Off-Grid Solar Market Assessment in Mozambique

Final report

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Abbreviations and acronyms

AC	Alternating current
ADEL	Agência de Desenvolvimento Económico Local
ADPP	Ajuda de Desenvolvimento de Povo para Povo
AECF	African Enterprise Challenge Fund
AMOMIF	Associação Moçambicana dos Operadores de Microfinanças
ARENE	Autoridade Reguladora de Energia
BTC	Belgian Technical Cooperation
CBF	Tax Benefits Code
CNELEC	Conselho Nacional de Electricidade
CSR	Corporate Social Responsibility
DC	Direct current
DFI	Development Finance Institution
DFID	Department for International Development
ECA	Economic Consulting Associates
EDENR	Strategy for New and Renewable Energy Development
EDENR	New and Renewable Energy Development Strategy
EDM	Electricidade de Moçambique
EDP	Energias de Portugal
ENDE	National Development Strategy
ENDEV	Energising Development
ESWG	Energy Sector Working Group
EU	European Union
FEDESMO	Forum de Energias e Desenvolvimento Sustentável de Mozambique
FUNAE	Fundo de Energia
GDP	Gross Domestic Products
GGGI	Global Green Growth Institute
GIZ	German Agency for International Cooperation
GMG	Green Mini Grids
HH	Households
ICP	Indicative Cooperation Programme
IDE	International Development Enterprise
IMF	International Monetary Fund
IMM	Institution Industrial de Maputo
INAE	National Inspectorate for Economic Activities
ISO	International Organization for Standardization
JD	Joint Declaration
LED	Light Emitting Diode
MAUS	Mobile Access and Usage Study
MDF	Market Development Fund
MDG	Millennium Development Goals
MIREME	Ministry of Mineral Resources and Energy
MWTP	Market Willingness to Pay

MZN	Mozambican metical
NES	National Electrification Strategy
NGO	Non-Governmental Organization
OGSP	Off-Grid Solar Products
PAYG	Pay-As-You-Go
PDENR	New and Renewable Energy Development Policy
PES	Economic and Social Plan
PV	Photovoltaic
RBF	Results Based Financing
REACT	Renewable Energy and Adaptation to Climate Technologies
ReFIT	Renewable Energy Feed-in Tarff
SADC	Southern African Development Community
SHS	Solar Home System
SPEED+	Supporting the Policy Environment for Economic Development
TA	Technical Assistance
TUV	Technical Inspection Association
UEM	Universidade Eduardo Mondlane
UK	United Kingdom
UNICEF	United Nations Children's Fund
UNIDO	United National Industrial Development Organization
US	United States
USAID	United States Agency for International Development
USD / $	United States Dollar
VAT	Value Added Tax
ZRD	Rapid Developing Zones

Note: All references to US$ or $ are to the United States dollar in the report. Exchange rate assumed to the Metical: 60 MZN to the US$.

Executive summary

ES0. Background

The total population of Mozambique is about 28.9 million, of which 70% live and work in rural areas. According to the World Bank (2016), 24.2% of the total population in Mozambique is connected to the national grid, whereas only about 6% of the rural population enjoys access to the grid. One of the aspects that influences this, is the fact that rural communities are often dispersed throughout Mozambique, which has a total land area of 786,380 Km2, making grid access difficult. Thus, in order to make reliable energy accessible for all, there is a need to look at alternative solutions.

Acknowledging the important role that access to clean forms of electricity can play in the development of the country, the Government of Mozambique (GoM) has joined the Sustainable Energy for All (SE4ALL) initiative and committed to a target of achieving universal access to electricity by 2030. Realising the potential of off-grid solar products to attain this goal, the Government, with the support of development partners, has committed to remove the most urgent market barriers in the off-grid solar sector and assist in accelerating the development of the market.

Thus, the purpose of this study is to assess the market opportunities and challenges for adoption and scale up of the off-grid solar market in Mozambique, by analysing the supply and demand side, the regulatory and enabling environment, the barriers to the market scale-up, and the options for intervention.

ES1. Development of the off-grid solar market in Mozambique

According to our analysis, the size of the potential market is large and the reason why it remains untapped is due to the various market barriers that prevent private companies from expanding their operations, particularly to rural, isolated areas.

The supply side assessment shows that there are several companies active in the market and their products are of relatively high quality. According to the demand size assessment peri-urban and rural households on average spend more than $12 per month to meet their total energy needs, electricity being only one component. On average, half of unelectrified households could afford a small solar system.

There are a number of interventions that would allow the market to reach its full potential. Most of these should target on the one hand the lack of working capital (supply-side constraint) that prevents solar companies from reaching those at the bottom of the pyramid, while on the other hand tackling the resource constraint at the household level to invest in quality solar systems (demand side constraint).

This Executive Summary is structured somewhat differently to the report to highlight the most important findings, in line with the above summary.

- ES2 outlines the regulatory framework and enabling environment for off-grid solar.

- ES3 gives our estimate of the size of the market.
- ES4 and ES5 summarise the supply and demand assessments respectively.
- ES6 has an analysis of barriers and recommended policy actions to expand the market.

ES2. Regulatory and enabling environment

Institutional structure of the electricity sector

The Ministry of Mineral Resources and Energy (MIREME) is responsible for policy and supervision of the energy sector in Mozambique. MIREME is committed to achieving universal access to electricity by 2030, the Sustainable Energy for All (SE4All) target year.

ARENE is the recently formed regulator for the entire energy sector. The main electricity enterprise is the vertically integrated national utility, Electricidade de Moçambique (EDM). The rural energy fund, FUNAE (Fundo de Energia), acts as a rural electrification agency in respect to electrifying the government's main administrative, health and education institutions in rural areas.

Legal and policy framework

The government's commitment to meeting universal electrification by 2030 in a sustainable manner is exemplified through the various national policies and strategies that shape the off-grid electrification market. These affirm that solar energy is to play an important role in the government's efforts to increase electricity access in rural areas. The most relevant regulations include:

- **National Development Strategy (ENDE) for 2015-2035**: The strategy was developed as a planning tool for promoting social and economic prosperity in the country. One of the main bottlenecks identified is lack of competitiveness. Four strategic pillars are identified as part of ENDE, while goals and benchmarks are established for each pillar. Energy access is considered a prerequisite for achieving goals under each of the four pillars.
- **Mozambican government's five-year plan for 2015-2019**: The five-year plan aims to boost the country's economic development and is one of the tools included in ENDE. The plan highlights the importance of renewable energy in contributing to the development of economic and social infrastructures. One of the objectives of the plan is to 'increase quality access and the availability of electricity, liquid fuels and natural gas for the development of social and economic activities, household consumption and exports'. The plan has set a goal to increase the country's electrification rate to 33% by 2019. The plan highlights that electrification efforts should focus on both grid extension and independent solar systems.
- **The Economic and Social Plan (PES)**: PES is published on an annual basis and highlights the priority areas for social and economic development, one of which

is energy access. The plan guides governmental action towards the implementation of the Government's 5-year plan (2015-2019).

Fiscal policy

The legal framework in Mozambique offers a number of fiscal benefits to renewable energy investors, however these are only granted to investments that generate electricity that would feed into the national grid. Such benefits include discounts in corporate income tax, import duty exceptions, deductions in the taxable income, etc.

Despite the various fiscal benefits that are applicable to investors active in renewable energy generation, renewable energy technologies, such as solar home systems and solar lanterns are still liable to VAT at the rate of 17% and import duties that vary between 7.5% and 20% depending on the component type. However, in reality the tax burden may be up to 30-40% if the fees provided to custom agents and 'facilitation' payments are also taken into account[1].

Quality standards regulations

There is currently a lack of policies regulating the quality of off-grid household products sold in Mozambique. This has resulted in an influx of inferior quality products in the market. According to interviews with established solar companies, this is likely to create a distorted view regarding the capabilities of solar products among potential customers, which in turn hampers the development of the market.

Mobile phone penetration

The mobile services sector in Mozambique has experienced unprecedented growth over the past decade. Mobile subscriptions rose from 2.3 million in 2006 to over 15 million in 2016. According to a recent study, approximately 82% of urban and rural communities have mobile coverage (to at least a 2G signal). Nine out of ten survey respondents reported that service quality is sufficiently high to allow them to send a text message.

While two thirds of respondents reported that they had used a mobile phone in their lifetime, there are significant differences across the target provinces. The highest percentage of use (86%) was recorded in Manica province. The lowest percentage was recorded in Zambezia province, where 46% of respondents reported that they had never used a mobile phone.

Mobile usage percentage also varies across demographic segments, notably gender and education level. According to the study, females are 22% less likely to use a mobile phone. On the other hand, higher education level seems to be linked to higher mobile phone usage. Only a fourth (26%) of respondents with no formal education reported that they had used a mobile phone.

[1] ODI 2016. Available from: https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/10251.pdf

Mobile money penetration

Mobile money services in Mozambique were first provided in 2010 via mCel's mKesh and are now available through two providers since Vodacom's M-PESA started its operations in 2013. Across mobile phone users, over one-third had transferred money using a mobile money service.

From the viewpoint of using mobile money to sell solar products, it is important to observe that overall mobile penetration is not in itself a good indicator of the extent to which PAYGO systems can be rolled out. Not only do mobile phone users need to be willing to use mobile money, but there are also supply-side constraints, in that mobile money vendors need to have reasonable access to commercial bank facilities. Hence the geographical spread of mobile phone coverage is always going to be greater than the extent of mobile money coverage.

The volume of mobile money transactions has also increased rapidly over the past three years. In 2016 alone, the number of financial transactions conducted over the mobile phones in Mozambique increased sevenfold, according to the central bank. Approximately 150 million transactions were recorded by the end of 2016, representing a sevenfold increase compared to the volume of mobile money transactions in 2015.

Zambezia province is characterised by a significantly higher percentage of mobile phone users who utilise mobile money services. In absolute terms, this number is more than twice the amount of mobile money usages than in any other province.

Mobile phone usage is often dependent on the ability and cost of charging the device. Almost half (47%) of those who charge their phones, do so from home, while 31% reported using a charging station.

Financial sector

Consumer financing

Traditional financial institutions in Mozambique are wary of lending to consumers for the purchase of solar products. This is because transaction costs for managing small loans are high compared to expected returns. Also, given the absence of lending history for these products, their risk profile is perceived to be relatively high.

While innovative methods of consumer financing, such as PAYG have spread out quickly in East Africa, they are not well established yet in Mozambique. Since payments are typically made via mobile money, an important enabling factor for the expansion of the PAYG model would be the rapid expansion of mobile money. In order for mobile money usage to take off, operators need to achieve a high volume of transactions, which in turn requires large capital investments and a high population density. Another obstacle for scaling up the use of PAYG has been the lack of clarity regarding leasing regulations for a non-financial institution[2].

Factors related to the various advantages of using mobile money, including the ease of making transactions and avoiding long waiting times in banks, as well as the potential to broaden and deeped financial inclusion are expected to contribute to a rapid growth in the

[2] Ibid

demand for mobile money usage over the next decade. Mobile operators are expected to respond to the higher demand by making access to mobile money more user friendly. This can be achieved through an interconnection of the three mobile money providers, between them and with the banking sector, to reduce potential network effects that customers may be facing when using a mobile mobey wallet.

Micro-financing institutions sector

Commercial lending in Mozambique is characterised by very high interest rates. High interest rates coupled with stringent collateral requirements present insurmountable obstacles for the small and medium sized companies operating in the off-grid electrification market. As such, most of the companies currently operating in the off grid solar market depend on their own finances or are raising international capital[3].

Lack of access to local credit also limits the ability of companies to import larger quantities, and thereby secure better price deals from their suppliers. This in turn results in higher consumer-facing prices, which may be prohibitive for low income groups.

The reluctance of large commercial banks to lend to solar companies has prompted micro-finance institutions (MFIs) to enter the solar market. An association representing all the MFIs in Mozambique, AMOMIF (Associação Moçambicana dos Operadores de Microfinanças), was established in 2007. The objective of AMOMIF is to promote the interests of MFIs during the discussions with the Central Bank of Mozambique[4].

In Mozambique, the off-grid electrification market relies extensively on donor institutions for financing and technical support. Most of these Development Finance Institutions (DFIs) and international cooperation agencies are organised in the Energy Sector Working Group (ESWG), which currently comprises around 25 organisations.

As of 2017, ESWG's members had participated in a total of 77 programmes with a total budget of $1.6 billion[5]. More than 60% of these projects are ongoing with an annual budget of approximately $220 million. However, only $10 million is allocated to off-grid electrification projects, with most of the budget spent on on-grid projects. Capacity building accounts for the highest share of programmes but also accounts for a small share of the overall budget, totalling $19 million.

ES3. Off-grid market size

According to the results from the modelling exercise combined with those from the market willingness to pay game, a pico solar light that costs 0.88 US cents/month (System 1, on a 24-month PAYG plan) is affordable to 94%, 98% and 86% of off-grid households in Manica, Zambezia and Maputo, respectively.

System 2, which allows the user to power three light bulbs, charge a mobile phone and power a radio is affordable to 87%, 72% and 82% of households in Manica, Zambezia and Maputo provinces, respectively. This system was modelled at 4.90 USD/month on a 24 month PAYG plan.

[3] FSDMOC 2015. Capital Markets Overview Analysis of the Mozambican Financial Markets
[4] IRENA 2012. Mozambique renewables readiness assessment.
[5] ALER 2017. Renewables in Mozambique – National Status Report

System 3, which costs $22.6 per month is only affordable to 12%, 19% and 22% of total households in Manica, Zambezia and Maputo provinces, respectively. This system allows the use of a small television in addition to lighting, phone charging and radio.

On the other hand, only 6%, 7% and 11% of total off-grid households in Manica, Zambezia and Maputo provinces, respectively, can afford System 4, which costs $61.2 per month. This system can power a small refrigerator in addition to the other appliances mentioned above.

For system 1, the total size of the addressable market across the three provinces is 1.3 million units, while for system 2 it is 1 million units. For systems 3 and 4 the addressable market is 191 thousand and 82 thousand units, respectively.

Table 1 Affordability by system and by province

Province	System 1 ($0.80/month for 24 months)	System 2 ($4.90/month for 24 months)	System 3 ($22.60/month for 24 months)	System 4 ($61.20/month for 24 months)
Manica	93.6%	86.8%	19.3%	7.2%
Zambezia	97.6%	71.9%	12.4%	5.6%
Maputo	85.6%	82.0%	22.4%	11.2%

The total number of off-grid households across the three provinces is 1.35 million, representing 30% of all the off-grid households in Mozambique.

Assuming that the average distribution of income and willingness to pay for solar products across the three provinces is representative of those in the remaining provinces, the total size of the ***national market for the system 1 type of products is 4.4 million, 3.5 million for system 2 type products, 645 thousand for system 3 type products, and 276 thousand for system 4 type products***.

ES4. Supply side analysis

The off-grid market in Mozambique can be divided into four main supplier groups:

- ❑ Registered businesses dedicated to the sale of solar-home systems and associated products/services;
- ❑ Registered businesses commercialising solar systems/services in addition to multiple other products/services offered;
- ❑ Informal (unregistered) traders offering solar products/services;
- ❑ Suppliers of solar systems as a result of subsidised initiatives (NGO, Governmental or CSR initiatives).

Registered businesses

In total, 25 registered businesses are either active in the Mozambican market or have an interest to enter the market in the near future. Only a few of them are currently operating at a large scale. The establishment of these businesses is mostly related to donor driven programs incentivising the market development of off-grid solar. Although the industry is

still in its early phase of development, several different reputable brands of solar home systems (those meeting Lighting Global Quality Standards) are currently sold through these companies. The average prices of solar kits (three lights, phone charging and radio) sold by these businesses is $126.

Informal traders of solar systems

The informal trade market in Mozambique is thriving, and significantly out-paces formal commercial activity. Most imported products available in the informal markets originate from South Africa, Tanzania, or China.

Vendors either obtain the systems directly from shops (in larger cities of Mozambique/South Africa) or through traders who import the systems and distribute them across several markets. It is common that no import taxes are payed, as the systems enter through informal channels. Furthermore, the quality of the solar systems sold through these channel varies, and usually the buyer is not given a warranty or an adequate installation guide.

Because of the general decline in the economy and reductions in disposable incomes, the volume of trade in the informal market has increased in the past years, as these goods tend to be of a lower cost. An informal supplier sells an average of ten solar systems per month. The business turnover is between $400 and $700 per month, with profit only accounting for 20-30% of that. SHS's sold through informal channels have an average price of $50. These systems do not have a quality certification nor associated guarantee. In most cases, households from rural off-grid areas purchase the systems from the informal markets in the cities.

Non-commercial distributors of solar systems

To date, the main drivers of off-grid solar projects have been donors, NGOs, and the Mozambique Energy Fund (FUNAE). FUNAE has been involved in more than 1,260 projects, including the electrification of small towns, schools and health centres[6]. These non-commercial actors provide valuable experience and understanding of the off-grid sector and household dynamics. As such, they can play a valuable role in stimulating demand for solar systems and engaging in awareness raising campaigns for quality solar products.

Productive use of energy system suppliers

A few companies have been identified which supply solar water pumping and irrigation systems as part of their equipment portfolio. These include Blue Zone (Maputo), True-North (Cabo-Delgado) and Water and Irrigation Solutions Moz Lda (Sofala). No companies have been identified which sell equipment for solar mills or other processing needs.

[6] Renewables in Mozambique – National Status Report, ALER, 2016.

Quality assessment of solar systems

Most of the systems sold in Mozambique do not have a quality certification. From 18 different solar products studied, only four met Lighting Global Quality Standards.

The systems without quality-verification varied in quality (according to expert opinion), of which most were found to be of low quality and low durability.

Value chain analysis

An assessment of the off-grid solar products value chain found that sales channels include own branded shops and third-party distributors. A common distribution model shared by all has been the use of door-to-door sales agents, who not only register interested clients, but also raise awareness regarding the various technologies available in the market.

Only two companies (SolarWorks and Epsilon) currently offer the PAYG payment option. Thus, some opportunities to expand distribution and logistics channels for SHS suppliers in Mozambique were identified to improve the value chain. The sector players that have been identified as potential partners include mobile phone operators, such as Vodacom, store chains (FMCG channels), such as Shoprite, petrol stations, such as Galp and Total, and several MFI's. Other players that can help overcome the high logistics cost include postal offices, couriers, and beverage transporters, such as Coca-Cola.

ES5. Demand-side analysis

In order to analyse the current off-grid solar market from the demand-side perspective, several consumer surveys were conducted in three Provinces, with the objective of assessing household socioeconomic conditions, perception of off-grid solar products, and the potential financial gains of using solar energy.

Numerous criteria, including the level of poverty, availability of grid-based infrastructure, and population density were applied for the selection of sites for the study. Accordingly, the study was conducted in a peri-urban[7] and a rural[8] area in each Province. The sites selected included:

- Two sites in the Maputo province (one in the Matola District and one in the Maluana District),
- Five sites in the Manica province (two in the Vanduzi District and three in the Chomoio District), and
- Two sites in the Zambézia province (one in the Quelimane District and one in the Nicuadala District).

[7] A peri-urban area can be defined as a transition zone where urban and rural characteristics and activities are present, and the landscape is subject to rapid change, induced by human activity.
[8] Rural areas have low population density, agriculture and related activities are usually the primary economic activity, and access to services is limited

Socio-economic baseline

Mozambique is classified as a low-income country[9] with 46.1%[10] of households living below the poverty line. Population density in Mozambique is low and concentrated along transport corridors, the coastline, and urban centers. However, as mentioned before, 70% of the total population live in rural areas and only about 6% of these households have access to the national grid. One of the factors that influence this, is the fact that rural communities are often dispersed throughout Mozambique, which has a total land area of 786,380 Km^2, making grid access difficult. Thus, in order to make reliable energy accessible for all, there is a need to look at alternative solutions, such as off-grid solar products.

On average, households are made up of five members living in houses with about six rooms/divisions. Households are generally made of cement bricks in Maputo Province, clay bricks in Manica Province, and wattle and daub in Zambézia Province.

In terms of education, on average 42.4% of the population in the study had attended primary school, and 45.7% had attended secondary school, while 4.8% did not attend school. Only about 3.6% of the population in the study had attended higher education.

The main economic activities are trade, agriculture, and formal and informal work. On average, 47.5% of those interviewed were women; of which, it was found, the majority are not fully aware of their husband's monthly income. However, it was found that most households earn, on average, about MZN 3,000 ($50) or less, per month. The average monthly expenditure per household across all Provinces, in both rural and peri-urban areas, is of about $79, of which, roughly 16.3% is spent on energy. In general, the socioeconomic condition of households in peri-urban areas is usually better than in rural areas.

Consumer perception of off-grid solar products

An assessment of consumer perception of off-grid solar products revealed that in terms of product **quality**, households are more indifferent in their opinion, as most of these have been exposed to sub-standard products. Nonetheless, about 43% of households in Maputo and 49% in Zambézia believe that solar products are of good quality. In Manica, roughly 13.4% of households stated that they bought their solar system because they believed these were of good quality. In general, households that are closer to areas connected to the grid did not agree that solar energy can give the same benefits as the national grid and give access to better lighting. On the other hand, nearly 61% of rural households believed that solar energy could give them access to reliable energy and provide the same benefits as EDM.

When questioned about **affordability**, 58% of the interviewed population believed that solar energy is expensive. However, it was found that households are not fully aware of their monthly energy expenditures and have not done a comparison of the financial savings and benefits that could be realized if they were to switch to solar energy. This suggests that most households underestimate their ability to afford solar energy. Although respondents were skeptical about using PAYG plans, most of them agreed that these plans would make solar energy more affordable to them. It was also found that financial conditions may not be the main barrier to households not purchasing solar energy, as the lack of knowledge and confidence in using solar technologies, as well as, the perception of quality and awareness of

[9] World Bank (2017) Data
[10] INE (2015). The Final Report on the Household budget and Expenditure Survey (IOF 2014/15)

the benefits of using these technologies, could have a more significant impact in decision-making.

In terms of **accessibility**, it was found that despite the limited availability of solar technologies, solar energy is, in general, accessible to most households that were interviewed. The majority of households in Maputo (76.9% of respondents) and Manica (71.1%), and almost half of the respondents in Zambézia, revealed that they had seen a solar off-grid product being sold before. However, it was found that the distances between the sale points and the household vary from 10 minutes to 5 hours. Moreover, it was found that solar energy companies, such as Epsilon Investimentos and Solarworks, have significantly contributed to making solar systems more accessible and introducing variety in terms of the technologies offered in the market. A factor that might influence a household's decision whether to purchase a solar system is the fact that over half of respondents believed that it would be difficult to find someone to fix their solar system when it breaks.

Awareness of solar energy was higher in the Provinces of Maputo and Manica, where over 90% of respondents[11] were aware of solar energy, while in Zambézia only 20% of respondents knew what solar energy was. This may be because unlike Maputo and Manica, there are no solar energy companies operating in Zambézia. In rural Manica, nearly 42% of households said that there are awareness campaigns in their area. Moreover, it was also found that from those that purchased a solar product in the peri-urban area of Manica, 43% them were influenced by word of mouth to make the purchase. While the awareness levels of mobile payment systems are very high across all Provinces, the willingness to use these systems to pay for electricity is lowest in Zambézia compared to the other Provinces.

Potential benefits related to solar energy that were cited by the households interviewed include a reduction of monthly energy expenses, ability to charge a phone at home, potential to start a business, ability to undertake activities at night, and the prospect of using a television and refrigerator. It was found that, 66.5% of households in Maputo and 80.7% in Zambézia, believed that solar energy could reduce their monthly energy expenditure; and about 46.4% believed that solar energy could help them start a business. While one-fourth of households in Manica believed that solar energy could allow them to use appliances such as television and refrigerators, most households interviewed did not believe that solar energy could power these appliances. Potential disadvantages related to the use of solar energy, according to respondents, include lack of knowledge regarding the technologies and how to use them, high risk of the system/kit to be stolen, and limited availability of parts in case the system breaks down.

Financial gains to households related to the purchase of solar products

Overall, peri-urban households in Mozambique are spending about $96 (MZN 5,774.77) per month on different goods and services, while rural households are spending nearly $65 (MZN 3,907.03) per month. Of these expenses, about 13.8% are energy[12] expenses in peri-urban households ($13), and 18.7% in rural households ($12). It is interesting to note that despite the income differences, households are spending nearly the same amount on energy. This may be because, although peri-urban areas use more sources of light (i.e.: 2 battery torches), the same sources are more expensive in rural areas.

[11] Both in peri-urban and rural areas
[12] Energy refers to energy for light, phone charging, and radio.

Monthly expenditure on energy varies according to income, as it was found that in both peri-urban and rural areas, low- to upper-middle income households mostly use battery torches, while for high-income households, EDM, solar energy, and car batteries are the most popular sources of light.

Additionally, it was found that energy expenditure also depends on geographical aspects. For instance, rural households in Manica are spending between 60% to 68% more than the other Provinces on energy. This may be due to the type of energy source bought, as well as, the amount and frequency of purchase, as it was found that monthly expenditure on batteries in Manica is 22% above the national average.

The financial gains to households related to the use of solar energy were assessed by estimating the pay-back period, which is the average time taken to pay off a solar system/kit in full, if the household were switch to solar energy. The current monthly energy expenditure was used to estimate the payback period.

The analysis was done for two hypothetical stores[13] that offered direct purchase of solar systems. In Store 1 duties and taxes are included in the price of the systems, while in Store 2, products do not include taxes and duties. As seen in the Table below, most households can pay off system 1 (which powers one light and charges a phone) within one to two months, if they were to pay MZN 1,000 ($16.66) in store 1, and MZN 660 ($11) in store 2[14]. However, it was found that though most households can afford system 1, this is not their preferred system. In peri-urban areas, for example, it was found that it could take households up to 8 years to pay off a system that satisfies their energy needs.

Table 2 Pay-back periods for solar systems

Game	System	Mozambique	
		Peri-urban	Rural
Store 1- Direct Purchase with duties/taxes	1	2 months	2 months
	2	8 months	9 months
	3	3 years and 2 months	3 years and 6 months
	4	8 years and 5 months	9 years and 2 months
Store 2- Direct Purchase without duties/taxes	1	1 month	1 month
	2	5 months	6 months
	3	2 years and 2 months	2 years and 5 months

[13] Store 1 and 4 of the Market Willingness to Pay (MWTP) exercise in Annex A4.
[14] Based on the rates established in the MWTP exercise.

Game	System	Mozambique	
		Peri-urban	Rural
	4	5 years and 7 months	6 years and 1 months

Based on the estimates of the Market Willingness to Pay (MWTP) exercise, solar energy was found to be a more cost-effective solution to households looking to have basic access to energy as compared to current energy sources used (batteries, kerosene, candles). However, even though households are able to afford system 1, the majority of them, based on their choice of preferred systems, would like to have larger solar systems that are not as affordable to them if acquired through direct payment. Thus, it is suggested that PAYG plans would be a feasible solution for these households.

It was evident during the study that the financial gains of using solar energy are not obvious to households. Thus, it would be necessary to ensure that households are aware of their current energy expenditure, know that there are options available to reduce this expenditure, and that solar energy could provide them with access to a more reliable source of energy. Moreover, there are other non-monetary gains that these households can experience that could be of great value but are not accounted for, such eliminating the time spent to travel to purchase batteries or to charge phones every week.

Financial gains to institutions related to the purchase of solar products

Out of all the institutions interviewed, it was found that 86% of them did not have access to electricity. According to 83%, lack of electricity connection in the area was the main reason. An additional 14%, which includes a public school and a public private partnership health facility, use EDM and solar energy, mainly for water pumps. (The remaining 3% did not respond to the question).The solar systems were either a donation from FUNAE or bought with donor funds.

When asked if the institutions would be willing to pay for a connection, 42% of the institution's caretakers[15] stated that they would be willing, but the majority observed that it is not a decision the school/health facility can make as it is dependent on government funds. However, all schools and health facilities stated that electricity would help in improving service provision, including offering night classes at schools for those who work during the day, and in the health sector for emergency services during the night.

It was found that institutions that do not have electricity, do not use any other source of light or power, as all their activities are carried out during the day. That said, it was found that these institutions can request for funds from the government when available, for services such as water and electricity; however, none of the interviewees mentioned this when asked if they could afford a solar system.

As there was no monthly energy budget it was not possible to estimate the payback period. However, during the interview with the Muhalaze Health Centre, it was found that the Centre was spending about $200 per month on energy prior to purchasing a solar system to

[15] These include Teacher, School Director, Nurse, and Doctor.

pump water. Upon acquiring the system, the Centre experienced a near 58% drop in their monthly expenditure on energy. Thus, it is evident that solar energy could also aid in cost reduction for institutions that are already connected to the national grid. Moreover, from the savings made, the Centre was able to purchase new medical equipment which will improve the quality of service provided in that institution.

It was found that most of those interviewed were not aware of the benefits solar energy could provide, usually questioning if solar technologies would have the capacity to provide power to an institution such as a health centre. There is an opportunity here to change this perception, perhaps by having local municipalities and other public institutions, in towns and cities, using solar energy, which could set an example that solar energy could be a viable solution to satisfy the energy needs of these institutions, or help in reducing costs.

Demand side insights and recommendations

- ***Consumers want products that are appealing and can provoke a sense of pride in using these products***. As it was seen, word-of-mouth advertising plays a significant role in household's decision to purchase off-grid solar products. As such, it is important that these products are aesthetically pleasing and can provide the benefits promised so that consumers are happy to recommend them, and change the way solar products are perceived.

- ***Educating consumers is key to ensuring that they have a good perception regarding the benefits and limitations of solar products***. There is a need for consumers to understand the distinction between a good quality product and a sub-standard one. Moreover, there is a need to educate households on the potential financial gains of switching to solar energy and ensuring that they are aware of their current energy expenditure.

- ***Consumers benefit from demonstrations and experiencing the products to build trust and develop an interest in this technology***. This would also play a significant role in educating consumers on how to use these products and increase their knowledge on the technology.

- ***Bundling solar products with other appliances would raise the attention of consumers*** and could be an added-value to the products, which, in turn, can contribute to the development of those communities. This would also significantly influence word-of-mouth advertising.

ES6. Market barriers and recommended policy interventions

Institutional and regulatory barriers

One major obstacle to the development of the sector is the low level of governmental coordination with regards to energy policies, and the lack of coordination amongst donors and with the government.

The absence of a shared vision and poor coordination between the key sector institutions constrains the development of a resilient market system.

Policy actions to overcome regulatory and institutional barriers:

- ***Shared policy vision:*** Policy inconsistencies that increase investment risks can be reduced by providing greater clarity on policy direction and agreeing on a shared vision for the private sector's role in increasing access to electrification in rural areas. This can be achieved by ensuring dialogue and exchange of market information between the key stakeholders.

- ***Greater stakeholder coordination:*** Establishing an open dialogue with the private sector is a crucial step to ensure coordination between different actors. Government and donors should agree on a national approach to target the lower-income segments of the market and strengthen national institutions. The Energy Sector working group is an existing forum for such a consensus to be reached. Effective communication between the government, donors, and NGOs is also fundamental to reduce uncertainty and encourage investor confidence.

Lack of quality standards

The diffusion of high-quality products is hindered by the lack of certification and national quality standards for solar equipment and appliances. Although the solar market is still emerging in Mozambique, the influx of inferior quality equipment over time is likely to distort consumer views of solar products, adding further constraints to development of the solar market.

Policy Actions on quality standards:

- ***Local standards accreditation:*** this should be based on adopting international standards (Lighting Global and IEC), but could also include accreditation of other products. The solar laboratory established with GIZ assistance at the Universidade de Eduardo Mondlane (UEM) and the SHS testing facility at the Instituição Industrial de Maputo (IIM), provide a nucleus of people with the necessary skills. The objective would be to protect customers, discourage import of inferior materials and prevent non-accredited products from accessing any future tax breaks which might be introduced.

- ***Warranty requirements*** of a minimum of one year should also be made compulsory to exclude sub-standard materials from the market and encourage solar companies to build stronger customer relations.

Access to financing and payment mechanisms

Lack of access to finance and to convenient payment mechanisms are major constraints for solar companies and households.

On the supply side, the time gap between the upfront payment to suppliers and the receipt of revenues from customers significantly impacts their cash flows and ability to regulate imports, which in turns negatively affects their financial sustainability. Wholesalers and distributors are also constrained in extending credit, expanding their distribution networks and undertaking marketing activities to boost demand. These challenges are further aggravated by the impact of currency depreciation, which raises costs on the import of equipment and adds risk and uncertainty to the market.

Policy action on supply side access to finance:

- ***Results-Based Financing (RBF) scheme,*** which would be a fund or programme that links the pay-out of financial support to pre-determined results.

  In particular, an RBF scheme could be used to provide incentives for suppliers to operate in remote rural areas that would not otherwise be served by private companies.

  The RBF instrument is seen as a cost-effective use of development funds and a way to encourage innovation. In contrast to conventional grants, RBF finance is disbursed against results actually achieved and independently verified.

While grant financing for start-ups will become available through the Market Development Fund (MDF) under the BRIHLO programme, funded by DFID (section 5.5), there is generally a lack of financing for already established solar companies to help them expand to rural areas. The development of a potential fund to support solar businesses operating in non-financially attractive areas is something that the World Bank could add support.

Consumer financing is constrained by a number of challenges including limited usage of mobile money across the country, weak mobile money penetration, and poor financial infrastructure.

Policy actions on demand side access to payment mechanisms and to finance:

- Raising awareness of mobile payment mechanisms and their benefits for end-users and creating an enabling environment for the widespread distribution of mobile networks;
- Improving collaboration between financial institutions and PAYG partners to increase PAYG availability in the country;
- Extending financial services to customers in rural and peri-urban areas through savings and credit cooperative organisations.

Import duties and VAT constraints

One of the issues that stakeholders identify as a key barrier to sector development is the high level of import duties and VAT, which increases the price to end-users, reducing the size of the market, and therefore, discourages investment in the country. Currently, all renewable energy technologies are subject to 17% VAT and between 7.5% and 20% import duty, depending on type of component.

Policy action on import duties and VAT:

- ***Temporary waivers of import duties and VAT*** on quality-verified products: to overcome this barrier, the government could develop specific provisions to reduce or exempt VAT and import duties on solar products, with eligibility criteria based on meeting quality standards. Such provisions would decrease prices for end-users, boost demand, and stimulate the development of the private sector.

Human capital and skills gap

The weak supply of skills in the market is perceived as a major obstacle to the development of the off-grid solar sector in Mozambique. The missing skills are mainly managerial competencies, business management, sales and marketing, logistics, and technical capabilities.

Companies face high search costs to recognise suitable employees without training certifications. At the same time, there are no incentives to employ and provide training for young workers, which in turn negatively affects youth employability and the ability to ensure innovation in the off-grid industry.

Policy actions to overcome human capital and skills gaps:

- ***Education and training*** – Cooperation between educational institutions and the private sector should be strengthened to bridge the skills mismatch and reduce the search costs to hire qualified personnel. Vocational training facilities should be created to improve technical skills and encourage entrepreneurship in the sector and provide capacity building for installation, repair, and maintenance services.

- ***Less stringent immigration requirements*** – given the critical role of transferring sector expertise and know-how at the technological and managerial level, the procedure for hiring foreign workers should be relaxed for the off-grid solar industry.

Distribution barriers

The high level of distribution costs is due to the dispersion of the rural population and the large distances between the ports of Nacala, Beira, and Maputo to the interior regions, exacerbated by the adverse condition of the road network, which substantially increases transportation and logistics costs.

Policy actions to address logistical barriers:

- ***Cooperate with institutions with a national presence*** - one possibility to reduce transportation and logistics costs is for solar companies to cooperate with post offices in distributing products.

- ***Cooperate with logistics companies*** - alternatively, or in addition, bus operators, couriers, and large companies including beverage transporters such as Coca Cola, could play a key role in decreasing logistics costs and ensuring a more efficient last mile distribution process. This would involve:

  - Implementing cost sharing initiatives with trucking companies to transport solar equipment;

  - Encouraging large companies to provide transport and other support services for solar off-grid as part of corporate social responsibility (CSR) activities;

- ***Providing direct financial assistance*** to solar energy companies from public and donor funding to cover parts of the high logistics costs of reaching rural areas. A

results-based approach would be appropriate for such a subsidy scheme, and this could thus be part of the RBF scheme mentioned earlier.

Market information

Market entrants find themselves on a steep learning curve because work that has already been carried out on the market for off-grid solar is often not readily available.

Policy action to make market information more readily available:

- ***Market information portal*** that collects all public studies relevant to the off-grid sector and relevant legislation documents.

Sustaining demand

The expansion of the solar off-grid sector is targeted at lower-income segments of the population, where ability and willingness to pay are weak. Factors that reduce the margins for competitively priced products, particularly in rural areas, include low levels of literacy and market awareness, anticipation of the main grid arriving, large distances between the main provincial capitals and the interior areas, and the widespread availability of low-quality products.

Policy action to address consumer information gaps and mis-information:

- ***Public campaigns*** on the benefits of quality off-grid products and mobile payment methods need to be conducted. The objective should be to consolidate and sustain market demand as accurate knowledge of off-grid technologies becomes more widespread.

1 Introduction

1.1 Background

Approximately 72% of Mozambique's 29.7 million people do not have access to the power grid, while in rural areas only 5% of the population enjoys the benefits of grid electrification.

Off-grid households rely on technologies such as battery powered torches and kerosene lamps to meet their lighting needs. These alternatives may provide lower-quality light and some are unsafe, damaging to health and more expensive compared to household clean energy products (solar pico products and solar home systems) that are used only by approximately 10% of households.

Acknowledging the important role that access to clean forms of electricity can play in the development of the country, the Government of Mozambique (GoM) has joined the Sustainable Energy for All (SE4ALL) initiative and committed to a target of achieving universal access to electricity by 2030.

However, according to current projections, only 50% of the population in 2030 will have access to the electricity grid[16]. With full national grid electrification being a long-term ambition, off-grid systems will complement the efforts to make electricity available to the people by 2030. Also, while grid connections are highly subsidized, their real cost can be between $500 and $2,000. On the other hand, solar home systems that provide full Tier 1 or higher electricity access for a household cost approximately $200.

1.2 Objectives of the study

This Final Report is submitted by Economic Consulting Associates Ltd (ECA) of the United Kingdom, together with GreenLight of Mozambique, and is the final deliverable for the assignment:

Off-Grid Solar Market Assessment in Mozambique

The objective of this study is to assess the market opportunities and challenges for adoption and scale up of the off-grid solar market in Mozambique.

The purpose of this report is to present the results of the analysis on all five tasks of the project, namely:

- **Supply side analysis (Task 1)**: The objective of this task is to provide a thorough overview of the main business players in the Mozambique off-grid solar market, assess the quality of off-grid solar products in Mozambique and provide a landscape of off-grid solar products in Mozambique.
- **Demand side analysis (Task 2)**: The purpose of this task is to conduct demand side analysis on off-grid solar products, including an analysis of consumer perception of off-grid solar products (OGSP), a discussion on financial gains to

[16] Energy Africa Compact for Mozambique

household and institutional users and an estimation of the off-grid product market size.

- **Regulatory and enabling environment (Task 3)**: The objective of this task is to analyse the regulations relevant to scale up off-grid solar market.
- **Barriers for market scale-up (Task 4)**: The objective of this task is to provide an analysis on various barriers facing off-grid solar in Mozambique.
- **Options for intervention (Task 5)**: The purpose of this task is to list and detail measures that can be taken by the government of Mozambique and its cooperation partners to strengthen the off-grid solar market in Mozambique.

The report is divided into the following sections:

- Section 2– Supply- side analysis
- Section 3 –Demand- side analysis
- Section 4 – Market size estimation
- Section 5 – Regulatory and enabling environment
- Section 6 – Market barriers
- Section 7 – Options for intervention

2 Supply-side analysis

2.1 Key Market Players and business models

The off-grid solar market in Mozambique can be divided into four main supplier groups:

- ❑ Registered businesses dedicated to the sale of solar-home systems and associated products/services;
- ❑ Registered businesses commercialising solar systems/services in addition to multiple other products/services offered;
- ❑ Informal (unregistered) traders offering solar products/services;
- ❑ Suppliers of solar systems as a result of subsidised initiatives (NGO, Governmental, or CSR initiative).

The four categories are discussed in more detail in the following section.

2.1.1 Registered businesses in off-grid solar market

In recent years, a number of companies have either been established to sell solar systems or have included solar systems as part of their portfolio (supplier groups 1 & 2). Although the industry is still in its early phase, several different reputable brands of solar home systems are currently sold through these entities. The establishment of these businesses is mostly related to donor driven programs incentivising the market development of off-grid solar. The GIZ managed Energising Development (ENDEV) program, for instance, offers results-based financing (RBF) through grants for companies selling solar systems meeting Lighting Global Quality Standards.

The upcoming DFID funded BRILHO program and the African Enterprise Challenge Fund (AECF) have similar objectives and offer various incentives to businesses to help them overcome the market barriers.

Although 21 businesses have been identified as either being active in the Mozambican market or with an interest to enter soon, only a handful of them are currently operating at a large scale. The most advanced company offering a Pay as You Go (PAYG) service to its customers in the southern part of Mozambique currently has just over 5,000 users and is expanding to the central and northern provinces. Another player that has recently started offering a PAYG option is running a pilot in Manica province with over 800 users.

Dynamiss is a Mozambique start-up and through the support of the RBF program by ENDEV they have sold approximately 600 systems since 2014. TOTAL has also entered the market selling several thousand NIWA solar systems through its petrol station network country-wide. Logos industries offers a promising model for solar system distribution. They are the official distributors for multi-choice (satellite television) with retailers across the country. These same channels can be used for the sale of their new range of solar kits.

Other companies active in the off-grid space are currently investing in mini-grids. These include Cronimet and Ecolibri with projects currently in the pipeline. Cronimet is entering

into a public private partnership with FUNAE and implementing a 300-kw solar mini-grid in Chiloane Island in Sofala province. Ecolibri is currently installing a 70-kw hybrid wind and solar system in Nampula province to power Coral Lodge and surrounding communities. The company is intending to use this site as a pilot project and potentially replicate the technology for rural electrification purposes. RVE.SOL, MocItaly, Grupo JFS and EDP have in the past explored opportunities to invest in the sector, but they have decided not to, due to regulatory challenges which will be discussed in the following sections of this report.

Decision making related to implementation of mini-grid projects is related to three main factors:

1. Sites with a high demand for productive use of energy;
2. Sites with anchor clients to sustain financial viability;
3. In response to government strategy associated with the FUNAE off-grid projects portfolio with identified sites for mini-grid implementation.

Besides the companies already operating in Mozambique, several international firms have shown interest in the Mozambican market. It is assumed that with a more favourable enabling environment, these firms will begin operation in the country.

Figure 1 Products from established SHS companies (from left: Logos; Solarworks; Green Watts)

Source: GreenLight

The solar systems offered by dedicated solar energy companies mostly meet Lighting Global Quality Standards and offer several benefits to end-users such as PAYG, correct installation (either through manuals or direct installation), and systems guarantee (Figure 1).

During the site visits for this assignment, it was observed that several stores selling low cost goods (low and mid-range electronic products imported from China) have begun incorporating solar systems as part of their offering (See Figure 2 and Figure 3). Both individual system components (PV panels, batteries, inverters, charge regulators) as well as SHSs are sold at a fraction of the cost compared to the solar systems typically supported through donor programmes, such as ENDEV (5.5). In Maputo for example, several Chinese-owned shops as well as the reference shop called METALEX are examples of where one can purchase lower cost solar energy products.

Figure 2 Casa Asa – Electronics shop in central Maputo selling solar energy components and SHS's

Source: GreenLight

Figure 3 SHS's sold at Casa Asa electronics shop in Maputo for less than $50

Source: GreenLight

Table 3 Price list of solar energy equipment sold at electronics shops

	Shop			
Component	Metalex (Maputo)	Casa Asa (Maputo)	Chinese shop (Chimoio)	Electric Shop (Quelimane)
10 Wp solar panel	1,180 MZN ($20)	1,050 MZN ($18)	700 MZN ($12)	600 MZN ($10)
20 Wp solar panel	1,890 MZN ($32)	1,350 MZN ($23)	1,200 MZN ($20)	1,200 MZN ($20)

	Shop			
50 Wp solar panel	3,780 MZN ($63)	3,000 MZN ($50)	3,200 MZN ($53)	N/A
100 Wp solar panel	6,980 MZN ($116)	5,500 MZN ($92)	N/A	N/A
12v 7 AH battery	1,250 MZN ($21)	700 MZN ($12)	700 MZN ($12)	800 MZN ($13)
12v 12 AH battery	2,510 MZN ($42)	1,200 MZN ($20)	N/A	N/A
DC to AC inverter (159 W Max)	1,600 MZN ($27)	N/A	700 MZN ($12)	900 MZN ($15)
DC to AC inverter (300 W Max)	3,150 MZN ($53)	N/A	1,800 MZN ($30)	N/A
DC to AC inverter (800 W Max)	6,050 MZN ($101)	N/A	N/A	N/A
Solar home system 3 lights/phone charging/lantern	3,100 MZN ($52)	3,000 MZN ($50)	2,500 MZN ($42)	N/A

As shown in the above table, households can purchase solar energy components for basic energy needs (lighting, radio, phone charging) at a starting price of just under $50. The cost of SHSs in these shops is also set at around the same price. Buyers have an option to scale-up according to energy needs when purchasing solar energy components with a higher capacity. It should be noted that charge regulators are not readily sold at these shops and correct installation guidance is not given by shop attendants. It is, however, noteworthy that in the Chinese-owned shops visited in Chimoio, a guarantee of up to 6 months is normally offered for systems sold.

2.1.2 Informal traders of solar systems

The informal trade in Mozambique is thriving and largely out-numbers formal commercial activity. Most imported products available in the informal markets originate through cross-border traders or supplied by wholesale agents. It is becoming increasingly common to find solar systems sold through this channel. Products range from complete solar kits (lights, phone charging, radio) to individual components (PV panels, batteries, inverters, charge regulators and accessories). The quality of these systems varies and usually the buyer is not granted a warranty or correct installations guide. The common perception regarding these systems is that they break down easily and are considered a risky investment. Annex A1 lists the largest informal (traditional) markets per province.

Three market places were visited for this assignment (two in Manica province and one in Maputo). A brief interview was carried out with the sales-people. **Error! Reference source not found.** presents the key messages from the interviews, while the full results of these interviews are presented in Annex A2.

Table 4 Key messages from the interviews

Types of systems sold and average price:	Most informal vendors sell individual components such as PV panels, batteries and inverters of different capacities. A combination of these system components with associated accessories can cost the buyer just under $50 for a functional basic solar kit (able to run 2-3 lights, phone charger and radio). Pico solar lights may cost an average of $5 which also have phone charging capacity.
Source of systems (where imported/bought from):	Systems are either sourced from South Africa or China. Vendors either obtain the systems directly from shops (in larger cities of Mozambique/South Africa) or through traders which import the systems and distribute across several markets. It was registered that some informal vendors order the systems through whatsapp groups and make payments via M-Pesa (Mobile money), bank transfer or cash upon collection.
Business volume (sales figures):	According to the vendors interviewed, the volume of business has reduced over the past years. On average 10 solar systems are sold per month. The business volume is between $400 and $700 per month, of which only 20% is profit.
Support offered to customers:	Limited support is offered to customers; however, some vendors in Maputo markets offer the same guarantee to end-users which is offered to them by the suppliers. Normally 30 days guarantee if a system component is faulty. A basic explanation is given to buyers on how to connect their solar system components, however no installation service is provided.
Profile of customers:	In most cases, households from rural off-grid areas purchase the systems from the informal markets in the cities. Large municipal (informal) markets are a common source for manufactured goods. Although the prices of these goods may be more expensive compared to some formal shops; it is common practice for households to purchase from informal markets due to the perception that products are cheaper and that one may bargain for them. Another customer segment are traders from rural areas which buy solar systems from the urban markets to re-sell in the rural areas. Customers usually know to buy the solar systems at the informal markets through recommendations and/or are exposed while visiting the market for other purposes.

The informal markets in both urban and rural areas of Mozambique are at the centre of commercial activities for low and middle-income households. Leveraging this channel to sell certified quality solar systems can therefore be a strategic distribution decision for suppliers of such systems. During the interviews with the informal vendors, they expressed an interest to sell better quality solar systems and be part of the supply chain for suppliers interested in this channel. It is recommended that a more comprehensive mapping of informal vendors is carried out for the purpose of exploring this option. Figure 4 and Figure 5 show examples of solar energy products sold at informal markets.

Figure 4 Solar energy component stand at Xipamanini Market – Maputo

Source: GreenLight

Figure 5 Individual solar energy components sold at informal markets

Source: GreenLight

2.1.3 Non-commercial distributors of solar systems

To date, the main drivers of off-grid solar projects have been donors, NGOs and the Mozambique Energy Fund (FUNAE). FUNAE possesses a solar PV manufacturing plant in Boane (Maputo province), which FUNAE uses to supply households and institutional users in rural areas with solar systems. Other system components are supplied by third party

suppliers. To date, FUNAE has been involved in more than 1,260 projects, including the electrification of small towns, schools and health centres[17].

In the absence of a developed market for quality solar systems in some regions of the country, NGOs such as Ajuda de Desenvolvimento de Povo para Povo (ADPP), Agência de Desenvolvimento Económico Local de Sofala (ADEL Sofala) and Kulima have bridged this gap by distributing solar systems as part of subsidised programmes. The NGOs in the sector have formed an association called FEDESMO – "Forum de Energias e Desenvolvimento Sustentável de Mozambique" (Mozambican Forum for Energy and Sustainable Development).

These non-commercial actors hold valuable experience and understanding of the off-grid sector and household dynamics. These actors can play a valuable role in stimulating demand for solar systems and engaging in awareness raising campaigns for quality solar products.

2.2 Productive use of energy system suppliers

The use of renewable energy as a vehicle for the development of local businesses and economic activities is as priority to the Government of Mozambique. The Policy for the Development of New and Renewable Energy (resolution 62/2009, 14 October) as well as the Strategy for New and Renewable Energy Development 2001-2025 (EDENR) both promote the productive use of energy through renewables.

With regards to systems supporting productive use of energy; a few companies have been identified which supply solar water pumping and irrigation systems as part of their equipment portfolio. These include Blue Zone (Maputo), True-North (Cabo-Delgado) and Water and Irrigation Solutions Moz Lda (Sofala). The target market is not however the Base of the Pyramid (BoP). No companies have been identified which sell equipment for solar mills or other processing needs. A handful of development organizations and NGOs do, however, focus on the productive use of energy. These include the International Development Enterprise (IDE), Ajuda de Desenvolvimento de Povo para Povo (ADPP), the Global Green Growth Institute (GGGI), and the United National Industrial Development Organization (UNIDO).

Market data points to several opportunities for commercial and productive use of energy in rural Mozambique. The following are some of these activities:

- ❑ Grain mills for processing of maize, rice and cassava;
- ❑ Metalwork shops;
- ❑ Woodwork shops;
- ❑ Barbers and hairdressers;
- ❑ Community cinemas and entertainment centres;
- ❑ IT kiosks and print / photocopy centres;

[17] Renewables in Mozambique – National Status Report, ALER, 2016.

- Tyre repair and air-filling stations (electric air compressors);
- Ice making and refrigeration services;
- Mobile phone charging stations;
- Commercial stalls and shops;
- Agriculture – Water pumping and irrigation

2.3 Quality assessment of solar systems

Most of the systems sold in Mozambique appear not to have a quality certification. This information is based on site visits to several suppliers (electronics shops, markets, companies distributing solar equipment) as well as information obtained from the household questionnaires. From 18 different solar products studied, only 4 met Lighting Global Quality Standards. The non-certified systems varied in quality (according to expert opinion), of which most displayed low-quality and low durability. The evaluation of quality has been carried in user trial tests whereby the battery charge and discharge capacity was evaluated in a select number of systems over a period of 30 days by the consultant. It is recommended that laboratory quality tests be carried out for these and other systems available in the market. GIZ-ENDEV has supported the establishment of a solar quality testing laboratory at University Eduardo Mondlane (UEM). The expert responsible for testing was available during the duration of this assignment, however an agreement has been reached to carry out the tests at a later stage.

2.4 Value chain analysis

The solar home system value chain remains underdeveloped and divided between different entities – the formal, the informal, and public.

Formal distributors of solar-home systems follow a similar process of import, distribution, and retail. The origin of products is in most cases from Chinese manufacturers. Units are shipped by sea and arrive in the several ports along the coastline (the largest being Maputo, Beira, Nacala, and Pemba) within an average time of two months. Clearing of systems is a bureaucratic and costly process, which typically involves the services of a clearing agent. Upon clearing the goods, the distributor is requested to pay between 7.5% and 20% import duties related to the cost of goods imported and an upfront 17% Value Added Tax (VAT) on the cost of the systems. Interviews with solar system distributors in Mozambique suggest that these import related taxes are among the greatest challenges for businesses to scale up as they directly influence end-user price in a sensitive economy.

Sales channels for formal distributors include own branded shops (such as for the case of Solarworks and Epsilon), third party distributors (such as small electronics shops, petrol stations and other vendors – such as in the case of the NIWA systems through Total petrol stations and the Fosera systems through local vendors, and Metalex electronic store). A common distribution model shared by all has been the use of door-to-door sales agents which not only register interested clients, but also provide an additional service of awareness raising and promoting the technologies. Sales agents typically receive a margin on sales (around 5% of the price).

Only two companies (Solarworks and Epsilon) currently use the PAYG payment model. The other companies interviewed all use direct-sales models. Payment in instalments has been tested by most companies, however in the absence of a PAYG management system (such as remote disconnection of units), it is difficult to recover cost from users. Synergies between micro-financing institutions and solar system distributors have not been strong. Few end-user financing opportunities currently exist targeting access to energy. PAYG has not yet scaled considerably due to a number of factors:

- Mobile money agents are mostly concentrated in urban areas as a direct result of the prescribed proximity to formal banking institutions (to register as a mobile money agent one must be no more than 50km distance from a formal bank). Many off-grid communities are futher away than this.
- Although awareness about the availability of mobile payment services is relatively high (according to survey results), knowledge regarding mobile payment procedures and willingness to use them is low. This may be because awareness raising and marketing campaigns are strongest in urban areas; as well as the location of mobile agents as mentioned in the point above.
- PAYG service providers need to spend a considerable amount of time and financial resources to educate potential customers on mobile payment literacy before making a sale. This effort may deter new PAYG market entrants.
- Deposit (or first instalment) required by PAYG companies upon receiving SHS may still be outside the reach of some households.

Informal vendors of solar systems are found in the larger urban markets across the country and increasingly present in rural areas. Systems are acquired either directly from electronic shops in the cities (Mozambique), South Africa, Zimbabwe, Zambia, Tanzania, and even brought from Kenya; or delivered by traders which import from abroad (most commonly from China). The informal vendors typically make a 20-30% margin on the sale of systems. It is not clear whether import taxes and VAT is paid upon entry of the system in the country; however, the lower prices of these system suggest that taxes are avoided. The sales model is direct (cash and carry) and payment modalities are typically not offered to end-users.

The table below shows the average price of SHSs sold through different types of distributors. The end-user price for quality-verified systems through official distributors is considerably higher compared to the non-certified systems sold through small electronics shops and the informal markets.

Table 5 Sales price comparison between different type of SHS distributors

Distributor type	Average price of SHS (MZN)	Average price of SHS ($)
Official distributors of quality-verified systems	7,567	$126
Electronic shops (non-certified systems)	2,867	$48
Informal vendors (non-certified systems)	3,000	$50

Source: GreenLight

2.5 Potential cooperation with other sector players

Some opportunities exist to expand distribution and logistics channels for SHS suppliers in Mozambique. The following sector players have been identified as having a strong presence in several parts of the country:

Table 6 Sector Players with Strong Presence in the Country

Type	Sector Players
Mobile phone operators and sales agents	Vodacom, Mcel, Movitel
Store chains	Shoprite, Savemore, PEP, VIP, Recheio
Petrol stations	Galp, Total, Petromoc, Engen, BP
Satellite Television Operators	Multichoice, Star-Time
Government offices in Provinces	FUNAE (public partnership)

Synergies may also exist in the transport of SHSs, through the following sector players:

Table 7 Synergies for the transportation of SHS

Type	Sector Players
Postal office	Correios de Mocambique (Mozambican Post Services), Post-Bus
Bus Operators	Nagi Transportes; Maningue Nice; transportes Nhancale; Etrago
Couriers	DHL, Skynet, Portador Diário
Beverage transporters	Coca Cola, Handling

2.6 Recommendations for World Bank support – Supply Side

The list below highlights some of the areas in which the World Bank may support the supply side of the off-grid solar sector:

- The value chain assessment shows that quality-verified solar products are considerably higher priced compared to solar products typically sold at informal markets. The assessment also indicates that products sold through informal markets may have bypassed the payment of import duties and taxes. As a means to create a level playing field, it is recommended that a financial mechanism be applied to reduce the end-user price of quality-verified solar products (such as RBF or import facility grants).

- The large majority of solar products sold in Mozambique do not have quality certification. A potential intervention may be to support distributors / suppliers in receiving certification (either Lighting Global Quality Standards or by developing a Mozambique-specific quality standard). This would allow suppliers and distributors to be eligible for potential sources of financing which are applied only to quality-verified products.

- In light of promoting the distribution of quality-verified solar products, an option is to make use of existing actors and networks (informal markets, electronics shops) as channels for the sale of such products. Data from interviews with vendors at the markets suggest that they are willing to sell products meeting quality standards if stock was made available to them. Small business loans tied to the purchase of quality-verified systems can be an example of a support mechanism. It is further recommended to conduct a detailed mapping of the solar product supply chain actors (formal and informal) so as to understand the scale of this distribution channel. Understanding more about these actors may also facilitate structuring programs related to business development training, which may promote their shift from the informal to the formal sector.

- PAYG is not yet widely adopted as a payment mechanism for SHS distributors. Currently only two companies are implementing this option. RBF can be used as an incentive for other companies to adopt PAYG technology as a means to facilitate end-user payment.

- Several challenges for the scale up of PAYG have been mentioned in this chapter (refer to section 2.4). Addressing the willingness of households to use this payment mechanism can be achieved by supporting awareness raising and consumer education programs. These campaigns may be carried out by the mobile money service providers (such as M-Pesa); government agencies (such as FUNAE); NGOs (such as Kulima, Adel and Livaningo), and/or the distributers of SHSs themselves if budget is available.

- The supply side assessment shows that there are few businesses focusing on the supply of solar systems for the productive use of energy. Furthermore, the few companies which have been identified do not focus on the low-income segment of the population. A financial incentive (such as RBF) for existing and new businesses to focus on the distribution of affordable solar products for productive use can scale up the availability of the technology to off-grid communities.

3 Demand-side analysis

3.1 Introduction

Limited access to electricity is one of the major challenges that the electricity sector is currently facing. The Government of Mozambique is committed to achieving the Sustainable Development Goal 7 – ensuring access to affordable, reliable, sustainable and modern energy for all by 2030. Thus, a more diversified energy sector, where households are not solely dependent on the national gird, is perceived as a solution to ensure off-grid households can have access to reliable power. Efforts to achieve this goal require a number of different interventions and this section presents an analysis of the current off-grid solar market from the demand side perspective. The analysis covers the following subjects, as per the Terms of Reference:

- Assessing the consumer perception of off-grid solar products, including their quality, affordability and accessibility through collecting primary data (Section 3.3).
- Analyzing financial gains to consumers through the use of off-grid solar products, based on their existing household income, energy expenditure, and expected cost of using off-grid solar products. The analysis was carried out on household users as well as institutional (e.g. schools, health centers) users. Distinction was made between urban/peri-urban and rural household users (Section 3.4).
- Estimating the current and potential off-grid product market size in terms of its value and volume. The analysis took into account, inter alia, household income, willingness to pay, product affordability, financing, government strategies, etc. The market size included both grid-connected users (as backup), users not connected to the grid, and institutional users (e.g. schools, health centers). Decomposition by province is also provided (Section 4).

For the purpose of better structuring the results section, an additional section presenting the socio-economic baseline (Section 3.2) is also provided. The methodology for the work is presented in Annex A6.

3.2 Socio-economic baseline

Mozambique is a vast country with a total land area of 786,380 Km^2 and a total estimated population of 28.9 million[18]; of which 70% live and work in rural areas (World Bank, 2018). It could be said that due to its immense size, population density in Mozambique is low, with an average 38 people per Km^2 (World Bank, 2017), and concentrated along transport corridors, the coastline, and urban centers.

Mozambique is classified as a low-income country (World Bank, 2018), and according to the household budget and expenditure final report (IOF 2014/15), 46.1% of households in

[18] INE, 2017 Census

Mozambique live below the poverty line. The IOF 2014/15 also reveals that there are significant differences in household consumption rates, access to basic services, and general social well-being, in the different regions and provinces of Mozambique. The lowest poverty rates (32.8%) are found in the South, followed by 46.2% in the Centre and 55.1% in the North[19]. The succeeding sections give an insight to this, as studies were carried out in the Southern Province of Maputo, the Province of Manica in the Centre, and Zambézia Province in the Centre, boarding with the North of the country. The IOF 2014/15 also states that poverty rates are higher in rural areas (50.1%) as opposed to urban areas (37.4%). This was also analyzed in the visited provinces.

According to the World Bank[20], 24.2% of the population in Mozambique is connected to the grid, approximately 6% of this are in rural areas. Although, off-grid energy solutions are slowly becoming common, there is no official data on off-grid electrification rates. The sections to follow shall give an insight as to where the 24.2% (connected to the grid) are found and what energy sources are the remaining 75.8% using.

The subsequent sections include an analysis of the socio-economic situation, in terms of basic household information, access to energy, monthly expenses, and income levels, in peri-urban and rural areas of the provinces visited. For the purpose of classifying income levels, the following classification, based on the current minimum wage[21], is used (Table 8):

Table 8 Income Thresholds in Mozambique based on current minimum wage

Income Threshold	Income Bracket
Low-income	< MZN 3,000
Low-middle income	MZN 3,001 – 5,000
Upper-middle income	MZN 5,001 – 10,000
High-income	>MZN 10,001

Note: Approx. MZN 60 to US$

This section focuses solely on the global results, therefore using aggregated data pertaining to the three Provinces. Detailed information can be found in Annex A6. [22]

On average, 47.5% of those interviewed are women and 52.6% are males. It is important to note that although a high percentage of women was considered in the survey, a large majority were not aware of their husband's monthly income, and were hesitant in accurately answering questions regarding monthly expenditure and in making decisions on the market willingness to pay game.

For the Maputo Province, it was found that in peri-urban areas, most households can be classified as upper-middle income, whereas in rural areas, they fall under the classification of low-middle income. For both Manica and Zambézia Province, households in both peri-urban and rural households fall under the classification of low-income.

Households in Mozambique can be made of wattle and daub, cement bricks, clay bricks, burned clay bricks, bamboo/reed/thatch and other materials. Households are generally

[19] IOF 2014/15
[20] World Bank (2016), SE4ALL Database
[21] Wage Indicator, 2018
[22] For the presentation of a national scenario, the results of the proposed work were aggregated. In the proposed annex, data can be found disaggregated by peri-urban and rural.

made of cement bricks in Maputo Province, clay bricks in Manica Province and wattle and daub in Zambézia Province. Households can be composed of one-unit with different compartments or multiple-units. It is possible to infer that one-unit with different compartments can be generally found in peri-urban areas and multiple units can be found in rural areas. The average number of compartments or rooms in the households or plot is 6. On average, households are made up of 5 members.

In terms of education, on average 42.4% have attended primary school, 45.7% have attended secondary school, 8.4% did not attend any school, and another 3.6% fell into the 'other' category, which includes technical school, higher education, or no response. In peri-urban areas, the percentage of respondents who have attended secondary, technical, and higher education is higher than in rural areas, whereas in rural areas, the percentage of respondents who did not attend school or attended primary school only was higher than in peri-urban areas. Berg et al (2017) have indicated that education in rural areas is poor in quality, particularly in the Northern and Central regions of the country, and higher education continues to reach only a fraction of the population generally clustered in a few major urban areas.

In terms of access to electricity, in Mozambique, approximately 75.8% of the population do not have access to electricity. From the socio-economic baseline, 79.3% of the respondents did not have access to electricity, while 20.7% had. The main source of electricity of respondents was the national grid (EDM), car batteries, and solar energy. All the respondents who are connected through the national grid have indicated that their payments are done through a computer management platform for prepaid electricity, better known as Credelec. There is a general high expectation from respondents who do not have access to electricity to be connected to the national grid, which can be an indicator that other sources of electricity are not yet widely known by the population.

The main sources of light in Mozambique are EDM fed lightbulbs, solar energy fed lightbulbs, battery powered torches, solar lanterns/torches, kerosene lamps, candles, firewood, artisanal battery torches, cellphone and other forms of light (such as car battery). According to Lam *et al.* (2012) burning kerosene may have drastic health consequences depending on exposure levels. Kerosene users have indicated that they feel discomfort when using kerosene for lightning.

In terms of household income, the main economic activities are trade, agriculture, formal and informal work. For peri-urban areas, respondents have indicated that they are mainly involved with informal work (28.5%), trade (24.6%), formal work (21.8%), agriculture (12.3%), and other work (7.8%). Only 5.03% did not work. For urban areas, respondents have indicated that their main activity is agriculture (32.39%), followed by trade (22.1%), informal work (21%), formal work (15%), other work (3.3%), while 6.1% did not work. In general, 60% of respondents have a secondary economic activity such as agriculture, trade, informal work, while 40% have only one main economic activity. It is important to note that monthly income may be over or underestimated as those who practice informal work do not have a standard monthly income, since their income is based on how much is made per day. Moreover, these households do not keep a record of daily earnings to accurately estimate their overall monthly income. Some respondents have indicated that they have additional sources of income which include family help, pensions, or other forms of support.

Table 9 Average household monthly expenditure on different goods and services

Expenditure	Peri-urban	Rural	Overall
Average monthly expenditure on rent	MZN 57.49	MZN 49.48	MZN 53.14
Average monthly expenditure on cooking fuels	MZN 562.16	MZN 224.52	MZN 378.70
Average monthly expenditure on energy for light	MZN 346.84	MZN 291.55	MZN 319.20
Average monthly expenditure on food	MZN 2,561.30	MZN 1,784.95	MZN 2,139.45
Average monthly expenditure on healthcare	MZN 176.27	MZN 152.75	MZN 163.49
Average monthly expenditure on transportation	MZN 683.06	MZN 369.44	MZN 512.65
Average monthly expenditure on mobile phone credit	MZN 454.01	MZN 277.40	MZN 358.04
Average monthly expenditure on charging phone battery	MZN 164.36	MZN 189.74	MZN 177.05
Average monthly expenditure on schooling	MZN 121.73	MZN 78.82	MZN 98.42
Average monthly expenditure on alcohol	MZN 363.44	MZN 239.56	MZN 296.13
Average monthly expenditure on batteries for the radio	MZN 284.11	MZN 248.82	MZN 266.46
Estimated average monthly expenditure per household	MZN 5,774.77	MZN 3,907.03	MZN 4,762.73

*Lighting is the average of all main sources of light. **Price of solar systems bought outright are not included as this is not a monthly expense.

Table 9 provides the average household monthly expenditure on different goods and services. The average monthly expenditure per household across all Provinces in both rural and peri-urban setting is MZN 4,762.73 ($ 79.30). In general, the socioeconomic condition of households in peri-urban areas is usually better than in rural areas. However, as a general trend, the data suggests that socioeconomic conditions worsened with geographic location, as the province of Zambézia seems to have the lowest overall income level for both peri-urban and rural areas. Thus, it can be concluded that living conditions are poorer in the northern part of the country and gradually improve in a southernly direction.

Annex A6 provides the technical sheet for the work carried out, with data disaggregated per Province (Maputo, Manica and Zambézia) and per setting (peri-urban and rural).

3.3 Consumer perception of off-grid solar products

This section discusses consumer perception of off-grid solar products in Mozambique. The World Bank has indicated three factors to be analysed, namely:

- **Quality** - an assessment of how well a product or a delivered service conforms to the client´s expectations;

- **Affordability** – generally refers to a user´s ability to purchase a good or a service; and

- **Accessibility** – generally refers to the ease/difficulty of obtaining a good or service at the time and place it is needed.

For the purpose of this task, additional questions, related to awareness and potential benefits from solar technology, were added to the household survey, these aspects are defined as followed:

- **Awareness** – generally refers to the knowledge interviewees have of a product or service itself and information of how to use it most effectively; and

- **Potential Benefits** – generally refers to the perceived potential benefits of users with regards to goods or services.

Annex A5 presents the technical sheet that includes information pertaining to the consumer perception of off-grid solar products in the three Provinces visited.

3.3.1 General Perception of Connection to the Grid

In the peri-urban areas of Mozambique, households are partly connected to the national grid or expect to be connected in the near future; in rural areas, however, households face a different reality. As mentioned above, about 24.2% of households in Mozambique have access to electricity, of these about 6% are in rural areas and 53.7% are in urban areas.

Recent data from EDM suggests that at the national level[23], the electrification rate is higher in the Southern part (~95.5%) of the country and lowest in the North (12.5%). It was revealed that in the Province of Maputo, roughly 40% of survey respondents, in both peri-urban and rural areas, indicated that they have electricity[24], while the remaining 60% of respondents do not.

The survey further revealed that, of the 40% of peri-urban households in Maputo with access to energy, the majority (84%) are connected to the national grid, while 12% have solar power, and 4% use alternative sources (i.e. car batteries). On the other hand, of the 35.5% of rural households with electricity, 95.5% have solar energy, and 4.6% use alternative sources. It was found that in this Province, households in the rural area have good perception of solar products. This may be because a solar company (Solarworks!) operates in Manhiça, the rural area visited in Maputo. When asked if they would be willing to buy off-grid solar products, 32.3% of Maputo rural households indicated that they already own a solar system, 38.7% expressed that they would be willing to buy a solar system, 8.1% indicated that they would not like to buy a solar system, and the remaining respondents indicated that they would buy depending on the price of the products.

The province of Manica was the first location visited, and after some fieldwork observations, it was decided to adapt the questionnaire, in order to maximize the quality of data collected. In Manica, consumer perception was initially accessed on an advantage/disadvantage basis. However, it was noticed that this did not give satisfactory perception data, as most households would be hesitant to provide an opinion since most of

[23] In urban, peri-urban, and rural areas.
[24] Electricity could be from the national grid, solar, and/or car batteries.

them had no previous experience with solar systems. Consequently, this question was altered to access perception on the basis of agreement/disagreement to presented statements[25]. In Manica Province, most respondents indicated that they do not have electricity in both the peri-urban and rural areas (75.9% and 84.5% respectively).

Solar energy is the main form of energy for those with electricity (50% in peri-urban areas and 61.5% in rural areas), followed by the national utility/EDM (42.9% only in peri-urban areas) and other sources, such as car batteries (7.1% in peri-urban areas and 15.8% in rural areas). In the rural setting of Manica Province, when households were asked if they would be willing to buy off-grid solar products, 78.6% expressed that they would be willing to buy a solar system, 8.3% indicated that they would not like to buy a solar system, and 13.1% said that they would buy depending on the price.

In the Province of Zambézia, as mentioned above, the levels of access to electricity are low in both in peri-urban and rural areas (12.9% and 7.9%, respectively). It was revealed that, of the 12.9% of peri-urban households that have access to electricity, 87.5% are connected to the national grid, and 12.5% have other sources[26] of electricity. On the other hand, of the 7.9% of rural households with electricity, 40% have solar energy, 20% use car batteries, and the remaining 40% use other sources[27]. In the rural setting of the Zambézia Province, when asked if they would be willing to buy off-grid solar products, 3.2% of the respondents indicated that they already own a solar system, 73% expressed that they would be willing to buy a solar system, 4.8% said that they are not willing to buy a solar system, and the remaining 19.1% indicated that they would buy depending on the price.

3.3.2 Quality

For this study, quality was defined as an assessment of how well a product or service meets a client´s expectation. In the assessment of perception related to quality, respondents were asked questions related to the following topics: i) solar energy can deliver the same benefits as the national utility; ii) solar energy gives access to better light; iii) solar systems are a good quality energy source.

In relation to solar energy delivering the same benefits as the national utility (EDM), the highest rates of agreement were found in the rural areas of Manica (53.6%) and Zambézia (69.8%) Provinces. Therefore, it is possible to infer that, since these areas are largely affected by the low electrification rate and because off-grid solutions can be readily available, the level of acceptance of these technologies in these areas is higher. On the other hand, the highest rates of disagreement are found in rural areas of Maputo Province (41.9%) and in peri-urban areas of Manica Province (36.2%). The proximity to areas that are connected to the grid and high expectation of communities to be connected to the grid could be a contributing factor to the disagreement with the proposed statements. The general trend regarding this question, though, is that respondents are neutral or are unsure if solar energy can deliver the same benefits as the national grid.

In relation to solar energy giving access to better light[28], the level of agreement is much higher in Zambézia Province (in both peri-urban and rural areas) than in Maputo Province. In the Maputo Province, most of the respondents are neutral or unsure if solar energy can

[25] The difference in these approaches can be seen on the technical sheet in Annex A5
[26] do not include generators, solar or wind and car batteries
[27] do not include generators, solar or wind and car batteries
[28] This question was only available for Maputo and Zambézia Provinces

give access to better light (39.7% in peri-urban and 25.8% in rural areas). Nonetheless, 28.6% of peri-urban and 43.6% of rural households in Maputo disagree that solar energy can give better light than the national grid.

In relation to the actual quality of off-grid solar products[29], it is generally accepted that solar products are of good quality in the sites visited (42.7% for Maputo and 48.8% for Zambézia), however, there is still a high percentage of respondents that are neutral or not aware of the quality of off-grid solar products (about 40.7% for Maputo and 26.4% for Zambézia). In Manica Province, one of the main reasons for households to purchase a solar system was because the systems available in nearby areas were of good quality[30] (14.3% and 12.5% in peri-urban and rural areas, respectively).

Quality is relative; often depending on a user's perception of a product based on acquired knowledge from previous experience or what has been said about the product. This is no different with solar energy in Mozambique. It was evident during the MWTP exercise[31], that some households already have a rough idea of quality, as when presented with the difference in prices for the same systems in store 1 (which includes duties and taxes) and store 4 (with no duties or taxes), it was observed that some households chose the most expensive store because they thought the cheaper one would be of poor quality.

To gain an understanding of the households' perception of quality, respondents were asked if they felt confident in their knowledge of solar technologies and how to use these. It was found that most of the households felt indifferent about their knowledge level, however, in rural areas of Maputo 37% of households stated being confident in their knowledge of the technology. Nonetheless, through observations in the field, it was found that even though households may state that they are confident in their knowledge, or know enough about solar technologies, most of these use their systems incorrectly. Furthermore, solar systems found in these areas are often sub-standard products, with no certification. This may significantly influence consumer perception of the quality of solar systems.

3.3.3 Perception of Affordability

In this study, affordability was defined as a user´s ability to purchase a good or a service. In order to evaluate the perception of affordability, a number of questions were identified: i) main reason for the purchase of a solar system in relation to its price; ii) how did respondents buy the solar system/kit; iii) if bought with upfront payment, how was the technology paid for; iv) perception regarding solar energy being affordable; and v) if financial conditions were the main barrier to respondents' inability to purchase solar systems.

In terms of the main reason for purchase of a solar systems, respondents in Maputo (48%), rural Manica (25%), and rural Zambézia (100%) specified that they purchased their solar system/kit because it was the cheapest one available. This means that these households recognised the need for a more reliable source of energy, decided that solar energy would be a viable solution, and were able to find a solar system/kit that is reasonably priced for them.

[29] This question was only available for Maputo and Zambézia Provinces
[30] Reasons for purchase of solar systems will be discussed throughout this chapter
[31] In Annex A4

In peri-urban Manica, decision to purchase a solar system was mainly based on the system powering a radio (21.5%) or charging a phone (21.5%)[32].

In general, across the 3 Provinces, respondents indicated that the payment of solar systems is done through a full upfront payment in cash. Only in rural Manica, was it found that 25% of those who purchased a solar system, pay for their system in weekly installments.

It is important to note that about 8.4% of peri-urban and 25.8% of rural households in Mozambique currently use solar energy. When the remaining 91.6% and 74.2% of households were asked why they had not yet acquired solar products, 54% in Maputo, 48.7% in Manica, and 71.5% in Zambézia said it was because it is expensive. However, it was observed in the field that most of the households were not aware of different options of solar technologies, nor the possibility of adhering to a PAYG plan. This may have influenced their perception of affordability, as through the interview sessions it was found that households became increasingly interested in the solar systems and prices used as references, and that they thought that solar energy could be a viable solution for access to reliable energy. Nonetheless, it was also found that respondents were sceptical of the PAYG plan as there was a fear that they would not always be able to make the payments.

Though most of the households believe that solar systems are expensive, they may still be able to afford it. It was found that households often underestimated their ability to afford solar energy, especially because most of the households are not fully aware of their current monthly energy expense using alternative sources (i.e.: batteries, kerosene, candles, and others), and have not made a comparison to analyse which energy source may be more cost-effective for them. This is discussed in more detail in Section 4 below.

It was also found that financial conditions may not be the main reason for households to not purchase a solar system. During the interviews it was understood that the solar systems that are available to most households, do not meet their expectations. Households often referred to knowing someone who bought solar panels, but these would break easily and did not have enough capacity to power more than a light. However, if the solar systems used in the MWTP exercise were available in their area, they would consider purchasing one. Thus, it is evident that households already have a negative perception of the quality of solar technologies since most of these are bought in informal markets, but households are willing to buy solar systems that are proven to give the benefits claimed; going as far as to prefer having solar energy as opposed to an alternative that requires them to make monthly payments. For this reason, it could be said that if households believe that the system they are purchasing is of good quality and can improve their lives, these would make the funds available.

3.3.4 Accessibility

Accessibility generally refers to the extent a user can obtain a good or service at the time and place it is needed or assessed in terms of proximity to a certain area. In terms of accessibility, the household survey had the following questions: i) main reason for purchasing solar system/kit is the close proximity to areas where systems are sold; and ii) if respondents have seen a solar system/kit for sale; iii) how far from the household was the point of sale; and iv) finding a service providers who could repair a solar kit/system.

[32] Peri-urban households in Zambézia did not own solar systems

One of the reasons for purchasing a specific type of solar system/kit, in the rural areas of Maputo and Manica was the fact that it was the only system sold in the area (4% and 12.5%, respectively). Though there may not be much variety in solar technologies in these areas, it was found that most of the respondents had seen solar technologies being sold; in Maputo about 76.9% of respondents had seen solar technologies being sold, in Manica 71.1%, and in Zambézia 48.4%.

Though the market is still largely dominated by informal sellers; in the Provinces of Maputo and Manica, there are currently solar energy companies that sell solar systems/kits. This has contributed to the awareness levels towards different solar technologies in the last years and contributed to making solar technologies more accessible to households.

In terms of the distance of the point of sale from household, the data suggests that distance varies, and no clear trend has been identified. Distance varies from below 10 minutes to more than 5 hours for most sites, with the exception of rural Maputo which varies from below 10 minutes to less than 4 hours[33]. Suppliers and informal markets where these systems can be found for sale have been identified (Section 2 of this report).

In terms of finding a service provider who could repair a solar kit/system[34], respondents in Maputo (45.6%) and Zambézia (63.9%) revealed that they thought it would be difficult to find someone to fix a broken system. This could also negatively influence a household's decision to use solar energy, since most households have heard that solar technologies break easily, as most of the solar systems being used in the areas visited are of sub-standard quality. Thus, there is a significant need to raise awareness about different solar technologies and quality, and make distinct differentiation between the solar technologies currently available that are not certified and the ones that are of proven quality.

3.3.5 Awareness

Awareness refers to the knowledge interviewees have of a product or service itself and information on how to use it most effectively.

Awareness of the existence of solar energy is generally high in the areas where the study was undertaken. In Maputo and Manica Provinces, more than 90% of the respondents in both peri-urban and rural areas were aware of solar energy. In Zambézia Province, awareness of solar energy is lower than in the other Provinces with approximately 20% of respondents indicating that they are not aware of the technology (27.4% in peri-urban and 19.1% in rural areas).

Awareness campaigns and/or direct marketing from companies are not generally present in the areas where fieldwork was undertaken, apart from rural Manica Province[35]. It is possible to infer that the results in Manica are associated with direct marketing undertaken by the solar company Epsilon Investimentos. Though about 87.1% of rural households in Maputo indicate that there are no awareness campaigns in the area, the highest confidence in terms of use of solar technology is found in this area (48.4%). Across all Provinces[36], approximately

[33] In the Technical Data Sheet presents the distance in time of how far the household is from the point of sale
[34] This question was only available for Maputo and Zambézia Provinces
[35] 41.7% of the respondents have indicated that there are solar campaigns about solar energy in the area.
[36] This question was only available for Maputo and Zambézia Provinces

30% of respondents have indicated that they are indifferent or do not know how to use solar energy, and roughly 30% of the respondents also indicated that they are not confident with the use of the technology.

Of the respondents that already have solar energy, the large majority would recommend solar systems/kits to others across all Provinces. From those who indicated that they would not recommend solar kit/systems, the reason behind this is the lack of parts available for replacement of faulty parts. In peri-urban Manica (42.9%) and rural Maputo (19.1%), respondents indicated that one of the reasons to purchase a solar system was due to a recommendation. It was observed in the field that word of mouth advertising had a significant impact on household perception of solar energy and their decision to purchase a solar panel.

In terms of awareness associated with mobile payments[37], across the three Provinces, respondents are very aware of this technology. Regarding the willingness to use mobile payment to purchase electricity, respondents in Zambézia Province present the lowest levels (74.2% and 58.7% in peri-urban and rural areas, respectively), while in Maputo and Manica Provinces, the levels of willingness to use this method of payment is high (79.4% and 83.9% in peri-urban and rural areas in Maputo, respectively, and 87.9% and 94.1% in peri-urban and rural areas in Manica, respectively). Epsilon Investimentos has indicated that the company itself has been involved in training local communities who are willing to buy solar systems/kits in the use of mobile payment. This may be an indication of the high awareness and high willingness to use mobile payments to purchase electricity in rural Manica.

In general, it is possible to infer that direct marketing or awareness campaigns from companies may influence rural households decisions to purchase a solar product, improve knowledge on solar technology, encourage the use of mobile payment technology, and generate greater awareness of the benefits of solar energy. This in its turn would influence a household's willingness to buy a solar system.

3.3.6 Potential Benefits

In terms of potential benefits, it was found that in Maputo and Zambézia Provinces, the reduction of energy costs/expenses (charging the phone/buying candles/etc.) and the potential of establishing a business are some of the main reasons behind the purchase of a solar system. On the other hand, in Manica the benefits include charging of phones at home, undertaking activities at night, the ability to use a television or fridge, as well as the possibility to start a business.

It was found that 57.1% of peri-urban and 75.8% of rural households in Maputo believe that solar energy could reduce their energy costs/expenses. However, 42.9% of respondents in peri-urban and 24.2% in rural areas disagree with this statement. In Zambézia, 69.4% of peri-urban respondents believe solar energy could reduce their monthly energy expense, while 12.9% of the respondents do not agree with this, and 17.7% are not aware. On the other hand, 92% of rural respondents believe that solar energy could reduce their costs, while 7.9% of respondents do not believe so. While the majority of households across all the provinces believe that solar energy could support them in establishing a business (in Maputo, 50.7% of peri-urban respondents and 64.5% in rural areas; in Manica 10.3% in peri-urban and 32% in rural areas; in Zambézia, 87.3% of rural households), the majority of households in peri-urban Zambézia (66.6%) do not believe that solar energy could aid them in establishing a

[37] The Technical Data Sheet presents the awareness levels irt mobile payments

business. In Manica, three aspects were generally regarded as the main benefits of solar energy, these include: charging phones at home (74% peri-urban and 91.7% in rural areas), undertake activities at night (39.7% of peri-urban and 53.6% of rural respondents), and/or use appliances, such as television or fridge (27.6% in peri-urban areas and 21.4% in rural areas).

In addition to this, it was possible to evaluate the potential disadvantages of solar energy in Manica, these include: lack of knowledge regarding the technologies and how to use them (29.3% in peri-urban and 33.3% in rural areas), inability to use a television or fridge (26.2% of rural households), lack of parts available (1.7% of peri-urban and 16.7% of rural respondents), high maintenance costs (1.7% in peri-urban areas and 11.9% of rural households) ,and that systems are known to break easy or are of low quality (19.1%).

There are some risks involved in the usage of solar energy in Mozambique. In all Provinces visited, respondents indicated that one of the main risks is that of a system being stolen (47.6% and 58.1% of rural households in Maputo; 10.3% in peri-urban and 34.5% in rural Manica; and 61.3% in peri-urban and 60.3% in rural Zambézia).

Out of the respondents that have not acquired a solar kit/system, 46.6% in peri-urban areas of Maputo have indicated that this is due to waiting to get connected to the national grid or previously owning a solar system that no longer works. In rural Maputo, along with all other areas visited, the main reason for not acquiring solar energy is because of a lack of financial means (65.6% in peri-urban areas and 59.8% in rural areas). Not knowing the benefits of solar or where to find a solar system, were also reasons given as to why solar systems/kit were not owned[38].

In conclusion, it can be said that consumer perception of the quality of solar technology, affordability, awareness levels, accessibility to diverse solar technologies, and overall perception of benefits, are all factors that are interlinked and inherently influence household decisions to purchase solar energy. These factors may even be among the most significant aspects households, unconsciously, consider when deciding to purchase solar products, rather than solemnly basing the decision on whether they can afford it immediately or not.

3.4 Financial gains to consumers when purchasing solar

The findings of this study suggest that about 79.3% of households in the peri-urban and rural areas of Mozambique do not have access to the national grid. Though it was revealed that 88% of households, both in peri-urban and rural settings, were aware of solar energy. Moreover, it was found that only about a quarter of rural households and nearly 9% of peri-urban households use solar energy as their main source of light.

The data suggests that this is due to the belief that solar energy is expensive, with over half of the population interviewed stating this as the main reason to not purchase a solar home system. Nevertheless, it was evident during the survey that households are unaware of their real monthly energy expenditure, as this was often underestimated. Consequently, this section analyses the households' current energy expenses, which include: energy for lighting, phone charging and powering a radio. This shall give an insight to the potential financial benefits of solar energy to off-grid households.

[38] Refer to Annex A5 on the "Accessibility" section for breakdown of this data.

Moreover, according to the USAID[39], the portion of the population in East African countries that is off-grid and can afford solar energy is smaller than expected. Thus, this section shall also explore how affordable solar systems are to households in different income groups.

3.4.1 Energy Monthly Expenditure and Purchase Behaviour

It was found that, overall, peri-urban households in Mozambique are spending about MZN 5,774.77 ($96.24) per month on different goods and services, while rural households are spending nearly MZN 3,907.03 ($65.11) per month. Of these expenses, 13.8% are energy expenses in peri-urban households, and 18.7% in rural households. Additionally, it was found that households in the Province of Manica spend more on energy than the other Provinces; rural households in this Province are spending between 60% to 68% more than the other Provinces on energy, a more detailed analysis of this information by Province and area is available in the Annex A5. Overall, peri-urban households in Mozambique are spending about $13.30 (MZN 795.31) per month on energy, while rural households spend about a dollar less, as seen in the table below.

Table 10 Average Energy Monthly Expense by area in Mozambique

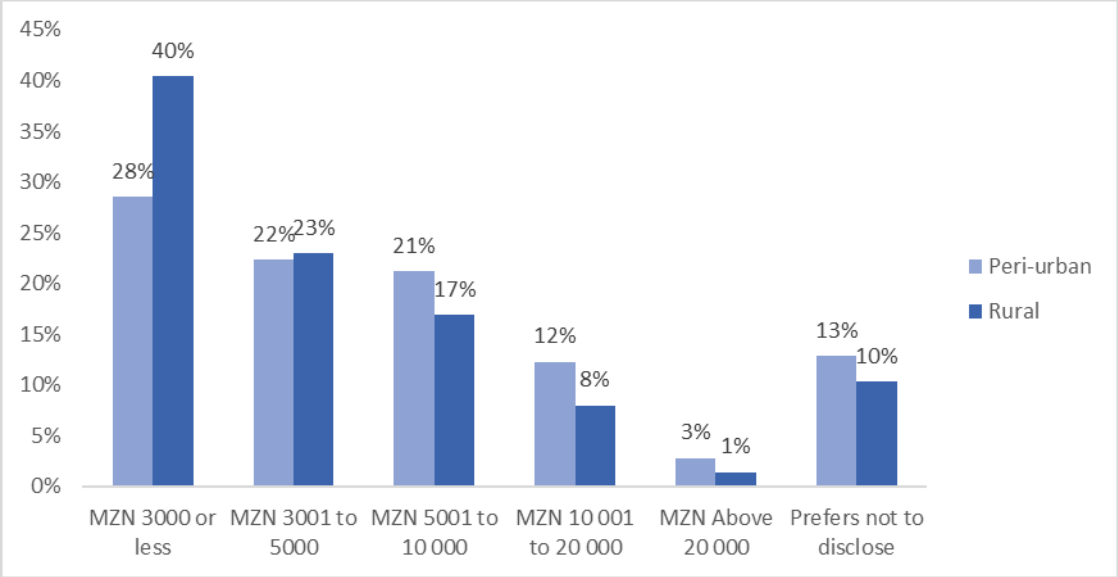
Area	Average of main sources of light	Batteries for radio	Phone charging	Total energy monthly expense
Peri-urban	MZN 346.84	MZN 284.11	MZN 164.36	MZN 795.31
Rural	MZN 291.55	MZN 248.82	MZN 189.74	MZN 730.11

It was found that, as an average, battery-powered torches are the most popular source of light across all Provinces, with over half of rural households and about 39% of peri-urban households in Mozambique stating that this is their main source of light. Furthermore, solar lamps were the second most popular source in rural areas, with 22% of the rural population using this source; and both EDM and kerosene were the most popular source in peri-urban areas, both used by 18% of the peri-urban population.

As stated in the socio-economic analysis, it could be said that most households in Mozambique fall under the low-income category, as about 28% of peri-urban and 40% of the rural population have an estimated total monthly income of MZN 3,000 ($50) or less. Figure 6 below illustrates the different population portions according to estimated monthly income.

[39] USAID (2017). Cost-Benefit Analysis of Off-Grid Solar Investments in East Africa. Washington D.C.

Figure 6 Income Brackets for Households in Mozambique



Source: GreenLight

Based on the income distribution demonstrated above, it was possible to trace the main sources of light used by different portions of the population within each income group. Table 11 below demonstrates this in rural Mozambique. It is evident that battery torches are the most popular source of light in low-income to upper-middle income households in these areas; whereas for high-income rural households, solar energy is almost exclusively used. It is also important to note that EDM is not used in rural areas, as these households are completely off-grid.

Table 11 Main sources of light used by rural households in different income brackets

Main Source of Light	Income Brackets in rural area				
	MZN ≤3,000	MZN 3,001 to 5,000	MZN 5,001 to 10,000	MZN 10,001 to 20,000	MZN >20,000
Artisanal battery torch	8%	10%	11%	0%	0%
Battery torch	62%	51%	53%	18%	0%
Candles	6%	4%	6%	6%	0%
Car Battery	1%	4%	0%	0%	0%
Firewood	2%	0%	0%	0%	0%
Kerosene	2%	4%	6%	6%	0%
Solar lamp	12%	18%	17%	71%	100%
Solar torch	5%	4%	8%	0%	0%
Telephone	2%	4%	0%	0%	0%

Source: GreenLight

In peri-urban Mozambique, it was also found that battery torches remained the most popular source of light for low-income to upper-middle income households, as seen in the table below. However, for high-income peri-urban household earning between MZN 10,001 ($166.68) to MZN 20,000 ($333.33), EDM is the most popular lighting source with 31.8% of the population within that income group using it; while, for those earning above MZN

20,000 ($333.33), the main source of light are car batteries, with 40% of the population using that source.

Table 12 Main sources of light used by peri-urban households in different Income Brackets

Main Source of Light	Income Brackets in peri-urban area				
	MZN ≤3,000	MZN 3,001 to 5,000	MZN 5,001 to 10,000	MZN 10,001 to 20,000	MZN >20,000
Battery torch	52.94%	47.50%	26.32%	13.64%	20.00%
Candles	1.96%	5.00%	10.53%	4.55%	0.00%
Car Battery	0.00%	2.50%	5.26%	4.55%	40.00%
EDM	7.84%	10.00%	23.68%	31.82%	20.00%
Firewood	1.96%	0.00%	0.00%	0.00%	0.00%
Kerosene	13.73%	22.50%	21.05%	22.73%	0.00%
Solar lamp	3.92%	2.50%	2.63%	13.64%	0.00%
Solar torch	3.92%	2.50%	0.00%	9.09%	20.00%
Telephone	5.88%	0.00%	2.63%	0.00%	0.00%
None	1.96%	0.00%	0.00%	0.00%	0.00%

Source: GreenLight

It was found that about 18% of peri-urban households in Mozambique are spending roughly MZN 504.76 ($8.41) on EDM. Credelec vouchers are usually bought either twice a month (46.4%) or once a month (32%). It was observed that households that use EDM were dismissive of solar energy, however, the majority of them experience frequent power cuts that last hours (78.6%), as seen in the table below. Moreover, of the 8.8% of peri-urban households that expressed being unsatisfied with the services provided by EDM, 40% said it is because EDM is expensive and they still experience frequent power cuts. Though it has not been considered by the on-grid households visited, solar energy could be an advantageous back-up energy source, as households often spend an additional amount per month on secondary sources of light to be used when there are power outages. This would be especially advantageous for the 29% of households in Zambézia that experience power outages up to 5 or more times per month and that last hours, and the 6% in Maputo that have power cuts that last days. Detailed information about monthly energy expenditure in each Province and area visited is also available in Annex A6.

It is evident that solar energy is most popular in rural areas. The table below, demonstrated that the majority of solar energy users purchase their systems outright; only about 25% of households in rural Manica have a PAYG plan. It was observed during the Market Willingness to Pay (MWTP) exercise, that respondents were hesitant to choose PAYGO options, as they would be sceptical of having debt and not being able to pay, especially as most of the population does not have a reliable source of income, as discussed above. It was found that, though the same type of solar systems is popular in both peri-urban and rural areas, solar energy is MZN 486.8 ($8.11) more expensive in rural Mozambique. Solar energy will not be included in the analysis to follow.

Table 13 Estimated Energy Expenditure for EDM and Solar Energy

Indicators	Mozambique Data	
	Peri-urban	Rural
EDM		
% that use EDM as main source of light	17.98%	0.00%
Average monthly expenditure on Credelec	MZN 504.76	MZN 0
Average amount spent per purchase	MZN 330.35	MZN 0
Frequency of Credelec purchase		
Every day	0.00%	0.00%
Several times a week	7.14%	0.00%
Once a week	14.29%	0.00%
Twice a month	46.43%	0.00%
Once a month	32.14%	0.00%
Frequency of Power cuts		
Once a month	29.41%	0.00%
Twice a month	20.59%	0.00%
3 times a month	11.76%	0.00%
4 times a month	14.71%	0.00%
5 or more times a month	5.88%	0.00%
It is rare	17.65%	0.00%
How Long Power Cuts Last		
Minutes	17.86%	0.00%
Hours	78.57%	0.00%
Days	3.57%	0.00%
Months	0.00%	0.00%
Solar Energy		
% that use Solar Energy as main source of light	8.43%	25.83%
Of the % that uses Solar Energy, % that bought the solar system outright	100.00%	90.63%
Of the % that uses Solar Energy, % that has a PAYGO Plan	0.00%	6.25%
Of the % that uses Solar Energy, % that received the solar system as a gift	0.00%	3.13%
Average price of solar system	MZN 2,338.88	MZN 2,825.68

Indicators	Mozambique Data	
	Peri-urban	Rural
Average amount paid per week	MZN 0.00	MZN 235.00
Type of Solar System/Kit Owned		
Large solar panel with battery	44.44%	46.88%
Small panel with light/torch with no phone charging	22.22%	12.50%
Small panel with light/torch and phone charging	33.33%	34.38%
Do not know	0.00%	6.25%

Batteries are largely used in both peri-urban and rural areas of Mozambique, however, on average, rural households are spending about MZN 111.89 ($1.86) more per month on batteries for light than peri-urban households. Though this may seem insignificant, it is about 15.3% of the total monthly energy expense for rural Mozambique. Batteries are mostly bought locally and once a week, as seen on the table below. As mentioned before, Manica has the highest energy expenditure amongst all the visited Provinces; rural households in this Province are spending up to MZN 511.77 ($8.52) per month on batteries for lighting.

Kerosene is mostly used by peri-urban households (18%), probably because this is a more expensive source of energy, as a litre of kerosene can cost up to MZN 77.09 ($1.28) and it is bought with more frequency, as seen on the table below. In peri-urban Manica, kerosene is bought daily and can cost up to MZN 1,112 ($18.53) per month. Purchase locations for kerosene vary largely, however, most of these are located up to one hour away from the household. This also suggests that there may be additional transport expenditure.

Candles are amongst the least used main sources of light. Average monthly expenditure on this source in peri-urban areas is of about MZN 115 ($1.91) and MZN 166.52 ($2.77) in rural areas. Peri-urban households in Maputo has the largest amount of candle users, about 13%, compared to the other visited Provinces, and though only 5% of rural households in Zambézia use candles, they spend MZN 7.08 ($0.11) more than households in Maputo. The socio-economic analysis suggests that living conditions worsen in a northern direction; it also seems that, as a general trend, energy costs also increase in a northern direction.

Table 14 Estimated Monthly Energy Expenditure for different sources

Indicators	Mozambique Data	
	Peri-urban	Rural
Batteries for Lighting		
% that uses batteries as main source of light	45.51%	60.09%
Average amount of batteries bought at once	5	4
Average number of torches used daily	1	2
Average monthly expenditure on batteries	MZN 268.01	MZN 379.9

Indicators	Mozambique Data	
	Peri-urban	Rural
Purchase Frequency		
Every day	1.45%	1.82%
Once a week	43.48%	41.82%
Several times a week	15.94%	20.91%
Once a month	18.84%	20.00%
Twice a month	0.00%	14.55%
Several times a month	1.45%	0.00%
Other- Every 2 months	17.39%	0.91%
Never	1.45%	0.00%
Purchase Location		
Local Market	83.82%	53.15%
Market in another locality	4.41%	18.02%
A private store owner in this village	11.76%	26.13%
A private store owner in another village	0.00%	0.90%
Other- Family store outside the house	0.00%	1.80%
Distance of Purchase Location		
Below 10 minutes	48.53%	52.25%
11 to 30 minutes	27.94%	25.23%
31 minutes to 1 hour	17.65%	11.71%
1 to 2 hours	4.41%	9.01%
Less than 3 hours	1.47%	0.00%
5 or more hours	0.00%	1.80%
Kerosene		
% that use kerosene as main source of light	17.98%	4.23%
Average amount bought at one time (litres)	2.12 L	2.42 L
Average price per litre	MZN 77.09	MZN 76.88
Average monthly expenditure for kerosene	MZN 298.96	MZN 382.11
Purchase Frequency		
Every day	20.69%	0.00%

Indicators	Mozambique Data	
	Peri-urban	Rural
Once a week	20.69%	0.00%
Several times a week	10.34%	33.33%
Once a month	24.14%	55.56%
Twice a month	17.24%	11.11%
Other- Every 2 months	6.90%	0.00%
Purchase Location		
Local Market	27.59%	11.11%
Market in another locality	3.45%	33.33%
A private store owner in this village	10.34%	22.22%
A private store owner in another village	0.00%	11.11%
At a petrol station	58.62%	22.22%
Distance of Purchase Location		
Below 10 minutes	20.69%	11.11%
11 to 30 minutes	48.28%	33.33%
31 minutes to 1 hour	20.69%	22.22%
1 to 2 hours	6.90%	33.33%
Less than 2 hours	3.45%	0.00%
Candles		
% that use candles as main source of light	4.49%	5.63%
Average amount of candles bought at once	4	3
Average number of candles used daily	2	1
Average monthly expenditure on candles	MZN 115	MZN 166.52
Purchase Frequency		
Every day	12.50%	25.00%
Once a week	37.50%	41.67%
Several times a week	37.50%	16.67%
Once a month	12.50%	16.67%
Distance of Purchase Location		
Below 10 minutes	37.50%	83.33%

Indicators	Mozambique Data	
	Peri-urban	Rural
11 to 30 minutes	25.00%	8.33%
31 minutes to 1 hour	12.50%	0.00%
1 to 2 hours	12.50%	8.33%
Less than 3 hours	12.50%	0.00%

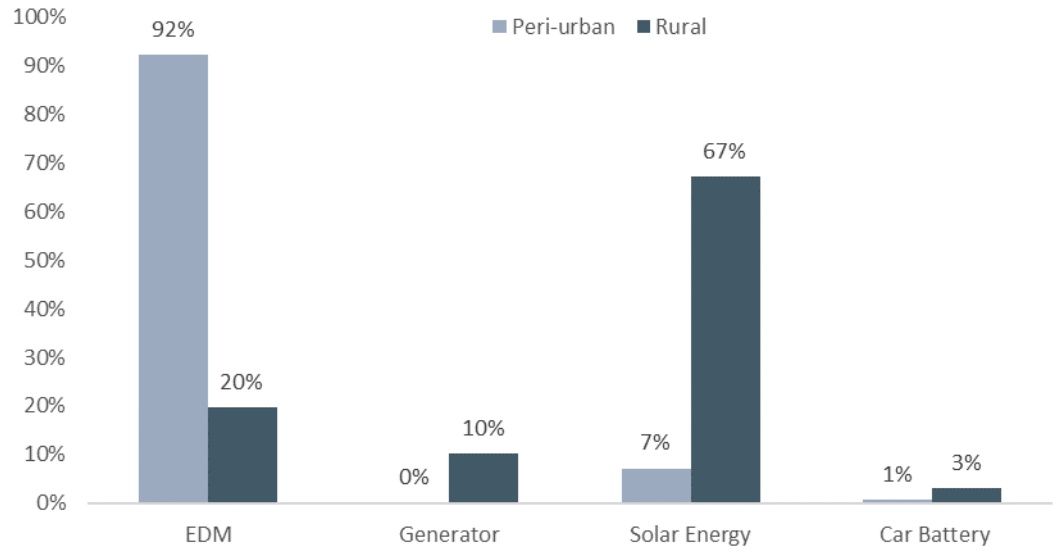
Source: GreenLight

The average monthly energy expenditure in peri-urban areas is about MZN 795.31 ($13.25) while in rural areas it is MZN 730.11 ($12.16). It is important to note that secondary costs that are related to purchasing alternative energy sources, such as cost of transportation, and costs of secondary sources of light, are not considered in the monthly energy expense. Moreover, in addition to the financial cost of these energy sources, it is also important to consider non-monetary costs, such as time lost when purchasing energy. This means that if these households were using solar energy, apart from making savings on the value spent on energy monthly, they would also save the additional money otherwise spent on transport, and would save time.

Apart from the main sources of light, monthly energy expenses also include batteries for radios and phone charging. It was found that 17% of peri-urban households and 24.4% of rural households own a battery-powered radio. On average, it is estimated that households in Mozambique are spending about MZN 266.46 ($4.44) per month on batteries for radio.

Cell phones are the most popular alternative source of light in Mozambique, which provides light for a short period of time, to undertake activities at night. 86% of peri-urban households and 78.9% of rural households in Mozambique own a phone, with an average of 2 cell phones per household. Of these, 34% of peri-urban and 42% of rural households pay to charge their phones. Phone charging costs on average, MZN 164.36 ($2.73) per month in peri-urban Mozambique and MZN 189.74 ($3.16) per month in rural Mozambique. It was found that both peri-urban (51.3%) and rural (29.8%) households charge their phones at someone's house. In rural areas, the source of energy used for phone charging is solar energy (67%), whereas in peri-urban areas it is EDM (92%). The data suggests that rural households that have solar energy, have turned this source of energy into a source of additional income.

Figure 7 Main sources of energy for phone charging



Phone charging frequency varies largely, however, it is seen that most peri-urban households charge phones every second day (~29%) and every third day (24%), while rural households mostly charge once a week (23.8%) or every second day (21.4%).

3.4.2 Affordability and Estimated Pay-back Period

This section discusses the financial gains to users by assessing the pay-back period, which is the average time taken to pay off a solar system/kit in full if the household were to use solar energy and no longer spend money on the other sources of electricity discussed above. To assess this, the expected cost of off-grid solar product usage was based on the Market Willingness to Pay (MWTP) exercise conducted in the field. This exercise consisted of five (5) hypothetical stores with different prices and payment plan options for the same four types of solar systems/kits. The MWTP exercise can be found in Annex A4. Households were asked to choose a system, or none, based on their socioeconomic condition. This information combined with the current energy expenditure provides an insight into the potential financial gains to household users. To facilitate the assessment, pay-back periods were be calculated for stores 1 and 4, which offered systems on direct purchase rather than a PAYG plan.

As discussed in the section above, households use different main sources of lighting, however, these are not always the most reliable nor most cost-effective sources. Thus, based on the potential savings from monthly energy expenses, the table below demonstrates the pay-back time for solar technologies.

Table 15 Pay-back periods for solar systems

Game	System-type	Mozambique	
		Peri-urban	Rural
Store 1- Direct Purchase with duties/taxes	1 (single light + phone charging)	2 months	2 months
	2 (multiple lights & phone charging + radio)	8 months	9 months
	3 (above + TV)	3 years and 2 months	3 years and 6 months
	4 (above + small refrigerator)	8 years and 5 months	9 years and 2 months
Store 4- Direct Purchase without duties/taxes	1	1 month	1 month
	2	5 months	6 months
	3	2 years and 2 months	2 years and 5 months
	4	5 years and 7 months	6 years and 1 months

The table above suggests that, overall, households in the study, both peri-urban and rural, are able to pay off system 1 within one or two months if other main sources of lighting, discussed above, were not used. Thus, it could be presumed that these households can afford access to basic reliable energy. That said, this may not be a good indication of affordability as energy expenditure, as well as household monthly income, greatly varies. Thus, respondents were asked to state the maximum they would be willing to pay, within their means, for their preferred solar system. The table below showcases households' preferred system in peri-urban and rural Mozambique. It is obvious on the table that, generally, as income levels increase, respondents would also opt for the more expensive systems. However, it is also seen that majority of low-income households prefer system 2[40] to system 1[41]. This means that although most households may be able to afford basic access to energy (system 1) as discussed above, they do not necessarily prefer system 1. PAYG options would be ideal for these households that have an interest in the other systems but do not have funds readily available.

It is also seen on the table that some households opt for not choosing a system, this may be because households are already connected to the national grid, awaiting the connection to the national grid, or because they fear that solar energy is too expensive and could possibly get them into debt.

[40] System 2 can power 3 lightbulbs, charge a cell phone, and power a radio.
[41] System 1 can power one lightbulb and charge a cell phone.

Table 16 Preferred solar systems in Mozambique

Income Bracket	Preferred System	Mozambique Data	
		Peri-urban	Rural
MZN 3,000 or Less	System 1	26.42%	30.12%
	System 2	30.19%	36.14%
	System 3	18.87%	18.07%
	System 4	20.75%	13.25%
	None	3.77%	2.41%
MZN 3,001 - 5,000	System 1	14.63%	6.25%
	System 2	26.83%	29.17%
	System 3	21.95%	25.00%
	System 4	31.71%	35.42%
	None	4.88%	4.17%
MZN 5,001 - 10,000	System 1	2.63%	8.33%
	System 2	13.16%	8.33%
	System 3	39.47%	30.56%
	System 4	31.58%	47.22%
	None	13.16%	5.56%
MZN 10,001 - 20,000	System 1	0.00%	0.00%
	System 2	9.09%	0.00%
	System 3	18.18%	11.76%
	System 4	59.09%	76.47%
	None	13.64%	11.76%
Above MZN 20,000	System 1	0.00%	0.00%
	System 2	0.00%	0.00%
	System 3	20.00%	33.33%
	System 4	60.00%	33.33%
	None	20.00%	33.33%

It was found that households in peri-urban Mozambique are spending about 14% of their monthly expense budget, for different goods and services, on energy. Rural households, on the other hand, are spending about 4% more[42] on energy than peri-urban households. The majority of rural households, as well as low-income and low middle-income peri-urban households, do not have access to a reliable source of energy, having to rely predominantly on batteries for lighting. These households could be spending about MZN 80.98 ($1.34) per week to have one light, while they could get access to better light for less than that. Based on the estimated values presented in the MWTP exercise (Annex A4), for about MZN 37 ($0.67) per month, households can have access to a solar lamp and phone charging, on a PAYG plan

[42] They are spending 18%

for 24 months. Moreover, if households opted for the 36-month PAYG plan the price would be about MZN 24 ($0.40) per month[43].

As discussed in the socio-economic analysis (Section 3.2), living conditions in Mozambique improve in a southern direction, while overall it was found that the cost of energy is higher in the areas with less ideal living conditions. On average, peri-urban households are spending about MZN 795.31 ($13.25) per month on energy, while rural households are spending about MZN 730.11 ($12.16). Energy refers to an average expenditure on energy for light, phone charging, and radio. Based on the estimates in the MWTP exercise, for between MZN 147 ($2.45) to MZN 220 ($3.66) per month, households can power three solar lamps, phone charging, and a radio. It is obvious that solar energy is a more cost-effective solution for access to reliable energy.

Based on the data collected, households are able to pay off system 1 within one to two months. However, not all households would like to have system 1. Nevertheless, as mentioned above, the majority of households in Mozambique are using one light and their average monthly energy expenditure is about MZN 762.71 ($12.71). On the MWTP exercise, in store 4, where no tax and duties are included in the price of the systems, system 1 costs about MZN 660 ($11), making it possible for most households to afford this. Moreover, an assessment of the potential cost of system 1 in two years revealed that households would spend about MZN 3,528.00 ($58.80) on the system, deposit included. For the same time frame using other sources of energy, the same households would be spending about MZN 19,087.44 ($318.12), which confirms that solar energy would be the most cost-effective solution for these households.

That said, households in different income brackets preferred different systems as seen in section 3.3. However, preferring a system does not indicate that the household is able to afford it. That said, it was observed that even though households may not have money readily available, they could get access to more funds if there is a necessity for it. Moreover, PAYG plans could also benefit the households that are willing to buy systems but do not necessarily have the funds available. However, it was found that households are still sceptical of solar energy; as discussed in section 2, a lack of knowledge and/or a negative perception of the quality of solar energy, greatly influences people's willingness to pay. Thus, households may choose to invest less on solar energy as they do not trust it. Consequently, it is important to consider the role awareness plays in household's willingness to pay for a system.

It was evident during the study that the financial gains of using solar energy are not obvious to households. Thus, it would be necessary to ensure that households are aware of their current energy expenditure, know that there are options available to reduce this expenditure, and that solar energy could provide them with access to a more reliable source of energy. Moreover, there are other non-monetary gains that these households can experience that could be of great value but are not accounted for, such as cutting down the travel time to purchase batteries or to charge phones every week.

[43] Monthly payments were preferred by households, as opposed to daily payments.

3.4.3 Institutional Financial Gains – General Trends

There are over 3,000 public schools and under 500 public health institutions in the Provinces visited. Table 20 below indicates the breakdown of these institutions in each Province visited. It was not possible to interview all these institutions during field work. However, a total of five schools and two health centres were interviewed. One school and a health centre were interviewed in the peri-urban area of Maputo, two schools and one health post in the rural areas of Manica, and two schools in Zambézia, in each area.

Table 17 Public schools and health institutions in the Provinces

Public Institutions[44]	Maputo	Manica	Zambézia
Primary School EP I	441	3	2946
Primary School EP II	284	10	8
Secondary School ESG I	50	73	105
Secondary School ESG II	22	22	40
Provincial Hospital	1	1	1
District Hospital	3	4	6
Health Centre	81	100	194
Health Post	8	3	32

From the institutions interviewed, it was found that 86% of them did not have access to electricity. Around 83% of them stated that the reason for this is because there is no electricity connection in the area. When asked if the institutions would be willing to pay for a connection, 42% stated they would be willing, whereas the majority expressed that it is not a decision the school/health facility can make as it is dependent on funds available from the public sector. The remaining 14% of public institutions, which includes a public school and a public private partnership health facility, had access to energy using EDM or solar energy, mainly for water pumps. One of the institutions that uses a solar system for pumping water is a school in rural Zambézia, which uses a solar system donated by FUNAE.

Though most institutions stated that funds for energy access are unavailable; all institutions stated that electricity would help in improving service provision. This includes offering night classes for those who work during the day, which would contribute to achieving the Government's goal for access to basic education by 2020[45], as well as, to allow health posts to provide emergency services during the night, as often when there is a night emergency patients have no other choice but to wait for the next day. Additionally, health posts would also benefit from having small refrigerators for storing vaccines and medicines that require refrigeration. This would significantly improve the quality of life of the population of that area.

It was found that there is a budget available in the Provincial level Health Care and Education Directorates for payment of services, such as electricity and water, when available. This budget can be made available to institutions, if there are funds, upon request.

[44] According to the PEE 2012-2016: EP I= First Degree Primary Schooling (Grades 1 to 5); EP II= Second Degree Primary Schooling (Grades 6 to 7); ESG I= First Cycle of General Secondary Education (Grades 8 to 10); Second Cycle of General Secondary Education (Grades 11 to 12) (MINED 2012).
[45] UNICEF (2017). Mozambique Budget Brief 2017: Education

Since most of the institutions did not have a budget for, nor currently pay for electricity, it is challenging to estimate the payback period for a solar system. However, it was found that all public institutions would rather buy solar systems outright if funds are available for this.

Solar energy can also be used to reduce costs of operation in institutions where energy demand is high. This can be seen in the case example below where the Muhalaze Health Centre, which is connected to the national grid, adopted solar energy to reduce monthly expenditure on energy.

The Muhalaze Health Centre Case

The Muhalaze Health Centre, located in a peri-urban area in Maputo Province, revealed that they adopted a solar system to pump water, in order to successfully reduce their monthly energy expenditure. Prior to adopting solar energy, the Centre was spending roughly MZN 12,000 ($200) per month on electricity; however, since obtaining solar panels for their water pump, they reduced their monthly expenditure on electricity to MZN 5,000 ($83.33), a near 58% drop. It was revealed that, as the Centre was able to reduce this cost, it could allocate the savings to other necessary areas, such as purchasing new sterilization equipment. The Centre is currently seeking a solar system to power the new equipment as the electricity bill has since increased by MZN 2,000 ($33.33) per month. It was also found that the Centre is looking to adopt solar energy at their other branches, either to reduce the cost or to provide light where there is no connection yet.

In general, it was found that most of those interviewed were not aware of the benefits solar energy could provide, usually questioning if solar technologies would have the capacity to provide power to an institution such as a health centre. There is an opportunity here to change this perception; perhaps by having local municipalities and other public institutions in towns and cities, use solar energy, to set an example that solar energy can be a viable solution to satisfy the energy needs of these institutions, or help reduce costs.

3.5 Key Insights and Recommendations for World Bank support – Demand Side

The list below highlights some of the areas in which the World Bank may support the demand side of the off-grid solar sector:

- Consumers seek products that are appealing and can provoke a sense of pride in using these products. As it was seen, word-of-mouth advertising plays a significant role in household decisions to use off-grid solar products. It is, thus, important that these products are aesthetically pleasing and can provide the benefits promised so that consumers are happy to recommend them and change the way solar products are perceived.

- Educating consumers is key to ensuring that they have a good perception of solar products. There is a need for consumers to understand the distinction between what a good quality product is and those that would not provide them with the claimed benefits. Moreover, there is a need to educate households on the potential financial gains

of switching to solar energy and ensuring that they are aware of their current energy expenditure.

- Consumers benefit greatly from seeing demonstrations and experiencing the products themselves, which helps to build trust and create interest. This would also play a significant role in educating consumers on correct usage practices and increase their knowledge on the technology.

- Options such as bundling with other products would raise the attention of consumers and could be an added-value to the products, which can in turn, contribute to the development of those communities. This would also significantly influence word-of-mouth advertising.

4 Estimation of potential market for off-grid solar

This section estimates the size of the market for off-grid solar products at the regional and national levels.

4.1 Brief Methodology

A model was developed by the consultant to estimate the potential market for solar products at the regional level. This model is based on affordability of solar products for the off-grid population, and is informed by the results of the household survey. A detailed description on the methodology can be found in Annex A6.

The model determines the number of off-grid households (per province) that can afford a certain level of monthly expenditure on solar products, based on their income and current energy expenditure patterns. As it is monthly expenditure that is modelled, the results are directly comparable to the pricing of PAYG products (or products with consumer financing). Four pricing points were tested in accordance with the household survey:

- For a 24-month payment plan a pico solar system with a single light and phone charger (system 1) can be acquired for $0.60 per month, given an initial deposit of $4.
- For a 24-month payment plan we estimate that a basic SHS (system 2, including multiple lights, phone charging, and a small radio) can be acquired at $4 per month, given an initial deposit of $22.
- For a 24-month payment plan we estimate that a larger SHS (system 3 - able to do all of the above plus operate a small TV) can be acquired at $18 per month, with an initial deposit of $110.
- For a 24-month payment plan we estimate that a complete SHS (system 4 - able to do all of the above, plus power small refrigerator) can be acquired at $49 per month, with an initial deposit of $293.

In order to derive the monthly fee rate that corresponds to the total price of the system we assume that the initial deposit is spread out across the duration of the payment plan. The four pricing points that were tested include:

- System 1: $0.80/month
- System 2: $4.90/month
- System 3: $22.60/month
- System 4: $61.20/month.

The potential market is determined by comparing the price of a product (in $/month) with the households' willingness to pay.

The willingness to pay for each solar energy system was derived from the MWTP game (described in section A4). The main inputs and sources used for the model are summarized below.

Table 18 Main inputs and sources used for the model

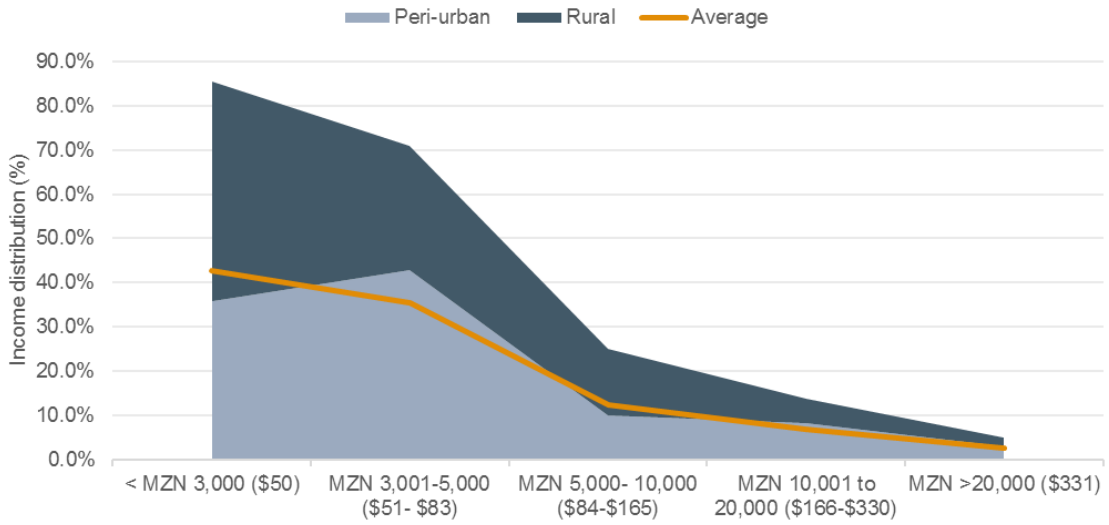
Data	Main sources
Population, population	Census 2017
Electrification rates	Census 2017
Population distribution by income	Household survey
Percentage of off-grid people in wealth quintiles	Consortium analysis based on Mozambique context
Maximum percentage of monthly income spent on lighting	Household survey

4.2 Main results

Manica

A significant share of the population in Manica (around 43%) earns less than $50 a month (the lowest income group), while only 2.5% of Manica's population earns more than $330 a month, as shown in Figure 8.

Figure 8 Income distribution in Manica



Source: ECA

The current electrification rate in Manica is 21.5%. With a total number of households of 381,202, this translates to 299,124 households currently lacking access to the grid.

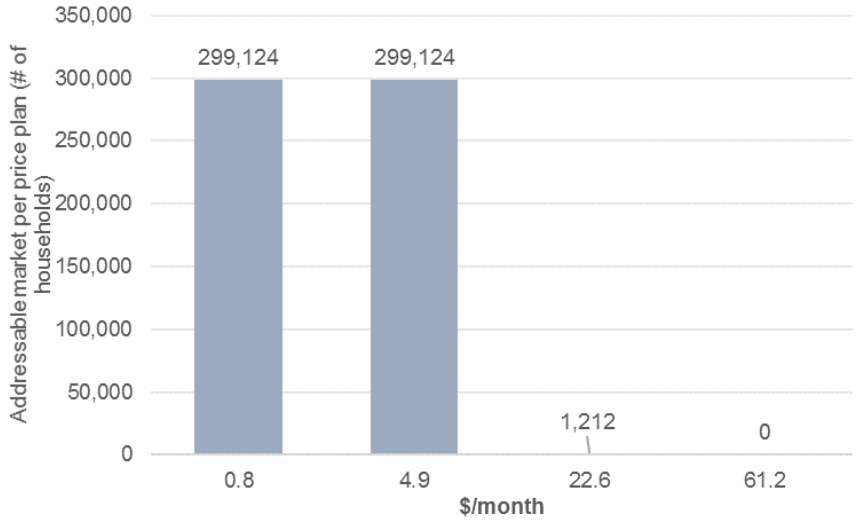
Using the data collected as part of the household survey and following the methodology that is described in Annex A6, the potential market is estimated based on the number of people from each income group that are able to pay the maximum monthly fee for a given solar product.

This estimation is based on reported household income per month and on the current monthly expenditure on alternative sources of energy.

According to the results of the model, the current potential market in Manica is 299,124 units for a PAYG system sold at $4.90 a month (system type 2). This represents 100% of the 299,124 off-grid households in Manica. Figure 9 shows the potential market in the region.

According to the results of the model, at higher monthly fees, the market is much smaller. For a monthly fee of $22.60 (system type 3), the potential market is estimated at 1,212 units, representing only 0.4% of the off-grid households.

Figure 9 Current potential market (No of units) (2018)



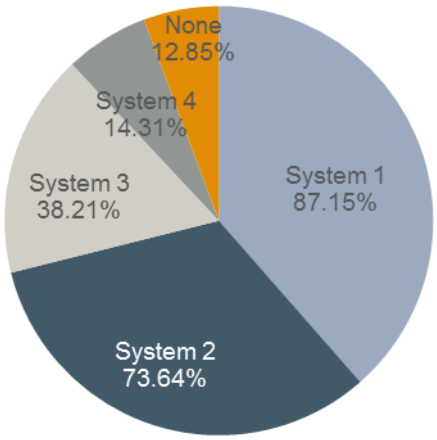
Source: ECA

However, as mentioned before, the results of the model are based on the current monthly expenditure on alternative sources of energy and do not take into account the following:

- **The higher intrinsic value of solar products**: Households might be willing to spend more on household solar products than what they are currently spending on alternative sources of energy, if they feel that the utility they will get is higher.
- **Lack of alternatives**: The amount of money that households are currently spending on energy consumption might not be representative of how much they are willing and able to spend. Households are often limited by how much they spend, not because they cannot afford to consume more, but because there is a lack of alternative sources of energy that would result in higher expenditures.
- **Hidden sources of income**: Most households in Mozambique do not have a steady income and while they have reported their average official income as part of the survey, they can often rely on the sale of cattle, or on relatives to make a purchase.

As such, the results of the model likely underestimate the actual size of the potential market for off-grid solar products. According to the results from the market willingness to pay (MWTP) game 14.31% of the households in Manica are willing, and consider themselves able, to afford system 4, which costs $61.20 per month.

Figure 10 MWTP game result for Manica

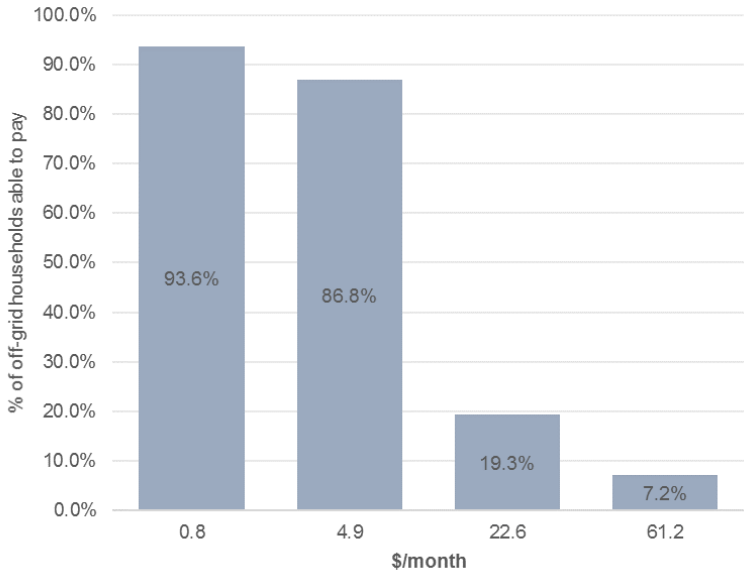


Note: The graph assumes that those households that can afford the most expensive system, system 4, can also afford systems 1,2 and 3.

While the methodology for the MWTP game was carefully designed and the enumerators were well trained to extract the required information from the survey participants, the results regarding systems 3 and 4 might be rather optimistic. This is because some respondents, despite the clear instructions, might be inclined to indicate the system they would like to acquire, rather than the system they can afford.

In order to obtain more accurate results regarding the actual size of the off-grid solar market in Manica, we have combined the results from the modelling exercise with the MWTP game results. The resulting estimates for each system type are shown in the figure below.

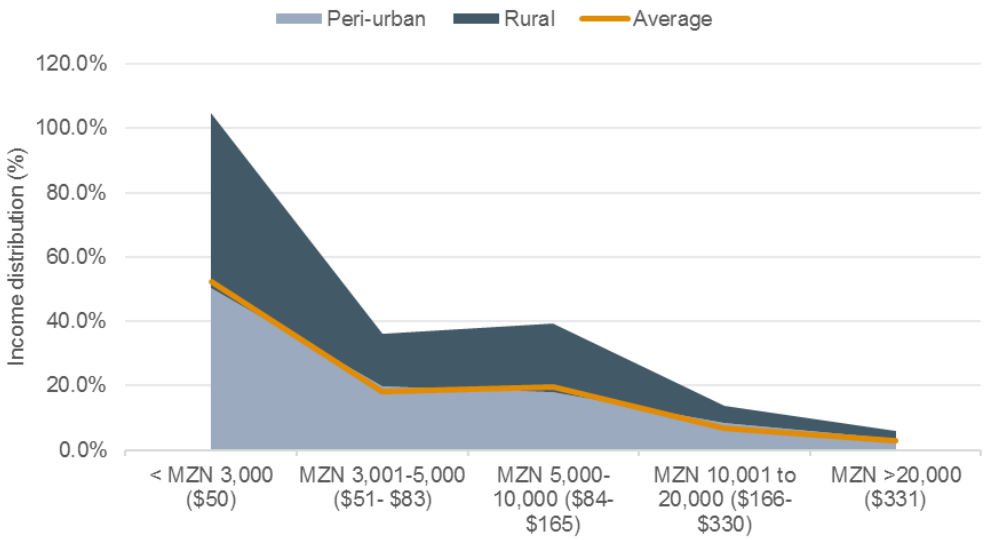
Figure 11 Addressable market in Manica



Zambézia

More than half (53%) of Zambezia's population earns less than $50 a month (the lowest income group), while only 2.9% of the population earns more than $330 a month, as shown in Figure 12.

Figure 12 Income distribution in Zambezia



Source: ECA

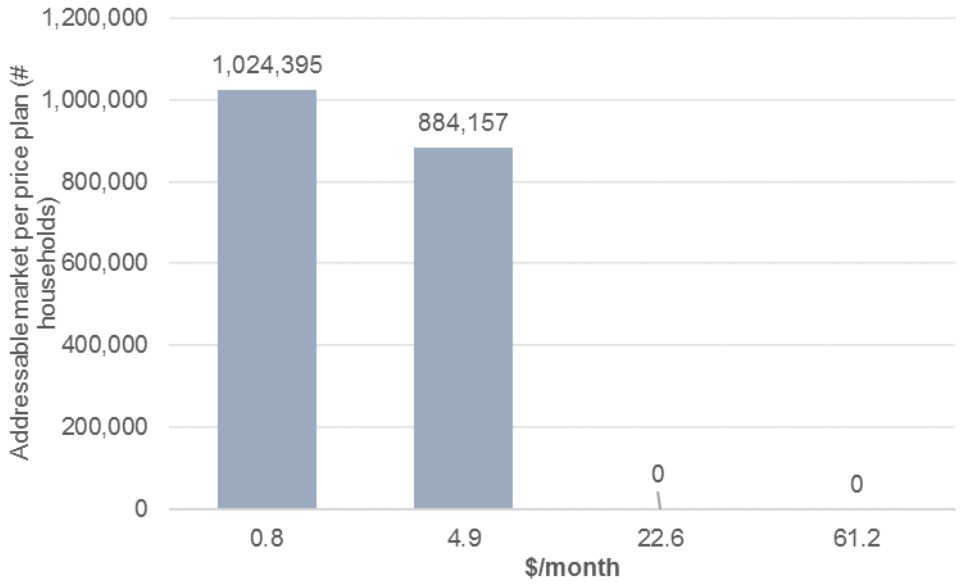
Zambezia has the lowest electrification rate, with only 12.5% of its population enjoying access to the grid. With a total number of households of 1,171,073, this translates to 1,024,395 households currently lacking access to the grid.

Using the data collected as part of the household survey and following the methodology that is described in Annex A6, the potential market is estimated based on the number of people from each income group that are able to pay the maximum monthly fee of a solar product.

According to the results of the model, the current potential market in Zambezia is 884,157 units for a PAYG system sold at $4.90 a month (system type 2). This represents 86% of the 1,024,395 off-grid households in Zambezia. Figure 13 shows the potential market in the region.

At a higher monthly fee rate, however, of $22.60 (system type 3), there is no addressable market, since no household is willing to pay the higher fee.

Figure 13 Current potential market (No of units) (2018)



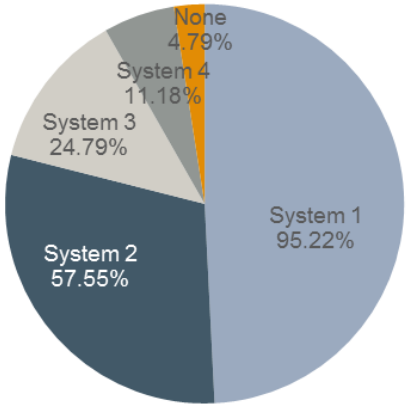
Source: ECA

However, as mentioned before, the results of the model are based on the current monthly expenditure on alternative sources of energy, and do not take into account the following:

- **The higher intrinsic value of solar products**: Households might be willing to spend more on household solar products than what they are currently spending on alternative sources of energy, if they feel that the utility they will get is higher.
- **Lack of alternatives**: The amount of money that households are currently spending on energy consumption might not be representative of how much they are willing and able to spend. Households are often limited by how much they spend, not because they cannot afford to consume more, but because there is a lack of alternative sources of energy that would require higher expenditures.
- **Hidden sources of income**: Most households in Mozambique do not have a steady income and while they have reported their average official income as part of the survey, they can often rely on the sale of cattle or on relatives to make a purchase.

As such, the results of the model likely underestimate the actual size of the potential market for off-grid solar products. According to the results from the market willingness to pay (MWTP) game 11.18% of the households in Zambezia are willing, and consider themselves able, to afford system 4, which costs $61.20 per month.

Figure 14 MWTP game result for Zambezia

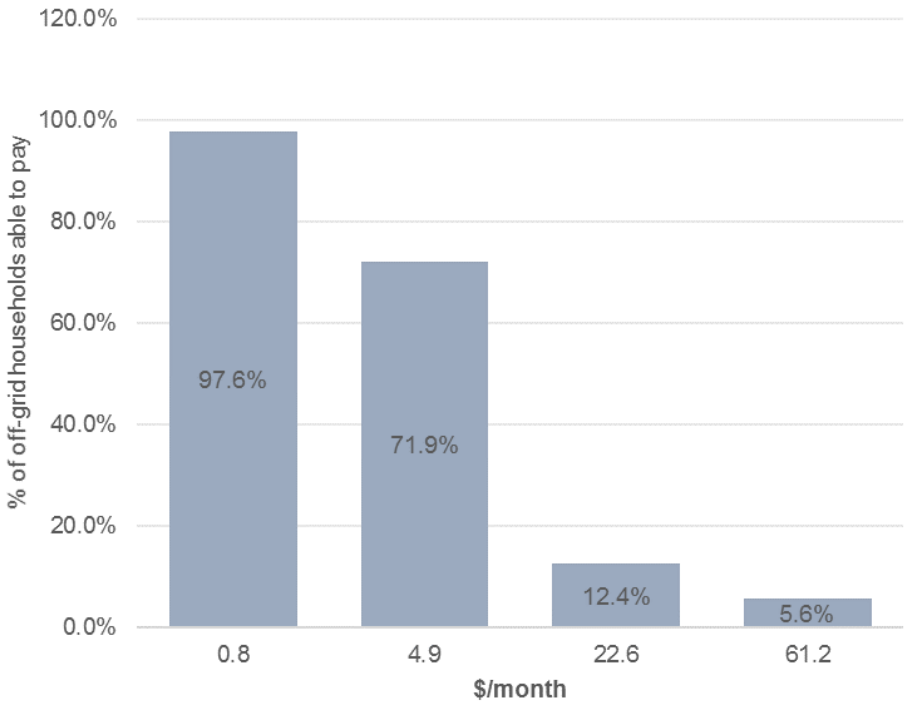


Note: The graph assumes that those households that can afford the most expensive system, system 4, can also afford systems 1,2 and 3.

While the methodology for the MWTP game was carefully designed and the enumerators were well trained to extract the required information from the survey participants, the results regarding systems 3 and 4 might be rather optimistic. This is because some respondents, despite the clear instructions, might be inclined to indicate the system they would like to acquire rather than the system they can afford.

In order to obtain more accurate results regarding the actual size of the off-grid solar market in Zambezia, we have combined the results from the modelling exercise with the MWTP game results. The resulting estimates for each system type are shown in the figure below.

Figure 15 Addressable market in Zambezia

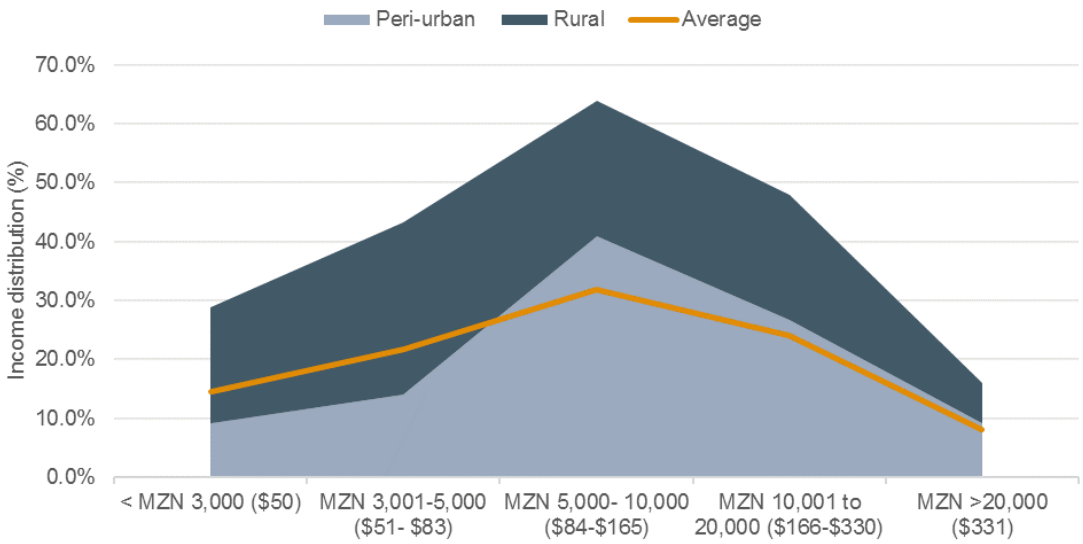


Maputo

Average per capita income is higher in Maputo as compared to the other provinces, with more than half of the population (56%) having a monthly income between $84 and $330.

Only 14% of Maputo's households earn less than $50 a month, while 16% of total households have an income of more than $330, as shown in Figure 16.

Figure 16 Income distribution in Maputo



Source: ECA

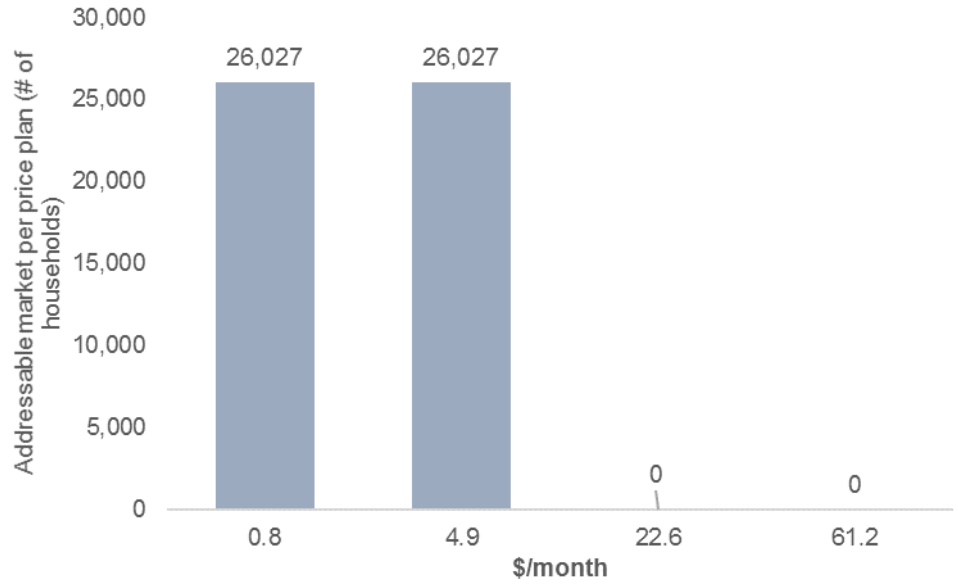
Maputo has the highest electrification rate with only 4.2% of its population lacking access to the grid. With a total number of households of 613,648, this translates to 26,027 households currently lacking access to the grid.

Using the data collected as part of the household survey and following the methodology that is described in Annex A6, the potential market is estimated based on the number of people from each income group that are able to pay the maximum monthly fee of a solar product.

According to the results of the model, the current potential market in Maputo is 26,027 units for a PAYG system sold at $4.90 a month (system 2). This represents 100% of the 26,027 off-grid households in the Maputo province. Figure 17 shows the potential market at the region.

At a higher monthly fee rate of $22.60 (system 3), there is no addressable market, since no household is willing to pay the higher fee.

Figure 17 Current potential market (No of units) (2018)



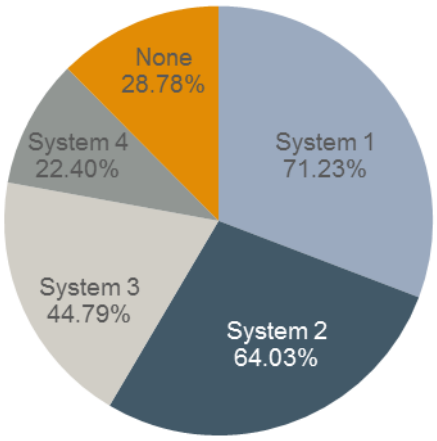
Source: ECA

However, as mentioned before, the results of the model are based on the current monthly expenditure on alternative sources of energy, and do not take into account the following:

- **The higher intrinsic value of solar products**: Households might be willing to spend more on household solar products than what they are currently spending on alternative sources of energy, if they feel that the utility they will get is higher.
- **Lack of alternatives**: The amount of money that households are currently spending on energy consumption might not be representative of how much they are willing and able to spend. Households are often limited by how much they spend, not because they cannot afford to consume more, but because there is a lack of alternative sources of energy that would require higher expenditures.
- **Hidden sources of income**: Most households in Mozambique do not have a steady income and while they have reported their average official income as part of the survey, they can often rely on the sale of cattle or on relatives to make a purchase.

As such, the results of the model likely underestimate the actual size of the potential market for off-grid solar products. According to the results from the market willingness to pay (MWTP) game 22.4% of the households in Maputo are willing, and consider themselves able, to afford system 4, which costs $61.20 per month.

Figure 18 MWTP game result for Maputo

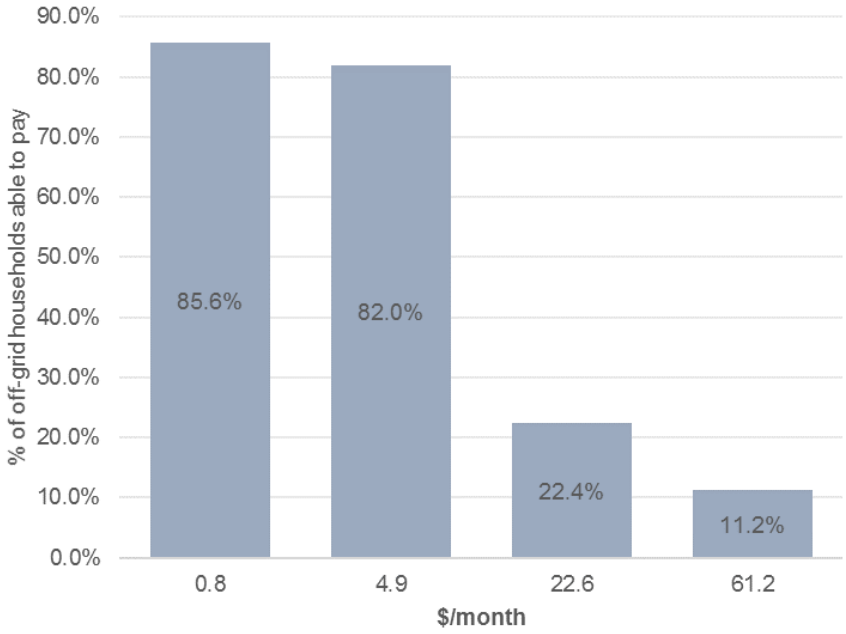


Note: The graph assumes that those households that can afford the most expensive system, system 4, can also afford systems 1,2 and 3.

While the methodology for the MWTP game was carefully designed and the enumerators were well trained to extract the required information from the survey participants, the results regarding systems 3 and 4 might be rather optimistic. This is because some respondents, despite the clear instructions, might be inclined to indicate the system they would like to acquire rather than the system they can afford.

In order to obtain more accurate results regarding the actual size of the off-grid solar market in Maputo, we have combined the results from the modelling exercise with the MWTP game results. The resulting estimates for each system type are shown in the figure below.

Figure 19 Addressable market in Maputo



Potential market across the country

Figure 20 presents the percentage of households that can afford each of the four system types tested in the three provinces where the household survey was conducted.

According to the analysis described in the above sub-sections, system 1 (single light and phone charging) is affordable to 94%, 98% and 86% of off-grid households in Manica, Zambezia and Maputo, respectively.

System 2, which allows the user to power three light bulbs, charge a mobile phone and power a radio is affordable to 87%, 72% and 82% of households in Manica, Zambezia and Maputo provinces, respectively.

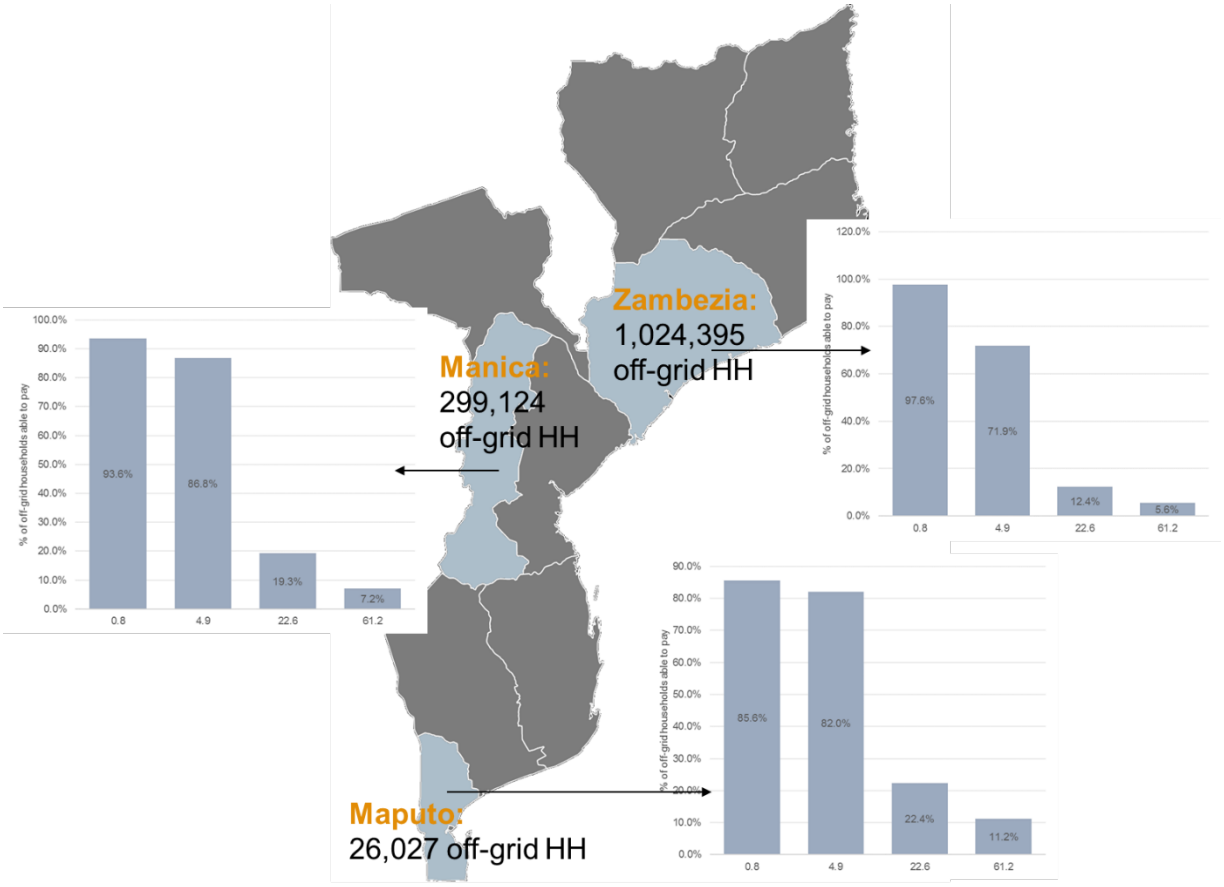
System 3 (all of the above, plus power for a TV), which costs $22.60 per month is only affordable to 12%, 19% and 22% of total households in Manica, Zambezia and Maputo provinces, respectively.

On the other hand, only 6%, 7% and 11% of total off-grid households in Manica, Zambezia and Maputo provinces, respectively, can afford System 4 (all of the above plus power for a small refrigerator), which costs $61.20 per month.

For system 1, the total size of the addressable market across the three provinces is 1.3 million, while for system 2 it is 1 million. For systems 3 and 4 the addressable market is 191 thousand and 82 thousand, respectively.

The total number of off-grid households across the three provinces is 1.35 million, representing 30% of all the off-grid households in Mozambique. Assuming that the average distribution of income and willingness to pay for solar products across the three provinces is representative of that in the remaining provinces, **the total size of the potential market for system 1 type of products is 4.4 million units, 3.5 million units for system 2 products, 645 thousand units for system 3 products and 276 thousand units for system 4 products.**

Figure 20 Current potential market (% of off-grid HH able to pay) per region



Note: The light blue area corresponds to those that are able to pay.

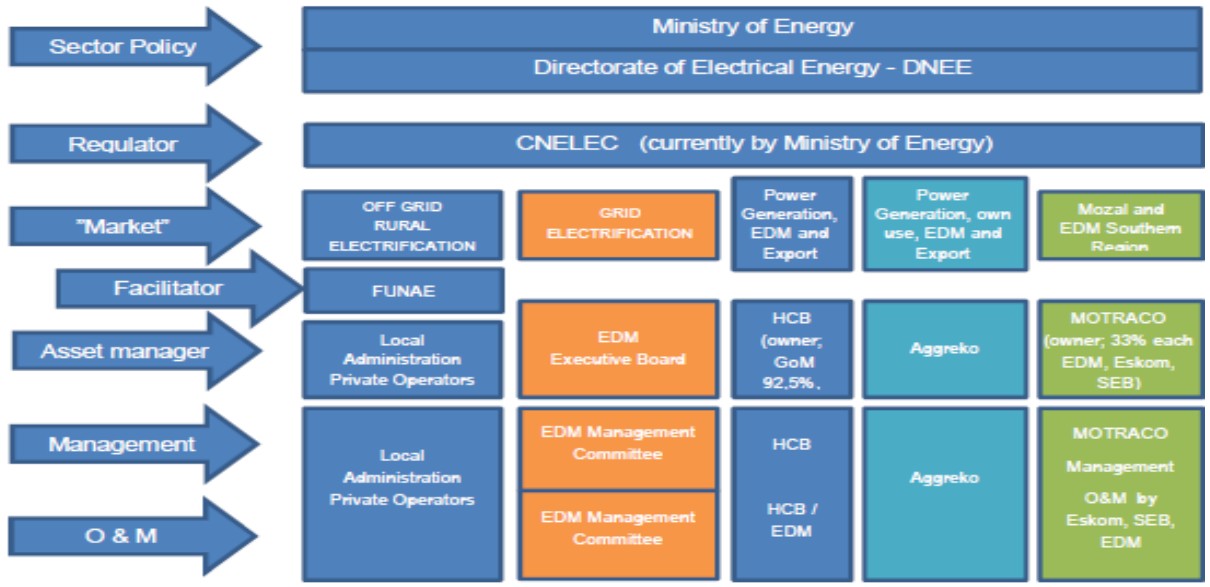
5 Regulatory and enabling environment

5.1 Institutional structure of the electricity sector

Figure 21 presents a summary of the institutional governance and operational structure of Mozambique's electricity sector.

The Ministry of Mineral Resources and Energy (MIREME) is responsible for regulating and supervising the energy sector in Mozambique. MIREME is committed to achieving universal access to electricity by 2030, the Sustainable Energy for All (SE4All) target year.

Figure 21 Mozambique electricity sector institutional structure



Source: USAID

5.2 Government regulations relevant to scale up off-grid solar market

5.2.1 Legal framework

The government's commitment to meeting universal electrification by 2030 in a sustainable manner is exemplified through the various national policies and strategies that regulate the off-grid electrification market.

These policies and strategies, despite being descriptive, confirm that solar energy plays an important role in the government's efforts to increase electricity access in rural areas.

A summary of the strategies and policies that are relevant to the off-grid electricity market in Mozambique is provided in the table below.

A National Electrification Strategy for achieving universal access to electricity is currently being prepared. However, this does not yet include an off-grid electrification strategy[46].

Table 20 Policy and strategies relevant to the off-grid solar sector

Policy or strategy	Key points relevant to the off-grid solar sector
National Development Strategy (ENDE) for 2015-2035	The strategy was developed as a planning tool for promoting social and economic prosperity in the country. One of the main bottlenecks identified is lack of competitiveness. Four strategic pillars are identified as part of ENDE, while goals and benchmarks are established for each pillar. Energy access is considered a prerequisite for achieving the goals under each of the pillars.
Mozambican government's five-year plan for 2015-2019	The five-year plan aims to boost the country's economic development and is one of the tools included in ENDE. The plan is based on five pillars. As part of the fourth pillar (development of economic and social infrastructures), the plan highlights the importance of renewable energy in contributing to the development of economic and social infrastructure. One of the objectives of the plan is to 'increase quality access and the availability of electricity, liquid fuels and natural gas for the development of social and economic activities, household consumption and exports'. The plan has set a goal to increase the country's electrification rate to 33% by 2019. In order to achieve this objective, the Mozambican Government proposes the following set of actions: (i) Diversification of sources of power generation in order to ensure security of supply, (ii) promotion of the construction of new power plants and the development of new electricity transmission lines, (iii) promotion of rural electrification by grid extension and solar systems (iv) electrification of health care centres through solar energy systems, and (v) the promotion of the construction of small hydropower plants.
Mozambican government's five-year plan for 2015-2019 (cont.)	The plan highlights that electrification efforts should focus on both grid extension and independent solar systems. Other areas that the Government associated with the promotion of the renewable energy sector, include: (a) safeguard and protection of natural resources under national jurisdiction, as a means to ensure the defense of Mozambique's sovereignty, (b) electrification of schools in rural areas, based on solar systems, with a view to promote an inclusive, effective and efficient education system, and (c) installation of solar and wind power systems to pump drinking water, as strategy to increase provision and access to supply services.

[46] *Development of the National Electrification Strategy (NES) – Draft.* Prepared for World Bank by AF-Mercados EMI in cooperation with Estudios Energéticos Consultores and Royal Haskoning DHV, April 2017

Law n.º 21/97 of 1 October - Electricity Law (Law 21/97)	The Electricity Act passed in 1997 allows for private participation in the electricity sector under a concession system, while maintaining a special position and responsibilities for EDM. However, the involvement of private sector operators in the renewable energy sector is, up to now, limited. A new Electricity Law has been drafted and is being submitted for in-depth public consultation.
Law n.º 11/2017, of 8 September	Enabling law for the creation of the Autoridade Reguladora de Energia (Energy Regulatory Authority) (ARENE). This was formally created in December 2017 but is still in the process of being properly established in the third quarter of 2018.
The Economic and Social Plan (PES)	PES is published on an annual basis and highlights the priority areas for social and economic development, one of which is energy access. The plan guides governmental action towards the implementation of the Government's 5 year plan (2015-2019). The most recent plans (PES 2016,2017 and 2018) show that higher electricity access is one of the government's top priorities. According to these documents a higher rate of electrification can only be achieved through a combination of grid extension and off-grid renewable energy sources, such as solar.
The Energy Strategy (2009)	The aim of the energy strategy is to 'create the conditions necessary to increase the access to diversified forms of energy, in a sustainable manner, whilst contributing to the well-being of the population and socio-economic development of the country'. With regards to off-grid electrification, the Strategy highlights the importance of intensifying the electrification efforts, prioritizing the expansion of the national grid while simultaneously providing alternative forms of electricity in rural areas and encouraging the cooperation between EDM and FUNAE. Emphasis is also placed on the productive and efficient use of energy.
The Energy Strategy (2009) (cont.)	The Strategy also highlights the importance of taxation in creating the right incentives for the modernization of the energy sector and in attracting private sector participation. The strategy also mentions that renewable energy 'must play an increasingly relevant role in the national energy balance, in order to reduce the country's dependence on fossil fuels and allow moving towards a more decentralized energy mix that makes greater use of endogenous resources, for which an inventory of resources and technological development are deemed crucial'. MIREME is currently revising the Energy Strategy.

The New and Renewable Energy Development Policy (PDENR), 2009	The main principles characterizing PDENR are Economic efficiency, Equity and Sustainability. PDENR focuses on meeting the energy needs of Mozambique in an sustainable manner, through the use of renewable energy resources. PDENR recognizes that Mozambique does not make use of its natural potential in new and renewable energy, and it highlights the need of making renewable energy available to more people. Some of the key objectives of the PDNER are: (i) the promotion of supply of quality new and renewable energy sources, (ii) the creation of a competitive new and renewable energy market, (iii) reducing negative environmental impacts at local and global Levels, (iv) contribution to income generation and job creation, and (v) the contribution towards the achievement of the Millennium Development Goals (MDG).
The New and Renewable Energy Development Strategy for the 2011-2015 period (EDENR), 2011	The strategy recognizes the importance of developing the use of renewable energy resources and has the following key strategic goals: ❑ Improving access to energy services based on renewable sources; ❑ Developing technologies for the use of renewable energy sources; ❑ Promoting private sector investment in the renewable energy sector. EDENR also establishes sector goals for both off-grid and on-grid renewable energy. Regarding the off-grid sector, EDENR places an emphasis on the importance of stand-alone energy systems that are usually powered by solar energy. The main objective of off-grid renewable energy is to facilitate development, fight poverty and ensure access to higher quality energy sources in rural areas.
Renewable Energy Feed-in Tarff regulation (ReFIT 2014)	Even though the Renewable Energy Feed-in Tarff regulation (ReFIT 2014) is not applicable to off-grid energy systems, it aims to promote the diversification of the energy supply by incentivizing investment in renewable energy generation. New and renewable energy investors that invest in generation projects that would feed electricity into the national grid are offered a guaranteed tariff, depending on the renewable energy source, as well as guaranteed access to the distribution grid, therefore reducing the risks of the investment. However, due to exchange rate fluctuations and other factors, the REFITs are not operational. The REFIT is currently being considered for revision by the National Energy Directorate.

5.2.2 Fiscal policy

The legal framework in Mozambique offers a number of fiscal benefits to renewable energy investors, however these are only granted to investments that generate electricity that would feed into the national grid.

The tax benefits are outlined in the Tax Benefits Code (CBF), approved by Law 4/2009, of 12 January. Such fiscal benefits include exemption from import duties and Value Added Tax (VAT) for the import of capital goods that fall under the category 'K' in the Customs Tariff and the import of respective parts (Article 21)[47].

Private companies engaged in renewable energy generation are also eligible for other fiscal benefits including discounts in the Corporate Income Tax equal to 80% in the first five years, reduced to 60% in the following five years and to 25% in the next five years (Article 22).

Further fiscal benefits are offered, according to the CBF, to investors operating in Rapid Developong Zones (ZRD), which are defined as 'geographic areas within the national territory with great potential in terms of natural resources, but lacking infrastructures and having a weak economic activity' (Article 39). The ZRDs are defined in articles 40 and 41, along with the activities eligible for the fiscal benefits. Such activities include the generation, transmission and distribution of electricity. Additional benefits for those companies operating in ZRDs include a tax credit provided for five years following the investment that corresponds to one fifth of the capital invested (Article 43)[48].

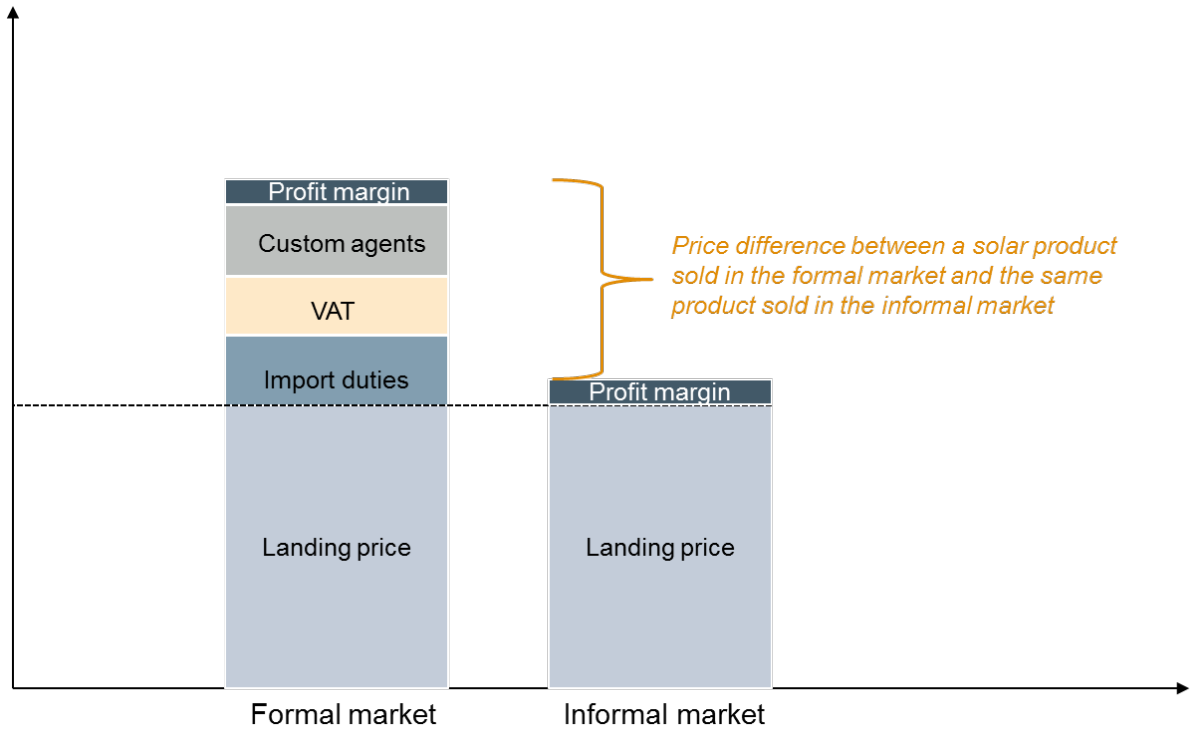
Fiscal benefits are also offered to companies that invest in local human capital (Articles 44, 18 and 19). Such benefits include a deduction in the taxable income up to maximum of 5% (or 10% if the training is for new technologies) in the first five years following the start of operations[49].

Investors can also take advantage of the various Bilateral Investment and Double Taxation Agreements that have been signed between the Government of Mozambique and other countries. Other benefits that are offered to investors in general, and which also apply for renewable energy projects, include the right to import capital and repatriate profits.

Despite the various fiscal benefits that are applicable to investors active in renewable energy generation, renewable energy technologies, such as solar home systems and solar lanterns are still liable to VAT at the rate of 17%, and import duties that vary between 7.5% and 20% depending on the component type. The table below shows the import tariffs that are applicable for each renewable energy product category. However, in reality the tax burden may be up to 30-40% if the rates provided to custom agents are also taken into account[50]. The impact of taxes on the retail price of solar products is illustrated in the Table 19, imports of any products from the Southern African Development Community (SADC) region do not attract any import duties.

[47] ALER 2017. Renewables in Mozambique – National Status Report
[48] Ibid
[49] USAID 2009. PARPA II Review—The Tax System in Mozambique, available from: https://www.open.ac.uk/technology/mozambique/sites/www.open.ac.uk.technology.mozambique/files/pics/d119378.pdf
[50] ODI 2016. Available from: https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/10251.pdf

Figure 22 Impact of taxes on the retail price of solar products



Source: ECA

Table 19 Custom duties applicable for off-grid electricity products

Product code	Description	MZN tariff	SADC tariff
850440	Static converters (eg. Rectifiers and inductors/inverters to convert dc to ac power)	5.0%	0.0%
850720	Other lead-acid accumulators (deep discharge solar batteries)	7.5%	0.0%
851310	Portable electrical lamps designed to function by their own source of energy- lamps	20.0%	0.0%
851319	Portable electrical lamps designed to function by their own source of energy- parts	20.0%	0.0%
853710	Photovoltaic system controller (charge controller for voltage not exceeding 1Kv	7.5%	0.0%
854140	Photosensitive semiconductor devices, incl. photovoltaic cells	7.5%	0.0%
940550	Non-electrical lampt and lighting fittings	20.0%	0.0%

Source: ALER 2017

Apart from the high rates of taxation that off-grid solar products are liable to, they also compete against subsidized traditional energy sources, such as kerosene. According to the

IMF, the fuel subsidy was equivalent to 1.1 and 1.5 per cent of Mozambique's GDP between 2012 and 2014[51].

Following the drop in international oil prices in 2015, the Government of Mozambique reduced kerosene subsidies, however in 2017, MIREME announced a further reduction in the prices of kerosene[52]. In 2017, the price of subsidised kerosene was 36 MZN/ltr.

The high level of taxation, coupled with steep competition from alternative fuels, makes the policy environment in Mozambique not very conducive to investments in off-grid solar products.

5.2.3 Quality standards

There is currently a lack of policies regulating the quality of off-grid household products sold in Mozambique. This has resulted in an influx of inferior quality products in the market. According to interviews with established solar companies, this might create a distorted view regarding the capabilities of solar products among potential customers, which in turn might hamper the development of the market.

FUNAE is currently producing its own solar panels. However, the lack of a fully automated manufacturing line for the production of solar PV panels by FUNAE has also resulted in several quality issues. It was not until recently, in March 2017, that the manufacturing plant received TUV International Certification[53].

5.3 Mobile phone penetration

The mobile services sector in Mozambique has experienced unprecedented growth over the past decade. Mobile subscriptions rose from 2.3 million in 2006 to over 15 million in 2016.

A large, multi-faceted, Mobile Access and Usage Study (MAUS) was commissioned by USAID and DFID in 2016 too determine access to mobile phones and services and describe patterns of mobile phone usage in the four target provinces, namely Manica, Nampula, Tete and Zambezia. The sub-sections below summarise the findings of this study that are most relevant to this assignment.

Network coverage and service quality is very good

According to the study, mobile coverage (at least a 2G signal) is approximately 82% across urban and rural communities. Also, nine out of ten survey respondents reported that service quality is sufficiently high to allow them to send messages. Manica was found to have the higher quality of coverage, with all three providers offering extensive coverage.

There is a relatively high prevalence of mobile use

While two thirds of respondents reported that they had used a mobile phone in their lifetime, there are significant differences across the target provinces. The highest percentage

[51] http://clubofmozambique.com/news/imf-supports-fuel-price-increase-aim-report/
[52] http://apanews.net/en/news/mozambique-cuts-prices-of-liquid-fuels
[53] Consultation with stakeholders

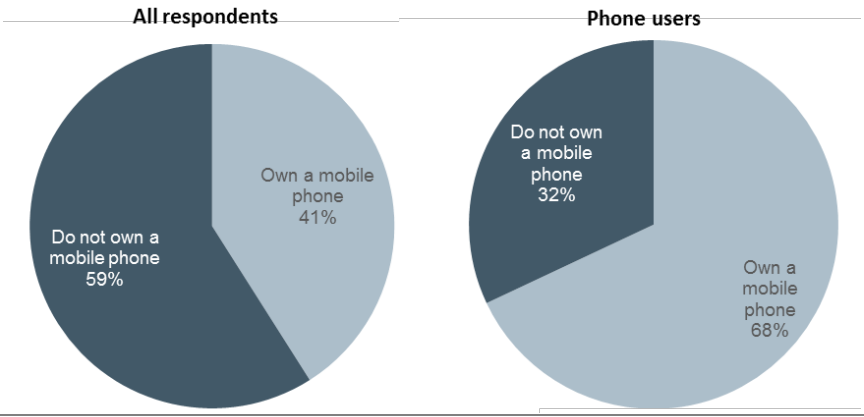
of use (86%) was recorded in Manica province. The lowest percentage was recorded in Zambezia province, where 46% of respondents reported that they had never used a mobile phone.

Mobile usage percentage also varies across demographic groupings, most notably gender and education level. According to the study, females are 22% less likely to use a mobile phone. On the other hand, higher education level seems to be linked to higher mobile phone usage. Only a forth (26%) of respondents with no formal education reported that they had used a mobile phone. This figure increases to 80% across respondents with at least secondary education and to 100% for those who reported "above secondary" education level. Widely available and affordable information and communication technologies (ICTs), such as radios, can complement mobile usage and reach those who don't own a mobile phone.

In terms of mobile phone ownership, 68% of respondents who had used a mobile phone before, reported that they own one now. This percentage is lower in Nampula and Zambezia provinces and stands at just over 50%. There are also noticeable discrepancies in mobile phone ownership in relation to gender. The exact percentage varies by location, but in general terms women are 27-38% less likely to own a phone.

While mobile phone users are comfortable using phones for calling and communicating via text and voice messages, data-enabled and advanced mobile services seem to be less commonly used, according to the study. While all mobile phone users know how to make calls and send messages, only two-thirds of users know how to utilize additional functions on their phone, and only one-third of them reported using more advanced services on their phone, such as browsing the internet, sending or receiving money or using social media.

Figure 23 Mobile phone ownership in Mozambique



Source: USAID 2016

The use of mobile money is quite common (one third of mobile phone users, including many who do not have a bank account))

Mobile money services in Mozambique were first provided in 2010 via mCel's mKesh and are now available through two providers since Vodacom's M-PESA started its operations in 2013.

According to the study, the use of mobile money is most common across urban phone users in the highest wealth quintiles who also have a bank account. However, transferring money via a mobile phone is widespread even among those who do not have acccess to a bank account. Out of all mobile phone users, 33% had used mobile money services. This is a fairly large proportion considering that mobile money is relatively recent, but from the viewpoint of using mobile money to sell solar products it is a warning that overall mobile penetration is not in itself a good indicator of the extent to which PAYGO systems can be rolled out. While phone coverage is an important determinant of the usage of mobile money, the latter also requires mobile money vendors to have access to commercial banks. Therefore, the limiting factor in the scale up of mobile money is the lack of financial facilities.

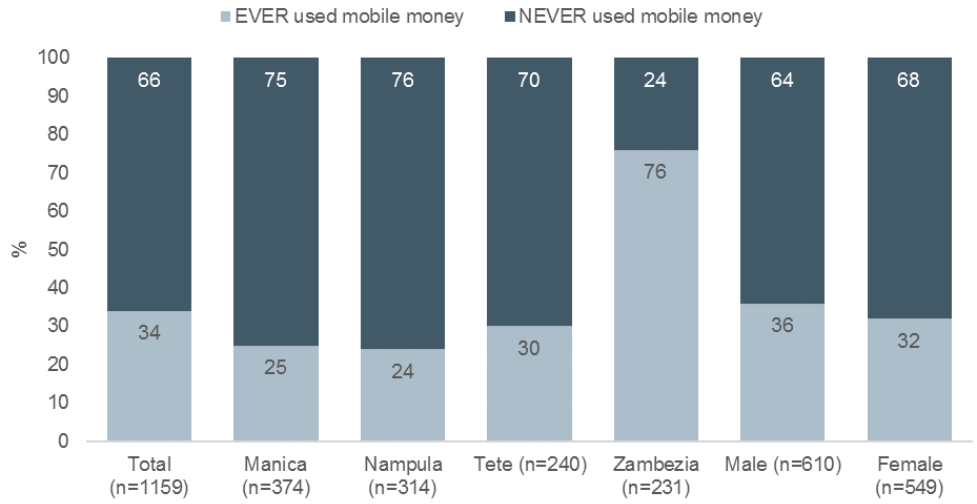
The volume of mobile money transactions has also increased rapidly over the past three years. In 2016 alone, the number of financial transactions conducted over the mobile phones in Mozambique increased sevenfold, according to the central bank. Approximately 150 million transactions were recorded by the end of 2016, representing a sevenfold increase compared to the volume of mobile money transactions in 2015.

The growth in the usage of mobile money is expected to increase exponentially over the next decade and will be triggered mainly by the following factors:

- Advantages of mobile payments, including the ease of making transactions and avoiding long waiting times in banks
- Positive experience recorded in other countries, including Kenya and Tanzania
- The flexibility of mobile finance
- The potential to broaden and deepen financial inclusion

It is to be noted that use of mobile money services is significantly higher in the Zambezia province, where just over three quarters of mobile phone users had transferred money using a cell phone. In absolute terms, twice as many people used mobile money in the Zambezia province than in any other target province. In terms of bank account ownership, 20% of households who do not have a bank account reported using mobile money. Educational campaigns, financial literacy training, as well as accessible printed brochures could increase the percentage of mobile money usage.

Figure 24 Use of mobile money, among phone users



Source: USAID 2016

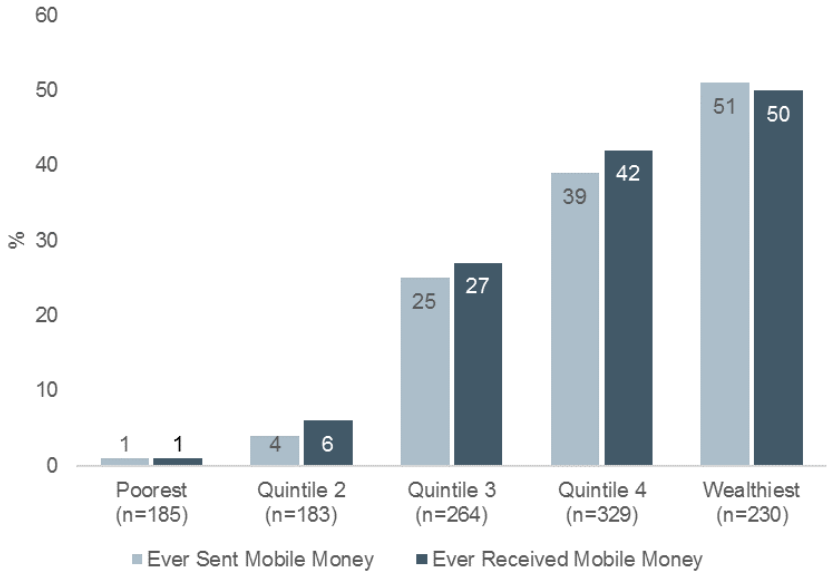
In terms of geographical patterns, respondents in urban areas were more likely to send or receive mobile money than those in rural areas. In the first group, the fraction of residents who had sent and received money was equal to 42% and 43%, respectively. For respondents in rural areas, these figures are 23% and 24%, respectively. The difference between sending and receiving money based on location was not found to be statistically significant, suggesting that remittance payments do not contribute to geographical differences in mobile money usage.

Zambezia province is characterised by a significantly higher percentage of mobile phone users who utilise mobile money services. In absolute terms, this number is more than twice as much as mobile money usage than in any other province[54].

The results of the survey indicate that respondends in the top two wealth quintiles are more likely to use mobile money services than those in the three bottom quintiles. Turning to the financial inclusion aspect, mobile money usage among households with no bank account stands at 20%, as opposed to over 50% for mobile phone users with a bank account. The results of the MAUS CATI survey suggest insufficient funds as the main barrier to mobile money usage for most of respondents (31.5%), followed by the lack of knowledge of how to use mobile money services (26.5%). Financial literacy training, educational campaigns and easily accessible printed materials could contribute to overcoming these barriers. Explaining the reasons behind higher mobile money usage in the Zambezia province could also help in understanding the main drivers behind mobile money usage.

[54] The high number of mobile money users has to do with the large population of Zambezia. In percentage terms the share of mobile phone users is very low in this province.

Figure 25 Use of mobile money, among phone users, by wealth index quintile



Source: USAID 2016

Across the target provinces, 18% of respondents reported using the internet within the past year. This fraction is higher than the national estimate of 9% in 2015, provided by the International Communications Union. This percentage is even higher amongst mobile phone users and equals approximately one third. As with mobile phone usage, significant variations in internet access are present. In Manica province, characterised by good coverage and high percentage of mobile use, 42% of men and 15% of females had used the internet in the last year.

Access to power is an important determinant of mobile phone usage

There is synergy between mobile phone uptake and the availability to the household of solar electricity devices, starting at the level of lanterns with charging sockets. For those without solar, mobile phone usage is often dependent on the ability and cost to charge the device, which varies between 10 and 50 meticais across the three target provinces. Almost half (47%) of those who charge their phones, do so from home, while 31% reported using a charging station. In Zambezia province, the latter percentage is significantly higher, with 53% of mobile phone users charging phones at stations and only 17% charging them from home. Over a quarter (26%) reported charging their phones at a neighbour's or friend's house. For 64% of respondents, the distance to charging stations is less than a kilometer.

5.4 Financial sector

5.4.1 Consumer financing

Traditional financial institutions in Mozambique are wary of lending to consumers for the purchase of solar products. This is because transaction costs for managing small loans are high compared to expected returns. Also, given the absence of lending history for these products their risk profile is perceived to be relatively high.

A business model that has helped overcome the lack of consumer financing is the pay as you go (PAYG) model. PAYG is an asset financing mechanism, allowing households to spread the cost of purchasing their solar products, predominantly SHSs and multi-light pico products, over time. PAYG involves regular payments over a fixed term ranging from six months to eight years, coupled in most cases with a small upfront payment.

The PAYG model has relaxed the assumption that households will only spend up to three months of saved disposable income on a product, and has allowed companies to view solar product sales as part of a long consumption ladder, rather than as one-off transactions. This has not only led to a significant rise in sale revenues but has also allowed households to gain access to more appliances and services, contributing to an increase in living standards[55].

While this innovative mechanism has spread quickly in East Africa, it is not yet well established in Mozambique. Since payments are typically made via mobile money, an important enabling factor for the expansion of the PAYG model is the rapid expansion of mobile networks. Despite a relatively high mobile phone penetration rate, the adoption of mobile money has been slow (see Section 5.3). In order for mobile money usage to take off, operators need to achieve a high volume of transactions, which in turn requires large capital investments and a high population density. The sheer length of the country's terrain makes such an investment more challenging compared with cases like Kenya, where the use of mobile use spread quickly across all parts of the country[56].

Another obstacle for scaling up the use of PAYG has been the lack of clarity regarding leasing regulations for a non-financial institution[57]. In order to overcome this problem, most companies that offer PAYG solutions retain the ownership of the equipment and charge consumers a fee for the use of the solar kits. While this model resembles the traditional leasing model, the fact that private companies retain the ownership of the systems circumvents the leasing regulations.

The risk of mobile-based consumer financing in the off-grid solar sector is further compounded by the depreciation of the exchange rate and the consumers' expectation that solar equipment should be subsidised[58].

Despite the obstacles, the first solar company offering PAYG started its operations in Mozambique (Maputo) in 2016. It is expected that more companies will start offering consumer financing in the next few years[59].

5.4.2 Micro-financing institutions sector

Commercial lending in Mozambique is characterised by very high interest rates. Despite the central bank cutting its benchmark interest rate from 18% to 16.5% in April 2018, commercial rates remain at high levels, at around 30%[60].

[55] Ibid
[56] DFID 2016. Business Environment Constraints in Mozambique's Renewable Energy Sector: Solar PV Systems and Improved Cook Stoves.
[57] Ibid
[58] Ibid
[59] Discussions with solar companies
[60] AllAfrica 2018. Mozambique: Bank of Mozambique Cuts Interest Rates Again, available from: https://allafrica.com/stories/201804120112.html

High interest rates coupled with stringent collateral requirements present insurmountable obstacles for the small and medium sized companies operating in the off-grid electrification market. As such, most of the companies currently operating in the off grid solar market depend on their own finances or are raising international capital[61].

The lack of affordable borrowing severely limits the capacity of solar companies to manage their inventory levels, extend credit to dealers, expand their distribution networks and invest in the marketing of their products.

Lack of access to local credit also limits the ability of companies to import larger quantities of stocking equipment and therefore secure better price deals from their suppliers. This in turn results in higher prices, which are often prohibitive for low income groups.

In order to combat this problem, the government, with funds from KfW, under the Sustainable Economic Development project, established a credit line $16.7 million in 2014, offering working capital loans to small and medium sized enterprises operating in the off-grid solar market.

This credit line, which is managed by BCI, also provides capacity building to financial institutions and financiers to improve their understanding of the off-grid electrification market[62].

However, the credit facility has not been successful in providing any loans to solar companies, for two main reasons. Firstly, according to BCI, no bankable project was identified and secondly, BCI has been in discussions with the central bank requesting lower rates under this facility in order to provide better deals to solar companies[63].

The challenges faced by private investors in the off-grid solar market are compounded by restrictions in the use of foreign currency and repatriation of capital.

The reluctance of large commercial banks to lend to solar companies, prompted the development of micro-finance institutions (MFIs). An association representing all the MFIs in Mozambique, AMOMIF (Associação Moçambicana dos Operadores de Microfinanças), was established in 2007. The objective of AMOMIF is to promote the interests of MFIs during the discussions with the Central Bank of Mozambique[64].

AMOMIF is involved in the Financing Mozambique portal, an initiative established by Swiss Capital Partners and Financial that offers a matchmaking function between potential projects and financiers. The portal also offers advice to project developments regarding the drafting of supporting documents and business plans[65].

5.5 Support programmes

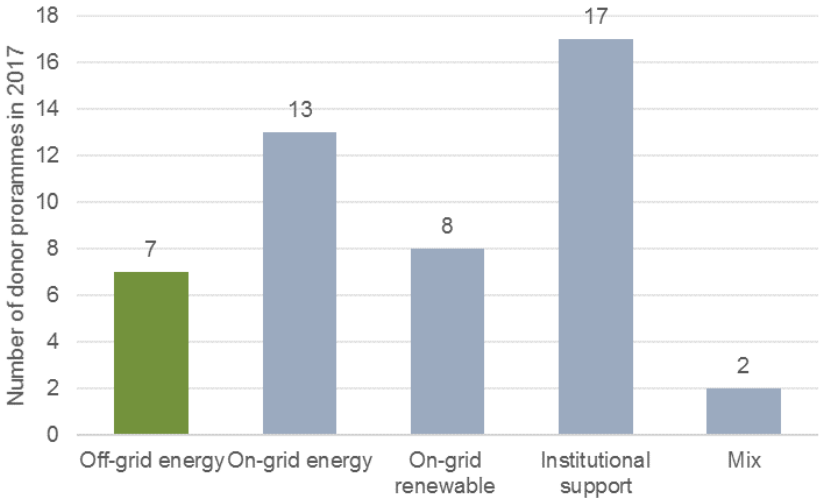
In Mozambique, the off-grid electrification market relies extensively on donor institutions for financing and technical support. Most of these Development Finance Institutions (DFIs)

[61] FSDMOC 2015. Capital Markets Overview Analysis of the Mozambican Financial Markets
[62] DFID 2016. Business Environment Constraints in Mozambique's Renewable Energy Sector: Solar PV Systems and Improved Cook Stoves.
[63] Ibid
[64] IRENA 2012. Mozambique renewables readiness assessment.
[65] Ibid

and international cooperation agencies are organised in the Energy Sector Working Group (ESWG), which currently comprises around 25 organisations.

As of 2017, ESWG's members had participated in a total of 77 programmes with a total budget of $1.6 billion (Figure 27)[66]. More than 60% of these projects are ongoing with an annual budget of approximately $220 million. However, only approximately $10 million per annum is allocated to off-grid electrification projects, with most of the budget spent on on-grid projects. Capacity building accounts for the highest share of programmes but also accounts for a small share of the budget, totalling $19 million. As shown in Figure 26, off-grid electrification accounted for a small share of the donors' project portfolio in 2017 (15% of total).

Figure 26 Donor programmes by sub-sector

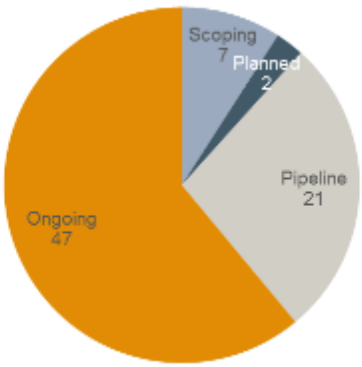


Source: ALER 2017

The ESWG members meet on a regular basis to exchange information about ongoing programmes and coordinate activities. The sub-working groups are also attended by Government institutions and state companies active in the energy sector. ESWG's joined initiatives have been limited and included the Sustainable Energy Joint Declaration and the Energy Africa Compact, both of which are briefly discussed below.

[66] ALER 2017. Renewables in Mozambique – National Status Report

Figure 27 ESWG's programmes by stage



Source: ALER 2017

A brief overview of the main donor programmes relevant to the off-grid market in Mozambique is presented in the sub-sections below.

ENDEV (GIZ)

The Energising Development (EnDev) programme managed by the German Agency for International Cooperation (GIZ) is the largest donor programme active in the off-grid electrification space. The programme was supposed to run from 2006 until 2016, but it has recently received a two-year extension to continue its operations until 2018.

Through technical assistance, market intelligence and financial support provided to private companies, EnDev encourages national private companies to invest in the supply of quality household solar products. EnDev is also assisting solar companies in establishing connections with producers and importers of quality solar products. The programme aims to supply 145,000 households with quality solar products.

By the end of 2017, the target was exceeded with more than 228,000 households, 9 social institutions and 51 small businesses, gaining access to electricity through off-grid solar systems.

The total budget of the EnDev programme is approximately $17 million, but apart from the off-grid solar component, a share of the budget is allocated to facilitate access to improved cookstoves.

BRILHO

BRILHO is part of ***'Energy Africa'*** – an initiative to remove regulator barriers to solar PV market expansion and improve donor cooperation in providing more effective support in 14 African countries to increase access to off-grid energy.

The programme includes the signing of ***compacts*** (agreements) between the governments and UKaid that outline the commitments of both parties in terms of improving the business environment for businesses involved in the provision of off-grid energy. The ultimate goal is to accelerate the expansion of the household solar market in Africa, helping bring universal energy access in the continent forward from the 2080 forecast that current trends indicate, to 2030.

BRILHO aims to implement the commitment that the UK has made as part of the Energy Africa campaign in Mozambique. The total cost of the programme is approximately £33 million and is expected to last from 2018 to 2024.

The programme's objective is to increase access to electricity through private sector participation and investment in off-grid energy solutions.

BRILHO has 4 complementary components[67]:

- **Market Development Fund (MDF) and Technical Assistance (TA):** Through a competitive tender, grants will be offered to start-ups supporting early market engagement. Working capital loans will also be provided to already established companies to allow them to expand. Financial support will be coupled by technical assistance, which will include market information sharing and matching the needs of businesses with local supply chain partners.

- **Demand Activation:** This component will include campaigns aimed at informing potential customers, primarily located in rural areas, regarding the benefits of modern energy solutions, as well as on the availability of mobile money and pay as you go (PAYG) mechanism.

- **Research and Dissemination:** Research will aim at filling the gaps in the literature regarding the successful and emerging business models for scaling-up the deployment of clean household energy products in Mozambique.

- **Policy Reform and Institutional Strengthening: As part of this component,** BRILHO will assist in the policy reform and will also provide capacity building to relevant stakeholders. Most of the support will be provided to the Energy Fund (FUNAE), since according to current plans residual BRILHO activities will be handed over to FUNAE following the completion of the programme.

Indicative Cooperation Programme (Belgian Technical Cooperation, BTC)

The Indicative Cooperation Programme (ICP), funded by the Belgian Technical Cooperation, was running from 2013 to 2017 and included two different programmes, namely the Renewable Energy for Rural Development, and the Institutional Strengthening and Capacity Development of the Ministry of Energy. The purpose of these interventions was to 'contribute to the economic productivity and social service delivery in rural Mozambique through the provision of access to sustainable, affordable and environment-friendly energy for the social integration of all population groups'[68].

As part of the first programme, BTC is currently working with FUNAE to support rural electrification efforts. With a total budget of around $15 million, BTC is investing in the development of new power projects, including mini-grids and solar water pumps, while also financing the rehabilitation of existing installations.

For the institutional strengthening component of the programme, BTC is working together with FUNAE to implement reforms that would create a policy environment that is more conducive to private sector participation for the provision of electricity in rural areas. For

[67] DFID 2017. BRILHO Business case.
[68] BTC Website.

this aspect of the project, BTC is cooperating with other donor agencies, such as DFID, in order to ensure coordination of actions.

The interventions mostly focus on strengthening the performance of the Ministry of Energy (MIREME) and the newly established regulator, the Conselho Nacional de Electricidade (CNELEC). The total budget for this programme is around $4.5 million. The specific objective of this initiative is to improve the performance of MIREME and CNELEC in advancing access to renewable electricity in rural areas[69].

Renewable Energy and Adaptation to Climate Technologies (REACT) Challenge Fund (AECF)

The Challenge Fund is a DFID funded initiative spanning from 2010 to 2021 with the purpose of catalysing private sector investment and innovation which increases access to low cost, clean energy for rural businesses and households, and/or provides products and services that help rural people and farmers adapt to climate change.

The Fund provides financial support to innovative household solar businesses in Africa (including Mozambique) with the purpose of accelerating access to affordable electricity in rural and peri-urban areas through off-grid and solar home systems.

Joint Declaration (JD) on Sustainable Energy

The Mozambique EU Delegation together with ESWG are promoting the signature of a Joint Declaration (JD) on Sustainable Energy with the Government of Mozambique.

The objective of this JD is to promote greater access to sustainable energy, increase the generation of electricity through renewable energy and improve energy efficiency.

So far, the JD has been signed by 14 EU member states with the Government taking an active role in prioritising the regulatory and policy reforms that are necessary in order to promote greater access to clean energy technologies, as well as regional cooperation within the SADC.

Policy Environment for Economic Development (SPEED+), USAID

The Supporting the Policy Environment for Economic Development (SPEED+) programme is a USAID funded initiative that was established in order to further develop a favourable business environment to attract private sector investment in the country, with the purpose of promoting inclusive economic growth and the conservation of natural resources. Specific objectives of the programme include reducing the cost of doing business, enhancing Mozambique's competitiveness, creating local opportunities for job and income growth and improving the business environment in trade and investment[70].

[69] BTC 2017
[70] USAID Website

Sustainable Economic Development, KfW

The government, with funds from KfW, under the Sustainable Economic Development project, established a credit line of $16.7 million in 2014, offering working capital loans to small and medium sized enterprises operating in the off-grid solar market.

Energy and Environment Partnership initiative (Finnish Government)

In 2013, the Finnish Government established the Energy and Environment Partnership initiative, which provided funding to FUNAE for the distribution of 920 pico solar system kits in Manica Province. Almost half of them were supplied to the settlement of Tsetsera in the Sussundenga district, while the remaining units were distributed in the District of Manica.

Beyond the above programmes, there is little activity in off-grid electrification. Smaller scale programmes exist, but they are mostly community based.

6 Barriers for market scale-up

A set of critical barriers for the development of the off-grid solar sector in Mozambique has been identified based on a consultation process, including interviews with private sector and development partners, discussions with various stakeholders and literature review. The main barriers facing off-grid solar in Mozambique can be classified into the following key categories:

6.1 Institutional and regulatory barriers

Despite the government's interest in involving the private sector to ensure access to electricity in rural areas, the operating and business environment in Mozambique is not yet conducive to the growth of the off-grid solar industry. One major obstacle to the development of the sector is the low level of government coordination with regards to energy policies, and the lack of coordination amongst donors, and with the government.

The absence of a shared vision and poor coordination between the key sector institutions constrains the development of a resilient market system. Government action is driven by different and often conflicting policy objectives, such as increasing connections, ensuring tariff affordability, securing revenues from VAT and import duties, and protecting local manufacturing. Moreover, although various national policies and strategies (listed in Section 5) reflect the government's commitment to achieving universal access to electricity, little emphasis is placed on the off-grid sector. Hence, the lack of clarity on the institutional and regulatory landscape for off-grid electrification creates uncertainty over what the priorities are for the sector development, increasing the perceived risk of investment.

In addition, policy-makers do not have the necessary technical knowledge of solar technologies to devise suitable policy actions tailored to different technology types, adding further constraints to the development of the sector.

6.2 Lack of quality standards

The diffusion of high-quality products is hindered by the lack of certifications and national quality standards for solar equipment and appliances. Currently no mechanisms on financial/fiscal incentives for quality-verified products are in place, therefore providing incentives for the import or local deployment of inferior products. Although the solar market is still emerging in Mozambique, the influx of inferior quality equipment over time is likely to distort consumer views of solar products, adding further constraints to development of the solar market.

The solar PV panels produced by FUNAE have been subject to several quality issues, among others caused by the lack of a fully automated manufacturing line. The plant received TUV International Certification for its automated production in March 2017.

The solar laboratory established with GIZ assistance at the Universidade de Eduardo Mondlane (UEM) and the SHS testing facility at the Instituição Industrial de Maputo (IIM), provide a nucleus of people with the necessary skills. Local standards accreditation in

Mozambique should be based on adopting international standards (Lighting Global and IEC) but could also include other products. The objective would be to protect customers, discourage import of inferior materials, and prevent non-accredited products from accessing any future tax breaks which might be introduced. In addition, the adoption of standards in uniformity with other countries are increasingly favoured by solar companies operating internationally.

6.3 Access to financing

The biggest constraint for the development of the off-grid sector in Mozambique is the limited access to finance, affecting both the supply and demand sides of the market.

Supply side constraints

The following supply-side barriers significantly hinder the scale-up of the sector:

- **Access to local credit –** Although funding for the start-up of solar companies is often obtained from the international market, the lack of access to local credit for working capital represents a major barrier for local producers, since it prevents them from purchasing the required equipment and achieving economies of scale. The time gap between the upfront payment to suppliers and the posterior receipt of revenues from customers significantly impacts their cash flows and ability to regulate imports, which in turns negatively affects their financial sustainability. Wholesalers and distributors are also constrained in extending credit, expanding their distribution networks, or undertaking marketing activities to boost demand. These challenges are further aggravated by the impact of currency depreciation, which raises costs on the import of equipment and adds risk and uncertainty to the market.

- **Funding to SMEs –** Most solar companies are classified as small medium enterprises (SMEs), which lack the necessary funds and access to the flow of capital from the financial sector. This is largely due to the misalignment between financial institutions' internal strategies and small medium enterprises. Although the Bank of Mozambique (BoM) and KfW have attempted to overcome this barrier by establishing a credit line directly targeted at micro, small and medium enterprises (MSMEs) and renewable energy suppliers, it did not achieve significant results. This credit line was designed to provide access to free technical advice to banking institutions which failed to deliver credit based on the claims that projects were not bankable and additional capacity building was needed to successfully assess projects. Nevertheless, as shown by a recent study by the Financial Sector Deepening Moçambique, credit lines have not succeeded in increasing appetite for lending because the banking sector in Mozambique is not equipped to reach all market segments.

- **High bank interest rates –** In 2016, commercial rates increased by nearly 30% as Mozambique's central bank raised its rate by six percentage points. High interest rates and stringent collateral requirements pose serious constraints for small and medium local companies that cannot access international markets; in addition, large commercial banks are unwilling to lend to small microfinance and

community-based financial institutions, which are still beginning to develop. This also negatively impacts the flow of capital to lower-income segments.

Consumer financing

The lack of consumer finance severely limits the opportunity to reach remote areas and poorer segments of the market. The development of the off-grid solar industry in Mozambique is constrained by a number of serious consumer finance challenges:

- **PAYG system and asset financing** – A widely adopted solution to provide customer finance is PAYG, allowing consumers to spread over time the cost of buying off-grid products. Asset financing allows suppliers to assign different risk profiles to various customer bases. Nevertheless, these innovative mechanisms are not yet well established in Mozambique, since payments are typically made via mobile money, a technology not widely adopted in the country, and rely on the rapid expansion of mobile networks. Even though 58% of the population is using a mobile phone, mobile money is not yet widely adopted, due to the difficulty of reaching rural areas and obtaining the skills and investment required to generate high volumes of digital money at scale. However, the large capital costs and high population density required for mobile money usage to scale up make such an investment particularly challenging in Mozambique. An additional issue is the requirement that the distance between mobile payment agents and banks in practical terms cannot exceed 30 km. On the other hand, in countries like Kenya, where mobile money use spread quickly across the country, operators have been able to achieve a high volume of transactions that favour the expansion of mobile networks and the PAYG model.

- **Poor financial infrastructure** - Rural and peri-urban areas are poorly served by financial services for customers compared to more developed financial markets such as Kenya, where savings and credit cooperative organisations successfully reach lower-income segments.

6.4 Import duties and VAT constraints

One of the issues that stakeholders identify as a key barrier to the sector development is the high level of import duties and VAT, which increases the price to end-users, reducing the size of the market and therefore discouraging investment in the country. Currently, all renewable energy technologies are subject to 17% VAT and between 7.5% and 20% import duty, depending on type of component.

While Ethiopia, Ghana, Uganda, Tanzania and Zimbabwe have successfully applied tariff and VAT exemptions for solar products, the lack of specific fiscal incentives in Mozambique is one of the factors likely to make investment in other Sub-Saharan African countries more appealing. Although the Investments Law and Tax Benefit Code offer a number of tax incentives to attract investment in some sectors of the economy, specific provisions for investments in the off-grid solar market are missing.

A second obstacle related to this type of barrier is the lack of consistency in applying duties, largely due to the discretionary nature of the relevant provisions. In addition, the lack of

knowledge by custom officers opens opportunities for corruption, theft of products and other difficulties at the ports and other customs posts.

A recent DFID study[71], carried out by ECA, provided estimates of the economic benefits from removing import duties on solar products through lowered prices, increased sales and subsequent benefits to users through avoided alternative lighting products and phone charging costs. These benefits are scaled up through multiplier effects in job creation, productivity improvements and higher incomes.

6.5 Human capital and skills gap

The weak supply of skills in the market is perceived as a major obstacle to the sector development in Mozambique. The missing skills are mainly managerial competencies, business management, sales and marketing, logistics, and technical capabilities.

A major barrier for the diffusion of off-grid solar system is the lack of after-sales support, given its direct impact on costs, product performance and customers' willingness to pay. Uncertainty around after-sales repair or support services might discourage customers from purchasing a solar product. Ensuring efficient customer service and technical support is fundamental to maintain high quality and reliability in the market. Nevertheless, the tariff and VAT scheme in the country increases the cost of spare parts, while specialised technicians are often not present in rural areas. Moreover, tracking and monitoring the use and distribution of products becomes increasingly difficult without adequate after-sales support.

Companies face high search costs to recognise suitable employees without training certifications. While there are a few examples of private companies providing training programmes to their local staff in Mozambique, there are generally no incentives to employ and provide training for young workers, which in turn negatively affects youth employability and the ability to ensure innovation in the off-grid industry.

Furthermore, recently approved regulations for hiring foreign workers have substantially increased the costs of this procedure, discouraging the transfer of expertise and know-how at the technological and managerial level. These procedural constraints represent a serious barrier for scale-up of the off-grid sector, heavily reliant on maintaining a high level of skills for technological upgrade and business development.

6.6 Market knowledge and distribution barriers

Additional constraints on the off-grid sector in Mozambique are distribution and market knowledge barriers, explained below:

- **Distribution barriers** - The high level of distribution costs is due to the dispersion of the rural population and the large distances between the ports of

[71] DFID 2016, Technical Assistance to model and analyse the economic effects of VAT and tariffs on picoPV products, Solar Home Systems and Improved Cookstoves, available from: https://assets.publishing.service.gov.uk/media/58484315ed915d0aeb000052/Fiscal_Study_Final_Report_MB_Final.pdf

Nacala, Beira and Maputo and the interior regions, exacerbated by the adverse condition of the road network which substantially increases transportation and logistics costs. As an example, the cost of moving a container from Maputo to the northern region is estimated at approximately $10,000. These barriers add further constraints on companies struggling to establish and consolidate their presence in the market, preventing the development of economies of scale in distribution and customer-care.

- **Market knowledge barriers –** The uncertainty over government priority areas and technologies for development increase the costs of market scale-up. These barriers reflect the lack of national research and development studies and the difficulty in accessing market research results. The low number of studies that have been conducted also contributes to creating doubts and uncertainty over customers' willingness to pay and purchasing power, leading to inefficiencies in the off-grid sector.

6.7 Weak demand

The expansion of the solar off-grid sector is targeted at lower-income segments of the population, where ability and willingness to pay are weak. A number of factors substantially reduce the margins for competitively priced products, particularly in rural areas:

- Low levels of literacy and market awareness prevent customers from valuing the benefits of quality-verified off-grid products and Mobile Payment methods, which are not well established in the country;
- Anticipating the extension of the grid, customers have lost confidence in the advantages brought by off-grid solar systems, aggravated by the lack of information and knowledge of this technology;
- The large distances between the main provincial capitals and the interior areas, exacerbated by the poor condition of the road networks, increase logistics and distribution costs, raising costs for end-users;
- Cheap, low-quality products are widely used in the market, limiting the potential for more expensive certified products of higher quality.

7 Options for intervention

The analysis in the previous section highlights that scaling up the market for off-grid solar products is currently hindered by a number of barriers.

This section proposes general actions to overcome the market barriers and increase the penetration of off-grid solar products in Mozambique. The proposed interventions are based on the information received from key stakeholders, including the government agencies involved in the market, donors and private companies.

7.1 Institutional and regulatory framework

Shared policy vision

Policy inconsistencies that increase investment risks can be reduced by providing greater clarity on policy direction and agreeing on a shared vision for the private sector's role in increasing access to electrification in rural areas. This can be achieved by ensuring dialogue and exchange of market information between the key stakeholders. The policy vision should encourage market operators to gradually develop the market, starting from segments with higher ability and willingness to pay and lower operational costs to develop the required market competencies, which can then be applied to reach the rural areas. In addition, greater support to the private sector is likely to increase investors' interest in the Mozambican off-grid market, with positive results in terms of innovation and competitiveness.

Greater stakeholder coordination

Establishing an open dialogue with the private sector is a crucial step to ensure coordination between different actors. Government and donors should agree on a national approach to target the lower-income segments of the market and strengthen national institutions. Communication between the government, donors, and NGOs is also fundamental to reduce uncertainty and encourage investor confidence.

Greater stakeholder coordination can be achieved through the organisation of quarterly meetings where government agencies, donors, and the private companies active in the off-grid space meet to discuss market barriers, possible interventions to overcome them, and set targets for the near future.

7.2 Quality standards

Given the impact of product quality on demand creation and willingness to pay for a new product, it is important to ensure that solar companies are supported in providing quality products and adequate services to their customers. Hence, minimum industry quality standards should be adopted in the solar off-grid sector through quality verification systems, building quality awareness and supporting the National Inspectorate for Economic Activities (INAE) to identify inferior products.

Warranty requirements of minimum two years should also be made compulsory to exclude sub-standard materials from the market and encourage solar companies to build stronger customer relations. Moreover, introducing import duty exemptions for products meeting Lighting Global Quality Standards is important to guarantee quality and prevent the import and deployment of inferior equipment.

Producers should be assisted in meeting quality requirements through the implementation of tailored capacity building. Resources should also be directed towards setting up labs and testing procedures. With support from AMES-M, a solar testing laboratory was developed at the Faculty of Science of the Eduardo Mondlane University (Universidade Eduardo Mondlane - UEM). This lab is used for testing solar lanterns, batteries and PV modules. There is also another laboratory, IMM (Instituição Industrial de Maputo), for testing SHSs. However, these institutions have insufficient capacity to establish a recognised quality standard system in the country. It is therefore recommended to strengthen their outreach and enhance their potential to serve the Mozambican market.

7.3 Access to finance

Access to finance is one of the main barriers to the sector development in Mozambique. Nevertheless, potential demand can be unlocked by introducing innovative financing opportunities for SMEs. A key policy recommendation to enhance access to financing and allow solar companies to expand their operations to rural areas is Results Based Financing (RBF). This financing mechanism is discussed below, together with options for enhancing consumer access to financing.

7.3.1 RBF Financing

While grant financing for start-ups will become available through the Market Development Fund (MDF) under the BRIHLO programme, funded by DFID (section 5.5), there is generally a lack of financing for already established solar companies to help them expand to rural areas. The development of a potential fund to support solar businesses operating in non-financially attractive areas is a topic where the World Bank could add value.

A Results-Based Financing (RBF) scheme is a fund or programme that links the pay-out of financial support to pre-determined results, where payment is only made upon verification that the agreed upon results have actually been delivered[72].

In an RBF scheme a 'principal' (e.g. an international development institution) takes the initiative to design, fund (and source funds), launch, and implement the RBF Fund. An 'agent' (a firm or agency) is contracted (by the principal) to deliver certain results against payment of an incentive (RBF grant). The results are defined precisely for each RBF scheme; they are generally goods and/or services which have the characteristics of a 'public good' that the market is constrained or unwilling to provide without a financial incentive. In the case of the off-grid solar sector, the grant should be targeted to companies operating in rural areas that would otherwise not be served by private companies.

The results need to be readily measurable (quantifiable) and verifiable. The financial risk of not achieving the results is shifted from the principal and the funders of the scheme to the

[72] World Bank: Results-Based Financing for Health (2013).

agent (the recipient of the grant funds). In return, the agent has autonomy in choosing the method to deliver the results.

The RBF instrument is seen as a cost-effective use of development funds, a way to encourage innovation, and to increase the agent's ownership of the scheme.[73] In contrast to conventional grants, RBF finance is disbursed against results actually achieved and independently verified.

Box 1 Using RBF to ensure off-grid solar products reach low income rural communities

- Off-grid solar products are unaffordable for a large proportion of the rural population. For suppliers, rural communities are expensive to serve while offering limited market opportunities.
- Off-grid solar products therefore face a 'viability gap' in the rural areas between what they need to generate in revenue to be sustainable and what their rural consumers are able to pay.
- Results-based financing (RBF) for off-grid solar products delivered to remote rural communities would provide ex-post grants to solar companies for each new installation, reducing the viability gap, thereby enabling provision of power to rural households at an affordable fee level.

Lessons learned from the application of RBF funds

While the RBF approach is broadly attractive, not all of the RBF schemes that have been designed and implemented in Africa are viewed particularly favourably, largely because they have not disbursed funds as efficiently as hoped or predicted, despite evidence of willing and able recipients. Therefore, it is critical to determine what factors have caused these facilities to succeed (or not) and learn from them in our RBF design. In particular, it is crucial to identify whether the causes of problems (perceived or actual) are endogenous (part of the fund design and implementation), or exogenous (related to the market and regulatory environment).

Our analysis has focused principally on the experiences of the Energising Development (EnDev) programme, a partnership between the Netherlands, Germany, Norway, the UK, Switzerland, and Sweden. Part of EnDev's work uses an RBF approach to promote sustainable energy access in 25 countries, including Mozambique, amongst countries in Africa. EnDev has conducted a comprehensive analysis of the strengths and weaknesses of its RBF efforts. Table 20 presents lessons, and their application to the design of the RBF Fund.

Table 20 Summary of lessons learned from other RBF facilities

[73] Results-Based Climate Finance in Practice: Delivering Climate Finance for Low-Carbon Development, section 2.1.1, WB/Frankfurt School-UNEP Collaborating Centre, 2017.

Lesson	Application to the Mozambique market
The objective of the grant facility should be very clear. A key question is to determine if the intervention is likely to be temporary/catalytic, or permanent	We believe that the need for rural electrification subsidies will not disappear in the near future, because of both economic and political pressures on rural populations and governments. As technology costs continue to fall, and other factors change, this requirement may change. Any RBF facility should carefully target the eligibility of the grant financing to ensure that only companies operating in rural areas receive financing.
Keep the approach as simple and narrowly defined as possible	A narrowly defined approach will minimize transaction costs in fund design and implementation. While meeting the needs of a range of solar companies can spur market development, trying to accommodate multiple objectives, and widening the pool of potential recipients, risks delaying the RBF, or preventing it from disbursing altogether. An initial Pilot phase, with a narrow approach, and the objective to prove the RBF Fund's concept will allow private companies to realize the potential of the sector.
Due diligence is one of the major transaction costs that should be minimized (within acceptable limits) for efficient fund disbursal	A degree of due diligence is necessary to give confidence to the Administrator that funds allocated to a particular project should be disbursed. However, as no funds are disbursed unless installations are verified (at least in the Pilot phase), the risk of poor funding decisions from inadequate due diligence is low.
Payments are based on results, and easy to verify	Attaching payments to multiple milestones and/or milestones that are difficult to verify adds complexity which may lead to further transaction costs and delays in disbursement. We propose a simple verification and payment process that will minimize these costs and increase alignment with the primary objective. Payments will only be made on the verification of live and active connections.
Disburse RBF upon completion	In order to fulfill the primary objective the RBF can only be disbursed once investments have been made. This requires recipients to source their own finance for the initial capital expenditure outlay.
Make the application process as simple as possible	We propose striking a balance between seeking critical information, and encouraging applications from applicants with limited capacity. With the primary objective to facilitate connections, the RBF Fund's priority will be to support those developers that already possess adequate capacity to handle the required application procedures.

Source: EnDev, ECA analysis

7.3.2 Consumer financing

The lack of consumer financing, similarly, can be addressed by a number of policy actions, including:

- ❑ Raising awareness of mobile payment mechanisms and their benefits for end-users and creating an enabling environment for the widespread distribution of mobile networks;

- Improving collaboration between financial institutions and PAYG partners to increase PAYG availability in the country;
- Developing tailored training programmes, financial education, and customer protection schemes;
- Extending financial services to customers in rural and peri-urban areas through savings and credit cooperative organisations.

7.4 Import duties and VAT exemptions

As discussed in the previous section, the existing legislation does not provide specific incentives for the solar off-grid sector development, creating uncertainty in the market. Hence, the government could develop specific provisions to reduce or exempt VAT and import duties on solar products, with eligibility criteria based on meeting quality standards. Such provisions would decrease prices for end-users, boost demand and stimulate the development of the private sector.

A recent DFID study undertaken by ECA, as mentioned above, on the impacts of tax exemptions in Mozambique concluded that several economic benefits are likely to result from removing import duties on solar products, including lower prices, higher sales and additional benefits reflecting the avoided lighting and phone charging costs of alternative products and positive spill over effects on employment and productivity.

In addition to reducing duties and VAT, consistency should be ensured by consolidating the categories under which different components are classified. As lack of clarity brings the risk of creating confusion and opening opportunities for corruption and theft of products, tax exemptions or reductions should follow a standardised procedure to avoid ambiguity across different product categories.

7.5 Upgrading skills

Skills shortage is a major obstacle to the sector development in Mozambique. Given the dynamic nature of the industry, technologies are constantly changing, and technical skills often need to be imported from other countries. Hence, two major policy actions are recommended to overcome this barrier:

- **Education and training** – Cooperation between educational institutes and the private sector should be strengthened to bridge the skills mismatch and reduce the search costs to hire qualified personnel. Vocational training facilities should be created to improve technical skills and encourage entrepreneurship in the sector and provide capacity building for installation, repair and maintenance services. Moreover, incentives should be introduced to encourage the private sector to train staff and increase youth employment.
- **Relax immigration requirements** – given the critical role of transferring sector expertise and know-how at the technological and managerial level, the procedure for hiring foreign workers should be relaxed for the off-grid solar

industry. Reducing operational costs will facilitate investment in skills upgrading and enable the development of local capacity.

7.6 Market knowledge and distribution channels

Improving market knowledge

Given the role of market knowledge for the development of the sector, a market information portal collecting public studies on the industry, licensing requirements, and relevant legislation should be created to coordinate market penetration with broader development objectives. Conducting willingness to pay studies in strategic locations such as priority areas and off-grid sites, and enabling market knowledge-sharing, would play an important role in the expansion of the sector.

Find innovative distribution channels to overcome high logistics costs

Attention should also be directed towards customer-care and distribution networks, enabling companies to consolidate their presence in the market. One possibility to overcome the distribution barrier, exacerbated by the dispersion of the population and poor condition of the road networks, is the increasing potential for **post offices** to cooperate in distributing products and achieving economies of scale.

In addition, bus operators, couriers and large companies including beverage transporters such as Coca Cola, could play a key role in decreasing logistics costs and ensuring a more efficient last mile distribution process. Improving coordination between actors and channels will also contribute to expanding distribution and access deeper into rural areas.

Finally, other measures to overcome distribution barriers include:

- ❑ Reducing corruption throughout the logistics value chain;
- ❑ Implementing cost sharing initiatives with trucking companies to transport solar equipment;
- ❑ Encouraging large companies to provide transport and other support services for solar off-grid as part of corporate social responsibility (CSR) activities;
- ❑ Providing financial assistance from public and donor funding to cover parts of the high logistics costs of reaching rural areas.

7.7 Sustaining demand

In order to sustain demand and encourage the development of the market, various policy actions can be implemented by the government of Mozambique.

Firstly, raising market awareness through public campaigns on the benefits of off-grid products and Mobile Payment methods is a key priority to overcome the lack of information and knowledge of this technology. Spending public resources to support demand is also

expected to generate positive externalities deriving from increased adoption and use of off-grid products.

The weak ability and willingness to pay for off-grid products are the major obstacles to the sector development in rural areas. Hence, enhancing distribution networks is likely to significantly decrease costs for end-users by reducing logistics and transportation costs.

Finally, given the wide use of cheap and low-quality products in the market, introducing minimum quality standards and certification systems will prevent the deployment and import of inferior products. In addition, as mentioned above, import duty exemptions for certified equipment play a crucial role in guaranteeing quality products and adequate services for customers, with positive effects for the sector development.

The main market barriers to the off-grid market scale-up in Mozambique and the policy actions recommended to overcome those barriers are summarised in the following table.

Table 21 Market barriers and recommended policy actions

Market barriers	Recommended policy actions
Institutional and regulatory	
➢ Low level of governmental coordination with regards to energy policy ➢ Lack of coordination amongst donors and with the government ➢ Absence of a shared vision and conflicting policy objectives ➢ Limited emphasis on off-grid electrification in national policies ➢ Lack of clarity on institutional and regulatory landscape ➢ Limited knowledge of solar technologies	➢ Providing consistency and clarity on policy direction by agreeing on a shared vision ➢ Ensuring dialogue and exchange of market information ➢ Establishing greater stakeholder coordination and support to the private sector ➢ Improving technical capacity of policy makers ➢ Ensuring efficient prioritization of development programs
Quality standards	
➢ Lack of certifications and national quality standards for solar equipment and appliances ➢ No fiscal/financial incentives for quality-verified products ➢ Insufficient local capacity with respect to testing and certification services	➢ Minimum industry quality standards through quality certification systems and support to INAE to identify inferior products ➢ Import duty exemptions for products meeting Lighting Global Quality Standards ➢ Assistance to IIM and UEM labs to set up testing procedures

Market barriers	Recommended policy actions
Access to financing	
➢ Lack of access to local credit ➢ Constraints in extending credit, expanding distribution networks, undertaking marketing activities and achieving economies of scale ➢ Currency depreciation and fluctuations in exchange rates ➢ Misalignment of strategies between financial institutions and SMEs ➢ Lack of funds for SMEs and limited access to financing ➢ High bank interest rates and stringent collateral requirements ➢ Weak mobile money penetration ➢ High prices of technologies and lack of financing services for customers ➢ Poor financial infrastructure	➢ Introducing innovative financing mechanisms such as RBF ➢ Developing pilot projects to demonstrate commercial viability ➢ Establishing dedicated funds and credit lines for off-grid solar companies and investors ➢ Raising awareness of mobile payment mechanisms and their benefits ➢ Increase PAYG availability by improving collaboration with PAYG partners ➢ Developing training programmes, financial education and customer protection schemes ➢ Extending financial services to rural areas through credit cooperative organizations
Import duties and VAT	
➢ High level of import duties and VAT, increasing price to end-users and discouraging investment ➢ Lack of specific fiscal incentives in the off-grid sector ➢ Inconsistency in applying duties ➢ Limited knowledge by custom officers ➢ Opportunities for corruption and theft of products	➢ Developing specific provisions to reduce or exempt VAT and import duties on solar products ➢ Applying eligibility criteria based on meeting quality standards ➢ Ensuring consistency by consolidating product categories and following an standardized procedure
Human capital	
➢ Weak supply of managerial, business management, sales and marketing, logistics and technical skills ➢ Lack of after-sale support and specialized technicians ➢ High search costs for suitable employees ➢ Lack of incentives to employ and provide training for young workers ➢ Procedural constraints for hiring foreign workers	➢ Ensuring cooperation between education institutes and private sector to reduce search costs ➢ Creating vocational training facilities ➢ Providing capacity building for installation, repair and maintenance services ➢ Introducing incentives for private sector to train staff and increase youth employment ➢ Relaxing immigration requirements and procedures for hiring foreign workers
Market knowledge	
➢ Uncertainty over government priority areas and technologies ➢ Lack of national research and development studies ➢ Difficulty in accessing market research results	➢ Creating a market information portal collecting public studies, licensing requirements, and relevant legislation ➢ Conducting willingness to pay studies in strategic locations such as off-grid sites and priority areas ➢ Strengthening national research and development systems

Market barriers	Recommended policy actions
Distribution channels	
➢ High distribution and logistics costs ➢ Dispersion of rural population ➢ Large distances between main provinces and interior region ➢ Adverse condition of road networks ➢ Inability to achieve economies of scale	➢ Supporting companies in consolidating their presence in the market and achieving economies of scale ➢ Exploiting the potential of post offices, bus operators, couriers, and beverage transporters to cooperate in distributing products ➢ Reducing corruption in the logistics value chain ➢ Providing financial assistance to cover parts of the logistics costs to reach rural areas
Sustaining demand	
➢ Low levels of literacy and market awareness ➢ Consumer confidence loss ➢ Wide adoption and use of cheap and low-quality products ➢ Private sector focus on donor-funded programmes rather than sector development	➢ Raising market awareness through public campaigns on benefits of off-grid products and mobile payment methods ➢ Enhancing distribution networks ➢ Introducing minimum quality standards and import duty exemptions for certified equipment

ANNEXES

A1 List of Informal Markets per Province

Province	Market
Maputo	Mercado Baixa
	Mercado Estela Vermelha
	Mercado Benfica
	Mercado Xiquelene
	Mercado Compone
	Mercado Magoanine
	Mercado Mucoreane
	Mercado Carimbo
	Mercado Laulane
	Mercado Adelina
	Mercado Junta
	Mercado Nwancacana;
	Mercado Baixa
	Mercado Xipamanini
Gaza	Mercado de Chibuto
	Mercado Esquema
	Mercado Limpopo
	Mercado Senta-baixo
	Mercado Mutxope
	Mercado Andane
Inhambane	Mercado Mafureira
	Mercado Maxixe
Manica	Mercado Francisco Manyanga
	Mercado Feira
	Mercado Mota
Sofala	Mercado Maquinino
	Mercado Goto
	Mercado Munhava
	Mercado Matope
	Mercado Xipangara
Tete	Mercado Kwachena Nhartanda
	Mercado OUA
	Mercado Cabinde
	Mercado Canongola

Province	Market
Zambezia	Mercado Aquima
	Mercado do Lixo
	Mercado Xabeco
	Mercado FAI
	Mercado Sococo
	Mercado Brandão
	Mercado Maningue
	Mercado Iciddua
	Mercado Namuinho
	Mercado Santagua
Nampula	Mercado Bombeiros
	Mercado Belenenses
	Mercado Aresta
	Mercado Cavalaria
	Mercado CFM
	Mercado Faina
	Mercado Matadouro
	Mercado Memória
	Mercado Poetas
	Mercado Muahivire
Niassa	Mercado da Canjala
	Mercado Marrupa
Cabo Delgado	Mercado de Montepuez
	Mercado das Batatas
	Mercado do Bangueia
	Mercado de Mbanguia
	Mercado Natite

A2 Results from supply assessment in informal markets

Manica informal market vendors

Questions asked:	Vendor 1	Vendor 2	Vendor 3	Vendor 4
1. Location and years of selling solar system components	Mercado Feira – 1 year selling solar products	Mercado Feira – 2 years selling solar products	Mercado Feira – 4 years selling solar products.	Mercado 38 – 1 year selling solar products.
2. Types of systems sold and price	- Solar radio with lantern and phone charge (Yuegan brand) = 900 MZN - Small solar lantern (BY brand) = 180 MZN - Larger solar lantern with phone charge (BY brand) = 350 MZN	- 40 WP solar panel (Solar Africa brand) = 3.000 MZN - SHS with one light and phone charger = 2.500MZN	- Solar panel (Sunshine Solar brand): 5W=500MZN; 10W=700MZN; 15W=1.000MZN; 20W=1.200MZN; 25W=1.400MZN; 30W=1.600MAN; 40W=2.500MZN; 50W=3.200MZN; 60W=3.800MZN; Battery 12v7.2Ah (Yuasa brand) = 800MZN Battery 12v7.2Ah (CSB Vietnam brand) = 700MZN Battery 12v9Ah (Portalac-Taiwan brand) =1.000MZN Inverter 300Wmax (Solar Africa brand) = 900 MZN Inverter-large (Solar Africa brand) = 1.800 MZN Solar phone charger adaptor for battery = 200 MZN	- 15 Wp Solar panel (Solar Module brand – China) = 900 MZN- 20 Wp Solar panel (Sunshine Solar brand – China) = 1.400 MZN -Battery 12v 7.2Ah (CSB brand) = 700 MZN -Battery 12v 17 Ah (CSB brand) = 1.500 MZN -Battery 12v 26Ah (CSB brand) = 1.800 MZN

Questions asked:	Vendor 1	Vendor 2	Vendor 3	Vendor 4
			Solar light = 250 MZN	
3. Source of systems (where imported / bought from)	Systems are imported from China through intermediaries. An importer (Chinese origin) in Beira receives an order via WhatsApp group and receives payment directly or via transfer to order systems from China.	Systems are bought at wholesale in Beira city from Chinese shop. Other solar systems bought through importer from South Africa, who brings by car to a collection point in Muchungue. Orders are arranged via phone and payment of 50% is given upfront. A 20% margin is made on sale.	In the past systems were bought in from South Africa, however with the exchange rate being unfavourable a new option is from Chinese importers. In 2017 a Chinese importer approached the vendor at the market and offered a range of solar products which could be imported from China. The vendor now collects these systems at a warehouse in Beira when stock arrives. The batteries continue to come from South Africa through an importer that brings them by truck. Schedule and orders are through WhatsApp.	Buys directly at shops in Beira or South Africa to resell in market. Transports via bus and public transport.
4. Number of systems sold on a monthly basis	- Up to 6 solar radios sold per month - up to 15 solar lanterns sold per month	One system sold per month.	- On average 10 panels sold per month (15Wp being most popular); - 10 batteries sold per month (7.5 Ah CSB brand being most popular); -2 or 3 inverters sold per month	- 10 solar panel per month -10 inverters -20 small batteries -8 large batteries

Questions asked:	Vendor 1	Vendor 2	Vendor 3	Vendor 4
5. Support offered to customer (guarantees, maintenance, installations, credit etc.)	No support or guarantee offered. If system works in the shop, it is the responsibility of the client and not the shop.	No guarantee offered to client. Just an explanation as to how to use the system.	-A basic explanation is given to buyers on how the solar systems work upon purchase. No installation support offered. - A money-back guarantee is offered only for batteries bought at a 60% cost.	- 7 day exchange guarantee if component not working. - No other support offered
6. Profile of customer	People from rural areas or areas where electricity is not available buy these systems.	People from rural areas buy to later resell in the rural areas.	In the past traders from rural areas would come buy from market to re-sell in villages. Now these traders have their own supply network with importers. Sales have dropped a lot because of that. Now most customers are people from neighbourhoods in the cities where the grid has no coverage.	People prefer to buy individual solar system components and build their own kit. Most customers are people from the rural areas.

Maputo informal vendors

Questions asked:	Vendor 1	Vendor 2	Vendor 3	Vendor 4
1. Location and years of selling solar system components	Xipamanini Market – 6 years selling solar products	Xipamanini Market – 12 years selling solar products	Xipamanini Market – 10 years selling solar products	Xipamanini Market – 5 years selling solar batteries
2. Types of systems sold and price	- Solar panel (Sunshine Solar brand):5W=700MZN; 10W=1000MZN; 15W=1.200MZN; 20W=1.700MZN; 25W=1.900MZN; 30W=2.500MZN; 40W=2.900MZN; 50W=3.500MZN; 100W=7.000MZN; - Solar Panel (Juta – South African): 10W=1.500MZN20W=2.500MZN50WP=5.000MZN Inverter (130 Wmax) = 1.000 MZN	- Solar panel (Sunshine Solar brand):5W=700MZN; 10W=1.200MZN; 30W=2.500MZN;35W=3.000MZN 40W=3.300MZN; 60W=3.800MZN; Battery 9Ah = 550MZN Inverter (150Wmax)=1.500 MZN Inverter (180WMax) = 1.800 MZN	- Solar panel (Severalbrands): 25W=1.000MZN; 50W=2.000MZN; 80W=4.000MZN;100W=6.000MZN 180W=7.500MZN; -Inverter (small) = 800MZN – Inverter (large)=1.800MZN	- Battery 7.2Ah (Rita brand) = 450 MZN-Battery 7.2Ah (Sensys brand) = 450 MZN - Battery7.2Ah (Eco brand) = 450 MZN - Battery 45Ah (Osaka brand) = 1.500 MZN - Battery 45 Ah (Voltron brand) = 1.500 MZN
3. Source of systems (where imported /	The Chinese systems are bought in a Chinese shop located in downtown Maputo (Osaka shop).	All products bought at Chinese shop in downtown Maputo (Baixa)	Purchases from a shop in Johannesburg – South Africa and brings to Mozambique using public transport.	The small 7.2Ah batteries are bought at a shop in

Questions asked:	Vendor 1	Vendor 2	Vendor 3	Vendor 4
bought from)	The South African systems are bought from a shop in Johannesburg and brought in by public bus (no import taxes/vat paid)			Johannesburg – South Africa. The larger 45Ah batteries bought at the Voltron shop in downtown Maputo.
4. Number of systems sold on a monthly basis	Around 10 systems per month	Sales have decreased in past years. Up to 4 systems sold per month.	Sales have reduced and now can sell up to 3 systems per month, as before it was around 10 systems. The 25Wp panel is most popular.	20 batteries a month (mostly small)
5. Support offered to customer (guarantees, maintenance, installations, credit etc.)	No guarantees or other support offered to customers.	30 days guarantee is offered for solar panel and battery.	The vendor gives a 5 months guarantee for the panel which corresponds to the guarantee given by the shop in South Africa. Defective panels taken back to South Africa for exchange.	The vendor gives a 6 months exchange guarantee for the batteries. The shop in South Africa gives 1 year guarantee.
6. Profile of customer	People from rural areas come to buy the systems. Also people who do not know the Chinese shops in town.	People who live in off-grid areas come to buy. The number of people has reduced substantially over the past couple of years.	Mostly people from rural areas come to buy but this number has reduced.	The clients like the quality of the batteries sold at this vendor and most clients

Questions asked:	Vendor 1	Vendor 2	Vendor 3	Vendor 4
				come from rural areas.

A3 Household Survey

Household Energy Use Questionnaire

INTERNAL INTRO	
Interviewer *Use codes	○ 001 ○ 002 ○ 003 ○ 004 ○ 005 ○ 006
Province	○ Maputo ○ Manica ○ Zambézia
District *Use codes	○ 1 Chimoio ○ 2 Gondola ○ 3 Maputo ○ 4 Manhiça ○ 5 Quelimane ○ 6 Maquival

City/Village *Use codes	○ 1 ○ 2 ○ 3 ○ 4
Neighbourhood	

SECTION I: GENERAL INFORMATION QUESTIONS	
1. Name of Interviewee:	
2. Gender **Pick one*	○ Male ○ Female
3. Position in household **Pick one*	○ Head of household ○ Husband/ wife ○ Son/ Daughter ○ Other relative ○ Other (specify) _____
4. Age *(*pick from 14-80):*	
5. What is the highest schooling level achieved in this household? **Pick one*	○ Did not attend school ○ Primary School ○ Secondary School ○ University ○ Technical School ○ Prefer not to say/ no answer ○ Other (specify)_____
6. How many people live in this house? *max 30	

7. How many infrastructures/rooms does this house/plot have?	
8. Does the head of the family have another house? **Pick one*	○ Yes ○ No ○ Do not know/ Prefer not to say/ No answer
9. What material is the house made of? **Please pick one*	○ "*Pau-a-pique*" (Wattle and daub) ○ Cement Brick ○ Clay Bricks ○ Kiln-fired Clay Bricks ○ Reed/Grass/Bamboo ○ Other (specify) _____
SECTION II: ENERGY USE QUESTIONS	
10. Is there electricity in your house (even if it's with a generator, solar, or other)? **Pick one*	○ Yes ○ No ○ Do not know/ No answer
11. *(If yes or do not know/no answer)* **What is the household's main source of electricity?** **Pick one*	○ EDM/ Electricity ○ Diesel Generator ○ Petrol Generator ○ Car Battery ○ Solar Energy (Panels) ○ Wind Energy ○ Other (specify) _____
12. *(if EDM)* **Do you pay for your electricity monthly or do you buy Credillec?**	○ Monthly ○ Credillec
13. *(if EDM Monthly)* **How much do you pay for electricity monthly?**	
14. *(if EDM Credillec)* **How often do you buy Credillec?**	○ Every day ○ Many times a week ○ Once a week ○ Twice a month (every 2 weeks) ○ Once a month

	○ Never ○ Other (specify)_____
15. *(if EDM Credillec)* **How much do you spend on Credillec every time you go buy?**	
16. *(if EDM)* **Are you satisfied with the services provided by EDM?** **Pick one*	○ Yes ○ No ○ Do not know ○ Prefer not to say/ No answer
17. *(if EDM not satisfied with service)* **Why are you not satisfied with the service?** **Pick multiple*	○ It is expensive ○ Customer services are not satisfactory ○ It makes equipment malfunction/ break ○ The quality of electricity is low/ fluctuates ○ There are frequent power cuts
18. *(if EDM)* **Within a month, how frequent are the power cuts?**	○ Once a month ○ Twice a month ○ 3 times a month ○ 4 times a month ○ 5 or more times a month ○ It is rare
19. *(if EDM power cuts)* **When there are power cuts, how long do these last?** **pick one*	○ Minutes ○ Hours ○ Days ○ Months
20. *(if Diesel Generator)* **How often do you buy Diesel for your generator?** **Pick one*	○ Every day ○ Many times a week ○ Once a week ○ Twice a month (every 2 weeks) ○ Once a month ○ Never ○ Other (specify)_____
21. *(if Diesel Generator)* **How much do you spend to buy Diesel every time you go buy?**	

22. *(if Diesel Generator)* **How many litres of Diesel do you buy every time you go buy?**
23. *(if Diesel Generator)* **How much do you spend on Diesel monthly?**
24. *(if Diesel Generator)* **What is the current price for a litre of Diesel?**
25. *(if Diesel Generator)* **Where do you buy Diesel for your generator?**
    **Pick one*
    - o Local Market
    - o Market in another locality
    - o A private store owner in this village
    - o A private store owner in another village
    - o At a petrol station
    - o Other (specify)_____
26. *(if Diesel Generator)* **How far from your house is the place where you buy Diesel (one way walking)?**
    - o Below 10 minutes
    - o 11 to 30 minutes
    - o 31 minutes to 1 hour
    - o 1 to 2 hours
    - o Less than 2 hours
    - o Less than 3 hours
    - o Less than 4 hours
    - o Less than 5 hours
    - o More than 5 hours
27. *(if Petrol Generator)* **How often do you buy Petrol for your generator?**
    **Pick one*
    - o Every day
    - o Many times a week
    - o Once a week
    - o Twice a month (every 2 weeks)
    - o Once a month
    - o Never
    - o Other (specify)_____
28. *(if Petrol Generator)* **How much do you spend to buy Petrol every time you go buy?**
29. *(if Petrol Generator)* **How many litres of Petrol do you buy every time you go buy?**

30. *(if Petrol Generator)* **How much do you spend on Petrol monthly?**	
31. *(if Petrol Generator)* **What is the current price for a litre of Diesel?**	
32. *(if Petrol Generator)* **Where do you buy Petrol for your generator?** **Pick one*	o Local Market o Market in another locality o A private store owner in this village o A private store owner in another village o At a petrol station o Other (specify)_____
33. *(if Petrol Generator)* **How far from your house is the place where you buy Petrol (one-way walking)?**	o Below 10 minutes o 11 to 30 minutes o 31 minutes to 1 hour o 1 to 2 hours o Less than 2 hours o Less than 3 hours o Less than 4 hours o Less than 5 hours o More than 5 hours
34. *(if Solar Energy)* **What type of solar system do you have in your house?** **pick one*	o Large photovoltaic panel with battery o Small panel with lantern/light without phone charger o Small panel with lantern/light and phone charger o Solar phone charger o Other (specify) _____ o Do not know o No answer
35. *(if Solar Energy)* **What brand is your solar system/kit?**	
36. *(if Solar Energy)* **What was the main reason that prompted you to buy this solar system/kit?**	o It was the cheapest o It was recommended o It is of good quality o It is the only one sold in my area

	○ It has a guarantee ○ It is big ○ It had an attractive/realistic payment plan ○ Other (specify)_____
37. *(if Solar Energy)* **Did you buy your solar system/kit outright or are you paying in instalments?** **Pick one*	○ Bought outright ○ Paying in Instalments every day ○ Paying in Instalments every week ○ Paying in Instalments every month ○ It was a present (if this skip 29-32)
38. *(if Solar Energy Bought outright)* **How much was your solar system/kit?**	
39. *(if Solar Energy Bought outright)* **How did you pay for your solar system/kit?** **Pick one*	○ Cash at shop or agent ○ Mobile payment (M-Pesa/M-Kash) ○ Other (specify)_____
40. *(if Solar Energy paying in instalments)* **How much do you pay per instalment?**	
41. *(if Solar Energy paying in instalments)* **How do you pay for your solar system/kit?** **Pick one*	○ Cash at shop or agent ○ Mobile payment (M-Pesa/M-Kash) ○ Other (specify)_____
42. *(if Solar Energy)* **In case of malfunction/breakage, what do you do?**	○ Buy a new one ○ Take back to the store/agent ○ Call the electrician ○ Do not know what to do ○ It has not happened yet ○ Other (specify)_____
43. *(if Solar Energy with an answer for O&M)* **How often do you require assistance to fix the solar system/kit?**	○ Once a year ○ Several times a year ○ Every 2 to 3 years ○ It has not happened yet
44. When do you expect EDM to reach your house? **pick one* **if answer was EDM skip this*	○ This year ○ Next year ○ In 2-3 years

	○ In 4-5 years ○ In more than 5 years ○ Do not know ○ Never ○ Do not want electricity from EDM
45. What is the main/ most used source of light in the household? **pick one* **if answer was EDM skip this*	○ Lightbulb fed by the generator ○ Lightbulbs fed by solar panels ○ Torch (with batteries) (after 36 go to 37-41) ○ Solar lantern ○ Wind-up lantern/torch ○ Kerosene (after 36 go to 42-48) ○ Candles (after 36 go to 49-52) ○ Firewood (after 36 go to 53-59) ○ Artisanal recycled battery/ LED light ○ Other (specify)_____
46. How many/ what quantity of these light sources do you use daily? (Number of lamps/ torches/ kerosene lamps/ candles…)	
47. *(if Torch with batteries)* **How often do you buy batteries for your torch(es)?** **Pick one*	○ Every day ○ Many times a week ○ Once a week ○ Twice a month (every 2 weeks) ○ Once a month ○ Never ○ Other (specify)_____
48. *(if Torch with batteries)* **What type of batteries do you buy for your torch? (*insert image option)** **pick one*	○ AAA ○ AA ○ C ○ D ○ Other (specify)_____
49. *(if Torch with batteries)* **How many batteries do you buy at once for your torch?**	
50. *(if Torch with batteries)* **Where do you buy the batteries?**	○ Local Market

*Pick one

- o Market in another locality
- o A private store owner in this village
- o A private store owner in another village
- o At a petrol station
- o Other (specify)_____

51. *(if Torch with batteries)* **How far from your house is the sale point (one-way walking)?**

- o Below 10 minutes
- o 11 to 30 minutes
- o 31 minutes to 1 hour
- o 1 to 2 hours
- o Less than 2 hours
- o Less than 3 hours
- o Less than 4 hours
- o Less than 5 hours
- o More than 5 hours

52. *(if Kerosene)* **How often do you buy Kerosene?**
*Pick one

- o Every day
- o Many times a week
- o Once a week
- o Twice a month (every 2 weeks)
- o Once a month
- o Never
- o Other (specify)_____

53. *(if Kerosene)* **How much do you spend to buy Kerosene every time you go buy?**

54. *(if Kerosene)* **How many litres of Kerosene do you buy every time you go buy?**

55. *(if Kerosene)* **How much do you spend on Kerosene monthly?**

56. *(if Kerosene)* **What is the current price for a litre of Kerosene?**

57. *(if Kerosene)* **Where do you buy the Kerosene?**
*Pick one

- o Local Market
- o Market in another locality
- o A private store owner in this village

	o A private store owner in another village o At a petrol station o Other (specify)_____
58. *(if Kerosene)* **Do you experience discomfort from using Kerosene (i.e: smell, burning eyes...)?**	o Yes o No
59. *(if Kerosene)* **How far is the sale point from your house (one-way walking)?**	o Below 10 minutes o 11 to 30 minutes o 31 minutes to 1 hour o 1 to 2 hours o Less than 2 hours o Less than 3 hours o Less than 4 hours o Less than 5 hours o More than 5 hours
60. *(if Candles)* **How often do you buy Candles?** **Pick one*	o Every day o Many times a week o Once a week o Twice a month (every 2 weeks) o Once a month o Never o Other (specify)_____
61. *(if Candles)* **How many candles do you buy at once?**	
62. *(if Candles)* **Where do you buy the candles?** **Pick one*	o Local Market o Market in another locality o A private store owner in this village o A private store owner in another village o At a petrol station o Other (specify)_____

63. *(if Candles)* **How far is the sale point from your house (one way walking)?**	o Below 10 minutes o 11 to 30 minutes o 31 minutes to 1 hour o 1 to 2 hours o Less than 2 hours o Less than 3 hours o Less than 4 hours o Less than 5 hours o More than 5 hours
64. *(if Firewood)* **How often do you buy Firewood?** **Pick one*	o Every day o Many times a week o Once a week o Twice a month (every 2 weeks) o Once a month o Never o Other (specify)_____
65. *(if Firewood)* **What quantity of firewood do you buy?**	
66. *(if Firewood)* **How much of this quantity of this firewood is used for light?**	
67. *(if Firewood)* **How much do you spend on firewood every time you go buy it?**	
68. *(if Firewood)* **How much do you spend on firewood every month?**	
69. *(if Firewood)* **Where do you buy the firewood?** **Pick one*	o Local Market o Market in another locality o A private store owner in this village o A private store owner in another village o At a petrol station o Other (specify)_____

70. *(if Firewood)* **How far is the sale point from your house (one-way walking)?**	○ Below 10 minutes ○ 11 to 30 minutes ○ 31 minutes to 1 hour ○ 1 to 2 hours ○ Less than 2 hours ○ Less than 3 hours ○ Less than 4 hours ○ Less than 5 hours ○ More than 5 hours
71. What is the alternative source of light in the household? **Pick one*	○ Lightbulb fed by the generator ○ Lightbulbs fed by solar panels ○ Torch (with batteries) ○ Solar Lantern ○ Wind-up Lantern/ torch ○ Kerosene ○ Candles ○ Firewood ○ Other (specify)_____ ○ Does not use an alternative source
72. How many of these light sources do you use daily? (Number of lamps/ torches/ kerosene lamps/ candles)	
73. How many cell phones are used in this household (including the interviewee's)? **if NONE skip to 69*	
74. Where do you charge you cell phone battery? **Pick one*	○ At home ○ At someone's house ○ At work ○ At the School/Hospital/ Other public institutions ○ At the market ○ With a merchant/store owner ○ Other (specify)_____

75. What source of energy is used to charge the phone? **Pick one*	○ EDM ○ Generator ○ Solar Energy ○ Other (specify)_____ ○ Do not know
76. How often do you charge your cell phone battery? **Pick one*	○ Every day ○ Every second day ○ Every third day ○ Every fourth day ○ Every fifth day ○ Every sixth day ○ Once a week ○ Other (Specify) _____
77. How much do you pay every time you charge each phone?	
78. How far from your house is the place where you charge your cell phone (if walking and one way)?	○ At home ○ Below 10 minutes ○ 11 to 30 minutes ○ 31 minutes to 1 hour ○ 1 to 2 hours ○ Less than 2 hours ○ Less than 3 hours ○ Less than 4 hours ○ Less than 5 hours ○ More than 5 hours
79. Do you use a radio with batteries? **if no go to next section*	○ Yes ○ No
80. *(If yes)* **How often do you buy batteries for the radio?** **Pick one*	○ Every day ○ Many times a week ○ Once a week ○ Twice a month (every 2 weeks) ○ Once a month

	○ Never (if this go to 86) ○ Other (specify) _____
81. What type of batteries do you buy for the radio? (*insert image choice) **Pick one*	○ AAA ○ AA ○ C ○ D ○ Other (specify)_____
82. How many batteries do you buy at once for the radio?	
83. How much do you spend to buy batteries for the radio every time you buy them?	
84. How much do you spend on batteries for the radio every month?	
85. Where do you buy the batteries for the radio? **Pick one*	○ At the village market ○ At a market of another village ○ From a private store owner ○ From a private store owner at another locality ○ At the petrol station ○ Other (specify)_____
86. How far from your house is the place you buy the batteries from (one-way walking)?	○ Below 10 minutes ○ 11 to 30 minutes ○ 31 minutes to 1 hour ○ 1 to 2 hours ○ Less than 2 hours ○ Less than 3 hours ○ Less than 4 hours ○ Less than 5 hours ○ More than 5 hours
SECTION IV: QUESTIONS ON THE PERCEPTION OF SOLAR ENERGY	
87. Do you know, or have you heard about solar energy?	○ Yes ○ No

**if does not know, explain what it is and ask again*	
88. Are there awareness campaigns for solar energy in your area?	○ Yes ○ No ○ Do not know
89. Have you seen a Solar system/kit for sale before?	○ Yes ○ No (skip 81)
90. *(if Yes)* **How far from your house is the location in which you saw this system/kit being sold (one way walking)?**	○ Below 10 minutes ○ 11 to 30 minutes ○ 31 minutes to 1 hour ○ 1 to 2 hours ○ Less than 2 hours ○ Less than 3 hours ○ Less than 4 hours ○ Less than 5 hours ○ More than 5 hours
91. To what extent do you agree/disagree that solar energy can give you the same benefits as EDM?	
92. To what extent do you agree/disagree that solar energy can give you access to better light?	
93. From the options presented, where red is not confident and green confident, how confident do you feel you know solar energy and how to use it?	
94. From very expensive to very cheap, how would you classify the cost of solar energy?	
95. To what extent do you agree/disagree that it is easy to fix/find someone to fix a broken solar system/kit?	
96. Do you think solar energy can reduce your monthly expenses?	○ Yes ○ No
97. On a scale of 1 to 5, where 1 is bad quality and 5 is good quality, how would you classify the quality of solar systems/kits, that you have seen/heard about/have?	

98. From the options presented, where red is does not help and green it helps, do you think that solar energy could help you start a business?	
99. To what extent do you agree/disagree that there is a lower risk of the solar system/kit to be stolen?	
100. Would you be willing to buy a solar system?	○ Yes ○ No ○ Maybe ○ Depends on the price ○ Already has ○ Other (specify)_____
101. Is there a reason why you have not purchased a solar system/kit? *pick multiple	○ Did not know the benefits of solar energy ○ Do not know where to buy a solar system to have at home ○ It is expensive ○ Do not trust it ○ It is not sold in the area ○ Other (Specify)_____
102. *(if already has solar)* **Would you recommend solar energy to others?**	○ Yes ○ No
103. *(if would not recommend solar)* **Why would you not recommend solar energy to others?**	○ Do not trust it ○ It is expensive ○ Do not find components to fix ○ Other (specify)_____
104. Is there a reason why you have not bought a solar system/kit yet?	○ Did not know the benefits of solar energy ○ Do not know where to buy a solar system/kit ○ Cannot afford it ○ It is not sold in the area ○ Other (specify)_____-
105. Have you heard about mobile payment systems (i.e: M-PESA/ M-Kash)?	○ Yes ○ No ○ Do not know

106. Would you be willing to use this payment system to pay for you daily solar energy access?	○ Yes ○ No, would rather use another form of payment (specify)_____ ○ Do not know
107. *(if no)* **What payment method do you prefer to use?**	○ Cash in hand ○ Bank transfer ○ Pay online/internet banking ○ Pay at the ATM
108. Which of these services do you use through your phone? **choose as many as you use*	○ M-Kesh or M-Pesa ○ Cell phone internet ○ Bank services (Izzy) ○ Credit transfer to friends/family/third parties ○ None ○ Other (specify)_____
109. How much do you spend weekly for M-Kesh or M-Pesa? **110. How much do you spend weekly for your cell phone internet?** **111. How much do you spend weekly for Bank services?** **112. How much do you spend per week for credit transfer?**	
SECTION V: HOUSEHOLD INCOME QUESTIONS	
113. How many of the people who live here work? *Max 30	
114. What is the main economic activity of your household?	○ Trade

*Pick one	○ Public Administration ○ Agriculture ○ Cattle ○ Fishing ○ Formal work ○ Informal Work ○ Other (specify)_____ ○ Do not work
115. *(if Cattle)* **Could you please estimate how many cattle you have (i.e: total number of pigs/cows…)** **116.** *(if Cattle)* **Could you please estimate the monetary value of your cattle?**	
117. What is the secondary/alternative economic activity pf your household? *Pick one	○ Trade ○ Public Administration ○ Agriculture ○ Cattle ○ Fishing ○ Formal work ○ Informal Work ○ Other (specify)_____ ○ Do not work
118. If you are not a home owner, how much do you pay for rent of your house? * Use Codes: 0 - means does not pay for this expense 999-means does not know/ Does not answer/ Prefer not to say/ Does not use this service/ It is not relevant	_____Mtn
119. How much do you spend monthly for cooking fuel (all types)? *Use code	_____ Mtn

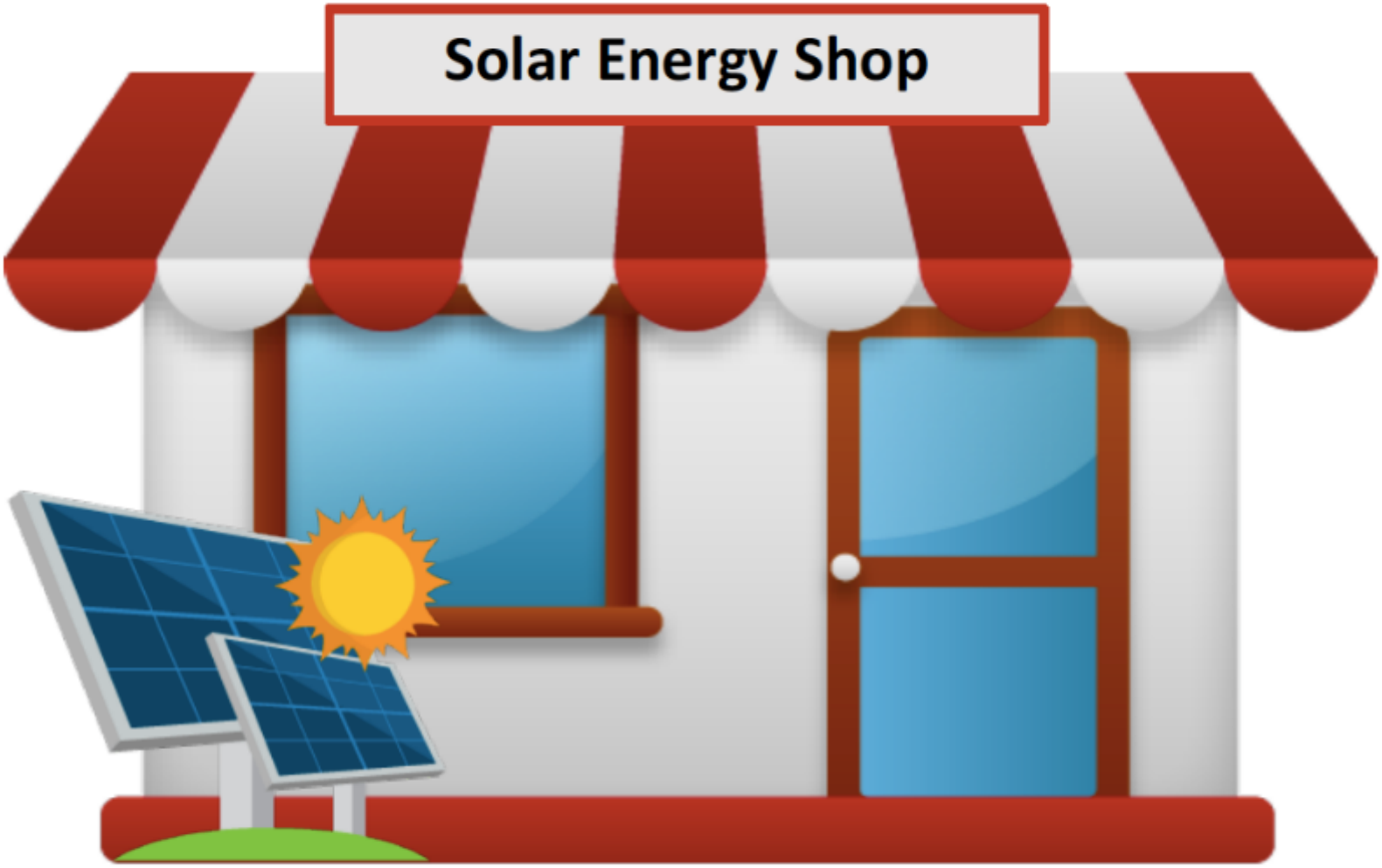
120. How much money do you spend monthly on food? *use code	_____ Mtn
121. How much money do you spend monthly on hospital and medication (for all members of the family)? *use code	_____ Mtn
122. How much Money do you spend monthly on transport (for all members of the family)? *Use code	_____ Mtn
123. How much Money do you spend monthly on airtime for your cell phones (all)? *use code	_____Mtn
124. How much Money do you spend monthly to charge your phone? *Use code	_____Mtn
125. How much Money do you spend monthly to pay school fees and materials for your children? *use code	_____Mtn
126. How much Money do you spend monthly on alcohol? *Use code	_____Mtn
127. What is the total monthly income (all salaries and other income sources)?	○ Mtn 3000 or less ○ Mtn 3001 to 5000 ○ Mtn 5001 to 10 000 ○ Mtn 10 001 to 20 000 ○ Mtn Above 20 000

128. Do you have any other source of extra income?	○ Yes, Pensions ○ Yes, Family help ○ No ○ Other (specify)_____
129. *(if yes)* **How much do you receive, in total, from this/these source/s?**	
SECTION VI: FUTURE ENERGY PROJECTIONS & MARKET WILLINGNESS TO PAY GAME	
130. What electronic equipment (shown on the photos) would you like to have in the near future, and what do you already have? **pick multiple*	○ 1 (light bulbs) ○ 2 (Small phone) ○ 3 (Smartphone) ○ 4 (DVD Player) ○ 5 (Laptop) ○ 6 (Radio) ○ 7 (Satellite dish and receiver) ○ 8 (Flat screen TV) ○ 9 (Conventional TV) ○ 10 (Fan) ○ 11 (Fridge) ○ 12 (Freezer) ○ 13 (Microwave) ○ 14 (Iron) ○ 15 (Oven) ○ 16 (Stove) ○ 17 (Kettle) ○ 18 (Sound System)
131. Imagine you are shopping for a solar system/kit and you go to shop 1 which sells systems outright with these choices (**show image***); which of these options would you pick?**	○ 1 ○ 2 ○ 3 ○ 4 ○ Would not buy any

132. Imagine you go to shop 2 which offers PAYG for 2 years, (show image*) which of these options would you pick?**	○ 1 ○ 2 ○ 3 ○ 4 ○ Would not buy any
133. Imagine you go to shop 3 which offers PAYG for 3 years, (show image*) which of these options would you pick?**	○ 1 ○ 2 ○ 3 ○ 4 ○ Would not buy any
134. Imagine you go to shop 4 which sells systems/kits outright (show image*) which of these options would you pick?**	○ 1 ○ 2 ○ 3 ○ 4 ○ Would not buy any
135. Imagine you go to shop 5 which is a solar mini-grid shop, where you can buy electricity on the Credillec system, which of these options would you pick?	○ 1 ○ 2 ○ 3 ○ 4 ○ Would not buy any
136. From all the stores presented, which was your favourite?	○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ None
137. From the options shown (show image*), which system/kit do you prefer?**	○ 1 ○ 2 ○ 3 ○ 4
138. What is the maximum value you would be willing to pay for your chosen solar system/kit?	

139. What payment option would you like to use to pay for your new solar system/kit?	○ Pay outright ○ Pay daily ○ Pay monthly ○ Pay in 1 or more instalments

A4 Market Willingness to Pay Game Outline


Solar Energy Shop

Shop 1: Direct Purchase

	Equipment which system can run	Price
1		1000 MZN (20 USD)
2		6000 MZN (100 USD)
3		30.000 MZN (500 USD)
4		80.000 (1330 USD)

Shop 2: PAYG plan for 24 months

	Equipment which system can run	Start fee	Monthly	Daily
1		220	37	1.2
2		1.320	220	7
3		6.600	1.100	36
4		17.600	2.933	94

Shop 3: PAYG plan for 36 months

	Equipment which system can run	Start fee	Monthly	Daily
1		220	24	0.8
2		1.320	147	5
3		6.600	733	24
4		17.600	1956	64

Shop 4: Direct Purchase (No duties/ taxes)

	Equipment which system can run	Price
1		660
2		3960
3		19.800
4		52.800

A5 Technical Sheet related to the Consumer Perception of Off-grid Solar Products

Technical Sheet related to the Consumer Perception of Off-grid Solar Products						
	Maputo		Manica		Zambezia	
	Peri-Urban	Rural	Peri-urban	Rural	Peri-urban	Rural
General						
Respondents already have a solar system	7.94	32.26	6.9	0	0	3.17
Respondents would buy a solar kit/system	34.92	38.71	70.69	78.57	41.94	73.02
Respondents would not buy a solar kit/system	36.51	8.06	1.72	8.33	14.52	4.76
Respondents would buy solar kit/system dependent on the price	9.52	12.9	15.52	13.1	30.65	19.05
Respondents would maybe buy	11.11	8.06	5.17	0	12.9	0
Awareness						
Respondents know what solar energy is	93.65	95.16	94.83	90.48	72.58	80.95
Respondents do not know what solar energy is	6.35	4.84	5.17	9.52	27.42	19.05
There are awareness campaigns in the area	17.46	6.45	1.72	41.67	3.23	6.35
There are no awareness campaigns in the area	77.78	87.1	93.1	48.81	90.32	82.54
Respondents are not aware if there are awareness campaigns	4.76	6.45	5.17	9.52	6.45	11.11
Respondents indicated that they have seen a solar kit/system for sale	71.43	82.26	67.24	75	48.39	65.08
Respondents indicated that they have not seen a solar kit/system for sale	28.57	17.74	32.76	25	51.61	34.92
Solar systems found close distance to households (below 30 min)	40	23.53	44.82	48.81	26.67	17.08
Solar systems found medium distance to households (between 31m and 2h)	35.56	52.94	51.72	30.95	60	58.54
Solar systems found far distance from households (between 2h and 5h)	24.44	23.53	3.44	20.23	13.33	24.4
Respondents are confident in use of solar energy	30.2	48.39	n/a	n/a	37.10	30.16
Respondents are not confident in use of solar energy	36.5	22.58	n/a	n/a	33.87	39.68
Respondents are neutral or not aware of how to use solar energy	33.3	29.03	n/a	n/a	29.03	23.81
Recommendation of solar kit/system to others if respondent had already purchased	80.0	95.0	75		0	100
Respondents would not recommend solar kit/system to others if respondent had already purchased	20.0	5.0	25		0	0
Mobile payments - respondents are aware	93.65	77.42	91.38	94.05	95.16	82.54
Mobile payments - respondents are not aware	6.35	22.58	8.62	5.95	4.84	17.46
Mobile payments - respondents would use for daily solar energy consumption	79.37	83.87	87.93	94.05	74.19	58.73

Mobile payments - respondents would not use for daily solar energy consumption	20.63	16.13	12.07	5.95	25.81	41.27
Type of mobile payment used by respondents: M-kesh/M-Pesa/E-mola	85.7	70.97	56.90	41.67	32.26	19.05
Type of mobile payment used by respondents: phone airtime transfer	39.68	53.23	32.76	27.38	16.13	9.52
Type of mobile payment used by respondents: internet on the phone	30.16	53.23	12.07	5.95	4.84	1.59
Type of mobile payment used by respondents: Banking System	11.11	6.45	15.52	3.57	3.23	1.59
Type of mobile payment used by respondents: None	7.94	24.19	37.93	51.19	62.90	79.37
Type of mobile payment used by respondents: other	3.17	1.61	0	3.57	0	1.59
Reason why respondents have not yet acquired a solar kit/system: do not know where to buy	1.72	4.65	3.7	7.14	0	1.64
Quality						
Respondents believe solar energy gives same benefits as EDM	33.33	22.58	34.38	53.57	35.49	69.84
Respondents do not believe solar energy gives same benefits as EDM	30.16	53.23	36.21	26.19	37.1	14.27
Respondents do not know if solar energy gives same benefits as EDM	36.51	24.19	29.31	20.24	27.42	15.87
Respondents believe solar energy can provide a better light	31.75	30.64	n/a	n/a	54.84	66.67
Respondents believe solar energy cannot provide a better light	28.57	43.55	n/a	n/a	25.81	11.11
Respondents do not know if solar energy can provide a better light	39.68	25.81	n/a	n/a	19.35	22.22
Respondents believe solar products are of good quality	37	48.39	n/a	n/a	45.16	52.39
Respondents believe solar products are of bad quality	22.22	11.29	n/a	n/a	32.26	17.46
Respondents are not aware of the quality of solar products	41.27	40.32	n/a	n/a	22.58	30.16
Respondents perceive it would be relatively easy to repair broken solar kit/system	19.05	9.67	n/a	n/a	22.58	7.94
Respondents perceive it would be relatively difficult to repair broken solar kit/system	49.2	41.94	n/a	n/a	51.61	76.19
Respondents are not aware of how easy or difficult would be to repair a broken solar kit/system	42.86	48.39	n/a	n/a	25.81	15.87
Affordability						
For respondents who already purchased a solar system, what is the reason: it was the cheapest	33.33	28.57	0	25	n/a	100
For respondents who already purchased a solar system, what is the reason: it was recommended	n/a	19.05	42.86	0	n/a	0
For respondents who already purchased a solar system, what is the reason: other (eg. good quality)	66.67	42.86	42.86	75	n/a	0
For respondents who already purchased a solar system, what is the reason: good quality	n/a	n/a	14.29	n/a	n/a	n/a
For respondents who already purchased a solar system, what is the reason: it is big	n/a	9.52	0	0	n/a	0
For respondents who already purchased a solar system, the payment was: upfront payments	100	95.24	100	75	n/a	100

For respondents who already purchased a solar system, it was acquired as a gift	n/a	4.76	0	0	n/a	0
For respondents who already purchased a solar system, it was acquired as weekly instalments	n/a	4.76	0	0	n/a	0
Respondents perceive the price of solar kits as affordable (cheap)	19.05	12.9	n/a	n/a	24.19	12.7
Respondents perceive the price of solar kits is not affordable (expensive)	23.81	53.23	n/a	n/a	40.32	63.49
Respondents are not aware of the price of solar kit/system	57.14	33.87	n/a	n/a	35.48	23.81
Accessibility						
Reason why respondents have not yet acquired a solar kit/system: financial conditions	43.1	65.12	59.26	38.1	74.19	68.85
Reason why respondents have not yet acquired a solar kit/system: do not know the benefits of solar	6.9	2.33	11.11	22.62	16.13	16.39
Reason why respondents have not yet acquired a solar kit/system: other reasons*	39.65	32.56	29.62	39.28	9.67	14.76
*do not know where to buy, it is not sold in the area or they are either happy with or waiting for EDM or had a solar system previously, but it has broken.						
In terms of payment method for electricity: upfront payment	76.92	90	n/a	n/a	93.75	92.31
In terms of payment method for electricity: other sources*	23.08	10	n/a	n/a	6.25	7.69
*other: online/internet/						
Potential Benefits						
Respondents perceive that solar energy could reduce their costs/expenses	57.14	75.81	n/a	n/a	79.03	92.06
Respondents perceive that solar energy cannot reduce their costs/expenses	42.86	24.19	n/a	n/a	20.97	7.94
Respondents perceive solar energy as a vehicle to establishing a business	50.7	64.5	n/a	n/a	69.4	87.30
Respondents perceive that solar energy cannot be vehicle for the establishment of a business	20.6	25.8	n/a	n/a	12.9	6.35
Respondents are not aware if solar energy can support in establishing a business	28.6	9.7	n/a	n/a	17.7	6.35
Respondents believe it is probable that the solar kit/system will get stolen after its purchase	47.62	58.06	n/a	n/a	61.29	60.31
Respondents believe it is less probable that the solar kit/system will get stolen after its purchase	36.41	27.42	n/a	n/a	19.35	31.74
Respondents don’t know if the solar kit/system will get stolen after its purchase	15.87	14.52	n/a	n/a	19.35	7.94
Advantages						
Allows to charge phone at home	n/a	n/a	74.14	91.67	n/a	n/a
There is no need to pay for batteries/kerosene/EDM	n/a	n/a	48.28	64.29	n/a	n/a

Allows to undertake activities at night	n/a	n/a	39.66	53.57	n/a	n/a
Can provide better light	n/a	n/a	37.93	50.00	n/a	n/a
Can use it for tv/fridge	n/a	n/a	27.59	21.43	n/a	n/a
It is cheaper	n/a	n/a	17.24	16.67	n/a	n/a
Can start a business	n/a	n/a	10.34	32.14	n/a	n/a
Other	n/a	n/a	17.24		n/a	n/a
Disadvantages						
Can’t use a tv/fridge	n/a	n/a	31.03	26.19	n/a	n/a
Lack of knowledge of technology and how to use it	n/a	n/a	29.31	33.33	n/a	n/a
System can be stolen	n/a	n/a	10.34	34.52	n/a	n/a
It is expensive to buy	n/a	n/a	8.62	19.05	n/a	n/a
Lack of parts available	n/a	n/a	1.72	16.67	n/a	n/a
Maintenance costs are high	n/a	n/a	1.72	11.90	n/a	n/a
It breaks easily/ it is low quality	n/a	n/a	0.00	19.05	n/a	n/a
Other reasons	n/a	n/a	41.38		n/a	n/a

A6 Potential market estimation: detailed methodology

Introduction

This section details the methodology used to estimate the potential market for off-grid solar products. For this purpose, a model was developed by ECA to determine the number of households that can afford a given level of monthly expenditure on solar products (e.g. $4.90/month). This model is best suited for products sold on a PAYG basis, or through a loan (e.g. bank/microfinance institution)[74].

Main methodological approach

The potential market model estimates how many customers are able to afford a product by examining two main factors:

1. **Household income** (expressed as monthly income)
2. **Willingness to pay** (WTP) for an off-grid solar system (expressed as % of income)

These two factors are multiplied, which provides the **maximum monthly price** that households are willing and able to pay for solar products.

This **maximum monthly price** is then compared with the price of a solar product to determine whether it is affordable or not.

Step-by-step explanation of the methodology

This section provides the main steps in the estimation of the potential market for solar products. In addition, the actual calculations for the Manica province are provided as an example.

Step 1: The population in the area is separated into income groups (ranges) based on their monthly income. The ranges are determined based on the data collected as part of the household survey.

Type of data needed: Population data, population distribution by income (monthly income).

Analysis for the Manica province:

INPUTS:

- Number of households: 381,202 (Census 2017)

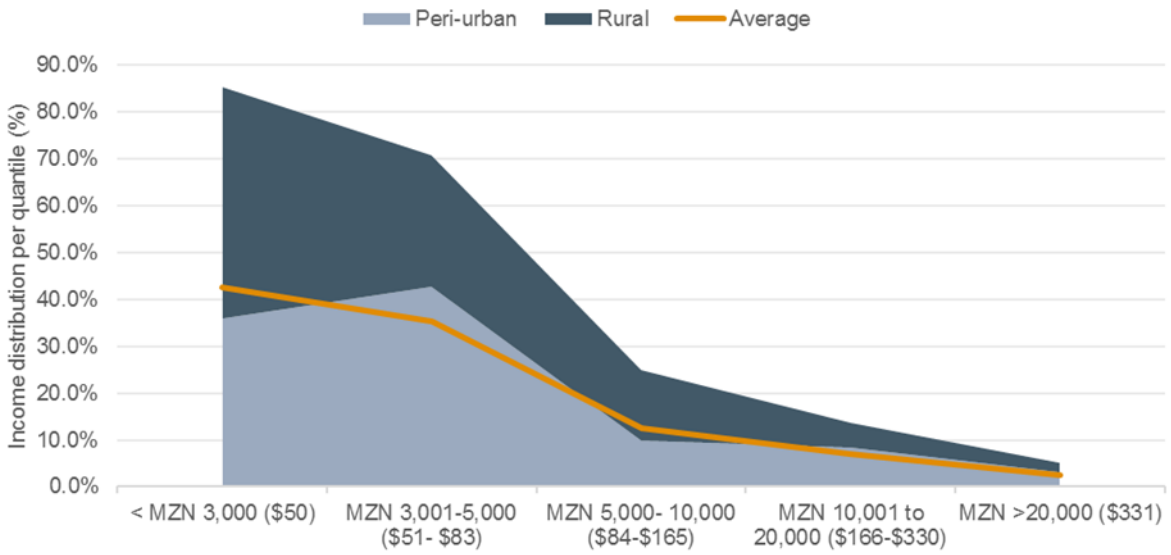
[74] The model could potentially be used for to estimate demand for cash sales of solar products if data was available on the capacity to save of rural households.

- ❑ Distribution of population by income: Distribution is based on the household survey and is presented in Figure 28.

RESULT: the number of households is distributed in 5 income ranges.

Income range ($/month)	< MZN 3,000 ($50)	MZN 3,001-5,000 ($51- $83)	MZN 5,000-10,000 ($84-$165)	MZN 10,001 to 20,000 ($166-$330)	MZN >20,000 ($331)
Number of households	162,743	135,048	47,658	26,215	9,538

Figure 28 Household distribution per income group



Source: ECA and GreenLight

<u>Step 2:</u> The number of off-grid people in each income group is calculated

Data needed: Percentage of off-grid population, percentage of off-grid population in each income range

Analysis for Manica:

The percentage of off-grid people in the region is known (Manica: 78.5%). The percentage of off-grid people in each income group is estimated based on the assumption that the poorest people are more likely to be off-grid than the richest (the poorest group is 5 times more likely than richest, 2nd poorest 4 times more likely, etc.). This assumption is based on evidence from other countries (notably FinAccess study in Kenya[75]), as there is no data on this for Mozambique.

	< MZN 3,000 ($50)	MZN 3,001-5,000 ($51-$83)	MZN 5,000-10,000 ($84-$165)	MZN 10,001 to 20,000 ($166-$330)	MZN >20,000 ($331)	*Total in province*
% of off-grid	95.9%	76.8%	57.6%	38.4%	19.2%	*78.5%*

[75] Kenya FinAccess household survey 2015, available from: https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/QUTLO2

RESULT: by combining the table of step 1 with the table of step 2 (percentage of households in each income range and the off-grid population in each wealth quintile) the number of off-grid people is calculated for each income range.

Income range ($)	< MZN 3,000 ($50)	MZN 3,001-5,000 ($51-$83)	MZN 5,000-10,000 ($84-$165)	MZN 10,001 to 20,000 ($166-$330)	MZN >20,000 ($331)	Total in province
Number of households off-grid	156,142	103,657	27,435	10,061	1,830	**299,124**

<u>Step 4:</u> Calculation of the maximum expenditure households can afford for a solar product, for each income range

Data needed: Percentage of income households are willing-to-pay for solar products.

Analysis for Manica:

INPUTS: percentage of income households are willing-to-pay

According to the results of the household survey, an average household in Manica spends approximately 926.75 Mzn a month ($15.36) for lighting, radio, and mobile phone charging. We assume that households would be able to afford a payment plan for a household solar energy product at a similar price, since they will no longer need to spend money on batteries/kerosene and charging their mobile phones at kiosks.

In order to differentiate between the level of expenditure across the five different income groups, we assume that the expenditure profile of households in the 2nd income group corresponds to the average across all income groups. We further assume that income groups 1 and 3 consume 20% less and 40% more, respectively, compared to level of expenditure of income group 2, while income groups 4 and 5 spend 40% more and 60% more, respectively, compared to the average level.

RESULTS:

Income range ($)	< MZN 3,000 ($50)	MZN 3,001-5,000 ($51-$83)	MZN 5,000-10,000 ($84-$165)	MZN 10,001 to 20,000 ($166-$330)	MZN >20,000 ($331)
Max expenditure ($/month)	12.3	15.4	18.5	21.6	24.6

<u>Step 5:</u> The potential market is determined by comparing the price of a product (in $/month) with the households' WTP. The population is assumed to be linearly spread in each income range.

INPUTS: Willingness to pay for each solar energy system.

The willingness to pay for each solar energy system was derived by the MWTP game (described in section A4). We used the prices of solar energy systems currently available in the market.

According to the household survey conducted:

- For a 24-month payment plan a pico solar system (system 1) can be acquired for $0.60/month given an initial deposit of $4.
- For a 24-month payment plan we estimate that a basic SHS (system 2) can be acquired at $4/month given an initial deposit of $22.
- For a 24-month payment plan we estimate that a larger SHS (system 3 - able to operate a small TV) can be acquired at $18/month with an initial deposit of $110.
- For a 24-month payment plan we estimate that a complete SHS (system 4- able to run small Refrigerator) can be acquired at $49/month with an initial deposit of $293.

In order to derive the monthly fee rate that corresponds to the total price of the system we assume that the initial deposit is spread out across the duration of the payment plan. The resulting prices are then:

- System 1: $0.80/month
- System 2: $4.90/month
- System 3: $22.60/month
- System 4: $61.20/month.

The potential market is estimated based on the number of people able to pay the maximum monthly fee.

RESULTS:

	$ 0.80/month	**$4.90/month**	**$22.60/month**	**$61.20/month**
	(HH energy expenditures ≥$0.8/month)	(HH energy expenditures ≥$4.9/month)	(HH energy expenditures ≥$22.6/month)	(HH energy expenditures ≥$61.2/month)
Total addressable market (#)	299,124	299,124	1,212	0
Number of HH unable to pay (#)	0	0	297,912	299,124
Total off-grid HH (#)	299,124	299,124	299,124	299,124

Key Data used

The table below summarizes the data sources that were used to estimate the market for PAYG sales in this study.

Data	Main sources
Population, population	Census 2017
Electrification rates	Census 2017
Population distribution by income	Household survey
Percentage of off-grid people in wealth quintiles	Consortium analysis based on Mozambique context
Maximum percentage of monthly income spent on lighting	Household survey

A7 References

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