BRILHO

Impulsionamos empresas
Iluminamos vidas

Productive use of Energy

Market Research- Off-grid summary

Elaborated by: Practical Action Consulting

UKaid
from the British people

Sweden
Sverige

SNV

Productive Use Intro: Definition, approaches, trend and technologies

PUE Market research | Study Context & objectives

Study Context

BRILHO's overall goal is to improve and increase energy access for people and businesses, leading to money saving, better well-being and livelihood opportunities for the low income population. It does this through a combination of:

Research & dissemination + **Market Demand Activation for Innovation & Investment** + **Capacity building** + **Policy Support**

There are currently multiple off-grid initiatives in Mozambique, but demand is a constraint. Productive uses of energy (PUE) is a key mean to overcome key barriers to the growth of energy businesses in rural areas in Mozambique where residential demand for energy from rural communities remains low, making it difficult to secure the income to recoup investment in energy infrastructure and grow markets for energy products.

Research objectives & methodology

Brillho carried out a study into the potential of PUE to support the growth of off-grid renewable energy in Mozambique. With the objective of Identifying 3 key uses of energy that provide the most potential, based on: practical viability, business case & impact. Using the following approach:

Research	• Desk & field research on potential PUE's revolving around 2 stage approach to define the technology that best fit • Scoped 4 districts from Nampula (Erati and Angoche) and Zambezia (Maganja da Costa and Gurue) • Worked with Local Government officials, entrepreneurs and critical suppliers to the ecosystem
Business & Financial Modeling	• Built business assumptions based on Canvas, interviews and desk research • Used Business Model Canvas based on that developed by Alexander Osterwalder, to model operation model for selected PUE's • Used research to identify financing gaps, propose capital structure and estimate Payback of selected PUE's

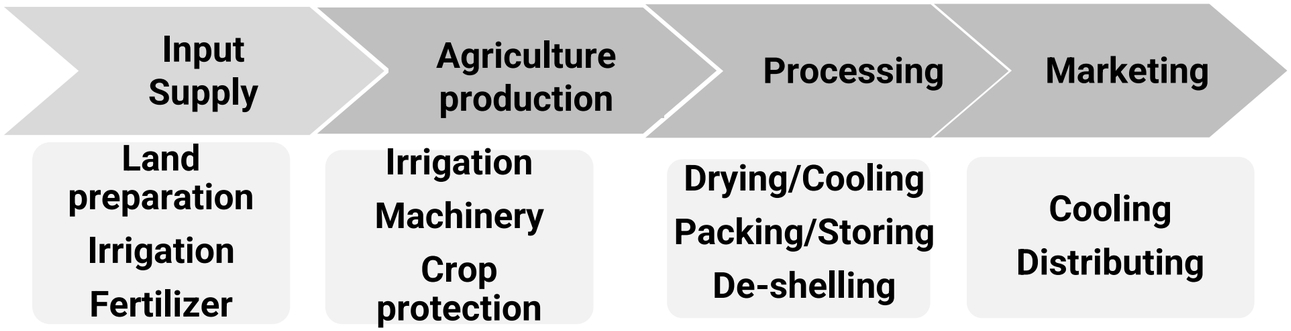
PUE Market research | PUE & the Rural economic activities in Mozambique

Mozambique Agriculture Technology key KPI's

3% *Of Cropland are Irrigated, per FAO*	**30%** *Loss after Harvest, due to bad storage, processing and cooling process (Technoserve, 2021)*	**7,3%** *Farmers Access to Irrigation technology (Technoserve, 2021)*

Agriculture value chain & Energy

- Agriculture main source of income for 79% of the populace Mozambique(Technoserve,2021), similarly in Africa
- KPI's above are a result of the low of electrification of PUE usage in the rural space/Off-Grid
- The chart illustrates correlation between energy & activities in agriculture



- Most Energy is consumed at the production & processing stages ~80
- Low levels of irrigation w/3Million Ha of irrigable area but only with 62,000 ha currently irrigated land

How Renewable PUE technologies can help

The BRILHO programme defines Productive Uses of Energy (PUE) as activities that involve the utilization of energy (both electric and non-electric energy in the form of heat, or mechanical energy) for activities that enhance income and welfare. And here is how it can help:

- Only about 39% of Mozambicans with access to Energy..target is 100% by 2030
- To meet this gap by 20230, Off-Grid initiatives will play a Key-Role supporting the On-grid expansion initiatives
- The renewable PUE can play a key role in off-grid not only as a contributor to agriculture value chain improvements but also as a demand and affordability enabler in the off-grid space
- These systems can leverage the Mini-grid connection now reaching these off-grid sites but can also be adopted as stand-alone solutions

PUE Market research | Global trends and initiatives

There are multiple initiatives across the globe, to set up programmes to research and promote PUE, with the following areas being currently on the spotlight:

- Market research,
- Research & Development (R&D),
- Early-stage grant financing
- Business Case pilots

Some of these initiatives spread across the globe are listed below:

Powering Agriculture	Was a multi-donor partnership that utilized a cross-sectoral approach, providing technology and business model innovation grants, increasing financing through an investment alliance, awareness raising and knowledge management
Access 2 Energy	a R&D institute focusing on productive use appliances that allow small businesses and smallholder farmers to generate a stable income, generate jobs and create robust local economic networks
Water & Energy for Good	is a new programme that builds on the learnings from Powering Agriculture and focuses on scaling water-energy-food innovations.
Productive Use Leveraging Solar Energy	is a research report exploring opportunities to catalyze growth in the market for PULSE micro-applications, which can be powered by small standalone solar systems.
Efficiency for Access Coalition	Multi-stakeholder coalition focusing on harnessing energy efficiency to accelerate access to modern energy services. PUE projects are the Global LEAP award &Low-energy-inclusive-appliances
PRODUSE	is a joint initiative from ESMAP, AEI and GIZ aiming to gain insights into the interaction of energy access and productive activities. PRODUSE has developed a manual, study and methodology.

PUE Market research | PUE Technologies overview

Productive use of electricity projects can be divided in electricity used for micro, small and medium-sized businesses (MSMEs) in rural settings as well as mechanical processes. For MSMEs electricity sources can be plug-and-play Solar Home Systems (SHS), component-based solar systems, mini-grids and the national grid.

Category	Examples	Comments
Production	Water Pumping solutions	-It involves three key components: the pumping mechanism itself, the pump controller, and the solar energy-generating technology
	Solar Spraying	-Used to spray a variety of chemicals, such as disinfectants, fungicides, herbicides, insecticides, and pesticides. -Some come equipped with integrated lightemitting diode (LED) lights to allow spraying at night.
Conservation	Fridges Freezers	-Includes the preservation of juices, meat, fish, and milk, as well as cooling and ice production. -The medical sector can use them for drug and vaccine storage
Processing	Grain mills Threshing Husking	-Are available in different types, including rice mills, cassava graters, paste makers, crushers, flour mills, and more.. -Current non-solar offgrid milling solutions, such as diesel-powered mills, are not viable in small communities,
	Food dryers	-Large quantities of agricultural products can spoil due to inadequate infrastructure and insufficient processing -Solar food dryers have the potential to prevent food losses, generate income, & promote food security
Livestock & Poultry	Egg incubators Milk chillers Fodder prepartion	-Incubators ensure that eggs hatch in bulk, which is an efficiency that many farmers prefer to the natural hatching -They often result in greater income generation for communities and empower women and youth
Fishing and aquaculture	Cold storage Fishing lights	

PUE Market research | PUE Technologies examples

Irrigation Pumps

Surface water pumps
- Wattage: 75w – 1.5kW
- Head: 6-75m

Submersible pumps
- Wattage: 0.45-22kW
- Head: 4-310m

Other - Livestock

Poultry incubators
- Wattage: 75w – 100W
- Capacity: 48-1000 eggs

Milk machines
- Wattage: 1,1kW
- Head: 20 cows/day

Cooling/Drying

Chilling systems
- Wattage: 40-200W
- Capacity: Up to 45l of milk/day

Refrigeration
- Wattage: 40-400W
- Capacity: 50-400l

Freezing/ice making
- Wattage: 95W
- Capacity: 1.2kg/day

Walk-in cooling units
- Wattage: 2kW+
- Capacity: 9 tonnes+

Fan cooling/drying
- Wattage: <50W
- Capacity: 25-100kg

Agro-processing

Flour Milling
- Wattage: 500-750W
- Capacity: 25 -160kg/hr

Husking/Threshing/Hulling
- Wattage: 100-375W
- Rice Capacity: 35 -70kg/hr
- Maize Capacity: 250kg/hr

Grating
- Wattage: 250W
- Capacity: 100kg/hr

Oil & nut presses
- Wattage: 1.5kW
- Capacity: 20kg/h

Source: PULSE, 2019

Mozambique Agriculture and fishing context

PUE Market research | Agriculture & Fishing Macroeconomics overview

Agriculture

Agriculture is the most important sector of the economy in Mozambique, being a source of subsistence:

- It provides the main source of income for 70% of the populace and 90% of women.
- It is predominantly rain-fed, carried out on farm sizes of under 2 Hectares (Ha) and is characterized by low productivity.
- In 2020, agriculture contributed around 25.58 percent to the GDP of Mozambique

Balance fo trade In USD

Year	2015	2016	2017	2018
Import	946,048	780,001	851,605	1,077,286
Export	587,711	451,569	548,142	552,630
Deficit	(358,337)	(328,432)	(303,463)	(524,656)

Source: Sustenta – Transformando Vidas, Ministério da Agricultura e Desenvolvimento Rural, 2020

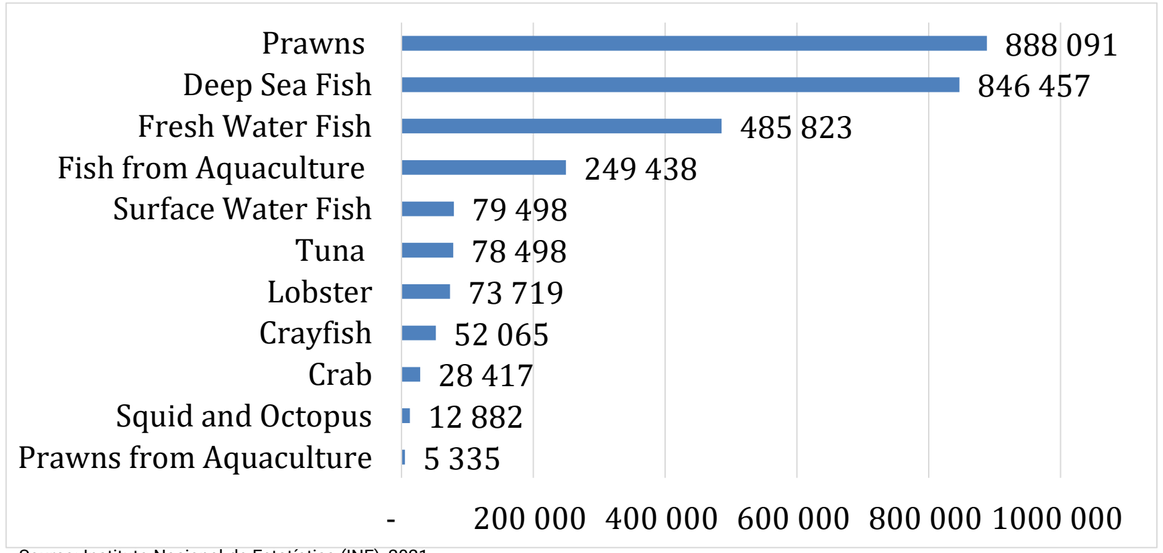
- Food expenditure are about 65% and 40% of the rural and urban families' budgets, respectively
- In spite of the great potential, the country continues with a negative balance of trade
- Government objective is to reduce the deficit and Technology/PUE will play a key role

Fishing

The fisheries sector is another important contributor to the country´s GDP and is the primary source of protein for a significant share of the population:

- 90% of annual fish catch is by artisanal fishing, 7% by industrial fishing
- 850,000 households, or about 20% of the population, rely on fisheries for part of their income
- For industrial and semi-industrial fisheries, products are processed aboard boats, entering inland conservation facilities only for storage and/or transport
- There are an estimated 1,169 fishing centers in Mozambique's coastal provinces - of which around 377 are in interior waters (IPDE,2014)
- Aquaculture is a growing segment of Mozambique's fisheries sector, offering opportunities to intergrade C&I solar across the value chain

Value of industrial and semi-industrial fishing, 2019 (MZN)



Source: Instituto Nacional de Estatística (INE), 2021

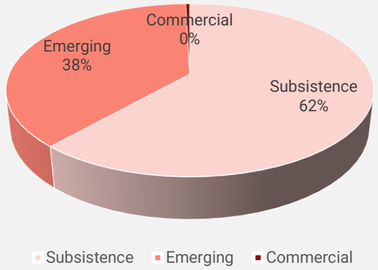
PUE Market research | Agriculture characteristics and key market indicators

Key Characteristics and categorization of Farmers

Exploration Size	Quantities	%
Small	3,962,073	98.70%
Medium	51,872	1.03%
Big	728	0.27%
Total	**4,014,673**	**100%**

Characteristics of explorations by TechnoServe

- 98.7% are smallholder farmers, about 3,9M
- Only about 1% are considered medium or large, this group is mostly focused on high income crops for export
- 29,3% of the small households are led by women



Farmers categorization by TechnoServe

- 61% are Subsistence/Familiar agriculture (<4ha area)
- 38% Emerging ... moving from subsistence to commercial
- 0.43% Commercial (>4ha area explored)

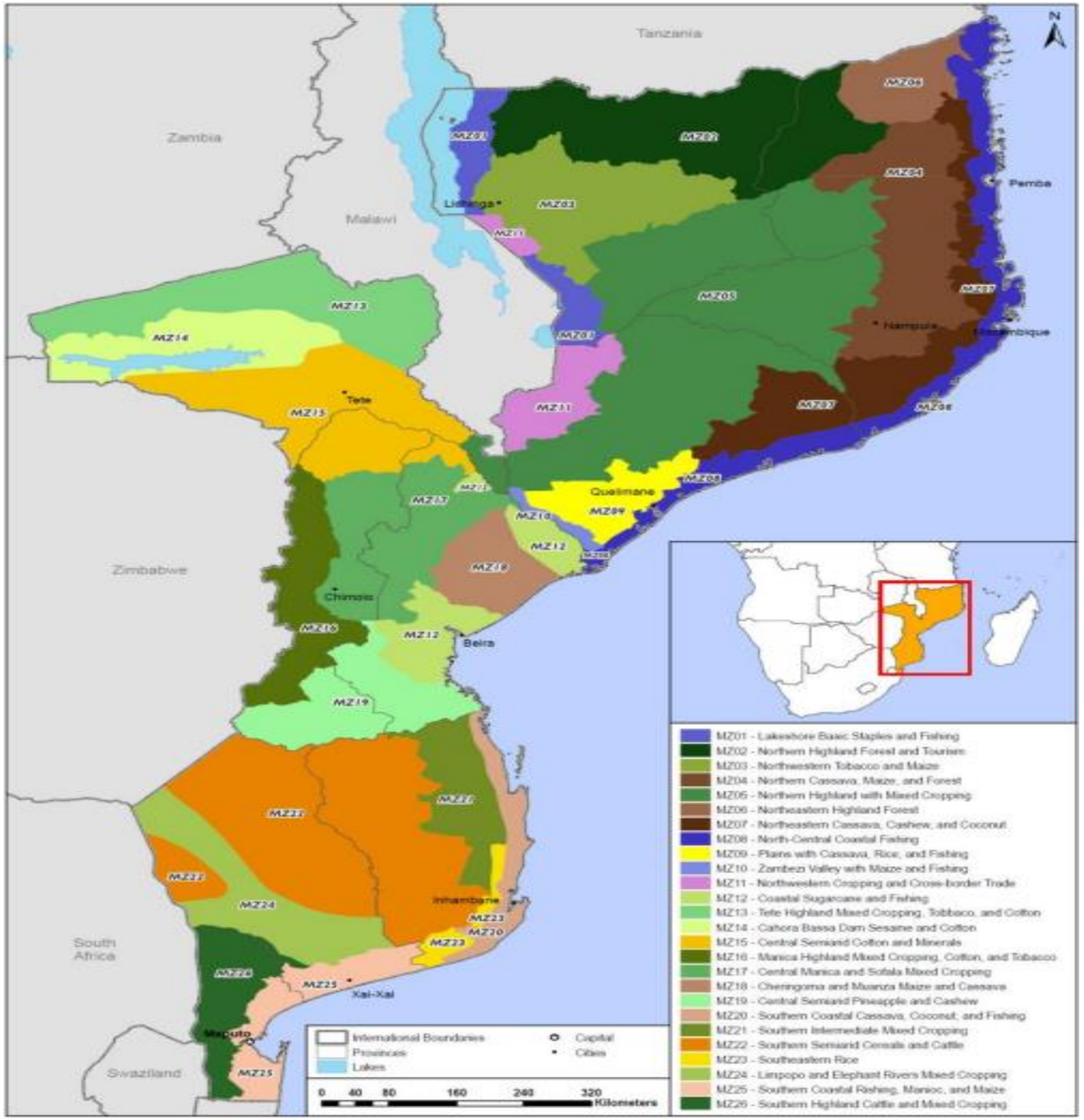
Indicative PUE market sizing

- The data presented on the left and previous pages strengthen the case for supporting off-grid PUE initiatives, since most smallholders are in rural areas working under 1.5Ha
- Total addressable market is 3,962,073 farmers
- Potential costumers with an already commercial behavior 1,505 587 farmers (Total smallholders x % of emerging and commercial farmers)
- This is a conservative approach. Since there is still potential on subsistence/familiar agriculture if right incentive is put in place to enable a commercial approach to agriculture

For Irrigation….

- Backing-out the portion with access to sustainable irrigation (7.3%)(Techno serve WIN report, 2021) number drops to 1,4M potential costumers or systems, considering that those with commercial behavior would not take part of associations

PUE Market research | Livelihood per province

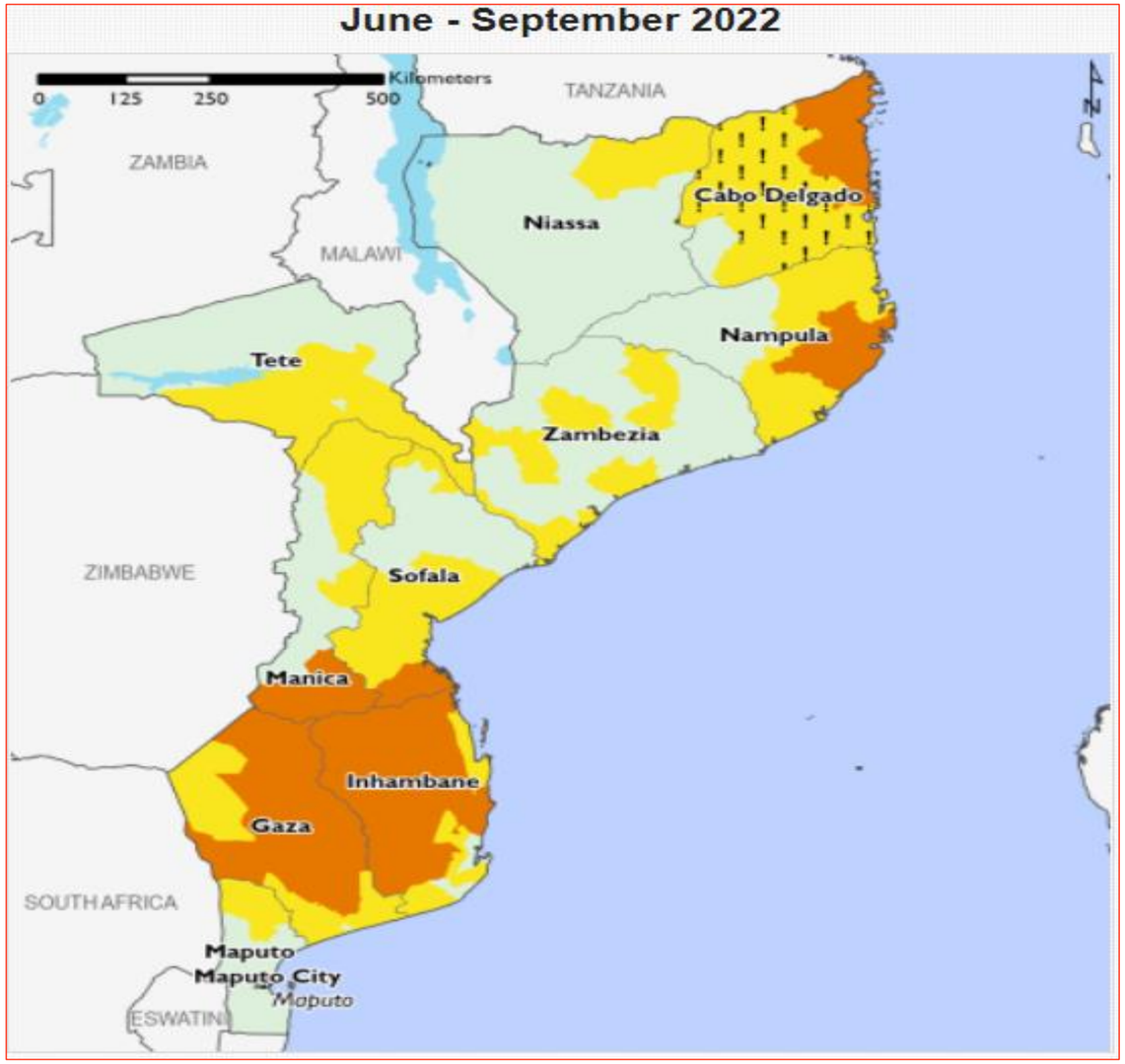


MAP OF LIVELIHOOD ZONES IN MOZAMBIQUE by FEWS NET Mozambique

- The LiveliHood Map matches sources of income and areas of Mozambique
- The data could support Off-grid business at a high level in understanding how to start scoping areas and match it with applicable PUE's technologies
- See below example of livelihoods in 5 Provinces:

Province	Zone
Cabo Delgado	Zone 4: Northern Cassava, Maize and Forest
	Zone 6: Northern Highland Forest
Nampula	Zone 5: Northern Highland and Mixed Cropping
	Zone 7: Northeastern Cassava, Cashew and Cononut
	Zone 8: North-central Coastal Fishing
Niassa	Zone 1: Lakeshore Basic Staples and Fishing
	Zone 11: Northwestern Cropping and Cross-Border Trade
	Zone 2: Northern Highland Forest and Tourism
	Zone 3: Northwestern Tobacco and Maize
Sofala	Zone 10: Zambezi Valley with Maize and Fishing
	Zone 12: Coastal Sugarcane and Fishing
	Zone 17: Central Manica and Sofala Mixed Cropping
	Zone 18: Cheringoma and Muanza Maize and Cassva
Tete	Zone 13: Tete Highland Mixed Cropping , Tobacco and Cotton
	Zone 14: Cahora Bassa Dam Seame and Cotton
	Zone 15: Central Semiarid Cotton and Minerals

PUE Market research | Food security map (Additional scoping criteria for regions?)



Food Security forecast based o- https://fews.net/southern-africa/mozambiquen

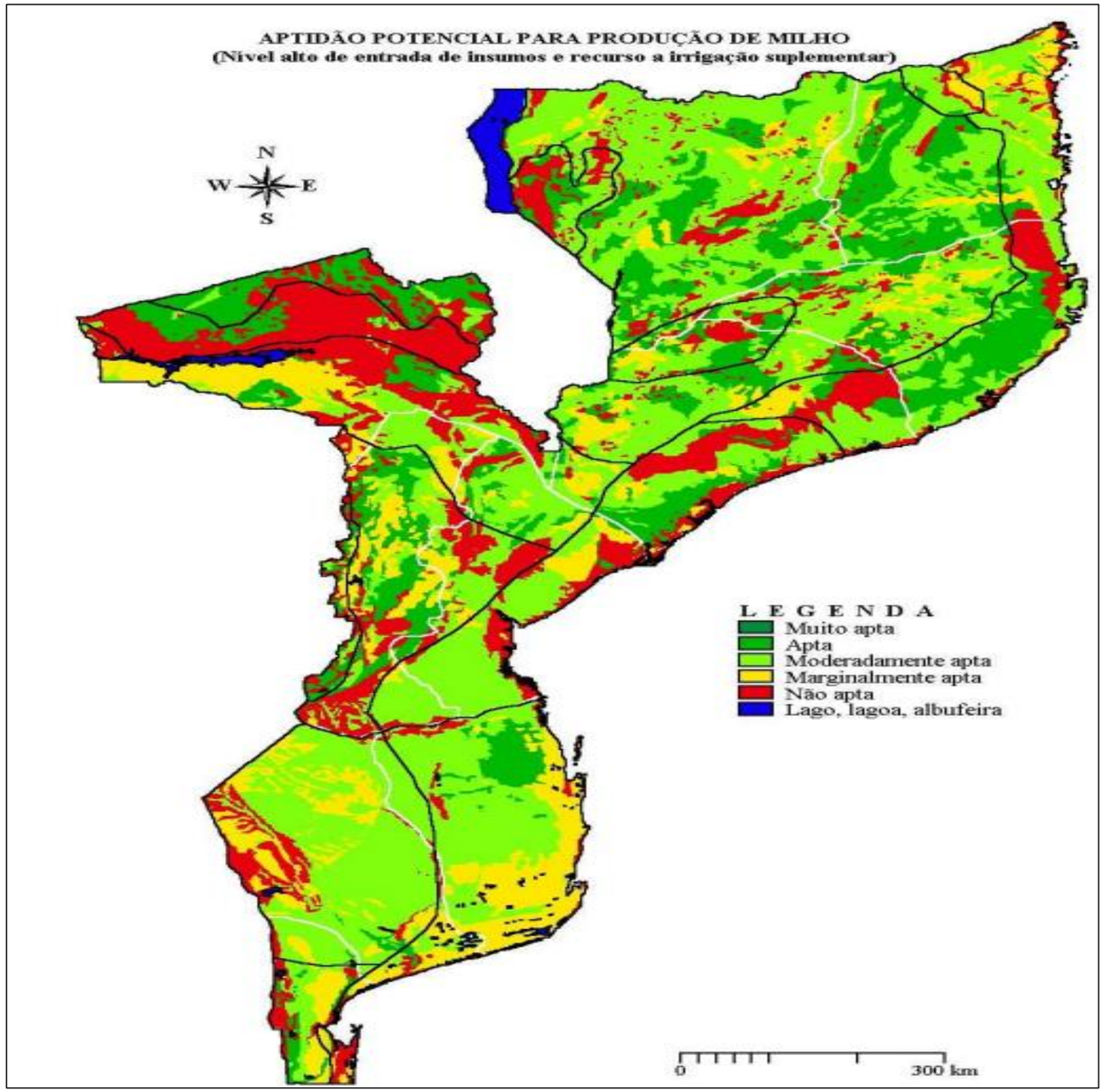
- Map shows periodical food security per province
- Map could support donors & government in understanding areas that could be supported by PUE, with the right incentives in place
- Map is dynamic and cyclical, based on harvest outcomes prediction, but resulting averages could be used to understand recurring weak areas
- It is possible to obtain information at district level, and if feasible could be additional PUE program implementation criteria
- Access: *https://fews.net/southern-africa/mozambiquen*

IPC v3.0 Acute Food Insecurity Phase

1: Minimal | 2: Stressed | 3: Crisis | 4: Emergency | 5: Famine

! *Would likely be at least one phase worse without current or programmed humanitarian assistance*

PUE Market research | Crop irrigation potential per province - Maize



Study and Map produced by IIAM – Instituto Nacional de Investigação Agrária

Considerations & Observations

Map illustrates Maize production potential using irrigation in these provinces:
- Soil type
- Climate characteristics
- Adaptability
- Potential income
- General constraints of implementation of irrigation systems

Based on the study by IIAM the ranking of the provinces with most irrigation potential for Maize crop is as follow:
- # 1 Niassa
- # 2Cabo Delgado
- # 3 Nampula (In scope of Brilho study)
- # 4 Zambézia (In scope of Brilho study)
- # 5 Tete
- # 6 Manica
- # 7 Sofala
- # 8 Inhambane
- # 9 Gaza
- # 10 Maputo

Study available for 6 other Crops to be shared by IIAM

Brilho Research approach: PUE selection process & PUE deep analysis

PUE Market research | Scoping -Selection and prioritization methodology

To identify which PUE's should be prioritized in the Mozambique context, the following approach was utilized:

Stage 1- A long list of 16 PUE was assessed against a set of criteria in order to identify the six with the most potential

Stage 2- Field research & secondary information were used to conduct a more detailed assessment of the six PUE, resulting in the identification of three with the most potential.

Stage 1

- Through desk research by & triangulation with EnDev recent assessment
- Criteria's used Potential scale of application, viability, attractiveness, potential social impact
- Internal discussions & classification into priority categories,

Category	PUE
1	Small Scale Pumping De-husking Grinding De-shelling
2	Oil Extraction Small Scale chilling(Fridge) Pasteurisation
3	Medium scale pumping Poultry Incubation Medium Scale chilling
4	Carpentry Fruit juicing Electric cooking Sugar cane juicing Crop spraying

Result of stage 1 assessment
Small Scale pumping
Oil Extraction
De-shelling
Small scale refigeration/ice making
Fruit juicing
Poulty incubation & heating

Stage 2

- Through field research & secondary information of the 6 selected criteria
- Usage of more detailed assessment approach and revision of criteria's to: Demand, enabling environment, private sector suppliers, impact
- Consideration of the linkages between PUE types & how a PUE may affect the overall environment for other PUE
- Categorization the PUE and then consideration which characteristics were important for BRILHO

Result of stage 1 assessment
Small Scale pumping
Oil Extraction
De-shelling
Small scale refigeration/ice making
Fruit juicing
Poulty incubation & heating

Result of stage 2 assessment
Small Scale pumping
Oil Extraction
De-shelling

PUE Market research | Scoping – Criteria score per PUE

Stage 2 Assessment Results

PUE type	Assessment criteria							
	Local priority*	Potential demand	Affordability	Adoptability	Private sector	Agri market systems	Impact	**Total score**
Solar pumping	Yes	6	2	7	8	7	9	**39**
Edible oil extraction	No	4	3	4	6	4	5	**26**
De-shelling etc	Yes	7	2	7	8	7	7	**38**
Fruit juicing	No	4	10	7	8	2	2	**33**
Small scale refrigeration	Yes	10	10	8	8	5	6	**47**
Poultry incubation	No	4	10	6	6	5	4	**35**

Solar Pumping

Demand… 123,950 farmers in scoped areas. The 4 districts of the study have < 1% irrigation rate (3,539ha). Around 3% for Mozambique, per FAO

Affordability… See business and financial model section

Private sector… 9 suppliers in country. Pump Brands include future pump and solartech and suppliers include SolarWorks

Impact.. It would increase productivity, resilience to climate change, reduce Labor for women /children that collect water from wells etc

De-Shelling

Demand.. De-shelling mainly takes place by hand across all the districts (replicated nationally). It's a process that would benefit multiple crops

Affordability…. See business and financial model section

Private sector…Machines available in Mozambique from private manufacturers who assemble the components by hand or by import

Impact…Reduction of crop losses leading to further increase in income Farmers who will benefit from the improved processing of their products.

Small Scale refrigeration

Demand…For the Nampula and Zambezia(scoped provinces) there are 181 and 206 fishing centers respectively that could be potential clients

Affordability…. See business and financial model section

Private sector..Fridges are widely available & can be provided in country from distributors. While ice-making machineries can be imported.

Impact…. Small Food and drink Retailers, families (who own equipment) and patients and managers of health facilities(where vaccines are stored).

Field research Business & Financial Models: Canvas risk assessment, Financial analysis

PUE Market research | Business Model analysis – Solar water pump – part 1

	Key Partners	Key Activities	Value Proposition
	Who are the important actors for this business?	What are the main activities of your business?	What value do you deliver to the customer?
Analysis/Challenge	The high CAPEX costs coupled with lack of access to finance hinder this PUE. To enable this, farmer associations could be formed, as well as the government and donors easing access to finance and providing subsidies	The two main activities are solar pumping for irrigation for the production of vegetables, and providing a water supply for human consumption, the latter is driven by the need for safe drinking water.	There are economic benefits to be had from increasing food production, through irrigation, and the sale of safe drinking water. The latter could be used to contribute towards O&M costs for both community resources, which could also be combined for efficiency.
Recommendation	Encourage the government and donors to improve access to finance and provide grants and subsidies for this PUE.	Associations need to be connected with relevant bodies that help develop systems to ensure water quality is maintained at required standard.	Support to business management capacity of Farm Associations so that they can manage the different elements of this business together
	Strengthen capacity of existing farmers groups where feasible. Consider support to new farmer groups but with specific attention to good governance and management capacity		

PUE Market research | Business Model analysis – Solar water pump – part 2

	Customer Relationships	Customer Segments	Key Reousrces
	What do you do to retain and satisfy your customers?	What are the different types of customers you have?	What are the resources used to operate the business?
Analysis/Challenge	No incentives such as discounts were provided, but personal relationships with customers are considered vital	Customers are from the same locality. The main customers for solar pumps are farmers, whilst customers for drinking water are evenly spread across the population (age and sex).	The key resources are a solar water pump, and a water treatment plant, which includes a point of sale. These resources need to near the point of use to reduce operating costs, whilst O&M is also a key component.
Recommendation			Support to suppliers (if necessary) to develop effective O&M service and spare parts provision

PUE Market research | Economics- Investment and Financing model – Solar Water pump

Overview & assumptions

$2.1M-2.4M

Investment needed (MZN)

- 2.5 kW pump powered by solar-PV without battery storage
- Water demand 100 m3/ha annually…16.3 m3 pumped water…88% for irrigation/12% drinking water…access to safe water for 1000 people
- Farmer association of 20 members…w/ 1.5 ha/member to be irrigate ~30 ha
- Only Stand-alone includes power source (solar-PV panels and electronics).

Investment summary

	Total Capex	Mini-Grid	Stand-alone
1	Building	65,168	65,168
	Power generation costs	0	255,725
	Equipment costs - water pump	153,435	153,435
	Equip. costs - water treatment technology (OSEC)	191,794	191,794
2	Equipment costs - borehole	543,417	543,417
3	Civil works costs	958,971	958,971
4	Development & Start-Up Costs	286,918	325,277
	Total Investment needed	**2,199,702**	**2,493,787**

	Financing Structure **	Mini-Grid	Stand-alone	% of Capital
5	Business Owner Resources (cash)	219,970	219,970	10%
6	Business Owner Resources (in-kind)	219,970	219,970	10%
7	Grant Subsidies	1,099,851	1,246,894	50%
8	Loan	659,911	748,136	30%
	Sources of Financing	**2,199,702**	**2,434,970**	**100%**

Commentary

1. Larger stand alone system, Using a 4 kW Solar-PV system, w/0 battery.

   Cost breakdown of TOTAL: 4,030 USD (255,725 MZN) :
   - PV: 0.35 USD/W --> 4000W * 0.35 = 1,400 USD
   - Structure and wiring: 300 USD/kW --> 4 kW * 300 = 1,200 USD
   - Transport: 500 USD
   - EPC margin and contingency costs: 30% (930 USD)

2. With a water pumping capacity of up to 16.3 m3/day.
3. Distributed water system, storage & treatment system for drinking water.
4. 15% of CAPEX (human resources, transports, registration, assessment, etc.)
5. Farmer Association of 20 farmers, each providing 10,999 MZN
7. Grants assumed to be available– either from BRILHO or other donor fund

PUE Market research | Economics- Income statement & Payback analysis – Solar Water pump

Financial analysis

Revenues	Mini-Grid	Stand-alone
1 Irrigation and sales of drinking water/monthly	41,450	39,950
Revenue per Year	**497,400**	**479,400**

Operational cost	Mini-Grid	Stand-alone
Raw materials	0	0
Salaries - Manager/sales	54,000	54,000
2 Salaries - Technicians	27,750	27,750
3 Electricity expenditure	37,980	0
4 Maintenance costs	203,557	203,557
5 Other	20,664	20,664
Transport	0	0
Taxes for small contributors (ISPC)	0	0
Loan Interest Payments	19,800	22,440
Total OPEX Costs per year	**363,751**	**328,411**

Economics - Payback	Mini-Grid Option	Stand-alone
Total Investment	2,199,702	2,493,787
Yearly Profit/(Loss)	133,649	150,989
6 Grant - Capex Subsedies	1,099,851	1,246,894
Payback time	**7.2**	**7.3**

Overview & Assumptions

The business plan foresees one revenue stream related to the crop processing service as a proxy, thus setting a unique price and unique quantity of processed crops. However, multiple crop processing could be activated, and this assumption can be split or integrated by multiple revenue streams

1. People served with drinking water is approximately 1,000.
2. Business assumed to employ 1 manager/sales and 1 technical member of staff.
3. 3,165 MZN/month for the mini-grid option. It is estimated considering the energy need to pump 16.3 m3/day of water.
4. Ordinary and extra maintenance, for both options, for the whole system.
5. Food & beverage for personnel, etc
6. Paybacktime of ~ 7 years for both cases, assuming no Margin expansion

PUE Market research | Business Model Analysis – Refrigeration – Part 1

	Key Partners	Key Activities	Value Proposition	Customer Relationships
	Who are the important actors for this business?	What are the main activities of your business?	What value do you deliver to the customer?	What do you do to retain and satisfy your customers?
Analysis/Challenge	Although the PUE has a low financial requirement, finance institutions and energy developers can stimulate development.	Soft and alcoholic drinks will be the main product sold in most businesses. Small scale sales of chicken and fish are also possible. Ice sales will only be significant in off grid areas. Research suggests there is not a large market for milk and juice sales	In off grid areas, the potential to preserve foodstuffs / improve quality is widely recognized and desired. There are real opportunities to use refrigeration to improve the variety of healthy food produce available – although there are also opportunities for refrigeration to drive the opposite (e.g. alcoholic drinks)	In both on and off grid areas, entrepreneurs provide incentives such as discounts, to encourage repeat customers. Personal relationships with customers are considered vital.
Recommendation	Encourage energy developers to include small scale refrigeration in a package of incentives for solar kits or mini grid sign-ups.	Support entrepreneurs to understand key areas of market demand and develop relationships with providers of produce where relevant (e.g. fish).	Support small scale refrigeration can include incentives to use it to increase availability of healthy food, enabling the achievement of nutritional objectives.	Support businesses to develop viable incentive structure. Support capacity development of staff so that they can use the promotion of healthy products to develop good customer relationships and loyalty.

PUE Market research | Business Model Analysis – Refrigeration – Part 2

	Customer Segments	Key Reousrces	Channels	Cost Structure	Revenue Streams
	What are the different types of customers you have?	What are the resources used to operate the business?	What supply and sales channels do your services or products have?	What are the main costs associated with your business?	What are the main products or services that make the most money in this business?
Analysis/Challenge	Customers are all from the same locality and evenly spread across the population (age and sex). No particular segment provides an opportunity for new business development	Shops is a key resource and may be owned or rented. Location of the shop is a critical factor and will have a big impact on sale. On average these retail shops employ 3.4 persons person (in addition to the owner)	Produce will mostly come from outside of the local area. The exception is local perishable products (e.g. chicken). There is little possibility of changing this. Competition from similar outlets is common.	See financial model	This is comprehensively dealt with in section 4.2.3.
Recommendation			Ensure businesses base business plans on understanding of local competition.		

PUE Market research | Economics- Investment and Financing model – Refrigeration

Overview & assumptions

$0.1M

Investment needed (MZN)

- Both scenarios include equipment (fridge), while only Solarkit includes power source (solar-PV panels, batteries and electronics).

Note: freezer is applicable with a similar CAPEX but higher energy consumption

- Tax for small contributors (ISPC) - 3% of revenues
- Purchasing of products from external market set at 40% of sales price. Purchasing of products from internal market (fish and chicken) at 60% of sales price.

Investment summary

	Total Investment	Mini-Grid	Stand-alone
	Building	65,168	65,168
1	Equipment costs	29227	0
	Scales	1,279	1,279
	Setting up and furniture	3,197	3,197
2	Development & start up costs	4,944	5,281
3	Equipment and power sources	0	36,000
	Total CAPEX Costs	**103,815**	**110,925**

	Financing Structure **	Mini-Grid	Stand-alone	% of Capital
4	Business owner equity	20,763	22,185	20%
5	Grant Subsidies	31,144	33,278	30%
6	Loan	51,907	55,463	50%
	Total Sources of Finanicng	**103,814**	**110,926**	100%

Commentary

1. Not applicable for Solarkit option and no fee for mini-grid connection, based on FUNAE advice
2. 5% of CAPEX (development costs: human resources, transports, registration, assessment, etc.)
3. Up front Solarkit costs, 20% of total Solarkit costs
4. 20% of Up-front Capital Investment (excluding monthly lease-to-buy payments). Owner investment payback period is 9 months for the mini-grid and 10 months for Solarkit.
5. 30% of Up-front Capital Investment (excluding monthly lease-to-buy payments). Grants assumed to be available to support start-up – either from BRILHO or other donor funded programmes
6. 50% of Up-front Capital Investment (excluding monthly lease-to-buy payments).

PUE Market research | Economics- Income statement & Payback analysis – Refrigeration

Financial analysis

Revenues	Mini-Grid	Stand-alone
1 Sale of drinks and food stuff	85,869	85,869
Revenues per Year	**1,030,428**	**1,030,428**

Operational cost	Mini-Grid	Stand-alone
Annual energy expenditure	0	72,000
Raw materials	644,160	644,160
Salaries- Business owener	54,000	54,000
2 Salaries Employees	47,436	47,436
3 Electricity expenditure	12,986	0
4 Equipment maintenance cots	6,204	6,204
Other	33,924	33,924
5 Transport	92,739	92,739
Taxes for Small contributors	30,913	30,913
Total OPEX Costs per year	**922,362**	**981,376**

Economics - Payback	Mini-Grid Option	Stand-alone
Total Investment	103,815	110,925
YearlyProfit/(Loss)	108,066	49,052
Grant- Capex Subsedies	31,144	33,278
Payback time	**0.7**	**1.6**

Overview & Assumptions

Sales of the water & soft drinks, alcoholic beverages (beer), basic foodstuff (average values), chicken and fish

1 As in the full PUE report, based on our research, "The average household savings recorded in the aforementioned villages is about 8,000 MZN". According to our experience and taking a conservative 25% of income being spent on food gives: 8,000/4 = 2000 MZN/month --> 43 customers/month.

2 The business employs 2 people, in addition to the owner

3 The 8.44 MZN/kWh is assumed to cost 1,082 MZN/month for the mini-grid option.

4 Based on maintenance costs reported by on-grid businesses, with half assumed to be spread evenly and half incurred in the fifth year. Solar power system maintenance costs assumed to be covered by equipment guarantees and/or Solarkit lease-to-buy payments.

5 9% of the revenue according to on grid data

PUE Market research | Business Model analysis – De-shelling – Part 1

	Key Partners	Key Activities	Value Proposition	Customer Relationships	Customer Segments
	Who are the important actors for this business?	What are the main activities of your business?	What value do you deliver to the customer?	What do you do to retain and satisfy your customers?	What are the different types of customers you have?
Analysis/Challenge	Research shows the importance of finance providers for off-grid areas to assist electricity access. Difficulty in managing seasonal cash flow associated with this PUE is a constraint	Options exist to diversify by either: buying the raw material and selling the finished product; or processing a variety of different crops. The former requires sufficient cash flow (to buy stocks of raw material), the latter requires investment to adapt technology.	On grid entrepreneurs have a much higher understanding of the value added to local customers than off grid entrepreneurs. Unless addressed this gap may be a slight operational risk that impedes the development of good business development and access to finance.	Customers come from local sources for on and off grid enterprises. On grid enterprises offer a number of incentives, including discounts for repeat customers. Personal relationships with customers are critical for retention. Off grid entrepreneurs did not seem to appreciate the potential of these strategies.	Majority of customers are low income farmers, approximately 50/50 male/female split. Enterprises need a business model based on low margins but high volumes. This means developing strong customer loyalty and a good reputation.
Recommendation	- Support Energy suppliers to facilitate Access to finance and integrate this activity in their service package this could be in the form of Energy providers taking on part ownership of some businesses - Encourage Donor programmes to promote interlinkage of partners between different PUE and sectors. - Capacity building programmes to strengthen PUE entrepreneurs' business management to mitigate the off-taker risk and improve Access to finance.	Focus on supporting simple processing service business models to start with. Support enterprises to carry out context specific assessments to explore if other adaptations of the model are viable.	Support to the capacity development of PUE businesses should include the development of an understanding of local customers' needs and potential for value to be added to their livelihoods	As above	Strengthen business management capacity of entrepreneurs so that they can incorporate customer incentives suitable for low income groups.

PUE Market research | Business Model analysis – De-shelling – Part 2

	Key Resources	Channels	Cost Structure	Revenue Streams
	What are the resources used to operate the business?	What supply and sales channels do your services or products have?	What are the main costs associated with your business?	What are the main products or services that make the most money in this business?
Analysis/Challenge	Most important resources are housing, equipment and means of transportation (although cost of this borne by customer). On average this sort of enterprise provides salaries for 2.6 paid employees who are seasonal. There can be concerns about how 'decent' this work is.	Channels are generally very localized with little option for diversity. As a result, local competition and the potential for the local market to be 'saturated' is a critical issue.	This is comprehensively dealt with in section 4.1.3.	This is comprehensively dealt with in section 4.1.3.
Recommendation	Before any support is provided, the availability of an adequate and resilient building should be verified by the energy supplier – so that safe working conditions & the maintenance of equipment can be assured. For this purpose, a budget for building construction is included in the CAPEX. Donor programmes should require supporting documents (e.g. photos & declaration) to assure that subsidies are used to power resilient & durable buildings.	Ensure local energy developer and / or PUE enterprises have carried out assessments of degree of current competition and market saturation		

PUE Market research | Economics- Investment and Financing model – De-shelling

Overview & assumptions

$0.5-0.6M

Investment needed (MZN)

- In the financials both scenarios include equipment (milling, de-husking, de-shelling machineries),
- Only Solarkit includes power source (solar-PV panels, batteries and electronics)
- Tax for small contributors (ISPC) - 3% of revenues
- Subsidies are available to support start-up – either from BRILHO or other donor funded programmes

Investment summary

	Total Investment	Mini-Grid	Stand-alone
	Building	65,168	65,168
	Raw Material	0	0
1	Processing Equipment	404,625	478,725
	Power System	0	0
	Electricity Connection Fee	0	0
	scales	1,279	1,279
	Toolbox	6,393	6,393
	Setting-up and Furniture	3,197	3,197
2	Development & start- up cost	24,033	27,738
	Total CAPEX Costs	**504,695**	**582,500**

	Financing Structure **	Mini-Grid	Stand-alone	% of Capital
3	- Business Owner Equity Investment	100,993	116,500	20%
4	- Grant Subsidies	100,993	116,500	20%
5	- Loan	302,817	349,499	60%
	Total Sources of Finanicng	**504,803**	**582,499**	100%

Commentary

1. At end of 4 year lease-to-buy period, the business owns the Solarkit. (MZN 487,725 paid upfront and 48 x MZN 9,973 monthly instalments, as per note on 'Annual energy expenditure' below).
2. 5% of CAPEX (development costs: human resources, transports, registration, assessment, etc.)
3. 20% of Up-front Capital Investment (excluding monthly lease-to-buy payments). The research found that business owners were not able to afford more than a 20% input, this was the maximum.
4. 20% of Up-front Capital Investment (excluding monthly lease-to-buy payments). Grants assumed to be available to support start-up – either from BRILHO or other donor funded programmes - and set at levels comparable to those seen in similar programmes in Mozambique and elsewhere.
5. 60% of Up-front Capital Investment (excluding monthly lease-to-buy payments). Interest rate as per BCI Eco Ambiental terms. This includes the costs of 15% interest rate repaid over 60 months.

PUE Market research | Economics- Income statement & Payback analysis – De-shelling

Financial analysis

	Revenues	Mini-Grid	Stand-alone
1	Crop processing services	54,000	54,000
	Revenues per Year	**648,000**	**648,000**

	Operational cost	Mini-Grid	Stand-alone
2	Annual energy expenditure	0	119,681
	Raw Material	0	0
	Salaries - Business Owner	66,792	66,792
3	Salaries - Employees	55,500	55,500
4	Electricity expenditure	110,256	0
5	Equipment maintenance	16,998	16,998
	Other	30,996	30,996
	Transport	0	0
	Taxes for small contributors(ISPC)	19,440	19,440
	Total OPEX Costs per year	**299,982**	**309,407**

Economics - Payback	Mini-Grid Option	Stand-alone
Total investment	504,695	582,500
Yearly Profit/(Loss)	348,018	338,593
Grant- Capex Susbesides	100,993	116,500
Payback time	**1.2**	**1.4**

Overview & Assumptions

The business plan foresees one revenue stream related to the crop processing service as a proxy, thus setting a unique price and unique quantity** of processed crops.

1. 216,000 kg/year are processed in the business model. In 2013/14, a total of 30,000 farmers produced approximately 50,000 MT on 39,000 ha of land (Perreira, 2015) -> 1.67 MT/farmer -> 1.67*1000 kg/farmer -> 1,670 kg/farmer. Thus, 216,000 / 1,670 = 129 -> about 130 farmers per year

2. This amount is paid each year for 4 years, based on 9,973 MZN per month, as per note above in 'Processing Equipment'

3. The business employs 2 people, in addition to the owner

4. Mini-grid cost based on electricity consumption from on-grid businesses surveyed, with 8.44MZN/kWh tariff as advised by FUNAE. Solarkit electricity costs covered by up-front capital costs and monthly payments as in Capex above

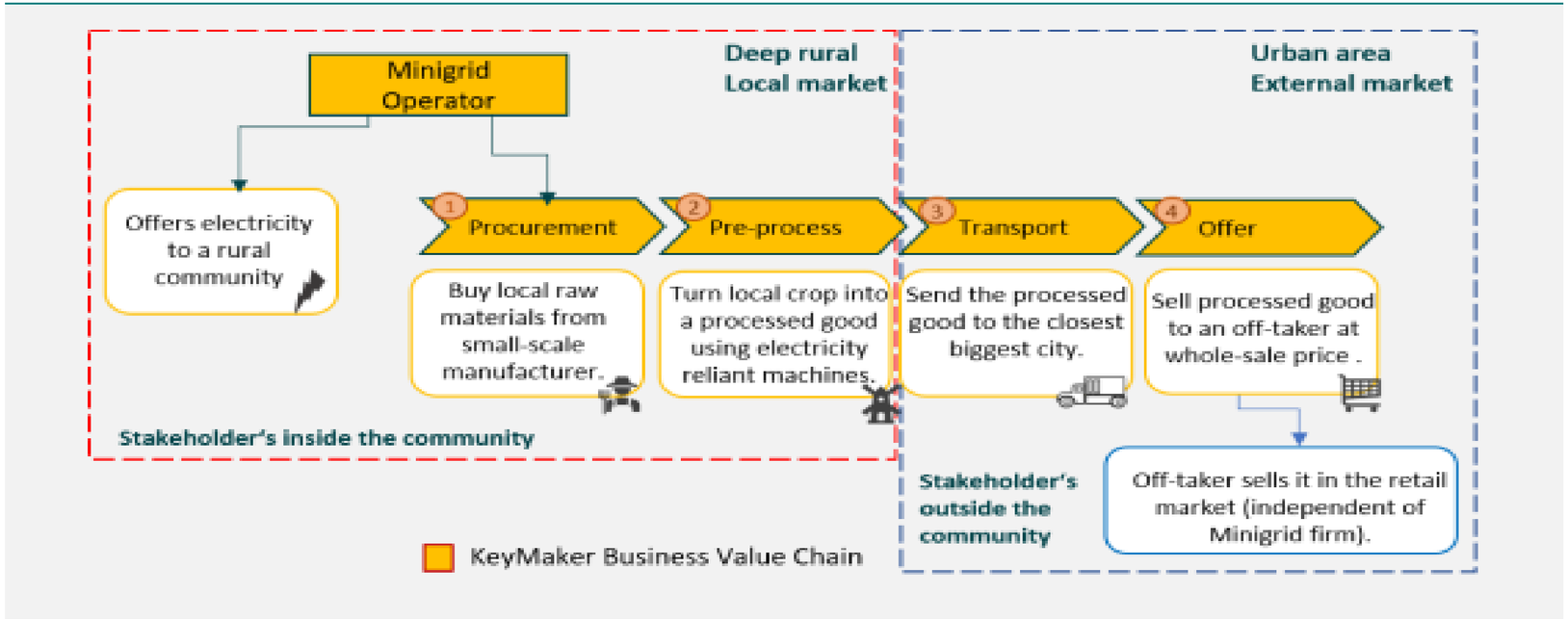
5. Based on maintenance costs reported by on-grid businesses, with half assumed to be spread evenly, for ordinary maintenance, and half incurred every fifth year, for extra maintenance

Other Models & Key considerations: Fundamentals to business models & Keymaker model example

PUE Market research | KeyMaker Model overview

The KeyMaker Model enhances a mini-grid company to expand from generating and offering one service -electricity- together with another complementary pre-processed good in two different markets. On top of that, the mini-grid firm opens a second business line, where it self-manufactures local raw materials and becomes a supply-chain manager of a local-resource product to be offered in a regional or national external wholesale market.

KeyMaker Value chain



Source: Keymaker model fundamentals, 2019

- Mini-grid firm offers, as usual, electricity to a rural community,
- Second step.. it buys pre-processed input raw materials to local small-scale manufacturers,
- Then the KeyMaker further manufactures the good (to a certain stage) using electricity-reliant machines.
- After the KeyMaker good is ready, the developer also transports it to the closest biggest city, where it is sold to an external off-taker.
- In this way, the developer produces electricity & processes goods locally, but distributes electricity in the local market (rural community) and distributes KeyMaker good in an external market (peri-urban market)

Appendix

PUE Market research | Tools to evaluate energy interventions & investments in Agriculture

Per FAO, the possible energy interventions along the agri-food chain are numerous and at times there is a need to prioritize them based on certain criteria. Several tools are available (some are available at no cost) to assist decision making on energy interventions & assess the most suitable and/or profitable options.

Summary of Tools developed by FAO

Type of Assessment	Tool
Value Chain Analysis	FAO Value Chain Analysis
Techno-Economic assessment of energy interventions at various steps of the agri-food chain	RETScreen (Software Suite) HOMER RAPSIM Energy Efficiency Benefits Calculator Diagnostic Tools for Investment (DIT) Power Irrigation Tool
Bionergy techno-economic assessment (biomass from agricultural sources)	Bioenergy Assessment Model (BEAM) BEFS Rapid Appraisal (Software Suite) Bio Chains Economic Evaluation (BEE)
On-Farm assessment	FARMDESIGN Farm Energy Analysis Tool (FEAT)

- FAO has developed a Value Chain Analysis (VCA)3 tool for decision-making that can be used for project-level decisions. Analyzing impacts of policy options through value chains provides policy makers and other stakeholders with anticipated evidence on likely changes directly induced by policies
- For energy techno-economic analysis & optimizing micro-grids or hybrid energy systems include RETScreen, HOMER and RAPSim. All these tools facilitate the decision making process at the project level, with a pure technoeconomic analysis
- Other tools such as the Farm Energy Analysis tool, are specific for on-farm operations and can be used for techno-economic analysis of both energy interventions and bioenergy production on-farm, although not in great detail. They can provide an assessment of how on-farm operations are affected by a change in direct and/or indirect energy inputs, including the associated economics.

PUE Market research | PRODUSE PUE implementation & evaluation toolkit

PRODUSE is an joint initiative by GIZ and EUEI PDF to broaden the knowledge about the background and the promotion of Productive Use of Energy. Its main objective is to close the existing gap of the lack of documentation of empirical analysis on how to practically promote the PUE for development practitioners. With this in mind, PRODUSE developed 2 critical manuals that can be consulted before, during and after a PUE initiatives:

A Manual for Electrification Practitioners

The document provides a simple framework and a systematic step-by-step approach with practical advice on how to plan, promote and implement productive use components in various electrification programs. Below are some examples of key modules explored on the document:

Feasibility and initial planning

- Module1: Decision making on whether to engage in PUE. E.g: How to develop Concept note, deciding if there is a case for PUE promotion
- Module2: PUE program cornerstones E.g: Objectives &Scope definition

Programme Design

- Module3: Analyse local economic structures & potentials for PUE
- Module4: Plan productive use promotion activities

Implementation

- Module5.4: Facilitating access to Finance
- Module5.3: Technical assistance to micro/Small medium enterprises

Monitoring & Evaluation

- Module6: Ensure Monitoring & evaluation.E.g: How to collect data

Access:http://produse.org/imglib/downloads/manual/euei_productive_use_manual_med.pdf

Measuring Impacts of Electrification on MSME's

Study objective was to (a) gain insights on the interaction between electrification and productive electricity usage by examining the impact of electrification on micro-enterprises and (b) improve the available toolkit for the impact evaluation of electrification programmes

- Literature review of electricity impact on economic development
- Methodology to assess linkage between electricity and income generation
- Electrification and Firm performance in Rural Benin
- Electrification and Firm performance in small manufacturing and services firms in Ghana
- Micro-Enterprise electricity usage in 2 export oriented fishing communicates at Lake Victoria, Uganda
- Impact Monitoring and evaluation of productive electricity use- an implementation guide for Project manager

Access:http://www.produse.org/index.php?lang=eng&page=5

Obrigado / Thank You

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