads must as well be served to enable trade between villages for longer periods. In Cabo Delgado are only main roads paved which results in over all bad road quality that hinders transport.

## 3.4 Credelec, a pre-paid system

Since 1995 has EDM been working with the pre-paid Credelec system [28]. The Credelec systems offers the consumer to by credits in advance to pay their bill in a similar manner as the credits bought for cellphones. The prepaid system has higher demand in structure then the regular billing procedure but has positive effects that are likely to reduce the costs in the short and medium time span also for the supplier [27].

> *Life-cycle costing studies have shown that prepayment is now proving a more cost-effective option of system operation then billed system for Eskom[7], at least in the short- to medium-run period [27].*

The Credelec system is likely to be a way of helping the poor to connect to the electricity grid without having problems with using more electricity then they could pay for in the end of the month. It also helps the electricity company reducing their costs for collecting the payment.

The Credelec system requires a stable connection between the prepayment meter and the mainframe computer at the electricity company. Both the extra meter and the cable and connection to the supplier ad up extra costs for the electricity connection compared to an regular connection where a monthly fee is paid. The advantages of using the prepaid system is how

[7]Eskom is the organization responsible for producing and distributing electricity in South Africa.

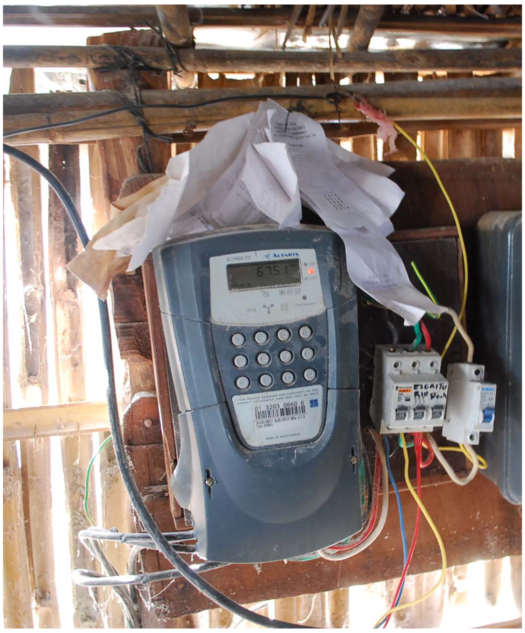

**Figure 2:** A Credelec terminal in use in a mill.

the consumer easily can manage the costs of electricity and when the credits are consumed will no additional costs occur.

From the supplier side has the Credelec system the advantages of no requirement of collecting bills or handling unpaid bills. In the study performed in South Africa has the risk of violent customers been mentioned as one thing that is less problematic with the pre-paid system compared to the ordinary system [27].

In many cases is the fact that the insecure income hinders the poor for installing electricity. Using candles is one way to not exceed the costs for light. In the Cabo Delgado Baseline study it has been noted that the cost of candles for shops can be as much as 600 Mt/month, this compared to use modern electric lightning of a cost of 5-6 Mt/month [26]indicates that if Credelec would be available to a lager extent there would be a potential to connect spatial users using low amounts of energy.

EdM has a stated on their homepage an ambitious goal where 78 % of the electricity connsumers late 2020[8] will use Credelec [28].

In the article of Tewari and Shah [27] the Credelec system is said that it helps the customers to better understand the relationship between the use of

[8]"'By late 2020, the CREDELEC system reached a universe of around 671.322 clients, which represents 78 % of the consumers of electric energy."' [28].

energy and the costs of using the equipment. The Credelec also eliminate the problem with the time and costs of disconnect and reconnect clients in those cases when the customer not have the ability to pay the bill. The reconnection acts immediately after new credits have been activated. Prepaid systems are now in use in several developing countries but also in United Kingdom, United States and South Africa.

## 3.5 The effect of using off-grid or grid connection

Rural areas could either be electrified by grid or for remote locations by off-grid. Apart from the technical perspective will the two options include or exclude other opportunities. The main discussions when choosing between the two of them is in general costs versus social benefits. The World Bank criticizes the use of off-grid systems and finds the investments hard to economically motivate where grid connections has higher economic rate of return [29].

What is worth to be noted is the running costs for grid and diesel. For grid are the costs between 1.07-4.64 Mt/kWh [30] compared to the cost for diesel that in the summer of 2011 cost around 50 Mt/liter in Cabo Delgado. (The energy content in diesel is 9,7 kWh/liter [31] resulting in an optimal theoretical cost of 5,15 Mt/kWh. It is not likely to assume that it is the case for small diesel generators).

### 3.5.1 Off-grid solution

Off grid solutions is primarily used in remote locations where small amounts of electricity is used and relatively high cost per kWh is accepted when no other alternatives is available.

The most common technology in Cabo Delgado is the use of diesel generators by single consumers. The advantage of using diesel generators is the ability to easily manage the running costs, the owner is not dependent of any other instance or availability to afford a grid connection. On the other hand are the running costs higher compared to grid electricity as shown in section 3.5. Lack of maintenance due to unawareness or no available spare parts causes the engine to break down. Transportation of diesel is another problem. When distribution fails either because of no traditional logistic problems or weather conditions hindering the transport the generator can no longer operate [26].

Funae is a public institution that works with off-grid solutions covering entire villages with electricity. When Funae choose to use diesel generators are the problems the same as above but also difficulties of who should pay for the diesel occurs. With Funae projects will more then single users have access to electricity, for example street lights, schools and hospitals can utilize the electricity but also productive units [32]. When different actors are interested in the use of electricity does other problems turn up. During day time is the use of electricity for lightening not common. Street lights and lightening for schools are usually running after working hours. This requires the generators to operate with low load and most significant without income generating activities running at the same time. Rural areas are poor areas where taxes for public lightening is hard to collect and when no productive use is operating are the question of who should pay hard to solve [26].

### 3.5.2 Grid connection

Grid connection is in many cases the most preferable alternative for the consumer due to low cost per kWh compared to the cost of diesel. Even if grid connection is desirable do remote consumer experience bad quality of the electricity [9] that may damage equipment. The costs for providing grid connections to remote areas is also very high. The supplier side also have to deal with collecting bills and connect/reconnect customers, something that is difficult and time consuming in remote areas. Specially when the bill it self many times can be worth less then the cost of collecting it making the costumer a loss affair for the electricity company [27].

Even if the grid electricity is seen as preferable by most customers was unsatisfaction noted when talking to customers. The long path from the generation in Cahora Bassa results in bad electric quality. One customer insisted that due to bad quality of the electricity had several of his mills been damaged.

## 3.6 Anchoring activity

In several articles has the term anchor or anchoring activity been mentioned [3, 4, 26, 27, 33]. The basic idea of an anchor is to stabilize and secure the use of electricity in a longer term. It has been found that different authors have used their own and many times weak definition of what an anchor is. In this section will different definitions be examined and similarities and differences be enlightened.

[9] Bad electrical quality can be identified by unstable voltages and an unstable frequency from the grid.

### 3.6.1 The supplier perspective of an anchor

The suppliers greatest concern regarding anchors for electrifications is the cost for distributing the power versus the income from consumers. In many cases is the extension of the grid a loss affair in monetary terms. In a report from Vattenfall Power Consultant [34] are anchors mentioned from the perspective of suppliers.

> *If an electricity-intensive business is available - a so called "'anchor users"' - it is more likely that the energy service business is also able to cover recurrent costs and recover investment. Sufficient revenue to cover costs and reinvestment needs, along with market infrastructure to ensure quality and continued service delivery is key for sustainable market-based rural energy provisions.*

To define activities as anchors from the supplier side focus is put on the ability to have a reasonable payback time that can secure the income and make sure that the investment is profitable. Meaning that the consumer will for a stable future consume rather high amount of electricity.

Few activities have on their own the possibility to be defined as an anchor from the supplier side over all due to high costs for extending the grid. Even just finding consumers that covers maintenance costs are unlikely to find i remote areas where the additional length from last stable connection point can be far. It is even more unlikely to find an anchor that has big demand of electricity in remote regions that lack other services such as roads and infrastructure.

What can be found in remote areas that can carry the costs are mega projects (for definition of megaprojects see section 3.7). Examples of mega projects are oilfields or mines, large activities that also can cover costs for other infrastructure and has a specific geographical nature that hinders them to place their activities at already structured places [35].

One can see that in this context is the author of the quoted report[34] more interested to see how the anchor projects can work in a way favoring the supplier side. This is just one point of view of the wanted features of an anchor for electricity. The other perspective concern in what content the electricity can benefit the consumer and villages receiving electricity in a social way.

### 3.6.2 The social anchor

Anchoring activities are important for the local communities for stabilizing the use of electricity. In this case may the advantages be different from the suppliers point of view. In the social anchor focus is put on income generation and positive social effects.

In the article by Mulder and Tembe [3] can the following be read about anchor projects

> *These "'anchor projects"' are supposed to create economic dynamics by establishing linkages with other sectors, thus initiating "'trickle down effects"'.*

The trickling down effect ensures that the anchor spreads the benefits from electrification out through the society by interconnecting different stakeholders. In many cases it may not be evident that if an enterprise is electrified will automatically the surrounding region benefit in a direct matter. If a local owner saves money from the alternative energy source it is not evident that the owner will lower the prices for the customers or in other ways strengthen the village in the short run and should there for not be seen as an anchor.

Mulder and Tembe continues [3]

> *...anchor projects in the area of agroprocessing, like the cotton fabric in the Ribáuè district, do establish linkages across the local economy and contribute to increasing agricultural productivity and other grass-root economic development in rural areas, thereby potentially generating substantial positive long-term macroeconomic effects.*

The Ribáuè case shows an direct anchoring effect where different actors can benefit from the electrification of one single project. The cotton factory creates jobs and shares the benefits from electrification with the local inhabitants.

When looking at the effect of electrification described in the above quote where inhabitants in the village can receive benefits from the electrification the discussion about who should pay for the distributions costs alters. In this case it is not only the actual electricity consumer who benefits from the electrification but the society as a whole. In that case should not only the user be responsible for the costs of connecting the village to the grid. From a wider perspective does this mean that the costs of connecting an area should not be put on the consumer alone but also may be shared with the rest of the population by e.g taxes.

Mulder and Tembe talks about the consequences of anchors in their article "'Rural Electrification in Mozambique Is it worth the Investment?"' [33] where they talk about possible effects for the society even if the anchor is unlikely to have immediate trickling down effect. From the field study conducted by the author of this report (described in methodology chapter 4.1 in Cabo Delgado it was noted that in the city of Pemba was a price scheme signed by the majority of the mill owners. The scheme defined the prices for milling and did not make any difference between grid connected mills or diesel mills. In this case would not the benefit from electrification lower the costs for the customers visiting the mill, the lowered costs for the mill owner only resulted in additional profit for the owner. This could refer to the case Mulder and Tembe [33]discuss when the electrification could be seen as a subsidy similar to subsidies of roads that rather improves the development of the infrastructure then being a social anchor with trickling down effects.

### 3.6.3 Resulting Anchor

There is a demand to find a complete definition of an anchor that could be used in a wider sense when describing projects that could have potential for electrification. The problem in this case is the wide variety of wanted properties where economic and social benefits not always correlate. An activity that could have positive effects for the society may have a negative effect on the payback results for the energy provider and should in that case still be considered an anchor from the governmental perspective where the provider would disagree. For that reason will the term anchor from now on be divided in to Social Anchor and Supplier Anchor.

A Social Anchor has:

- trickling down effects, introducing electricity has greater impacts for more people then the one primarily affected by electricity.

A Supplier Anchor:

- Consumes electricity in such great amounts that the extra costs for extending the grid can be economically viable from the supplier side. The Supplier Anchor can either cover maintenance costs or optimally cover the costs for extending the grid from last stable connection point.

## 3.7 Definition of size for Enterprises

The following terminology has been used in this report regarding the definition of the size of an enterprise. The definition is based on Mozambican legislation [36] and is shown in Table 1.

**Table 1:** Clasification of industrial establishments [36].

| Category | Initial investment (USD) | Power capacity installed or to be installed (KvA) | No. of Employees |
|---|---|---|---|
| Large | Equal to or greater than 10.000.000 | Equal to or greater than 1.000 | Equal to or greater than 250 |
| Medium | Equal to or greater than 2.500.000 | Equal to or greater than 500 | Equal to or greater than 125 |
| Small | Equal to or greater than 25.000 | Equal to or greater than 10 | Equal to or greater than 25 |
| Micro | Less than 25.000 | Less than 10 | Less than 25 |

According to the legislation is a company defined as the largest category where at least two conditions are fulfilled.

In this report will also the term "‘*Mega project*’" be used. Mega projects, as mentioned by Mulder and Tembe [33], will refer to projects that do not lack fundings for realizing their project and can afford constructing complementary services on their own. Mega project is sometimes dependent on geographical conditions that hinders them from being located where infrastructure already exists. As examples can mines and oil fields be mentioned.

# 4 Method

This section describes the methodology behind the study. First a theoretical overview is given, then some practical issues impacting both the methodology and the results are discussed.

## 4.1 Methodological idea

The work was divided in three separate parts: (1) pre-study and literature review; (2) 8 weeks of field work; (3) analysis, further literature review and documentation. Step one and three were performed in Sweden and step two in Mozambique. Essentially, data collected are of three different types, the first type is stakeholder opinions obtained through semi-structured[10] interviews which were mainly performed in Maputo. The second is a mapping of existing production activities in Cabo Delgado obtained through structured[11] interviews with representatives of the district services of economic activities (Servico Distrital de Actividades Economicas) as well as representatives of the district administrations (Governo do Distrito). The third is data on the effects of electrification upon production activities, this data was collected by site visits on production units and structured interviews with their managements. In the case of the mapping of production activities, some cross-checks with existing literature and statistics are possible.

Interviews in Maputo were in general held in English while those in Cabo Delgado were in Portuguese. One of the project group members are of Portuguese-speaking origin and were responsible for holding the interviews in Cabo Delgado.

The goal of the study is to understand if Cabo Delgado has a potential for utilizing productive use of electricity from the two anchor perspectives described in 3.6, so how do one determine if an area has this potential?

There are two components to this, one is to understand what production activities exist, and the other is to determine their potential. The methodology for the first component has already been described, the methodology for the second follows now.

The basic idea behind determining the potential for productive use in non-electrified rural regions is to compare the output and costs of electrified activities and non-electrified activities.

[10] Semi-structured is characterized by having a defined thread for questions posed, but allowing the discussion to stray according to the respondents area of expertise.

[11] Structured is characterized by strictly following questions that are predefined and written on an interview sheet.

Note that there is a choice made here to compare *production units* instead of *villages* who are electrified or non-electrified. The alternative has the advantage of including measurements of activities that are created after electrification has been done[12]. It does, however, also carry a number of downsides, the major ones being that it is difficult to isolate the effects of electricity compared with other effects in small samples, it is also difficult to handle the time aspect, that is the fact that it takes time for technologies to diffuse in new environments and there is not enough samples to divide villages into clusters electrified at different time points (so electrified villages may not be comparable).

The full interview sheet used for production unit interviews can be found in the appendix, these questions were posed to the manager of the mill (most often the owner, in the case of associations, the questions were posed to the chairman of the association). The questions were initially developed during the prestudy phase, however the earliest visits to production units in Cabo Delgado were used to test the questions regarding understandability and answer frequency. The interview sheet was thus somewhat changed during the study. For the mapping of activities, the main question posed to obtain the data was: "“What type of economic activities do you have in this district?”", the respondent to this question was generally the head of the districts service of economic activities (in some cases, when this person was unavailable, the questions were posed to a employee at the same institution). It was also the answer to this question that determined if an activity would lie within the interest of the study. A general attribute an activity would need, is that it brings money into the district from outside[13] (and not just reallocates money within a specific district or village), thus, for example, local carpentries fall outside the scope of this study (these are also very small).

In total, 14 out of 16 district services of economic activities were interviewed, a total of 40 production units were visited (26 of these were mills) and 9 stakeholders were interviewed in Maputo (2 consultants, 2 foreign aid representatives, 2 representatives of EdM, 1 representative of Funae, 1 representative of the Ministry of Energy and 1 local researcher)[14]. Besides the

[12] Ideally, it would be possible to compare the distribution of production sizes in electrified vs. non-electrified villages. If, for example, non-electrified villages have similar production levels and the production level of electrified villages are distributed exponentially/linearly etc. you immediately have a direct and comparable measurement of productive use potential (though no clue on how to identify it).

[13] Note that most types of energy cost reductions fall under this category.

[14] It is the authors opinion that visits to the Ministry for Planning and Development as well as the Institute of National Statistics would have been helpful and relevant. This was however omitted due to lack of time.

project related visits/interviews, a number of activities to get a more thorough understanding of the country and its culture were performed. These included discussions with expatriates and locals residing in Mozambique, as well as a visit to an NGO based eucalyptus production project in Namaacha (bordering South Africa).

## 4.2 Practical methodological issues

Due to bad road quality it is very difficult to travel long distances in Cabo Delgado, availability of proper cars[15] for a reasonable price further discourages long-distance travels. For these reasons production unit visits have been restricted to the south-eastern part of Cabo Delgado, i.e. the districts of Pemba, P/Metuge, Mecufi, Ancuabe and Chiure.

For the mapping, several visits were made to districts administrations as well as district services of economic activities. For those who were not visited directly, many (representatives of services of economic activities) were interviewed during a province exhibition on economic activities held in Pemba in July. The combination of these two types of visits led to mapping of most of the districts in Cabo Delgado.

When making production unit visits (and also some administration visits) we were often aided by a representative of the Industry and commerce in Pemba. While this made it much easier to get around and get in touch with relevant people, it also may affect the respondents answers. In one case, we were accompanied by a local district administrator who directly interfered in the interviews and attempted to change the respondents answers[16]. In many cases it seemed likely that respondents did not know the answers to some of our questions and chose to answer in a way that seemed reasonable, further, it cannot be ruled out that respondents in some cases may have tried to identify what answers we were looking for and change their response accordingly. This should be kept in mind when reviewing data and it should be *well* understood that actual values may fluctuate widely from what is presented here.

The interviews with stakeholders regarding their opinion on productive use may, of course, be subject to errors in our understanding of the respondents opinions.

[15] I.e. cars who are able to run without at least one mechanic visit a day.

[16] The respondents answer was that he paid less tax than regulated and that his activity was unlicensed, the administrator attempted to change the answer to the correct tax level, as well as claim that his activity was indeed licensed.

# 5 Result

This section describes activities and the result. Each section (except for petroleum extraction) contains an information box. The information box gives a quick overview of the activity regarding size, typical number of workers, what kind of anchor it might be and how many activities that have been found. Most data presented in this chapter are the result from the field study performed in Cabo Delgado in the summer of 2011, see section 4.1.

## 5.1 Description of activities

The following activities are seen as income generating and were investigated to see how they fit in to rural development and primarily rural electrification towards productive use.

- Cotton production
- Petroleum extraction
- Mining
- Milling
- Sawmill
- Cashew nut factories
- Fish freezers
- Salt production

This study aimed at finding large and medium size enterprises that could be suitable for rural electrification strategies. What was noticed during the field study was the non-existence of larger unelectrified activities in the Cabo Delgado. Below will identified activities be described, even those categorized as small.

### 5.1.1 Cotton production

Cotton production is defined as a large industry and from Mulder and Tembe [3] it is known that the introduction of grid-electricity to cotton factories can make a difference for the company and the village where it is located. The result in this section is primarily based on an interview performed in Pemba

**Table 2:** Cotton production information as result from this report.

| | |
|---|---|
| Size | Large |
| Workers | 400-1500 |
| Anchor | Supplier Anchor & Social Anchor |
| Quantity | 1 |

with the only cotton producer in Cabo Delgado, Plexus [37] [17]. During the interview it was clearly stated that the investments needed for connecting the factory to the grid was high but with gird electricity was the cost for production dramatically lowered[18].

Cotton factories has high energy demands and in the case of the Montepuez factory were a separate substation required to not interfere with the surrounding village. The substation for the factory has the capacity of 1 MW.

Before Montepuez received grid connection the consumption of diesel was almost 3000 liters /day with a total cost of 90 000 USD/month, using grid electricity lowered the monthly cost to 15-20 000 USD.

Mulder and Tembe [3] finds cotton factories interesting from an anchor point of view. It is therefore interesting to see if there is a possibility for more cotton factories to open in Cabo Delgado. When this question where asked to Plexus on their view the answer was without doubt *No.*

Plexus is the only operator at the market and have the permission from the government to utilize the cotton production in Cabo Delgado. According to Plexus it is very unlikely that someone else would enter the market. At this moment is only two factories operating in the Cabo Delgado region (one is located in Namapa, outside Cabo Delgado, but geographically close enough to work under the same conditions) but a third have been operating a few years ago but was closed down. If an increase of cotton production would occur will the production easily, and cost effectively be raised in the two existing factories before re-opening of the closed factory would be considered. This makes an opening of a new cotton factory in a new location very unlikely for the upcoming 5 years. If new plantation sites would occur would the raw cotton be transported to any of the two existing factories.

This could be summed up as follows; Cotton factories could play an important role as an anchor but it is unlikely that more factories will open in

[17] Plexus is a cotton producer with exclusive rights for the concession in the province of CaboDelgado.

[18] ""The impact is not huge, it is massive!"" a quote regarding the effects of receiving grid electricity.

Cabo Delgado.

### 5.1.2 Petroleum extraction

In the North East parts of Cabo Delgado oil and gas fields have been discovered [38]. Several large companies is already in the offshore area and it is likely that more will join. Oil extraction are one of the mega projects that on their own can establish infrastructure to support projects. This report has not made any surveys regarding oil extraction due to its early stage. In the nature of mega projects could they be seen as anchors from the supplier side.

### 5.1.3 Mining

**Table 3:** Mining information as result from this report.

| | Mine |
|---|---|
| Size | Mega project |
| Workers | N/A |
| Anchor | Supplier Anchor |
| Quantity | 0 |

There is no mining activity at the moment in Cabo Delgado but a graphite mine in Ancuabe that was closed down a couple of years ago will re-open in a few years [35, 39]. The mine closed down for different reasons but it is expected that with grid electricity will the benefits from the mine be greater resulting in new speculations. There are also plans to open a mine in Mazeze. Mining is a high energy consuming activity, together with high revenues can mining be seen as a mega project that can afford complementary services for their production [35, 39].

Apart from graphite also marble production have existed in the region. There are geological preconditions in the Cabo Delgado region that may attract other mines in the future but at this moment is nothing planed [35].

### 5.1.4 Mill

The milling "‘industries’" in Mozambique are out of importance for local inhabitants in rural villages. Graining mill is traditionally done by hand, in most households is this the duty of woman [40]. In many villages does electrical or diesel-electrical mills exist. In general they are very small and out of interest for a study looking at medium and large enterprises but from a

**Table 4:** Milling information as result from this report.

| | Mill |
|---|---|
| Size | Micro-Small |
| Workers | 2-35 |
| Anchor | Social Anchor |
| Quantity | >800 |

social anchoring point of view could their existence be worth noticing due to their common existence and it is a productive service that exist i many villages. What is to be noted is the lowered costs per kWh for the mill owners when using grid connected electricity instead of using diesel[19]. However is the effect of the lowered costs for the customers unknown even if the mill owner can save money from a shift. Smaller mills has usually 2-3 employees. Within the city of Pemba does a few larger milling enterprises exist as well in some of the larger cities in Cabo Delgado. These are however in all cases they defined as small activities according to the definitions found in section 3.7. For Pemba city is grid the most common energy source for larger mills but at least one owner had two diesel-electrical mills as backup in case of power black outs. Larger mills have 10-35 employees depending on season and production.

#### 5.1.5 Sawmill

**Table 5:** Sawmill information as result from this report.

| | Saw Mill |
|---|---|
| Size | Medium-Large |
| Workers | 30-900 |
| Anchor | Supplier Anchor & Social Anchor |
| Quantity | 16 |

Out of 16 identified sawmills operating in Cabo Delgado has interviews been performed with two different ones [41, 42]. These interviews correlate in general terms and says that the potential for forestry industry in Mozambique is good but critics regards infrastructural limitations, problems with an unfair market and a business climate that could be better. Cutting timber in to

[19]This has been shown in interviews performed during the field study and could also be seen with rough calculations in Appendix C.

**Figure 3:** Traditional milling done by hand.

planks is preferable for transportation and is also required by Mozambiquan law if exported out of the country [42]. Rumors do how ever indicate that some export of timber do illegally exist which hinders a fair market.

Forestry industry requires both operators in the saw mill as well as workers in the field. For one company with 900 workers where 600 of them working in the field. That results in a somewhat similar trickling down effect as found in the cotton case due to high amount of workers and involving work opportunities in a larger area then just the location of the saw mill.

The location of saw mill differs. Some are located in already electrified areas, others are diesel driven and some of them are mobile and could operate in the field. Cost savings for using grid electricity instead of diesel power are of importance. That indicates that from an economical perspective there can be an incentive to locate a sawmill where grid already exist instead of being dependent on diesel.

The energy consumption for saw mills are rather high. According to the source is the costs for diesel three times the cost of labor making a grid connection having a big positive impact on the economy for the company. The shift to grid electricity resulted in savings worth 30-45 000 Mt/month [41]. The importance for the saw mill owners to cut the costs for energy can

**Figure 4:** The photo shows a common type of grid connected mill and a man milling. The construction of the mill is also common for diesel mills.

bee understood when the cost of diesel is almost three times the cost of the total salaries of the workers [41]To be noted in general is that a large part of consumed diesel for a sawmill can not be replaced by electricity, most part of diesel is used for cutting and transportation of timber.

### 5.1.6 Cashew nut factories

**Table 6:** Cashew nut factory information as result from this report.

| | Cashew nut |
|---|---|
| Size | Medium |
| Workers | 250-300 |
| Anchor | No |
| Quantity | 2 |

One out of two cashew nut factories in Cabo Delgado where examined. This factory employs between 250-300 people depending on season and available workers. Nuts are pealed by hand for better quality then roasted and finally being packed before transportation. Electricity is mainly used for packing and lights which results in low amounts of electricity used compared to the number of workers. The price for the final product is much dependent on the quality where pealing by hand has better results then mechanical pealing.

The investigated factory is now grid connected where the cost of electricity is around 10 000 Mt a month with general tariff [20]. The factories do not require grid connection but due to lower energy costs it is preferable. According to one source was the economic benefits for using grid instead of diesel as energy source 20-30 % [43].

Cashew nut factories have trickling down effects from creating work opportunities. It is however not an intensive electricity consumer nor is electricity the limiting factor for the production. The limitation for the factory where the difficulties to find enough workers during high season which often occur when its time for the workers to harvest at home [43]. In Cabo Delgado was two cashew nut factories identified at the time of the investigation. It was also found that cashew nut factories have opened and closed from time to time which indicates that more factories could open in the future [24].

Table 7: Information for fish freezers as result from this report

| | Fish Freezers |
|---|---|
| Size | Micro |
| Workers | - |
| Anchor | Social Anchor |
| Quantity | 9 |

### 5.1.7 Fisheries

Mozambique has more then 430 km of coast facing the Indian ocean where only in the Cabo Delgado region more then 13 000 fishermen are active. Even with small boats is the catch good. Macomia has for instance some areas where the fishermen throws back fish when the catch is to big. 8% of the fishing is for self subsistance and the rest is available at the market [44]. With access to freezers the fish could be processed and sold to other regions futher in to the country, something that today only is done in small scale and mostly as dried fish. The potential for processing fish is good and could help Cabo Delgado both economicaly where the prize for frozen fish is 100 Mt compaired to 30 Mt for fresh fish, but also helpoing in the case of malnutrition for people living further away from the coastal line [44].

There are only a few freezers operating in the Cabo Delgado region today, where Mocimboa Da Praia has the most functional one. Rural fish markets that can handle frozen fish are under discussion but none are so far operating. The location of the markets for discussion are Darumba/Pangane (Macomia), Gimpia (Pemba), Mbuizi (Palma), Megaruma (Pemba-Metuge) and Pequeue (Mocímboa da Praia) [44].

Towever there are problems with the fishing industry of small scale. There are few organized associations, there are many small fishing villages remote located where each landing site has small quantities making a commercial freezer to expensive. Some islands has the best fishing waters but grid connection to these places are difficult [26]. The government want to license all fishermen but finds the fishermen reluctant to the idea [44]. It is however unclear what information the fishermen has received about the licensing and what the actual purpose of such a action would be. There might be a risk that the fishermen fear taxes if they become licensed and therefore avoid to respond [44].

The fishing industry could function as a social anchor where the social benefits are good. The problem is however the electrical distribution and lack

[20]EDM uses different tariffs for different customers more can be read in appendix D.

of other infrastructural services. The power consumption from single freezers are very low and will not make a grid extension viable from a supplier perspective. To enable the trade of frozen fish must also the logistic precondition exist. In this case is the coexistence of electrification and complementary services easy to see. Just electricity will not be the solution.

#### 5.1.8 Salt production

**Table 8:** Salt production information as result from this report.

| | Salt Production |
|---|---|
| Size | Small |
| Workers | 20-35 |
| Anchor | No |
| Quantity | Unknown |

Along the coastal region does some salt extraction sites exist. By leading sea water in to basins and let the sun dry of the water salt can be extracted and collected by man power. For the extraction part is electricity not necessary and the extraction sites do not depend on access to electricity. In some cases is water pumped in to basins by diesel pumps instead of using tidal water. Electricity can however be useful in a more productive way. For refining salt is electricity used for pumping water to wash the salt clean. Refined salt has a better value on the market but the increased value of the product is not enough to make it economical beneficial to use diesel for the pumping. This is not done at the extraction sites due to lack of electricity. The extraction methods are basic where digging and collection is done by man power, each site employs around 20-35 men for sites of the size 10-14 ha.

## 5.2 Summery of activities based on anchor definition

In table 9 have investigated activities been allocated to what kind of anchor the belong according to the definition mad in chapter 3.6.

## 5.3 Identified activities

In this section are those activities that may be out of interest for rural electrification strategies listed. One section concerns those encountered outside Pemba and therefor counted as rural. Section 5.4 lists activities in relation to Pemba that consumes most electricity.

**Figure 5:** Salt production site outside Pemba. Seawater is lead in to the basins where sun evaporates the water and the salt can be collected.

**Table 9:** Activities listed in order of Anchoring.

| Activity | Anchor type | Comments |
|---|---|---|
| Cotton Production | Supplier/Social | No expansion possible in near future |
| Petrolium Extraction | Supplier | |
| Mining | Supplier | |
| Milling | Social | |
| Timber Mill | Supplier/Social | |
| Cashew nut factory | No anchor | not primarily effected by electricity |
| Fisheries | Social | |
| Saltproduction | No anchor | not primarily effected by electricity |

### 5.3.1 Identified activities during field study complemented with literature studies

Table 10 shows activities found in Cabo Delgado that may be out of interest for a rural electrification strategy. The table is a results from the field study performed in Cabo Delgado in 2011, documents from Governa da Provincia de Cabo Delgado [45]-[60] together with a report from Scanteam [26]. The data has been complementing each other but also helpful for cross validating data.

The summary of different activities have been assembled from interviews conducted during the field study and similar study from the report "“the Cabo Delgado baseline study”" [26], documents received from Industry and Commerce in Pemba [65] and the Portal do Governo de Cabo Delgado [24]. Regarding number of mills have figures been varying heavily between different sources. The reason for this may be time differences, the oldest figures are from 2005 and the number of mills can change dramatically in a few years. The definition of which mills to be counted may differ between different reports and statistical data. In some cases are only larger mills noted while others also list smaller ones. This report focuses on productive use for medium and larger activities, although smaller activities not are seen as anchors from a supplier perspective could smaller activities be seen as social anchors where also small mills can be out of interest from a social perspective regarding rural electrification.

Excluded from this list are activities closely connected to the city of Pemba. Pemba can not be seen as rural in this project from an electrification perspective. Pemba received early electricity 1977 and have other advantages and infrastructural opportunities that will not be found in Cabo Delgado else where. In table 11 are the largest electricity consumers in Cabo Delgado listed and it is found that for the top 20 list all activities are closely connected to Pemba.

## 5.4 Largest electricity consumers in Cabo Delgado

In previous section the focus have been on rural activities in Cabo Delgado where Pemba have been excluded. In this section and specifically Table 11 are the 20th largest electricity consumers in Cabo Delgado [30] listed where the majority is closely connected to Pemba.

1. Empresa de Aguas 1 Estacao is the regional water company supplying the district with water.

2. Pemba Beach is the luxury 5 star Pemba Beach hotel with air conditioner in all room, outdoor pools and other high intensive electrical appliances.

**Table 10:** Activities found in Cabo Delgado as a result of this report described in section 5.3.1

| District | Population (2006) | Mills[a] | Sawmill | Additional Utilities |
|---|---|---|---|---|
| Ancuabe | 109 792 | 88 | | Graphite mine |
| Balama | 126 116 | 62 | | |
| Chiure | 230 044 | 126 | | Cashew nut factory |
| Ibo | 9 509 | | | |
| Macomia | 81 208 | 12 | 1 | |
| Mecufi | 43 573 | 10 | | |
| Meluco | 25 184 | 39 | | |
| Mocimboa da Praia | 94 197 | 34 | 5 | |
| Montepuez | 185 635 | 55 | | Cotton factory, rice dehusk, marbel |
| Mueda | 120 067 | 130 | 3 mobile | |
| Muidumbe | 73 457 | 20 | | Rice dehusk |
| Namuno | 179 992 | 134 | 6 | |
| Nangade | 63 739 | 41 | | Cashew nut factory |
| Palma | 48 423 | 22 | | |
| Pemba[b] | 65 365 | 5 | | |
| Quissanga | 35 192 | all on diesel [c] | 1 | |

[a] It is unknown how large part are grid connected but in general are the majority running on diesel.
[b] Excluding Pemba city.
[c] The number of mills are unknown but there are only a few of them and all of them are running on diesel.

**Table 11:** The following table shows the largest electricity consumers in Cabo Delgado during an unknown month. The figures should not be taken for granted but rather seen as guiding and listing of large electricity consumers [30]

| | Client | Average consumption during a month (kWh) |
|---|---|---|
| 1 | Empresa de Aguas 1 Estacao | 491 508 |
| 2 | Pemba Beach | 235 922 |
| 3 | Anadarko | 63 072 |
| 4 | Aeroport Mozambuiqe | 55 291 |
| 5 | Hospital Provincial | 51 876 |
| 6 | IMAP | 46 914 |
| 7 | Empresa de Aguas 2 Estacao | 39 091 |
| 8 | Radio Mocambique | 34 524 |
| 9 | Complexo Nautilus | 33 971 |
| 10 | SOS | 31 152 |
| 11 | TDM Estacao Terrena | 28 110 |
| 12 | Porto de Pemba | 26 560 |
| 13 | Arco Iris | 25 876 |
| 14 | Gary Jhon Wilson | 25 609 |
| 15 | DP Agricultura | 24 719 |
| 16 | Kauri Resort | 21 369 |
| 17 | Banco de Mocambique | 20 500 |
| 18 | Osman Yacub | 17 550 |
| 19 | Pemba Agro Industria | 16 464 |
| 20 | Plexus Namapa | 11 564 |

3. Anadarko is a company searching for oilfields in the coast out of Cabo Delgado.
4. Aeroport Mozambique is the airport in Pemba.
5. Hospital Provincial is the main hospital in Pemba.
6. IMAP, IMAP instituto de magistério primário (primary teacher training college)
7. Empresa de Aguas 2 Estacao is the second pumping station in the district.
8. Radio Mocambique is the national radio station.
9. Complexo Nautilus is a tourist complex that offers air conditioned rooms and a casino.
10. SOS an SOS Children's Village in Pemba [61]
11. TDM Estacao Terrena, EDM is the national telephone company
12. Porto de Pemba, Pemba port.
13. Arco Iris, missionaries village in Pemba [62]
14. Gary Jhon Wilson, Tourist complex.
15. DP Agricultura, Department of Agriculture.
16. Kauri Resort, Hotel with air conditioner.
17. Banco de Mocambique, bank of Mozambique
18. Osman Yacub, a grocery store in central Pemba
19. Pemba Agro Industria [63]
20. Plexus Nampa, Plexus is a cotton producer with exclusive rights for the concession in the province of CaboDelgado.

As has been mentioned before are most data uncertain. It is unclear at what time the measurements in Table 11 where performed. It is there for not clear if this is correct order for each activity in every state.

To be noted is that of the 20:th largest electricity consumers in Cabo Delgado 16 are located within the city of Pemba, the two pumping stations for water are located close by and supporting Pemba with water. Consumer number 19 is located within 20 km from Pemba. Last on the list is the Plexus Namapa that actually is located outside Cabo Delgado but is supported from the substation in Cabo Delgado.

It should also be noted that 13 out of 20 activities are social or governmental infrastructure, only one are in the processing industry and for those not related to government or foreign aid are hotels.

It is however unclear if the list is complete. At least the Plexus cotton factory in Montepuez could be assumed to be on the list when data from Plexus headquarter shows that the Montepuez factory is using 6-7 times more electricity compared to the Namapa factory.

Appendix B shows table 12 where the use of electricity for different mills are listed as a sample of mills in Cabo Delgado. The consumption is from 9000 kWh down to almost zero. The highest figures are encountered in the city of Pemba where larger enterprises coordinates several mills in their factories. For owners using a single mill the consumptions varies with operating hours and load. In these cases generators are usually in the size of 15-20 kW.

## 5.5 Result from investigated activities

What could be seen from interviews performed in Cabo Delgado is the effect that electricity has for the businesses. The major advantage from shifting from the diesel generated electricity to grid connection is the reduced cost. The interview conducted with Faustino Catingue,Director Financeiro CFO at Plexus [37] showed that the total cost savings for the cotton factory when changing energy source would be one sixth of the price when using grid instead of diesel. As Mr Catingue expressed it him self "'*The impact is not huge, it is massive!*'".

The phenomenon of lowered costs for using grid connection could be noticed also for smaller enterprises as small as mills. Even if the costs are hard to calculate due to low quality of input data C it could be taken for sure that the impact for the owner is out of big interest. It is however hard to determine how this would affect the costumers of the mill. There are both cases where the owner lowers the cost for milling in that way share the advantage of cheaper energy with the society, and cases like Pemba where a milling society have fixed prices for all customers to avoid competition between businessmen. In that case is the cut of cost only effects the owner and the trickling down effect earlier described as one of the wanted properties for an anchoring activity from the societies point of view is lost.

It is hard to interpret the accuracy of the given figures about the amount of activities in the Cabo Delgado region specifically for what is encountered as small and micro. What can be noted though is the resolution of small activities mentioned as small or micro. These activities are very small and would not act as anchors alone, yet they are registered by the government. This shows that even if registers are outdated or unreliable larger activities defined as medium, large or mega project would not be missed out during a study like the one performed by Scanteam, or the field study that has been conducted for this report.

# 6 Discussion

The results of this study can be summarized as a discouragement to the focus on existing productive use during electrification in the north Mozambican context. It shall not be forgotten however, that productive use may play a very important role if it is encouraged/introduced by external forces along-side infra-structural developments and complementary services. The results presented here shows that the quick solution of empowering existing production is insufficient to reach benefits in the order described by the study of the Ribáuè electrification project.

The introduction of production by external forces may be difficult due to low levels of education, lack of entrepreneurship traditions and the difficult business climate in Mozambique (Mozambique ranks 140 out of 175 countries at the 2006 World Bank 'Ease of doing business' ranking [3]). Nevertheless, there are many NGOs operating in Mozambique [64], some with the direct goal of initiating and sustaining business projects. The efforts of the government, foreign aid institutions and NGOs should be coordinated to implement production/businesses along-side infrastructural developments and complementary services (such as micro finance institutes), and, of course, include sustained support to initiated projects. This conclusion may not be new, but its relevance cannot be sufficiently stressed.

The effects of utilizing policies to direct electrification can be further discussed, since grid extension in Mozambique is funded by foreign aid, any directing of electrification effectively also means a directing of aid money. To emphasize productive use in electrification processes thus means that one utilize aid money to mainly improve the situation for production unit owners who also are the relatively affluent members of poor communities. This may be inconsistent with many foreign aid policies who advocate reduced inequalities as a goal for development work. Long-term poverty reduction due to an emphasis on productive use rests on trickling down effects along with possibilities for electrification alongside implementation of complementary services. The magnitude of these trickling down effects may be debated, nevertheless, they can be expected to exist, especially in the case of cotton which is concession driven (to reach social benefits) and in the case of mills where the mill owner is a local villager and hardly can be considered affluent in an international context.

There is another aspect that should be understood when reviewing the results, this is that social anchoring relies on that money actually flows into certain areas, and not just reallocates within these areas[21]. In relation to the productive uses of electricity studied here however, it is almost always cases which previously were served by diesel generators, thus, cost reductions obtained directly means a reduction of money flowing out from the region (since oil extraction and diesel refinement are not located in Cabo Delgado).

One business type that has not been directly studied here is that of tourism. It is clear from the data of the highest electricity users that tourism plays a relevant role from the supplier perspective. It can also be assumed that it is relevant from social perspective as well, though the size of these effects are unclear since tourist activities often are run by, and owned by, foreigners. Nevertheless, tourism should not be forgotten when discussing productive use of electricity.

In relation to power sector reform, it can be seen that Cabo Delgados electricity usage is low, resulting in that privatization of transmission and distribution systems probably will result in a halt in power extension in Cabo Delgado. Further, generation has difficulty competing with the low prices of Cahora Bassa electricity, resulting in that power sector reform in the form of privatization probably is an invalid route to take for rural Mozambique at the moment. Note that, vertical unbundling while keeping the generation, transmission and distribution companies within state management still may be a possible route.

[21] A case where money only would reallocate within an area would be businesses such as cell phone charging or barbers.

# 7 Conclusion

A series of conclusions can be drawn from the results of this study.

- The big electricity consumers in Cabo Delgado are almost exclusively social/governmental institutions, either directly or indirectly funded by foreign aid. There are some exceptions, these are mainly tourism, but also oil prospecting and one cotton factory as the 20th biggest consumer. Meaning that productive activities has, so far, played a very small role for the electricity consumption of the region.

- From supply perspective (economic viability for EdM), anchor possibilities are close to zero.

- In comparison with the other productive activities found, cotton factories receive an exceptional immediate boost from electrification (due to cost reduction). Sawmills receive a mild boost, also in terms of cost reduction. Electricity have less impact on the others, especially cashew processing (the only other main production facility in rural settings) receive very little benefit from electrification.

- A result from the finding that cotton receive much higher boost than the other production activities is that the Ribáuè cotton factory, promoted as an example of rural production that should be identified when planning electrification, is a very specific case that may not be reproducible among other types of production that exist on the country-side.

- From income-generating perspective there are limited possibilities for anchoring, the big facilities are already grid connected, among those that are not connected, grid connection have a cost reduction effect on mills (who are widely distributed in Cabo Delgado), the size of this effect is however unclear.

- Out of the three production improvements (productivity increase, work-hours increase, cost reduction), cost reduction is the most significant one while increased work-hours and productivity increase seems to have a very limited effect (which may increase as time progresses). An effect of this, is that identification of existing production that can benefit from electrification in a non-electrified area is equivalent to looking for diesel generators[22].

[22] Only in the short term, since there are activities run by diesel generators, it is also clear that electricity enables previously non-existent production to appear.

- EdM tries to emphasize productive use when performing electrification, but they, along with some of their consultants are of the opinion that there are no production activities in the north of Mozambique sufficiently large to yield any benefits for the suppliers from these attempts.

## 7.1 Final recommendation

As were laid out in the results and discussion, this study has shown that a focus on *existing* productive use may not work in Cabo Delgado. A result that might be valid for Southern and Eastern Africa in general. Still, productive use has proven to be a very important element in rural development. We therefore advocate that the following three components should be introduced simultaneously and in a coordinated fashion: (1) Infra-structural development such as electrification, (2) complementary services supporting productive use and (3) direct support in creating relevant and sustainable production activities. The first point naturally falls on EdM and/or Funae. The second and third points can be supported by either government agencies or NGOs that already exist in Mozambique. Still a coordinating entity is required, this entity already exist in the form of the Ministry for Planning and Development. This ministry should thus be given sufficient resources to coordinate development work that is being carried out in Mozambique and make sure sufficient focus is given to each of the necessary components in any given geographical area. There may be many obstacles to effective coordination, these include differing policies and objectives among the different relevant groups (ministrys, EdM, Funae, NGOs, Administrations of Economic Activities etc.). Researchers should therefore aid in understanding the current coordination efforts being made, and from there, describe how these can improve.

# References

[1] Project paper on a proposed restructuring of the energy reform and access project for the republic of Mozambique; Energy Team, Infrastructure Group, Africa Region, The World Bank; 2007

[2] Personal communication, Linus Hammar, Tek. Lic. Chalmers University of Technology, 2011-04-05

[3] Mulder and Tembe, Rural electrification in an imperfect world: A case study from Mozambique, 2008, Energy policy

[4] Vattenfall Power Consultant AB, Productive uses of energy: Report Cabo Delgado Province, 2008

[5] Jörg Peters, Marek Harsdorff, Florian Ziegler. Rural electrification: Accelerating impacts with complementary services, 2009

[6] Rural electrification of the Brazilian amazon - Achievements and lessons, Maria Gomez, Semida Silveira, 2010, Energy policy.

[7] Issues related to rural electrification using renewable energy in developing countries of Asia and Pacific, Tania Urmee et.al., Energy Policy 2008

[8] Ahlborg and Hammar, Drivers and barriers to rural electrification in Tanzania and Mozambique - grid extension, off-grid and renewable energy sources, Accepted for publication in World Renewable Energy Congress 2011

[9] Final Master Plan Report, Volume 1 Summary of Master Plan Study; Electricidade de Mozambique, 2004

[10] EdM Tariffs, EdM Official site, Accessed 2011-12-09
`http://www.edm.co.mz/index.php?lang=en`

[11] Linus Hammar, Helene Ahlborg, Sverker Molander; Power sectors actors' views on productive use, private sector involvement, and renewable energy in rural electrification of Mozambique and Tanzania; 2011, Manuscript

[12] Transparency International Official site, Corruption Perceptions Index, Published 1st December 2011, Accessed 2011-12-09, `http://cpi.transparency.org/cpi2011/results/`

[13] CIA World Factbook, 2011, Accessed 2011-11-14 https://www.cia.gov/library/publications/the-world-factbook/geos/mz.html

[14] N. Wamukonya, Power sector reform in developing countries: mismatched agendas, 2002, Energy Policy

[15] J. Karekezi and S. Kimani, Status of power sector reform in Africa: impact on the poor, 2002, Energy policy

[16] World Bank, Power sector reform, http://go.worldbank.org/3ZPDR311B0 , Accessed 2011-11-04

[17] J. Karekezi and S. Kimani, Have power sector reforms increased access to electricity among the poor in East Africa, 2004

[18] Description of EdM, EdM Official site, Published 3rd December 2009, Accessed 2011-11-07 `http://www.edm.co.mz/index.php?lang=en`

[19] V. Ranganathan. Rural electrification revisited, 1993

[20] N.P.A. Smith, Key factors for the success of village hydro-electric programmes, Renewable energy, 1994

[21] Ray Holland et. al., Decentralized rural electrification: The critical success factors, World renewable energy congress VI, 2000

[22] White R. GEF-FAO Workshop on Productive Uses of Renewable Energy: Experience, Strategies, and Project Development, June 18-20 2002, Workshop Synth. Rep., UN Food Agric. Organ., Rome, Italy.

[23] Businessdictionary.com `http://www.businessdictionary.com/` Last accessed 20th Jan 2012.

[24] Ministerio da Administracao Estatal. (2005) `http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/` Last accessed 24th Jan 2012.

[25] Mirjam Palm (Senior Program Manager, Energy, Environment and Climate Change. Embassy of Sweden, Maputo) interviewed by the author on 26 May 2011

[26] Scanteam, Final Report: Baseline Study for Rural Electrification Project in Cabo Delgado Province, Lot1, Mozambique, 2010

[27] D.DTewari, Tushaar Shah. An assessment of South African prepaid electricity experiment, lessons learned, and their policy implications for developing countries, 2003

[28] EdM. (2009-12-14). CREDELEC Meter. Available: http://www.edm.co.mz/index.php?lang=en. Last accessed 20th Jan 2012.

[29] The World Bank. The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits, An IEG Impact Evolution. 2008

[30] Received document from the local EDM office in Pemba July 2011.

[31] Glenn Elert. (2006). Energy Density of Diesel Fuel. Available: http://hypertextbook.com/facts/2006/TatyanaNektalova.shtml. Last accessed 24th Jan 2012.

[32] Valerito Pachinuapa, (Quality and Environmental Unit, funae.co.mz) interviewed by the author on 30 May 2011

[33] P. Mulder and J. Tembe, Rural Electrification in Mozambique Is it worth the Investment?, 2006

[34] Vattenfall Power Consultant AB, Productive uses of energy: Draft report, 2008

[35] Dr Hans Wontka, (Graphit Kropfmühl AG, Ancuabe) interviewed by the author on 9 July 2011

[36] Industrial Licensing Regulations, Economic Activity Classifier (CAE-Rev.1) Decree 39 2003 of 26 November

[37] Faustino Catingue, (Plexus, Financeiro, CFO.) interviewed by the author on 7 July 2011

[38] Anadarko Petroleum Corporation. (Feb 07, 2011). Anadarko Announces Discovery Offshore Mozambique. Available: http://www.anadarko.com/. Last accessed 20th Jan 2012.

[39] Ramiro Nguiraze, (Provincial Directorate of Mines and Energy, Director) interviewed by the author on 8 July 2011

[40] Thomas Bergman, (Vattenfall Power Consultant, Maputo) interviewed by the author on 26 May 2011

[41] Faruk Jamal, (Miti LDA, owner) interviewed by the author on 8 July 2011

[42] Rikard Ehnsiö, (Mocambique Madeira, owner) interviewed by the author on 7 July 2011

[43] Adpaly Ekar, (Koroshi Mocambique) interviewed by the author on 22 June 2011

[44] Ms Beatriz Isidoro, (Provincial Directorate of Agriculture/ Department of Fisheries) interviewed by the author on 8 June 2011

[45] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Ancuabe Provincia de Cabo Delgado. Available: http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Ancuabe.pdf. Last accessed 24th Jan 2012.

[46] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Balama Provincia de Cabo Delgado. Available: http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Balama.pdf. Last accessed 24th Jan 2012.

[47] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Chiure Provincia de Cabo Delgado. Available: http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Chiure.pdf. Last accessed 24th Jan 2012.

[48] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Ibo Provincia de Cabo Delgado. Available: http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Ibo.pdf. Last accessed 24th Jan 2012.

[49] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Macomia Provincia de Cabo Delgado. Available: http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Macomia.pdf. Last accessed 24th Jan 2012.

[50] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Mecufi Provincia de Cabo Delgado. Available: http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Mecufi.pdf. Last accessed 24th Jan 2012.

[51] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Meluco Provincia de Cabo Delgado. Available:

http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Meluco.pdf. Last accessed 24th Jan 2012.

[52] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Mocimboa da Praia Provincia de Cabo Delgado. Available: http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Mocimboa.pdf. Last accessed 24th Jan 2012.

[53] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Montepuez Provincia de Cabo Delgado. Available: http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Montepuez.pdf. Last accessed 24th Jan 2012.

[54] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Mueda Provincia de Cabo Delgado. Available: http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Mueda.pdf. Last accessed 24th Jan 2012.

[55] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Muidumbe Provincia de Cabo Delgado. Available: http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Muidumbe.pdf. Last accessed 24th Jan 2012.

[56] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Namuno Provincia de Cabo Delgado. Available: http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Namuno.pdf. Last accessed 24th Jan 2012.

[57] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Nangade Provincia de Cabo Delgado. Available: http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Nangade.pdf. Last accessed 24th Jan 2012.

[58] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Palma Provincia de Cabo Delgado. Available: http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Palma.pdf. Last accessed 24th Jan 2012.

[59] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Pemba Provincia de Cabo Delgado. Available: http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Pemba.pdf. Last accessed 24th Jan 2012.

[60] Ministerio da Administracao Estatal. (2005). Perfil do Distrito de Quissanga Provincia de Cabo Delgado. Available: http://www.cabodelgado.gov.mz/informacao/perfil-dos-distritos/Quissanga.pdf. Last accessed 24th Jan 2012.

[61] SOS barnbyar. Available: http://www.sos-barnbyar.se/. Last accessed 20th Jan 2012.

[62] Iris Ministries Canada http://www.irismin.ca/home Last accessed 24th Jan 2012

[63] Z.A.I Zemun Agro Industrial http://www.pembazemun.com/contactus.html Last accessed 24th Jan 2012

[64] Stefano Belluci, Governance, Civil Society and NGOs in Mozambique, Management of Social Transformations Discussion paper 56, UNESCO, 2002

[65] Direcao Provincial da Industria e Comercio, Governo da Provincia de Cabo Delgado.

# A Interview sheet for production units

Name of Business

Type: ☐ 1. Carpentry ☐ 2. Mill ☐ 3. Salt-Work Sites ☐ 4. Others:____________________

Name of Owner: Location (quarter/district): Date:

<u>Establishment Characteristics</u>

1. Plot Area:____________$m^2$
2. Operation Time: From_________h to _________h
3. National Grid Connection
   1. Not Available ☐
   2. No Connection. ☐
   3. Illumination only. ☐
   4. Electrical Appliances. ☐
4. Walls Material
   1. Mud Wall ☐
   2. Brick Wall ☐
   3. Other:____________________ ☐
5. Roof Material
   1. Corrugated galvanized zinc tiles ☐
   2. Thatch Roof ☐
   3. Other:____________________ ☐
6. Illumination
   1. No Illumination ☐
   2. Oil Lamp ☐
   3. Incandescent Lamp ☐
   4. Fluorescent Lamp ☐
7. Inventory. (Big sized equipment only)

| Equipment | N° | Price |
|---|---|---|
| 1. Transport (Car, trucks, etc.) | | |
| 2. Gristmill | | |
| 3. Corn Huller and Grinder | | |
| 4. Rice-Huller | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | | |
| 9. | | |
| 10. | | |
| 11. | | |
| 12. | | |

8. More notes

________________________________________

________________________________________

<u>Business Characteristics</u>

1. Beggining Year ☐☐☐☐
2. Description of the activities

________________________________________

________________________________________

3. Final Products and Prices
   a).________________________________
   b).________________________________
   c).________________________________
   d).________________________________
4. Products are sold
   1. Within the village. ☐
   2. To Neighboring Villages. ☐
   3. To Other Districts. ☐
   4. To Other Countries. E.g. ☐

   ________________________

   ________________________

5. Provenience of raw material.
   1. Produced locally
   2. Local Market.
   3. Other Villages.

6. Ownership.
   1. Single Ownership
   2. Association
   3. Foreign Subsidiary

7. Employees.

   7.1 Present number __________.

   7.2 Initial number__________. Reason for change:__________

8. Initial investment __________MTZ

9. More notes

---

---

Owner Characteristics (For single ownership only)

1. School Years
2. Parents Schools Years
3. Electrical Appliances at home (list)
4. More notes.

---

---

Area Characteristics

1. Is the area electrified?
   1. Yes. Since: ____________
   2. No

Grid Connected Consumers

1. Connection Year

2. Connection Cost. __________MTZ

   *Includes contract and installation costs.

3. Type of Tariff
   1. Domestic
   2. General
   3. Low tension great consumers
   4. Medium Tension

4. Average Monthly Consumption. __________MTZ or __________kWh

5. Consumption of previous month. __________MTZ or __________kWh

6. Electrical Capacity Installed __________kVA

7. Has any electrical appliance been acquired after the first year?
   1. Yes 2. No

8. Perception of grid connection quality over production.
   1. Stable. No negative effects over production
   2. Unstable. But no effects over production.
   3. Unstable. And limits activity time.
   4. Unstable. And limits production capacity.
   5. Other.

9. In case of change from diesel to electricity:

   9.1 Perception of electricity effect over production.

   *Open question. Do not read options.
   1. Reduces costs
   2. Increases production due to extended working hours.
   3. Increases production due to better performance of equipment.
   4. Other. ____________________

   ____________________

10. More notes.

---

---

---

Diesel Consumers

1. Daily Consumption. __________Liters
2. Consumption of previous month. __________Liters
3. Price of Diesel. __________MTZ/Liter
4. Distance to the closest gas station. __________km
5. More notes.

_____________________________________________

_____________________________________________

Production

1. Production Capacity. __________day/season
2. Initial Production Capacity. __________ day/season
3. Level of production in the previous month/season.__________
4. High season months.__________
5. Low season months. __________
6. Business constrains: What is the main obstacle to increase production and revenue?
    1. Access to water ☐
    2. Access to electricity ☐
    3. Access to raw materials ☐
    4. Access to credits ☐
    5. Expansion of markets ☐
    6. Competition ☐
    7. Other. ____________________ ☐
7. More notes.

_____________________________________________

_____________________________________________

Accounting

1. Maintenance costs in the previous year __________MTZ

   1.1 Single cost list ______________________________

   ______________________________

   ______________________________
2. Salary __________MTZ per worker
3. Average primary materials costs __________MTZ/ month

   3.1 Single cost list______________________________

   ______________________________

   ______________________________
4. Taxes costs __________MTZ/ year
5. Revenue in the previous month __________MTZ
6. Revenue in previous year__________MTZ
7. More notes.

_____________________________________________

_____________________________________________

_____________________________________________

# B Average monthly electricity consumption for mills

**Table 12:** Average monthly consumption for mills

| Name | Avg. monthly usage (kWh) | Location |
|---|---:|---|
| Moageira Milena | 9458 | Natite-Pemba |
| Moageira Candido Azize | 424 | Paquite-Pemba |
| Moageira Abdul Rachide Guige | 2076 | Cariaco-Pemba |
| Moageira Jose Calavete | 11,7 | Cariaco-Pemba |
| Moageira Chiquito | 927 | Cimento-Pemba |
| Moageira Califa | 15,7 | Ingonane-Pemba |
| Moageira Canas | 1162 | Natite-Pemba |
| Moageira Roldao da Conceicao | 35,2 | Alto Gingone |
| Moageira Rafael | 8,8 | Alto Gingone |
| Moageira Grao de Ouro | 2673 | Alto Gingone |
| Moageira Jose Calavete | 58,6 | Alto Gingone |
| Moageira Manuel Correia | 234,4 | Cimento-Chiure |
| Moageira Fatima Sitaube | 23,4 | Nahavara-Chiure |
| Moageira Rosa Almesse Massai | 70,3 | Mieze |
| Moageira Estevao Antonio | 5423 | Montepuez |
| Moageira Patricio Jose | 2588 | Napai-Montepuez |
| Moageira Antonio Trinta | 538 | Nawa-Montepuez |
| Moageira Paulo | 967 | Napai-Montepuez |
| Moageira Fatima Sacur | 500 | Napai-Montepuez |
| Moageira Manuel Correia | 52,6 | Montepuez |
| Moageira Benjamim | 63,8 | Mirige-Montepuez |
| Moageira Raimundo | 172 | Nacate-Montepuez |
| Moageira Lionce Julai | 656 | Nacate-Montepuez |
| Moageira Victor Sanviches | 2258 | Montepuez |
| Moageira Horario Antonio | 41 | Montepuez |
| Moageira Joaquim | 46,7 | Montepuez |
| Moageira Joaquim | 67 | Montepuez |
| Moageira Joao | 386 | Montepuez |

# C Calculations on gathered data from mills

The field study included a survey of 28 mills, a total of 11 had data for both production quantities and cost for diesel or electricity. The following data are the results from the 11 mills and a short calculation on the difference between diesel users and grid users.

The row marked "'Low"' has the lower value of an interval, and "'High"' the higher value of an interval.

**Table 13:** The cost for milling one kg using diesel.

| Id Number | 7 | 8 | 22 | 26 | 28 | 40 |
|---|---|---|---|---|---|---|
| Mt/kg (Low) | 1,486 | 0,372 | 14,96 | 1,603 | 0,25 | 2,137 |
| Mt/kg (High) | | 0,743 | | 2,244 | | |

Number 22 in table 13 was removed since its an outlier. The result indicate that cost per kilo for a mill using diesel would be 1,27 Mt/kg with a standard deviation of 0,83.

**Table 14:** The cost for milling one kg using grid.

| Id Number | 3 | 5 | 15 | 16 | 23 |
|---|---|---|---|---|---|
| Mt / kg (Low) | 546,4 | 0,667 | 0,25 | 0,038 | 0,178 |
| Mt / kg (High) | 819,6 | 0,933 | 0,5 | 0,056 | 0,266 |

Number 3 and 16 in table 14 were removed since they are outliers. The result indicate that cost per kg for a mill connected to the grid would be 0,47 Mt/kg with a standard deviation of 0,30.

The results are weak when the standard deviation is almost in the magnitude of the actual value but it still gives a hint that the cost for using diesel are higher then the cost of using grid also for small activities as mills.

# D Tariff

**Table 15:** The EdM tariff regarding electricity from 2011 [30]

| Consumos Registados (kWh) | Tarifa Social (MT/kWh) | Tarifa Domestica (MT/kWh) | Tarifa Agricola (MT/kW) | Tarifa Geral (Mt/kW) | Taxa fixa (Mt) |
|---|---|---|---|---|---|
| De 0 a 100 | 1,07 | | | | |
| De 0 a 300 | | 2,5 | 2,97 | 2,97 | 85,35 |
| De 301 a 500 | | 3,53 | 4,24 | 4,24 | 85,35 |
| Superior a 500 | | 3,71 | 4,64 | 4,64 | 85,35 |
| Pre-pagamento | 1,07 | 3,18 | 4,26 | 4,26 | |