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Milling as a Productive Application in Green Mini-Grid (GMG) Systems

Practitioner Guide

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Practitioner Guide:
Milling as a Productive Application in Green Mini-Grid (GMG) Systems

Written and edited by the GMG Facility Kenya

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The contents of this document are the sole responsibility of the GMG Facility Managing Entity for a Financing Program aiming at the promotion of private initiatives in green mini-grids improving access to electricity in Kenya and may not, under any circumstances, be considered as a reflection of the opinion and the official position of the AFD, DFID and/or EU-AITF.

The milling guide is a support tool and should not be considered legal or strategic business advice. It is assumed that practitioners have:

1. Conducted technical and financial feasibility analysis specific to their company/situation.
2. Carried out adequate due diligence, including legal requirements.
3. Consulted the relevant communities to seek informed consent.

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The Green Mini Grid Facility Kenya avails funds and supports green and sustainable mini-grid electrification in Kenya. The Green Mini Grid Facility Kenya provides technical assistance, investment grants and output-based grants to catalyse investment in this sector while providing support to the Kenyan National Electrification strategy. The Green Mini Grid Facility Kenya is supported by DFID and the European Union African Infrastructure Trust Fund (EU-AITF) with the Agence Française de Développement as the implementing partner for the facility.

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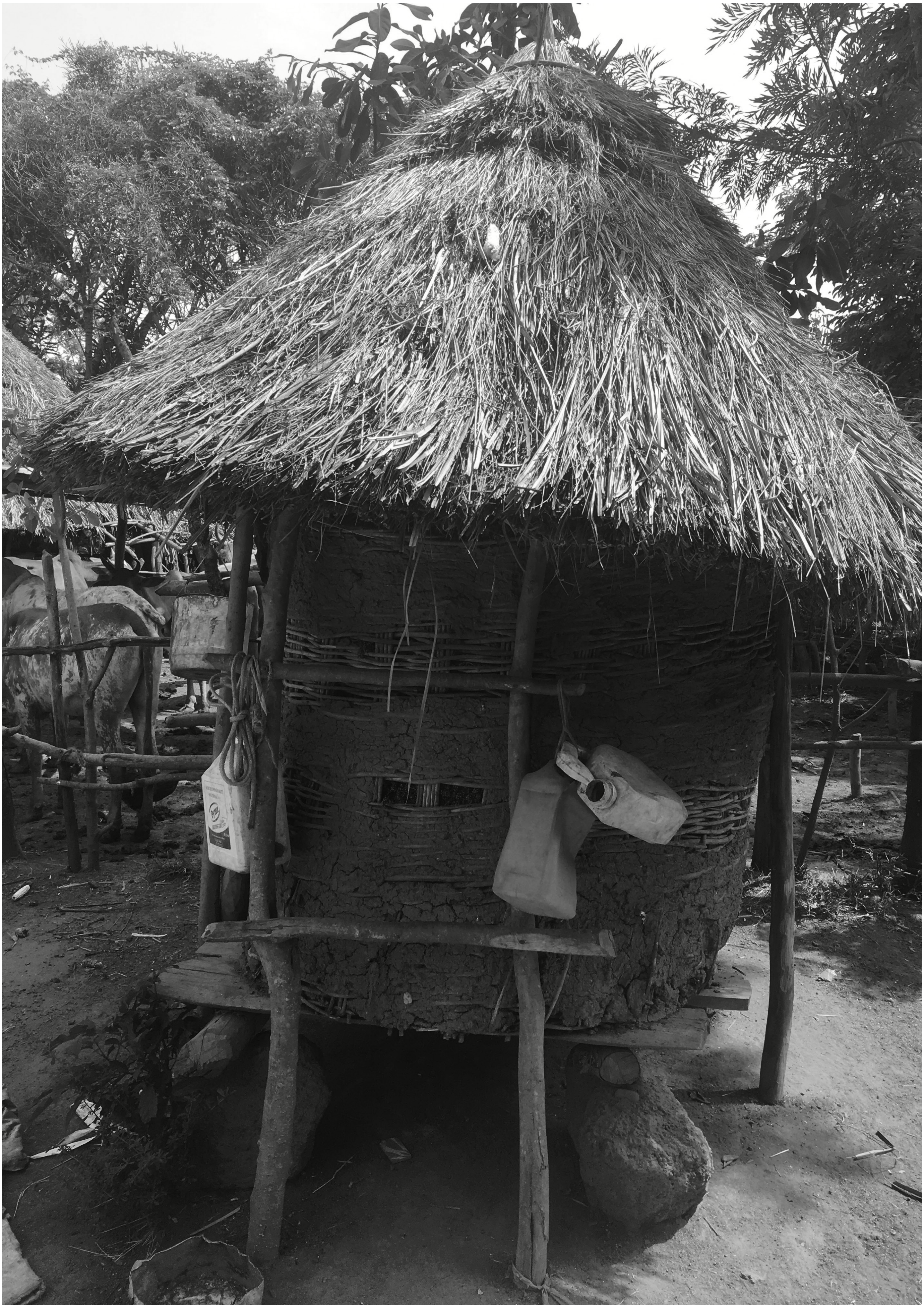
List of acronyms

AC	Alternating current
AFD	Agence Française de Développement (French Development Agency)
BoP	Bottom of the pyramid
CAPEX	Capital expenditure
CBO	Community based organization
DC	Direct current
DFID	The Department for International Development
ESIA	Environmental and Social Impact Assessment
EU-AITF	European Union - Africa Infrastructure Trust Fund
GAPs	Good agricultural practices
GMG	Green mini-grid
hrs	Hours
IRR	Internal rate of return
KEBS	Kenya Bureau of Standards
kg(s)	Kilogram(s)
km	Kilometer
KPI	Key performance indicators
kW	Kilowatt
kWh	Kilowatt hour
kWp	Kilowatt peak
LCOE	Levelized cost of energy
M&E	Monitoring and evaluation
MT	Metric tonnes
NCA	National Construction Authority
NGO	Non-governmental organization
NPV	Net present value
O&M	Operations and maintenance
OAF	One Acre Fund
OSHA	Occupational Safety and Health Act
OPEX	Operational expenditure
PU	Productive use activity
PV	Photovoltaic
SACCO	Savings and credit cooperative organization
SHS	Solar home systems
SMEs	Small and medium-sized enterprises
TA	Technical assistance
USD	United States Dollar
VFD	Variable Frequency Drive
W	Watts



Introduction

Productive uses of energy refer to the utilisation of electricity for income and employment generating activities. Productive use activities (PUs) can be a catalyst to rural development and sustainable economic growth, providing opportunities for job creation, skill development, increased income, market access and reduced vulnerability. PUs can also accelerate the success of green mini-grid (GMG) projects, by increasing demand for energy and increasing household income, thereby enabling people to purchase more energy and 'climb the energy ladder'.

This guide is designed to provide support to practitioners to make effective decisions and aid in implementation of PUs. In order to catalyze economic development in a community through PUs there are many variables and complex dependencies that must be addressed by multiple stakeholders including mini-grid developers, financial institutions and small to medium enterprises (SMEs). Cottage industry activities tend to be easier to set up and generate faster returns from integration with clean energy solutions, than large, capital intensive PUs that tend to need more resources and have a longer break even period. Financial viability of any PU is essential to ensure the benefits reaped by the community are sustained and to ensure mini-grid developers can effectively provide the quality and quantity of energy needed.

This guide is designed to provide support to practitioners to make effective decisions and aid in implementation of PUs.

A green mini-grid in a rural community

Purpose

The guide is the result of the GMG Facility Kenya's extensive work to support mini-grid developers and the mini-grid industry at large to address sector level barriers to expanding off-grid electrification, with an emphasis on increasing market access and social inclusion for bottom of the pyramid (BoP) consumers and businesses. A Sector Mapping conducted in 2017 highlighted that practitioners had a limited understanding of how productive use activities should be integrated into mini-grid planning and operations. This Guide is the final product of a technical assistance (TA) project that seeks to address this barrier.

This guide aims to help practitioners assess whether milling is an appropriate, beneficial and financially viable productive application, both for a community and for a mini-grid developer. It also provides guidance for practitioners on how to operationalize a milling PU, recognizing the complexity of doing so.

This guide is organized as a series of tools that can be applied independently or together, based on the individual needs of the practitioner, the objectives of the activity, and the participating community's circumstances. It establishes a set of best practices to be considered and is not an exhaustive list of how to integrate PUs into off-grid electrification initiatives.

Grain milling and its scalability potential is an attractive PU option for mini-grids

Who should use this Guide

The guide is relevant for practitioners involved in rural electrification initiatives, including:

- Mini-grid developers
- NGOs and donors working to increase rural electrification and pilot or implement PUs
- Investors in mini-grid companies and projects in rural areas.
- Communities interested in attracting a mini-grid developer to partner on addressing electrification needs.
- Government officials and regulators setting policy on green energy development activities.
- Companies seeking to partner with mini-grid developers to establish or grow their businesses, such as productive use technology companies.

Ideally the guide should be used during the feasibility stage of development for mini-grid developers, as the tools offer important considerations that will help in the decision-making process for practitioners to ensure more accurate assessment of demand when considering sites; ultimately improving success for the communities that benefit from rural electrification. However the tools are also designed to be used as a resource in areas where a mini-grid is already operating.

This guide is organized as a series of tools that can be applied independently or together, based on the individual needs of the practitioner.

How to use the Guide

The guide includes five separate tools that can be used independently, as needed by the individual user. It is organized sequentially so that if a practitioner is starting the process from scratch, the guide will help them to follow from business case assessment (economic feasibility) to business model design, implementation and monitoring.

Where possible, examples are included to describe concepts and if appropriate, templates are provided. These are intended to be adapted by the user, depending on specific contexts.

This guide will help practitioners follow from business case assessment to business model design, implementation and monitoring.

Contents of the Guide

Tool 1:

Feasibility checklist to help practitioners determine whether a milling PU is viable within their context.

Tool 2:

Business model guidance to help practitioners identify the most appropriate business model for the productive use application. It focuses primarily on the ownership configurations, which involves partnerships with other actors. The tool also provides tips on effective community engagement.

Tool 3:

Technical considerations and requirements to highlight considerations for equipment conversion or reconfiguration and provide guidance on mini-grid sizing.

Tool 4:

A detailed plug-and play financial model that allows practitioners to assess various scenarios based on the business model options in Tool 2 and anticipate costs, revenues and future investment needs.

Tool 5:

Guidance on monitoring and evaluation, including suggested indicators and data collection tools and processes.

Overview of the milling value chain (maize as proxy crop)

Maize is the most cultivated and consumed crop in Kenya

Maize is the most cultivated and consumed crop in Kenya, providing about 65% of staple calorie intake to the Kenyan population. The majority of rural and urban households, across all income groups, consider maize and maize meal as important items in their food basket. Data analyzed from FAOSTAT shows an average of 3.6 million metric tonnes are produced in Kenya annually, with an average yield of 1.67MT/ha that is lower than Eastern Africa's average yield of 1.82MT/ha and a global average of 5.4MT/ha. The country produces enough maize to feed the population based on estimated per capita consumption but when other uses like seed, feed and manufacturing are considered, the supply falls short of demand. This gap is met by regional imports and in times of severe deficit the government typically waives import duty to allow maize from other countries.

Maize in Kenya is commonly consumed in the form of maize flour for *ugali* and porridge making it the most milled grain.

Maize in Kenya is commonly consumed in the form of maize flour for *ugali* and porridge making it the most milled grain, hence its availability and access is key to the success of setting up a milling enterprise. Maize flour consumed is either in the form of sifted flour processed by large scale milling firms or the less refined whole meal or grade one flour from hammer mills, popularly referred to as *posho* mills, owned by micro-entrepreneurs. Although increasing in prominence in the rural areas, sifted maize flour is consumed by only 26% of the rural households, making the straight-run *posho* maize meal the most popularly consumed in the rural areas.

Given the wide practice of grain milling and its scalability potential, it is an attractive PU option for mini-grids in locations where maize production is widely practiced and conventionally consumed.

The maize value chain is quite complicated with many participants and cross-relations. The following table looks at the various stages in the maize supply chain and the significance of each stage to the milling process.

Value chain point	Characteristics	Significance to milling PU
Input supply	Seeds and fertilizer sourced from local agro-dealers. Though improved seed is highly adopted, purchase of fertilizer is minimal with most farmers citing high costs.	Compromise on input quality affects yields which results in lower harvests and consequent low availability of maize for milling throughout the year
Production	Cultivation is mainly small-scale and manual. Maize is produced in two seasons annually, with the long rains season yielding more production than the short rains due to adequacy of rainfall. Sporadic drought conditions in the recent past have resulted in significant crop failures	Good agricultural practices (GAPs) during production enhances productivity thus increases the amount of maize available for consumption. Overdependence on rain results to low yields or total crop failure in case of severe droughts causing maize shortage and increasing market prices
Marketing	Farmers sell their surplus to local village aggregators who collect and bulk for sale to both wholesalers and retail traders in the local market. Small scale farmers sell their maize when prices are lowest immediately after harvest to meet pressing cash needs or for fear of losing it to storage pests due to lack of appropriate storage facilities.	Most households consume their post-harvest stored reserves for milling. However, often, the stored grain does not last till the next season hence they have to buy their rations from the market for milling. The higher the prevailing market prices the less grain quantities bought, and consequently less quantities milled.
***Posho*-milling**	*Posho* milling happens throughout the year since families consume *ugali* daily –mixing maize with sorghum and dried cassava to make a more nutritious *ugali*. Unlike commercial millers, *posho* millers do not package, distribute or sell flour; instead clients bring in their own grain for milling and pay for the service provided.	The *posho* millers mill higher volumes and run for more hours immediately after harvest when grain availability is high then gradually dwindles in three months till the next harvest.

Value chain point	Characteristics	Significance to milling PU
Consumption	Sifted and readily milled flour is mainly consumed in urban centres - rural folk prefer milling their own maize because it is perceived as healthier and it is also cheaper to buy grain and mill rather than purchase readily milled flour. Urban households that may not have time to buy and mill their own grain purchase milled flour from retail stores that mill various flours and mix them for sale to consumers.	During off-season, when families deplete their stored grain, households reduce the quantity of maize meal they consume since they need to purchase it when prices are higher. This directly leads to less milling.
Value chain support	While there are some public and private sector entities that aim to improve efficiency in the value chain through provision of a range of business development services, these are few and far between. Support services include extension to farmers, inputs financing (seed, fertilizer, storage) and crop insurance.	*Posho* mill owners also receive financing mainly from micro-financing entities to purchase the hammer mills. However in most cases, this is facilitated by another revenue stream alternative to the milling e.g. salaried employment.

There are a number of constraints that impact on value delivery and efficiency in the maize value chain. In table below we discuss their impact on milling and propose corrective measures to mitigate their effect.

Constraint	Impact on milling PU	Corrective measures
Seasonality	Since production is not year-round, seasonal fluctuation of maize availability at the household level directly impacts on the frequency of milling and quantity milled.	Enhanced production know-how aiming to increase productivity will improve maize availability at the household level hence have more grain to last before the next harvest and help smooth out availability of maize to year-round.

Constraint	Impact on milling PU	Corrective measures
Low maize quantities	This is caused by a combination of factors, including insufficient rainfall, small land sizes, poor agronomic practices, low soil fertility, inadequate use of quality seeds, striga weed infestation and low adoption of fertilizer use due to high costs. This affects maize quantity available for milling.	Extension support for GAPs and improved access to quality inputs through farmer friendly credit support are key. With land size constraints and only 17% of Kenya suitable for rain dependent agricultural production, improved maize yields on existing cultivated land will generate the extra-required maize, addressing seasonal gaps highlighted above while providing income opportunities from surplus sales.
Post-harvest storage	Whether producing surplus or not, some farmers sell off their maize immediately to avoid post-harvest losses as a result of weevil infestation due to poor storage practices. Keeping very little for household consumption results in purchasing when maize prices are high leading to reduced household rations and less milling.	With increased production outlined above, there is need to promote storage technologies appropriate for small-scale producers e.g. hermetic bags that facilitate household-level storage and have been tested and proven to be effective if used correctly. This will assist families to keep their maize for longer without having to sell it prematurely hence ensuring extended household availability as well as reducing expenditure spent on buying maize. Improved production and better post-harvest storage will also facilitate selling of maize at better prices during shortage, assuming no immediate cash needs compel premature sales.
Competition	In some areas, the number of *posho* mill businesses in the same locality are within walking distance to each other hence compete for the same few clients in the village. Given the low maize supply context, this presents a challenge of milling sufficient quantities to break even and realize some profit.	*Posho* milling business has no entry barrier as long as one has capital to invest in the hammer mill. Therefore this, coupled with the perception of demand for un-sifted flour, it is a quick investment for an entrepreneur to make. Being a free market, number of businesses cannot be controlled, however one can offer value added service to keep their existing customer base and attract new clients.

Case Study Introduction: Developer Y In Busia County

Busia County is located in Kenya's western region. The main economic activity here is trade between neighbouring Uganda and Busia town - the county's administrative headquarters and largest town. Away from the urban setting, the county's economic mainstay is agriculture and fishing, with cassava, millet, sweet potatoes, beans, maize and sugarcane being the principal crops.

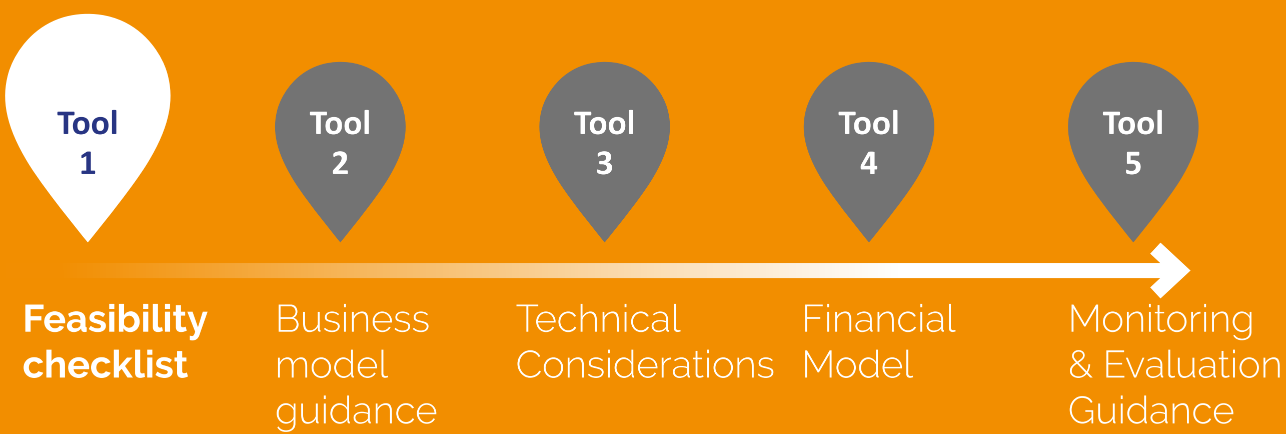
In a village in Busia county, within Funyula sub-county, there are approximately 170 households mainly producing maize, beans and cassava and with two cows on average for the households' daily milk consumption. Families in this locality consume *ugali* often if not daily, warranting frequent visits to the *posho* mill as freshly milled flour is preferred, rather than milling in bulk and storing flour. Maize is produced in two seasons annually, with the long rains season yielding more production than the short rains due to adequacy of rainfall. *Posho* mills are used intensively immediately after harvest for approximately three months, after which milling frequency and volumes drop until the next harvest (about three months later).

Seven years ago, Developer Y set up a solar-powered mini-grid in the village. The mini-grid distributes electricity for household consumption to the community with 152 households currently connected. The mini-grid comes as containerized solution: it has an installed solar capacity of 7.5 kWp and delivers AC power for about 600 kWh per month.

Furthermore, it powers several enterprises including a village cinema hall, hair salon, restaurant, a juice parlour, a water purifying business and two shops.

Building on this success, Developer Y has identified ten new sites that will enable electricity distribution to 15 neighbouring villages targeting some 1,800 households. After having assessed the economic activities in the selected sites, Developer Y has identified milling as a potential productive use activity. An opportunity was identified to connect existing millers running diesel-powered hammer mills to the mini-grids, as well as support enterprise owners who can purchase appropriate electric mills to be powered by the mini-grids. Though it is fundamentally hard to make milling business connected to a mini-grid a viable PU activity, it does present a huge opportunity due to the extensive use of *posho* mills in rural Kenya. The mills will create employment, increase economic and commercial activity within the community, and also generate additional energy demand to support the viability of the mini-grids.

Tool 1: Feasibility checklist



Purpose

At the early stages of mini-grid development, developers conduct in-depth feasibility studies that include demand assessments, cost/benefit analyses, environmental impact assessments, community consultations, and a host of other studies and diagnostics needed to assess business viability and ensure compliance. However, these assessments rarely allow for a meaningful consideration of opportunities to integrate productive uses of energy and the feasibility of various PUs.

This tool is designed to help practitioners who have identified milling as a potential opportunity in a particular context to understand the financial and socio-economic potential of a milling PU integrated with a mini-grid. The checklist highlights questions to be answered, key data points to be collected and unit economics needed for the success of a milling business. It will enable practitioners to make an informed decision on whether to proceed further with a milling PU.

The checklist can be used by those contemplating developing new mini-grid sites as well as those evaluating PU opportunities in existing sites. It is designed to be used as a first step decision tool before investing extensive time, money and effort in setting up a milling PU.

This tool is designed to enable practitioners to make a decision on whether to proceed further with a milling PUs. It helps to understand the financial and socio-economic potential of a milling PU integrated with a mini-grid.

Feasibility Checklist

Consult communities to confirm interest

It is essential to the success of any PU activity that it is relevant to and sought by a community. Community engagement meetings and focus group discussions help to ascertain whether residents are interested in milling facilities in their community. Engaging community members to hear their views on their energy needs, gauge support levels for the mini-grid and assess demand for the PU, and doing so from the outset, will help prevent conflict and complexities that could contribute to the failure of the project.

Mobilizing participation is best done by engaging with community leaders. Examples of discussion points include:

- Ask community members (men, women and youth) to explain their understanding of productive uses of electricity. Ask the community to explain the reasons why it is important to promote productive uses of electricity.
- Discuss with the community what productive activities are generally undertaken by men, women and youth in the community, and the types of energy used; and whether their productivity can be improved if electricity was accessible.
- Discuss with the community other new productive activities that they could undertake if electricity was available. This will provide insights into community perspectives without preferences of the mini-grid developer having an influence. If milling is highly rated then the PU will be addressing an existing community need. If not, do they perceive milling services as a necessity in their community? If the answer is still no, then community uptake of the services might be problematic.
- Ask the community if milled grain is a key component of their family meals. If yes, then demand for milling services is explicit and if not the PU application may not be relevant.
- Additionally, when considering sale of flour other than milling as a service, it is key to understand whether the community prefers milling their own flour versus buying ready-milled flour to gauge initial market reception.

The GMG Facility has several resources to assist with community engagement, including the community engagement section in Tool 2 and the Facility's Manual of Procedure, Guidelines to improve the social and economic impact of GMG projects (July 2017) which includes con-

Key Steps in Value Chain Analyses

1. Identify value chain to analyse
2. Map out different stages of the chain and how they link to one another
3. Identify actors involved at each stage and their roles
4. Describe the support environment that facilitates business development and operations
5. Indicate existing opportunities that would foster business growth
6. Highlight constraints in the chain that will impact on capacity utilization and explore solutions

siderations on social/gender inclusion and mainstreaming in design, development and management of proposed interventions, to enhance communities' participation in decision making and support economic opportunities for communities.

Conduct value chain(s) analysis

A value chain analysis gives insights into opportunities and gaps that would either support setting up a milling PU activity or identify alternative options that are more viable for the mini-grid developer's context. It will also reveal any activity linkages where the impact on milling might not be obvious, for example by highlighting how input supply is linked to grain production levels and how that ultimately impacts on milling due to adequacy of raw material supply. The value chain analysis should concentrate on the most milled grains since their supply affects intensity of business activities and consequent demand for power.

Assess the market potential

For the milling PU to be viable, the mini-grid site must be located in an area where the population's consumption of milled grain is high, and therefore there is demand for milling services. For a milling enterprise to be successful, two key considerations should be addressed: i) availability and accessibility of raw grain and ii) proximity to milling customers/consumers.

Key information needed to address these considerations include:

- How much grain does the target community mill in a week or month? This information can be collected by engaging women focus groups who give household-level data, whose average can be used to extrapolate to the larger community population. For a milling PU to be viable, a minimum of 11kgs (assuming a 7kW electric mill) needs to be processed per day.
- What are the consumption trends and preferences in the target community that might impact on the milling business? For example:
  - Is consumption of milled grain the same all year round or does it increase/decrease at various periods? How will this affect milling and consequent fluctuation of power demand?
  - Do consumers prefer Grade 1 flour or straight-run *posho* milled flour? This will inform the kind of equipment to acquire and its expected power use.
- Is grain available throughout the year? Seasonal availability gaps are a challenge to frequency or intensity of milling. Additional considerations include climatic conditions, yields and production levels, grain market pricing, and factors affecting stability of raw material supply. The best source of this data is the local Agriculture Office (Sub-County level) who collect and compile year on year crop production data and monitor market prices for their reporting.
  - Insight into supply consistency will help anticipate fluctuations in demand and therefore power use, and/or indicate what need there is to buy and store grain in anticipation of high market prices (for a milling enterprise selling flour). If grain availability and access due to high prices is a challenge most part of the year, then the milling PU will not be a viable enterprise.
- What is the community's purchasing power? This will indicate whether community members can afford to purchase costlier ready-milled flour or are only able to pay for milling services. Households with stable income can pay for services and have relatively higher resilience in times of high grain prices.

Determine competitiveness

There are various factors determining competitiveness of a milling enterprise including service fees and product pricing, product quality, service differentiation, community, reputation and location.

Key information needed:

- Where do community members currently mill their grain? Are there any competing mills in the locality or do they travel to a neighbouring village? How far? If there are other mills, do they offer homogeneous services/products or differ in service delivery and/or product distribution?
- How many mills currently exist in the area and how are they performing? Is there sufficient demand to warrant new entrants or is competition too stiff with supply higher than demand? If existing mills are operating under capacity then setting up a new milling business is unlikely to be viable. Are existing mills viable customers for power supply from the mini-grid? If these mills run for short periods during the day, their demand load might be too low to make any economic sense for conversion. Are existing mills willing to connect to the mini-grid and is this technically feasible?
- How much money is spent weekly/monthly on milling and other associated services (e.g. transportation) that could be saved by providing milling services locally, powered by a mini-grid?

Data points needed:

- quantities of grain milled by each mill per day/week/month
- costs of production
- current fees/prices charged
- expected revenue estimates.

Consider incentive programs and other forms of potential subsidy that might either prevent a milling business from being competitive or support its creation. Examples of enabling schemes include government loans to youth and women for enterprise development, donor-funded projects involved in pro-poor financing or agricultural development projects focusing on grain value chains (e.g. increasing yields, improving market infrastructure). These projects can help improve efficiency in the value chains and/or reduce costs of doing business.

Evaluate current and necessary expertise

Existing milling enterprises imply existing expertise, though level of skills may vary depending on factors like prior experience, education level, technical knowledge of equipment, training received and types of products/services offered. Other than the skills to operate the mill, business acumen and management skills are also key to ensure profitability and sustainability of the enterprise. Whether the mill is owned by a community group, individual or run by the mini-grid developer, skilled personnel are needed for day-to-day operation of the mill and strategic planning for long term success. Where business management know-how is wanting, capacity building should be sought either funded by the mini-grid developer or by identifying an appropriate partner e.g. an NGO that offers business skills training for rural development.

Compare electricity costs

Affordability of power will highly be dependent on the tariff schedule. The charges must be enough for the mini-grid developer to get a return on investment in reasonable time and at the same time be set at a level that the consumer can afford to pay for it. In areas where diesel-powered mills exist, affordability will also include conversion costs (see Tool #2 and Tool #3 for more detail) and considerations of opportunity cost of using mini-grid power versus diesel. The following are key guiding questions:

What is the approved commercial tariff? How affordable is the tariff given the nature of milling business in consideration? Is the milling revenue stream higher than this recurrent cost?

How does the tariff compare to fuel costs in a diesel-powered mill? Mini-grid power is likely more costly than the equivalent fuel costs of a diesel-powered mill. Nonetheless, are there any other explicit benefits that act as an incentive for existing millers to convert their diesel-powered mills into electric ones? Is there a subsidy strategy to reduce the additional tariff cost to be paid by the business compared to their fuel costs? What are the conversion costs involved? Are these costs affordable to the mill owner, are they willing to cover them? If not, is the developer willing to support the conversion financially?

If existing businesses have to be relocated within vicinity of the mini-grid site, what is the cost implication and how willing is the mill owner to pay for it?

If answering the above questions indicates a tariff cost lower than current diesel consumption and conversion costs that can be recovered within reasonable time from milling revenue or flour sales, then the business is likely to be viable.

Assess legal and regulatory requirements

Milling business activity is regulated at the county and national levels of government. Before establishing such an enterprise, the mill owner should liaise with the relevant regulatory bodies to ensure that they have the requisite business permits and licences to operate. The regulations focus on food hygiene, physical planning, employment terms and business permitting. A mill offering flour as a finished product will have more requirements to comply to due to handling and distribution of food compared to an enterprise whose only business activity is milling as a service.

An assumption is made that the mini-grid developer has met all the pre-requisite conditions under the framework of the Energy Regulatory Commission including getting approval for the commercial tariffs that the mill will be charged for the power used.

a. Management and operation of the mill

Trade licence should be obtained: Under the Crops Act No. 16 of 2013, maize is categorized as a scheduled crop. Being a scheduled crop, the national and county governments have formulated policies on the regulation of various processes by dealers involved with such crops. Section 18 makes it mandatory for any person who is involved in manufacturing or processing maize to obtain a licence. Manufacturing or processing maize without a licence is an offence.

Single Business Permit should be obtained: The County Government Act No. 17 of 2012 mandates county governments to enact by-laws that provide for the levying of Single Business Permit Fees and issuance of Single Business Permits.

Business should be registered: Section 4 of the Registration of Business Names Act requires that every individual or corporation having a place of business in Kenya that does not use its names must be registered. Unless the mill is being conducted by the mill owner in his/her own name, that business must be registered.

b. Construction of the mill

The construction of the mill will require approvals from various regulators.

Under the Physical Planning Act no. 6 of 1996, the county government is mandated to regulate developments within the county. Section 30 of Physical Planning Act requires that any person who is carrying out developments within a county shall obtain development permissions. Construction of a mill would require development approval by the county government.

The National Environmental Management Authority (NEMA) manages the environmental effects of new developments in line with the National Environmental Management Act. Before the construction of the mill, the owner requires an Environmental and Social Impact Assessment (ESIA) licence.

Construction must also be registered by the National Construction Authority (NCA) under the National Construction Authority Act.

c. Health Safety and Health Regulations

In order to comply with hygiene standards, the Occupational Safety and Health Act, Public Health Act and the Food, Drugs and Chemical Substances Act should be reviewed. The Occupational Safety and Health Act provides for application of registration of the premises. The Public Health Act ensures that the public is protected by ensuring that any production premises are maintained in good hygienic conditions and the handlers of food properly certified. The Food, Drugs and Chemical Substances Act regulates the product by ensuring that there is no adulteration.

Kenya Bureau of Standards (KEBS) is the regulatory body tasked with ensuring that goods and services produced in Kenya or imported meet set minimum standards. Section 10 of the Standards Act No 7 of 2004 provides that every commodity being manufactured or processed has to have certified the standards set out by KEBS. Therefore, all milling products must meet the standards issued by KEBS and be approved.

Confirm compatibility

What is the power demand from existing mills and/or expected new mill(s)? Does the mini-grid have the capacity to meet this demand? Is the system design scalable to allow for an upgrade and incremental capacity to address demand growth in the future? If so, at what cost?

What is the likely timing (hourly, seasonally) of milling? What times of the day is milling carried out? How would the mills' power loads affect distribution and use of power by other users at different times of the day? Can milling be shifted to mini-grid off-peak times or operate under dispatchable load tariffs in ways that increase capacity?

How compatible is the distributed power with the available milling equipment? (See Tool#3 for details on technical considerations). If available equipment is three-phase configured, is the mini-grid power three-phase? If not, can the single-phase distribution be upgraded to three-phase for compatibility? In the case of an existing diesel-run mill, the equipment undergoing conversion should also be compatible with the mini-grid for the PU to be viable.

Ascertain suitability of site

Analyzing market potential above would inform on the best location of the milling enterprise with respect to milling service demand and product distribution in the case of flour sales. Furthermore, it is key to assess the viability of the location of the PU with respect to the mini-grid site.

How far is the mini-grid site from the existing milling enterprises or proposed new milling premises? The shorter the distance of the mills from the mini-grid site, the lower the cost of power distribution and less power lost in distribution. Are existing millers willing to relocate closer to the mini-grid site? What are the cost implications of relocating and who will cover the cost – mill owner or mini-grid developer?

The milling enterprise might be in independent premises but in some instances the mini-grid developer might set up premises to house the business either directly operating it or leasing out to an independent business owner. The premises should be located where there is consumer traffic flow at or near the site or easily accessible by community members.

Financial feasibility assessment

At the feasibility stage, a high-level financial assessment should be performed to inform a go/no-go decision on the productive use activity. The objective of this initial feasibility assessment should be to assess whether the product of the PU activity can be offered on terms that are competitive or better than prevailing options.

In the case of the milling PU, this can be done by comparing the expected unit production cost of the milling service to prevailing market price in the mini-grid community. The key inputs needed to perform this calculation are as follows:

- Expected unit production cost: specifications of milling equipment including cost, useful life, production capacity per hour and power rating
- Prevailing market price of milling service

With these inputs, the unit production cost can be estimated using the calculator shown in the table below.

Milling business activity is regulated at the county and national levels of government. Before establishing such an enterprise, the mill owner should liaise with the relevant regulatory bodies to ensure that they have the requisite business permits and licences to operate.

Ref.	Category	Units	Calculation
Milling Production Estimate			
(a)	Electric Mill Useful life	yrs	Input
(b)	Electric Mill Operating Hours	hrs	Input
(c)	Lifetime Operating Hours	hrs/day	(a) x (b) x 365 days
(d)	Hourly Production Capacity	kgs/hr	Input
(e)	Lifetime Production	kgs	(c) x (d)
Fixed Cost			
(f)	Machine Cost	$	Input
(g)	Fixed Cost	$/kg	(f) / (e)
Variable Cost			
(h)	Expected Tariff	$/kWh	Input
(i)	Mill Power Rating	kW	Input
(j)	Lifetime Energy Consumption	kWh	(i) x (c)
(k)	Lifetime Energy Cost	$	(h) x (j)
(l)	Variable Cost	$/kg	(k)/(e)
Output			
(m)	**Unit Production Cost**	$/kg	(g) + (l)
(n)	**Prevailing Market Price**	$/kg	

Table 1: PU Financial Feasibility Calculator

There are two key analyses that can be performed using the calculator:

- Comparative Analysis: calculate unit production cost based on estimate of Expected Tariff and Electric Mill Operating Hours (a measure of demand)

- Break-even Analysis: goal-seek for Expected Tariff or Electric Mill Operating Hours (a measure of demand) that results in a unit production cost that is equal to prevailing market price

The Comparative Analysis can be performed if the user has high-confidence in the Expected Tariff or electric mill operating hours. If the user would like to assess the break-even Tariff or electric mill operating hours at which the electric mill would be feasible from an economic standpoint then the break-even analysis should be performed.

Review capital requirements and availability

Understanding the capital investment needed for undertaking a milling enterprise is an important consideration at this stage. This is dependant on the viewpoint of the stakeholder. For a mini-grid developer, the capital investment includes the cost of upgrading the system including generation and distribution infrastructure. For the mill owner, the primary costs are related to the purchase of new milling equipment or conversion of existing equipment. Key considerations in estimating cost should be the power rating of the mill which is in turn should be informed by expected market demand and capacity utilization. Mini-grid developers and mill owners should also assess the availability of financing options at this stage.

Complementary enterprises

In cases where milling is unlikely to be a standalone viable PU activity in the short-term, the community consultation and value chain analysis steps should help identify other potential complementary PU activities. The choice of the complementary PU activity should be part of an integrated strategy to offset risk and create economic activity in the short term. The same requirements, steps and considerations in this feasibility tool apply to any complementary enterprise.

Case Study – Developer Y

Having considered the factors highlighted in the feasibility checklist, Developer Y decided milling is a viable PU activity only if combined with a complementary enterprise that would apply in most of the 11 identified sites.

Community consultation

- Maize production and trading was identified as the mainstay of the community
- Milling was recognized as the leading agricultural activity in the area that would benefit from power connection
- It was discerned that all surveyed households in the area consume *ugali* very often if not daily.

Competitiveness

- Five mills identified in the area charge homogeneous fees for milling services (US$0.05 per kg)

- No existing enterprise is currently offering flour as a product. All are exclusively service providers.

Value Chain Analysis

- Maize was considered as the proxy value chain for milling with key findings indicating:
- Maize yields are as low as 2 bags (180kgs), which is mostly for household consumption as straight-run *posho* flour. Hence measures should be taken to increase yields for PU viability.
- Availability of maize fluctuates seasonally which also impacts on pricing and quantities of maize milled per household.
- Maize flour is consumed year round whether on or off-season with households purchasing grain when their stored reserves run out.

Market potential assessment

- The quasi-daily consumption of *ugali* implies demand for milling as a service or for readily-milled flour
- There are more than five milling enterprises in the locality
- Households of 5-8 members mill 12-20 kgs of flour per week.
- *Ugali* flour is a mix of maize, sorghum and cassava which is preferred to plain maize due to nutritious value.
- The daily break-even quantities (the point at which unit production cost is equal to the prevailing market price) for a 7kW (converted) and 3kW electric mill (new) are approximately 11kgs and 10kgs, respectively. This is due to the relatively low upfront capital requirement of milling equipment, but it should be noted that at these quantities, the energy consumption of the mills is also negligible.

Evaluate current and necessary expertise

- Identified lack of expertise in maize production. Requested technical assistance from the GMG Facility for value chain analysis.
- Identified a potential partnership with local NGO to improve maize production through access to quality inputs
- Partnered with a donor-funded initiative to provide business skills training to existing entrepreneurs

Compatibility

- Existing mills will have to be assessed for viability to be converted into electric mills.
- Output capacity of the mini-grid infrastructure may need to be enhanced to power the mills and upgraded to 3-phase power to accommodate milling equipment.
- Talks are underway with a local equipment supplier to pilot an electric mill and assess compatibility and efficiency levels

Regulatory requirements

- ESIA Licence
- NCA Certificate
- Development Approvals from the county Government
- Registration of the premises under OSHA Act
- Permits under Food, Drugs and Chemical Substances Act and Public Health Act.
- Certification of the products by KEBS
- The mini-grid developer has an approved energy tariff but that does not cover the milling. The developer may require to apply for a tariff approval to cover the milling activities.
- The milling enterprises will have to comply to laws governing business licensing in Busia county and nationally.

Suitability of site

- The current site is relatively far from the existing mills hence businesses would have to be moved closer for connection.
- Other new proposed mini-grid sites have mills operating within 600m radius
- The existing mini-grid is close to the village centre hence easily accessible by community members

Financial feasibility

- Conversion of existing milling equipment is not feasible in this context hence new milling equipment is recommended for installation.
- The Break-even analysis indicated that as long as Developer X can offer a Tariff that is below 1.13 $/kWh and 2.03 $/kWh, for a 3kW and 7kW mill producing approximately 150 kgs of flour per day, the unit production cost of an electric mill would remain competitive with the prevailing retail market price of milling (0.05 $/kg) in the mini-grid community.

Complementary enterprise

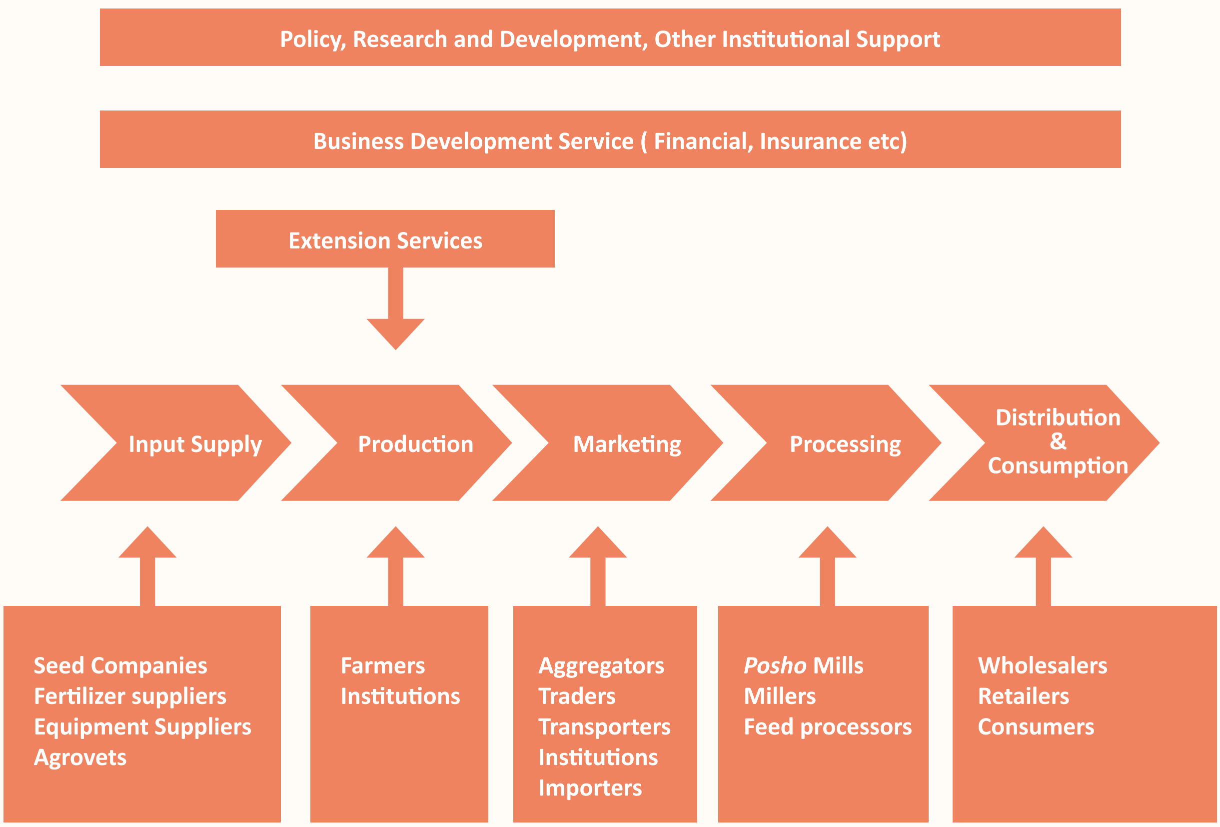
- Since milling is unlikely to have immediate impact due to the technology-related and maize volume challenges, the sites should be complemented with another PU.
- A milk cooling opportunity was identified since all interviewed maize farmers keep dairy cattle.
- Viability is contingent on current dairy production levels being increased to facilitate milk aggregation for sale in the prevailing milk deficit context.
- Dairy is a capital intensive venture and would require financing for those who cannot afford to purchase cattle and pay for its support before milk production commences.

Compare electricity costs

- The equivalent cost of using diesel generation is 0.37 $/kWh which is lower than prevailing mini-grid tariffs. However, the enterprise would still be profitable at the prevailing mini-grid tariff of 0.59 $/kWh. At this stage, the developer would have to consider providing additional incentives to convince the mill owner to connect to the grid and also perform a detailed financial feasibility analysis using Tool 4 to assess the cost-benefit of integrating the PU activity

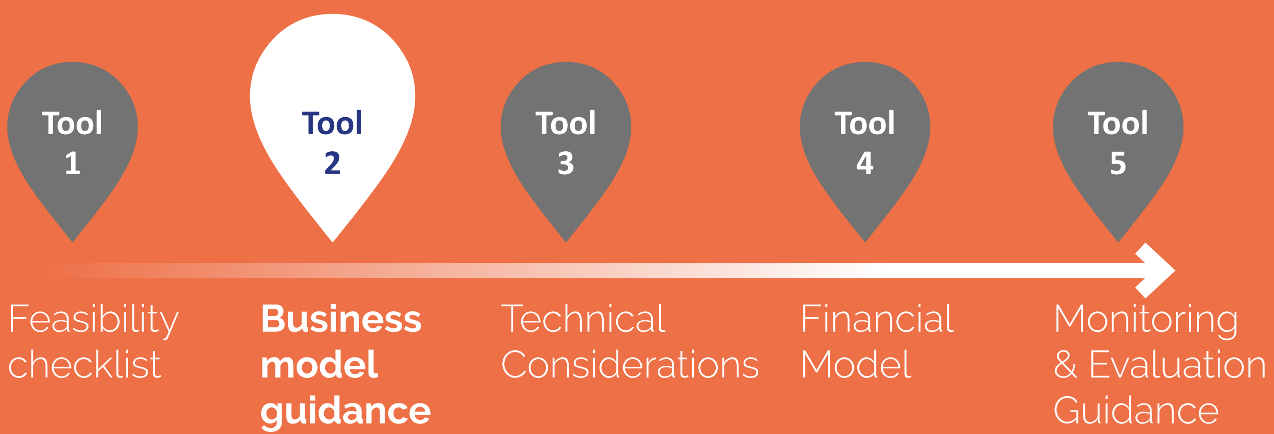
Capital availability and access

- Existing mills were all purchased through access to credit implying financing availability- any conversions and installations would need facilitated financing.



Fugure 1: Sample value chain map showing five major stages of a maize value chain in Busia county

Tool 2: Business model guidance



Purpose

Once the feasibility checklist in Tool 1 is complete, practitioners need to then identify the most appropriate business model for a milling PU connected to a mini-grid. This will depend on the unique context in which the mini-grid developer is operating in terms of project objectives, regulatory frameworks, community involvement, available financing and the technical and managerial capacity of the mill owner(s).

Tool 2 is designed to help practitioners assess various business model options and their advantages and disadvantages, in order to choose the one which delivers optimal value for a specific context. The models illustrated in this tool are not exhaustive of all options possible for a milling business, but offer guidance on what conditions to look out for in choosing an appropriate model and present a common framework through which options can be compared. Different ownership scenarios are demonstrated, risks analyzed and mitigation measures proposed to guide implementation of the respective models.

This tool is designed to help practitioners assess various business model options and their advantages and disadvantages, in order to choose the one which delivers optimal value for a specific context.

Common factors and minimum requirements

Other than the basic requirements outlined in Tool 1: Economic feasibility checklist, there are several fundamental conditions that underpin setting up a milling PU project:

1. Community demand and buy-in: since the milling enterprise will depend on members of the community as customers, it is essential that the community is in favour of the activity.

2. A credible and reliable partner: an entrepreneur, community group or organization already running a milling business in the area and willing to connect to the mini-grid or one interested in establishing and operating the *posho* milling enterprise where none exists.

3. Financing: directly by the mini-grid developer, self-financing from the mill owner, an independent financial institution, investor or development partner (e.g. donor, NGO).

4. Availability of electric milling equipment: compatible with the existing or projected mini-grid power output. Ideally, the equipment should be energy efficient. (Refer to technical considerations in Tool 3).

5. Convenient location of mill and mini-grid: A site to establish the milling premises, both convenient to consuming households and within recommended proximity to the mini-grid site.

Choosing A Business Strategy - Service Delivery Vs Product Sales

The milling enterprise, whether existing or new and regardless of who owns it, can adopt one of two business strategies or a hybrid of both:

(1) **Service delivery:** Offer milling services to the community - customers come to the mill with their own maize, whether stored or bought, and pay for the milling service only

(2) **Product sales:** Mill flour for sale - mill owner produces or buys the grain, mills it and sells it to consumers or retail shops locally or in neighbouring communities.

The financial viability of the two scenarios is explored in detail in Tool 4. Within these two scenarios, milling services are more common, but selling flour is more profitable.

Specific considerations:

- **Demand:** Willingness of community members to purchase ready-milled flour rather than mill their own. Most households in rural areas grow and store grain for household consumption and mill it as needed. Where community members prefer milling their own grain over buying flour, the product sales scenario would not be viable.

- **Affordability:** The cost of processing flour and consequent impact on affordability to target customers would highly influence viability of product sales.

- **Revenue:** Additional costs of running a business to sell flour compared to milling as a service should be enumerated and both revenue streams analyzed to determine the most favourable profits. However the profit margins will not be significant to the enterprise if there is no market potential which should be determined initially in the feasibility stage (See Tool 1 under Market potential assessment).

- **Provision of support:** A mini-grid developer could provide support to promote the higher-margin business model (sales of milled flour), eg. through subsidized tariffs at par with effective diesel cost, access to markets and capacity building.

Which Ownership Model To Choose

The ownership model will vary depending on the answer to two main questions:

1. Is there a mill currently operating at the site?

2. Is there a capable individual or group willing to set up a milling enterprise?

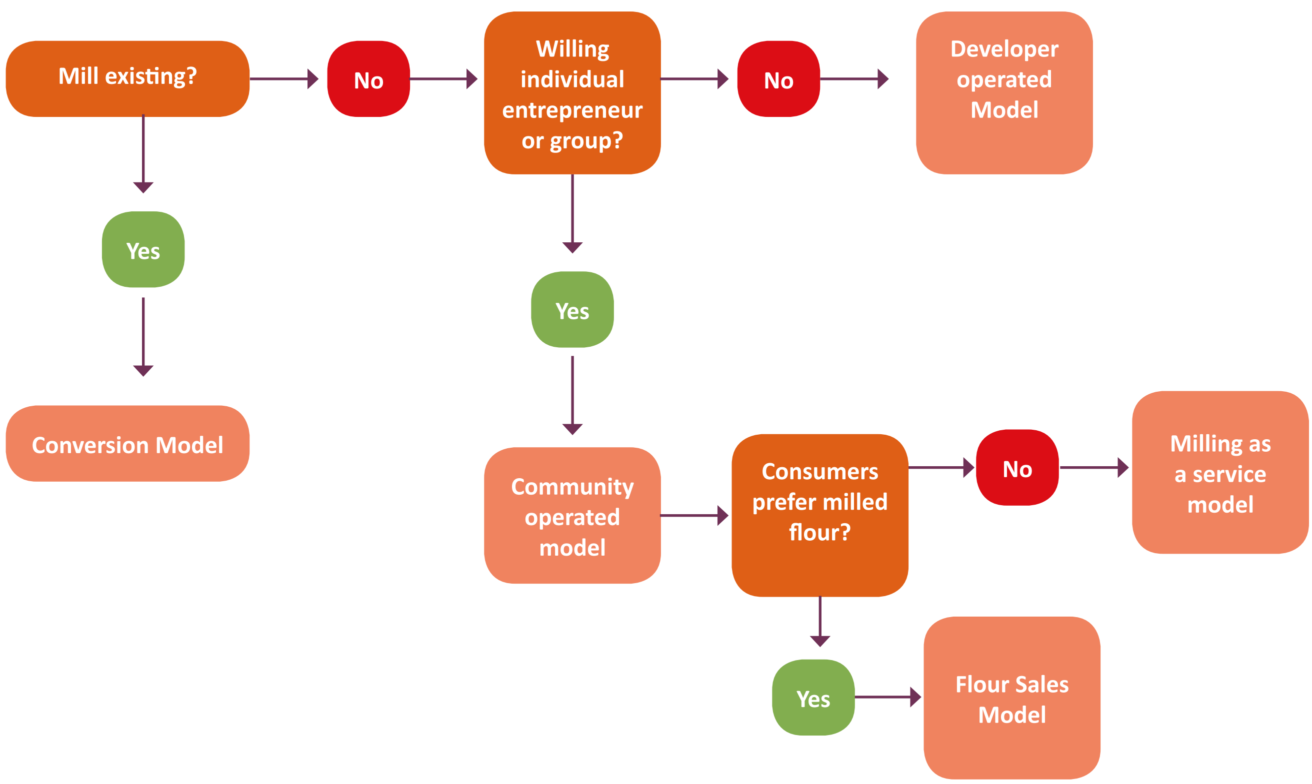


Figure 2: Decision map to determine appropriate business model

If there is an existing milling business at the site

Community owned model

If the feasibility analysis indicates one or more existing milling businesses in the area of interest, it may be possible to convert the current mill to to be powered by the mini-grid. This may not be limited to one milling business, and is dependent on the capacity of the mini-grid. Existing diesel-powered mills are viable for conversion only under specific financial and technical considerations (See Tools 3 and 4).

Specific considerations:

- **Compatibility:** feasibility of converting the existing milling equipment into an electric mill. An evaluation of the machinery should reveal any challenges and provide an opportunity to estimate conversion costs.
- **Cost of conversion:** conversion and installation should be affordable to the miller where financing is not available. The mini-grid developer might have to give technical and financial assistance to aid conversion.
- **Willingness to integrate:** willingness of the miller(s) to integrate with the mini-grid and relocate closer to the mini-grid site if needed. If the site is not already selected, the mini-grid operator may consider locating the project near the existing PU for ease of set up.
- **Cost of power:** cost of power (commercial tariff) for the converted electric mill compared to fuel cost of diesel-run equipment. Cost of power has proven to be higher than fuel costs therefore for milling to be a viable PU, the mini-grid developer might consider offering incentives to switch from fuel driven machinery to mini-grid connection, e.g. through subsidisation of cost, financial support or capacity building.
- **Developer support:** Given the cost-related challenges posed by conversion of existing mills, the developer should provide support that either reduces cost of operations for the mill owner or increases profit margins.
- **Community capacity.** If the selected entity is a CBO, community association, self-help group or similar, it is likely that they will need to receive support in governance, management and other capacity strengthening areas. Since these types of groups tend to change leadership often, the more established the group, the less potential problems with continuity, commitment and compliance with agreed terms.

Advantages/disadvantages of this model:

- For the mini-grid developer: prior operations provide data to help estimate power usage for demand projections and long-term planning. Existing milling business saves time and effort in finding alternative reliable PU though developer might have to invest in business support incentives (e.g. cost subsidies and access to finance) to motivate mill owners to connect to the mini-grid.
- For the mill-owner: it requires less capital to convert an existing diesel-run mill to electric compared to investing in a new business. However, the operational costs are expected to increase due to relatively higher power tariffs hence the need for the mni-grid developer to provide additional incentive.

If there is no existing milling business at the site

In the case where milling has been identified as the most viable PU activity yet no milling business currently exists close to or within the mini-grid site, there is an opportunity to establish a new business that will be connected to the mini-grid. This opportunity also applies in a scenario where a milling business is present but service demand is higher than the capacity of the mill. The two ownership models set out below - Community owned and Developer owned - provide options for how to integrate milling into the mini-grid.

In these scenarios, new equipment is sourced and installed at the mini-grid site. Incentives for a mill owner to choose mini-grid connection rather than diesel powered operations include up-front cost savings on gen-set equipment, reliability and convenience of uninterrupted power supply, and reduced need to travel for fuel purchase.

Community owned model

In this set-up, the mill is installed, operated and maintained by an individual member of the community, an established community group or an association e.g. a cooperative. This ownership model will involve participation of the mini-grid developer to support the interested entity – either directly or through a third party – in sourcing appropriate equipment, financing, installation and in some cases capacity building on operations and business skills.

Specific considerations:

- **Business credibility:** The previous business performance of the identified entrepreneur/ group should be reviewed to assess their capacity to operate a business. This can be done through reviewing historical business records and interviewing community members for triangulation. The mill owner(s) should be known and trusted by the community and demonstrate capacity to repay equipment loan where financing is provided.

- **Efficiency and clarity of roles:** individual-owned businesses can be simpler than group-owned businesses since decision-making is concentrated in one person rather than a group. Management arrangements for group-owned businesses need to be very clear on individual roles/responsibilities to avoid confusion.

- **Group dynamics:** In the case of a community group or association, dissonance among group members could present challenges in running the business and ensuring effective decision-making processes. It is important for the mini-grid developer to understand leadership integrity, power relations and politics within the group to help manage disagreements.

- **Ownership transition:** In the case where the mini-grid developer or other party (e.g. NGO) assists the individual or CBO by establishing and managing the operation in the start-up phase, a clear ownership transition plan should be agreed and documented.

- For sustainability of the PU business, a group should be institutionalized to ensure a well-established structure and continuity. Disadvantage for developer: Group leadership could change whenever elections happen and membership structure varying as new members join hence possibility of continuous need of training necessary increasing costs of PU support.

Advantages/disadvantages of this model:

- For the mini-grid developer: the developer is not involved in the day-to-day running of the mill so can concentrate on core business. But relying too heavily on a single enterprise outside of the developer's control to create substantial power demand may be risky.
- For the community: sense of communal ownership increases responsibility and community member(s) can use profits from the business to support other community development projects. But if owned by a group, conflicts amongst members might adversely affect business management and operations. Furthermore, communities may lack the financial and technical capacity to install, operate and manage businesses, and there is a financial risk of committing to debt payments and ongoing operational expenses.

Developer owned model

There may be instances where a mini-grid developer chooses to establish and operate a milling business, either permanently, or for an interim period with a plan to hand over ownership to a community-based entity in the long term. This means both power distribution and the milling business are owned and operated by the same party, at least initially, and gives the mini-grid developer full control over the PU application. This model creates an additional power load for the mini-grid, offers a much-needed service to the community and is a source of additional revenue to the mini-grid developer. For some developers this business model may be the best way to enable the mini-grid's minimum operational capacity, especially in very poor communities.

Specific considerations:

- Willingness and capacity of the mini-grid developer to take on an additional enterprise alongside their core power generation and distribution business.

- Projected income generation and analysis of other non-financial benefits of the milling business (e.g. social impact on community) will help the mini-grid developer make a decision on the worthiness of the venture and analyze the opportunity cost of not setting up a milling business.

- Ownership transition: In the case where the mini-grid developer operates the business as a start up with plans to hand-over ownership to an individual or community based group in the long run, a clear ownership transition plan should be agreed and documented.

Advantages/disadvantages of this model:

- For the mini-grid developer: creates an additional revenue stream, while increasing demand on the mini-grid and giving the mini-grid developer full control over their customer base. Can contribute to improving community relations by demonstrating commitment and market confidence. But is also outside the scope of the mini-grid developer's expertise, and capital costs to establish the mill (if borne by the mini-grid developer) may be oppressively high.

- For the community: provides a milling service or product within the community, where none existed before, cutting down transport costs. Due to the developer's stake in the business they have an incentive to maintain high-quality electricity services which benefits the consumers. But carries risks of crowding out a potential locally owned enterprise.

Does the PU activity require financing? ---- YES

In the event that self-financing is not possible, the milling equipment and business set up can be pre-financed through a range of financing options:

a. **Direct mini-grid developer finance:** This involves the mini-grid developer providing financing for the purchase of milling equipment, installation and potentially business support. This could be 100 percent financing or co-investment alongside the mill owner(s). Financing could be in the form of a business development grant embedded in the developer's start-up budget or a loan to be paid back by the business over an agreed period of time. Under the latter scenario, the cash is paid out to the equipment supplier and recovered from the business through an agreed payment plan. The developer would have to be willing to take up the financing risks involved, particularly where guarantorship or collateral do not apply. Decisions regarding terms of payment, guarantee or collateral and other contractual issues will need to be clearly outlined. In Kenya, financing in the form of a loan may have regulatory ramifications, which should be understood before embarking on any financing activity. Another context might have the developer set up a business center and install the milling equipment, then lease out the entire enterprise at an agreed monthly fee with the entrepreneur meeting the business operations and maintenance costs. This is effectively a lease-to-own model where ownership transitions to the entrepreneur (individual or group) once all payments have been settled.

b. **Third-party financing:** This financing approach requires a partnership with a financial institution, government financing initiative or a commercial investor. The commercial partner may be the equipment supplier who could agree to a payment plan guaranteed by the developer where deposit payment for machinery is made and the reminder paid out in instalments. Partnering with a bank could include access to tailor-made credit products considering the type of business and revenue cycle. The mill owner could also have an independent source of credit (e.g. SACCO, group lending, NGO funding etc) that does not involve the developer's direct involvement. These third party financing scenarios are lower risk for the developer than cases where the developer has to provide direct guarantorship. However, these options may not always be available and conditions for accessing financing may be too stringent (eg. loans are difficult to qualify for or unaffordable due to high interest rates). The most typical financing product offered by a commercial financial institution is asset finance. The main advantage it offers over traditional finance products is that the asset being financed can be used as collateral. This means that businesses do not need to guarantee all of their business and (or) personal assets to secure financing. Financial institutions use their existing lending policies and procedures, and standard loan terms, in extending credit facilities for PU equipment. For smaller loan amounts, a credit guarantee would be required by a bank that can be provided by the developer or a third party guarantor. Figure below shows the typical financing terms that are offered for PUs.

c. **Development partner support:** There may be an opportunity to partner with a development institution which can provide social capital (patient capital) where there is clear evidence of community impact. This capital is often in the form of a soft loan with favourable repayment terms, or may even be a grant. Such support is mainly tied to community development and inclusive growth goals like youth employment, women empowerment, improved access to finance and SME business support development.

Loan Amount Range (KSH)	Tenure	Interest Rate	Deposit	Collateral
10,000 – 100,000	<12	13% + Processing Fee + Credit Life Insurance	30%	Mortgage & registration of equipment Credit guarantee
101,000 – 300,000	<24	13% + Processing Fee + Credit Life Insurance	30%	Mortgage & registration of equipment Credit guarantee
>300,001	<36	13% + Processing Fee + Credit Life Insurance	30%	Mortgage & registration of equipment Any formal collateral

Table 2: Typical financing terms that are offered for PUs

Partner roles and potential alliances

Rural electrification projects often involve many other actors influencing the success of the project. It is key to identify project stakeholders and determine potential partners to identify areas of support and synergy as well as anticipate potential sources of opposition. Relevant stakeholders in a milling business could range from the community and government institutions to private sector entities and NGOs.

National and County government

The success of a milling PU is highly dependent on grain production. In Kenya, agriculture is a devolved function under the oversight of county governments. Despite mini-grids being supported and served under the Ministry of Energy, close collaboration with Ministry of Agriculture officials can help to address constraints that emerge from the value chain analysis, eg. through the provision of extension support that helps improve production yields. Additionally, local government officials are key sources of information at the feasibility assessment level and a valuable resource in mobilizing community members. They can also help identify other potential partners working in the area. Terms of engagement should be clear at the outset since in some instances payments may be requested for participation in developer's activities or developer's resources requested to facilitate service delivery.

Farmers' Cooperatives/Associations

These are key entry points in communities where the population is dependent on agriculture. Farmer groups also offer a cost effective and time efficient way to engage communities in communication and trainings. Group leaders can help mobilize members, communicate important messages, and also act as local trainers if capacity is built.

In a scenario where milk cooling is pursued as a complementary PU to milling, a dairy cooperative engaging in milk collection could be a strategic partner. The cooperative can operate the milk cooler, facilitate milk aggregation in the community and sell to either a milk vendor or processor in bulk. Alternatively, an entrepreneur (individual, group or commercial company) could set up a milk cooling facility and purchase milk from the cooperative or aggregate from its members.

Non-Government Organizations (NGOs)

There are numerous NGO activities targeting rural development in various parts of Kenya. Areas of interest vary from capacity building and trainings, financing, market access facilitation to gender and youth empowerment. Engaging the community through an already known NGO partner could gain the developer in-roads in gaining trust from the community members. Caution should be taken though to avoid collaborations with organizations that have conflict with community members or bad reputation on what they do and how they work. In the milling context, NGOs could be a source of third-party financing with friendly conditions to the borrowers. They can also assist conduct business skill trainings to entrepreneur groups or individuals willing to start milling and have no previous experience or with existing businesses that need better management for profitable performance. NGOs providing extension services can also join in the efforts to improve production to boost grain availability at household level. They would play similar roles to support milk cooling by financing equipment, dairy extension services and capacity building including business management skills and even value addition training to produce dairy products like pasteurized milk and yoghurt which will help increase and diversify income. The developer should take into account that NGO initiatives operate within limited timeframes and plan partner activities strategically with mutual agreement on an exit strategy in advance.

Financial/Microfinance institutions

Institutions providing financial services to the community are key partners where friendly credit products are made available. This is not limited to financing milling equipment but also facilitating access to quality inputs for grain production to improve yields, micro-loans for other business activities run by the mini-grid users, savings accounts to help build community members' financial resilience and other services such as financial literacy training programs.

Equipment suppliers

A partnership with makers of off-grid "green" milling machines could help pilot compatible equipment with the mini-grid developer. This could serve as a demonstration to raise awareness among existing *posho* mill owners and also allow testing of the technology and its reception by customers. For example, AgSol produces an off-grid hammermill that could be set up by an enterprising community member, either self-financed or financed by the developer/ other intermediary using a lease-to-own model.

Off-takers

With combined efforts to increase production in the target community, households will aim to sell surplus grain for income. A partnership with a grain buyer may not directly benefit the developer but will boost overall income in the community (and therefore purchasing power) and contribute to improving community relations by demonstrating the developer's goodwill and commitment to the community's well-being. In the milk-cooling context, partnering with a reliable aggregating milk vendor or local dairy processing company would provide a market for dairy farmers' surplus milk. Additionally, the milk vendor could be a potential mini-grid customer owning a milk cooler connected to the grid.

Community engagement

Without adequate community engagement and measures to increase demand, mini-grid projects in rural developing country communities rarely lead to improved incomes and livelihoods. Before planning a mini-grid project and deciding on the most viable PU, developers need to understand the local context. If the PU activity is to be sustainable and widely replicable, planning should be specific to the conditions found in the community. These conditions can only be understood by engaging community members to hear their views on their energy needs, gauge support levels for the mini-grid and assess demand for the PU. Engaging the community from the outset will help prevent conflict and complexities that could contribute to the failure of the project. This is also a good platform to pick up on the community's expectations and manage them accordingly.

Different cultures assign different social norms, attitudes and roles to women and men that translate into different tasks within the household, in their communities, and in economic activities. These differences also affect the opportunities that women and men have in all spheres of life, including opportunities that access to energy offers. In order to ensure that these differences are put into consideration when planning and implementing a milling PU, the developer is encouraged to use a gender lens throughout the entire process, from design to implementation to operations & maintenance. For example, food preparation in rural communities is usually a role for women in the household. They are also the ones responsible for milling grain warranting their visits to the miller or they send the children to run the errand while they tend to other household chores. In many cases, the man of the house will provide the cash to cover the milling cost but to find out how much flour is milled or consumed in a household, the developer would get more accurate data from a group of women than from men.

Without adequate community engagement and measures to increase demand, mini-grid projects in rural developing country communities rarely lead to improved incomes and livelihoods.

Generally, community members will be more receptive to milling and complementary activities if they feel part of decision-making processes. It helps to outline the broad opportunities and benefits to the community at large, including employment and income-earning opportunities, both for consumers gathering raw materials to be processed or stored as well as for those directly employed in operating the equipment. A good example is pointing out aggregating opportunities for youth to sell surplus grain to off-takers or providing milk transport services to the milk-cooling center.

Best Practices

Community engagement works best where it is an ongoing process enabling relationships and trust to build and strengthen over time. Individual engagement events should be planned and designed with this in mind and aim to contribute to the overall objectives of the engagement process.

Right at the planning stage of the engagement process the community's diversity should be acknowledged and used to inform the best approaches to ensure maximum inclusivity. Below are recommendations to engaging communities in the milling PU activity development process.

DO	DON'T
• Consider the capacity and ability of different stakeholders to participate, and involve all members of the community.	• Arrange meetings at times and in places that are difficult for women to access.
• Ensure all channels of communication employed are interactive and allow for feedback from all community members.	• Employ communication methods that are insensitive to literacy and numeracy levels in the community.
• Make special considerations for hard to reach groups such as young people, the elderly, minority or socially excluded groups. • Conduct additional separate meetings for women to be able to speak freely.	• Use separate meetings for women and other marginalized groups to exclude them from participating in broader community meetings with men.

DO	DON'T
• Communicate the vision for the project and lay out plans clearly and openly.	• Assume that a few representatives will accurately transmit your message to the wider community.
• Adhere to national laws and regulations regarding public participation (see Legal section).	• Raise expectations and make promises that are not achievable within the financial realities of the project.
• Establish an internal community engagement team and feedback mechanisms.	• Stop community engagement efforts after the project is established. Ongoing communication is part of improved management.
• Make provision for interpreters and signers where needed, and use techniques including public barazas, key informant interviews, roundtable meetings, focus group discussions.	• Leave verbal agreements to interpretation. Best to document all community meetings and negotiations, and rely on legal contracts for critical and potentially sensitive issues, such as land leases.
• The number and mode of engagements should ensure maximum participation and inclusivity.	• Ignore conflicts and divisions within the community.

Equipment sourcing

Equipment supply is a key challenge for PU financing for mini-grids. To be successfully deployed, PU equipment needs to meet many parameters:

- Accessible for purchase in or near mini-grid communities, many of which are remote rural areas
- Affordable, both in terms of upfront capital expenditures and on-going operating expenditures
- Quality vetted – durable and reliable over time, and often under harsh conditions
- Compatible with mini-grid technical specifications
- Supported by a warranty and after sales service
- Creditworthy suppliers

Single-phase AC electric milling machines available in Kenya are less expensive on average but also twice less efficient than DC models due to power losses. The best configuration would be larger three-phase AC models, but not all mini-grid settings offer a three-phase system as it requires more capital expenditures.

Case Study: Milling Conversion Model

Introduction

A power demand assessment conducted by Developer Y illustrated insufficient power load from household lighting and appliance use, both in the existing mini-grid site and new mini-grid development sites. Through the feasibility checklist in Tool 1, Developer Y identified milling as a high potential PU and maize was identified as the most milled grain. However the value chain analysis and market potential assessment revealed that milling would need to be complemented with milk cooling for economic viability due to the low volume of maize being produced.

The milling PU will be piloted in the existing mini-grid site and scaled up in 10 newly identified sites whose characteristics are similar to the pilot site.

Deciding on the business model

Using Tool 2, Developer Y used a decision map to determine that the most appropriate business model in the prevailing context was the conversion model with community ownership.

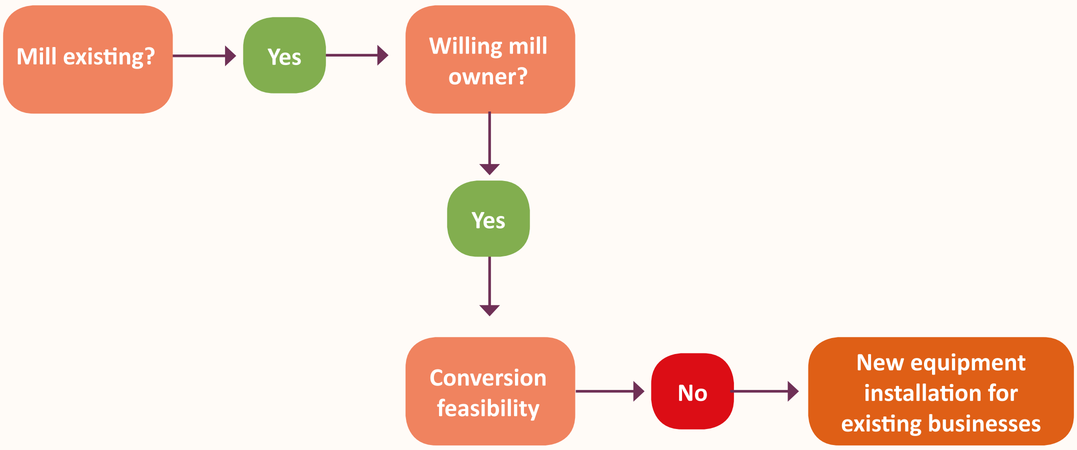


Figure 3: Decision map for determining ownership model

Since there are several mills in the locality of the current mini-grid, the conversion model was initially identified as the most ideal. However, using the financial analysis in Tool 1, the developer concluded that it was not economically viable to convert the five existing mills under the conversion model, and at the same time assessed demand for milling and market potential would not support additional milling businesses. Therefore a hybrid model was adopted where instead of setting up new businesses, existing milling enterprises acquire new electric milling equipment that can be connected to the mini-grid. Though the current capacity of the mini-grid is not sufficient to power a mill, Developer Y plans to upgrade the current site to increase output capacity and all 10 additional sites are designed considering existing enterprises' power demand to ensure generation of adequate power.

Some key considerations in determining an appropriate model for Developer Y and address arising challenges:

- **Competition:** Developer Y is sensitive to directly competing with the operations of existing milling operators by installing additional and/or new electric mills. It wants only to work with existing, interested mill owners.

- **Demand:** Similarly to the existing milling owners, Developer Y must be confident that an investment in a mini-grid to support one or more milling machines is economically feasible. The biggest value driver is daily processing demand which in turn drives energy consumption. Current processing demand is too low to support a new enterprise.

- **Proximity to mini-grid site:** The closest mills are located across the main grid line and outside the coverage of the mini-grid distribution which means the mill owner, though willing to run an electric mill, also needs to agree to move the enterprise to a convenient location. The developer is willing to provide premises space at the existing commercial centre next to the mini-grid site, which is a central location for customers.

- **Cost of conversion:** The cost of converting diesel-run mills into electric and installation differ negligibly to acquiring a new mill. Additionally, new equipment would run more efficiently compared to retrofitting new parts to outmoded technology.

- **Expertise:** Developer Y's core expertise is in operating mini-grids, not in milling. Despite this, Developer appreciates the need to play a more active role in increasing energy usage and is open to exploring different strategies to generate demand through capacity or ecosystem building, equipment sourcing guidance and financing support

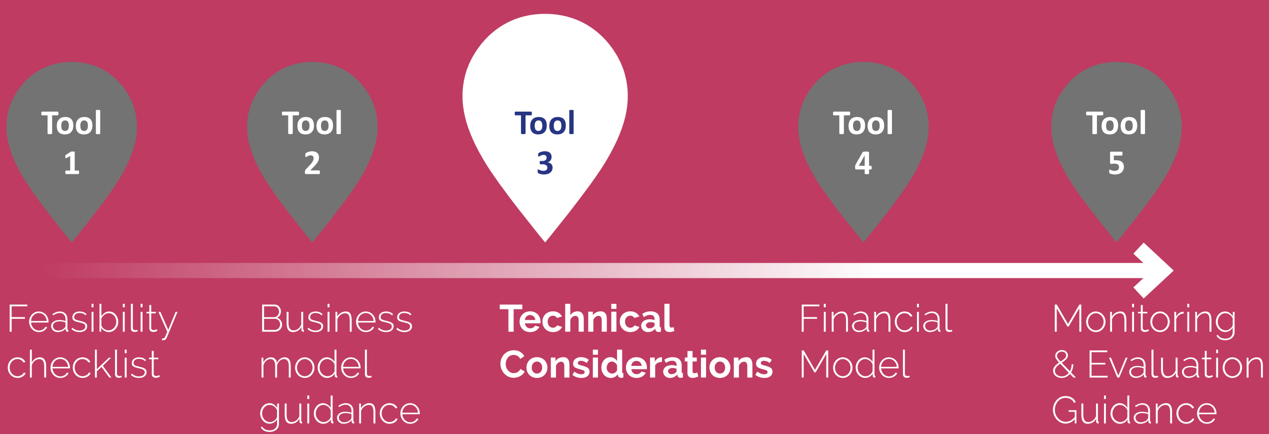
- **Cost of power:** Financial modelling (see Tool 4) indicated that fuel costs in a diesel-powered enterprise are much lower than prevailing power tariffs affecting profitability of the business. Though the break-even analysis shows profitability in a business milling a minimum of 150kgs per day charging $0.05/kg, the value chain analysis indicated less volumes milled during off-season months due to grain shortage. In this context, Developer Y is considering adopting a subsidization strategy to cushion the milling business either through direct self-financed subsidy or grant-funded subsidization of tariff costs by a development partner.

- **Potential alliances:** The value chain analysis conducted at feasibility stage identified One Acre Fund (OAF) as a key potential partner to provide technical assistance and credit products to farmers aiming at improving yields and thereby increase grain available for domestic consumption and surplus sales. OAF are willing to partner in areas within their selected geographic coverage in Busia County. Additionally, a financial institution is interested in partnering with Developer Y to pilot asset financing including milling equipment.

Risk	Mitigation
Seasonality of maize and other grain production will affect optimal use of power year round.	Partnering with OAF and extension service providers to improve yields.
OAF's current input financing project might end before existing mini-grid is upgraded and 10 new sites are established	Developer Y to implement upgrading plans within set timelines and continuously engage with OAF for joint workplaning where necessary.
A milling PU in Developer Y's context is not economically viable as a standalone PU activity	Developer Y acknowledges implementation challenges and has a mitigation strategy that includes developing complementary PU applications (alongside cottage industry enterprises currently running off the mini-grid).
Limited knowledge of operating new equipment	Training conducted to the mill operators on daily processing and periodic servicing

Table 3: Risk and mitigation strategies identified for Developer Y

Tool 3: Technical Considerations



Purpose

This tool provides technical considerations around integrating a milling PU with a mini-grid, with a particular focus on:

- the different types of grids and what needs to be done at the level of the mini-grid or the level of the mill to ensure compatibility
- how the mini-grid can best provide sufficient power to meet the demand of the mill at all times

This tool provides technical considerations around integrating a milling PU with a mini-grid.

Technical Feasibility Checklist

It is recommended that the owner of the business seeks advice from the minigrid developer to confirm that the equipment or technical solution sought are compatible and efficient for the entrepreneur.

Is the mini-grid compatible with the type of power needed for the mill?

A regular small commercial mill is generally rated around 6 kW, with a start-up power of three times its nominal power, hence around 18kW. It generally runs on three-phase. A 1-hour running time per day represents 6 kWh consumption daily, or hence 180 kWh monthly.

Rotary equipment such as mills require up to three times their nominal power as start-up power. The grid should therefore be able to provide 18 kW further to the regular demand.

The decision process is as follows, assuming the mill requires 3-Phase AC power.

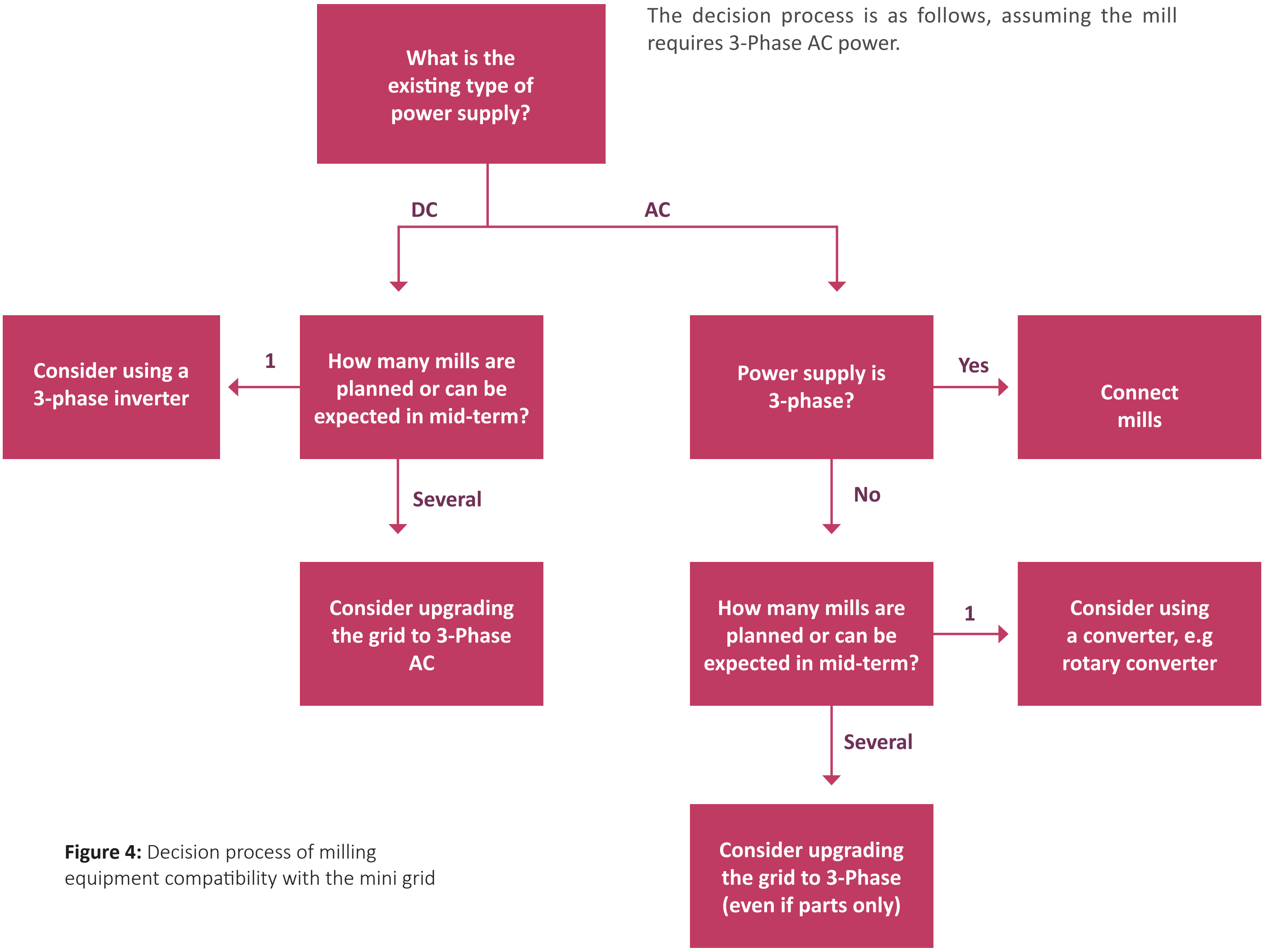


Figure 4: Decision process of milling equipment compatibility with the mini grid

One should always bear in mind that the most compatible grid network is a 3-phase AC grid. A 3-phase AC grid will become necessary sooner or later as the overall demand increases or if the main grid is interconnected.

One should always bear in mind, that a DC grid can carry less power and less far than an AC grid. If there is a high demand at the end of a long distance (more than a few hundred meters), a DC grid will not be technically feasible because it will cause too much voltage drop through the line.

Retrofit of a single-phase AC grid to 3-phase AC

If mini-grids are operational and are based on a thermal power source such as diesel generators, it is certain that they are operating on AC. A developer may therefore need to think about upgrading the grid to a 3-phase grid.

Single-phase power is delivered through single cables whereas three cables are needed for 3-phase. Therefore, if one wishes to upgrade a grid from single to 3-phase, a retrofit of the complete overhead cabling will be necessary, unless 3-phase cabling was deployed from the beginning, while planning ahead. A 3-phase retrofit can also be done to parts only of a minigrid.

Re-cabling is not necessarily very costly if the same poles can be used to carry the cables, and it is in fact a frequent activity as the power demand increases in villages or towns. If a system is upgraded from single to 3-phase, no upgrade or retrofit needs to be done at the grid connections of the consumers, since 1 single phase can be taken at any point to connect their house or business.

Retrofit of DC grid to AC

If mini-grids are operated on DC power, retrofitting to an AC grid is more complex for the following reasons:

- It must include new cabling and power conversion units
- Connections to users, and therefore users' internal cabling, must also be adapted

In the case of a retrofit, the DC part of the grid should be confined to power production and storage only whereas the AC part of the grid should be used for power supply and consumption: this is the most typical and optimised way of production / storage / supply and consumption of power.

Using individual Converters

If a grid retrofit is not an option because of the incremental cost, or because it is not expected that more than one PU will be connected, it is possible to use converters.

There are ways to convert any type of power to other types, although some conversions are not common. The following points shows the conversion possibilities from the most common to the least common:

- DC to AC (single or 3-phase): this can be done thanks for regular inverters. These can either be battery inverters, i.e connected to a single voltage source, or solar inverters which are adapted to the changing voltages of solar panels

- AC single phase to AC 3-phase: this can be done using rotary phase converters of variable Frequency Drives (RFD). However more reliability can be obtained directly from a 3-phase source (typically a diesel generator)

A few cost example for converters are shown below

- 20 kW rotary phase converter ~ 5,000 USD

- 20 kW three phase battery inverter ~10,000 USD

What technical options are available to provide incremental power?

In order to supply enough capacity to account for the mill, the options are to either:

- increase the solar array / battery storage or supply an additional diesel generator.

If the PU load is high and / or punctual, the cheapest option will be by far to install a diesel generator to provide incremental peak power. Although this is not a green option, it can be a solution for short-term increments, until the demand load is sufficient to justify additional infrastructure.

Power delivered by a thermal source such as diesel generators is completely dispatchable, which implies that this source delivers the exact power which is needed by the consumers, obviously up to the maximum power of the generators. Therefore, when planning a conventional mini-grid powered by a generator, the peak load determines the power of the generator to be installed and the rest of the load is automatically supplied.

To bridge the gap between power demand and solar power supply, one can either implement:

- a diesel generator: low in CAPEX but high in OPEX
- a battery bank: high in CAPEX but low in OPEX

The decision path for a mill PU is shown below in dark grey. Other types of PU activities could follow the light grey path depending on their consumption patterns.

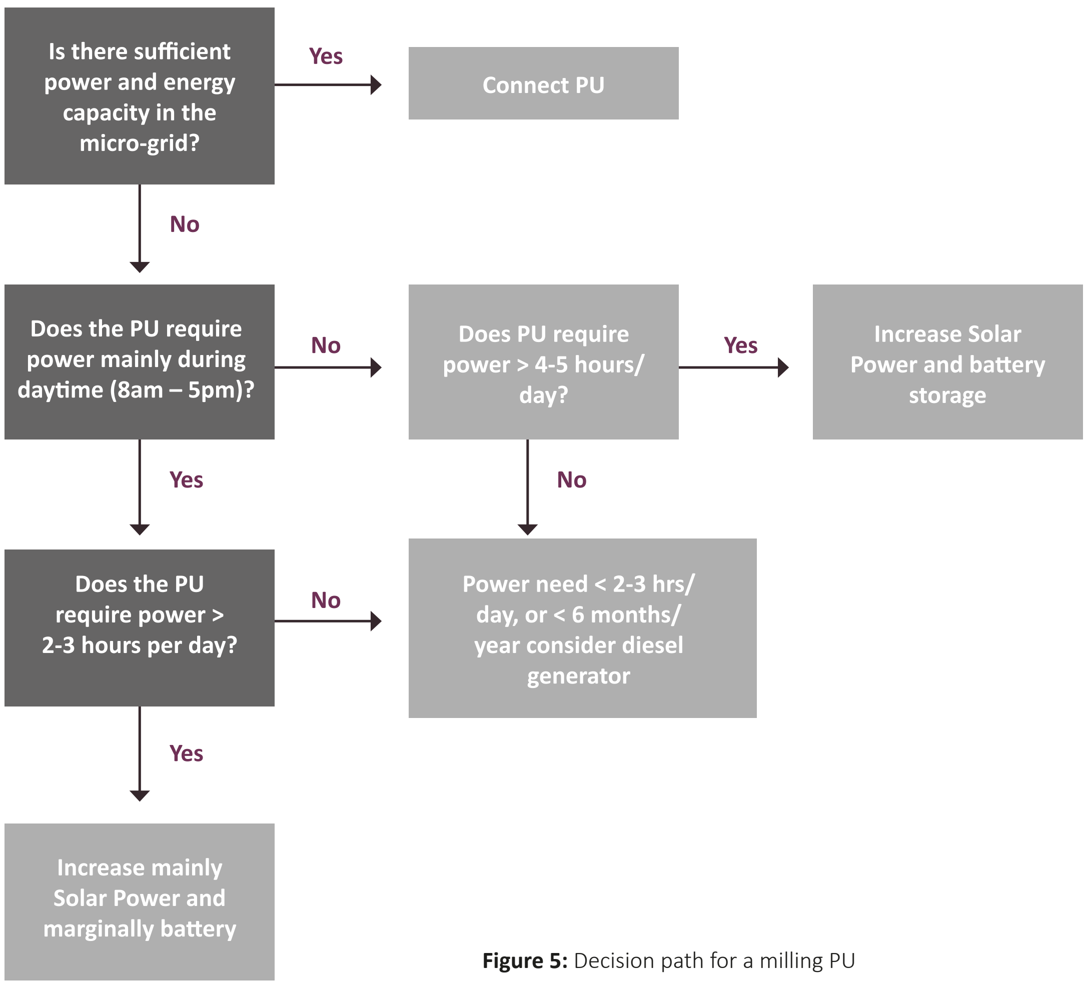


Figure 5: Decision path for a milling PU

Punctual vs long energy demand

A solar system provides about 5 full load hours per day: a 20kW solar system will therefore provide on average 100 kWh per day. Since the cost of kWh is mainly determined by the investment costs, the system will not be viable if the 20 kW demand is only during 1 or 2 hours.

On the other hand, the cost of kWh from a diesel generator is principally determined by the operational costs (cost of diesel). Therefore a diesel generator running 1 hour per day will cost 5 times less than one operating 5 hours a day. A diesel generator is therefore optimum for short term incremental energy.

If the milling activity requires punctual energy, typically 1 to 2 hours per day, an additional diesel generator is technically more appropriate.

Daytime vs night time energy demand

Solar power is a non-dispatchable source: it does not follow the demand, but rather the solar resource. Most of the solar energy is available when the sun is high, between 10am and 2pm, and there is therefore a mismatch between the maximum supply at midday and the maximum demand in the evening. The production of a 150kW solar system is shown below.

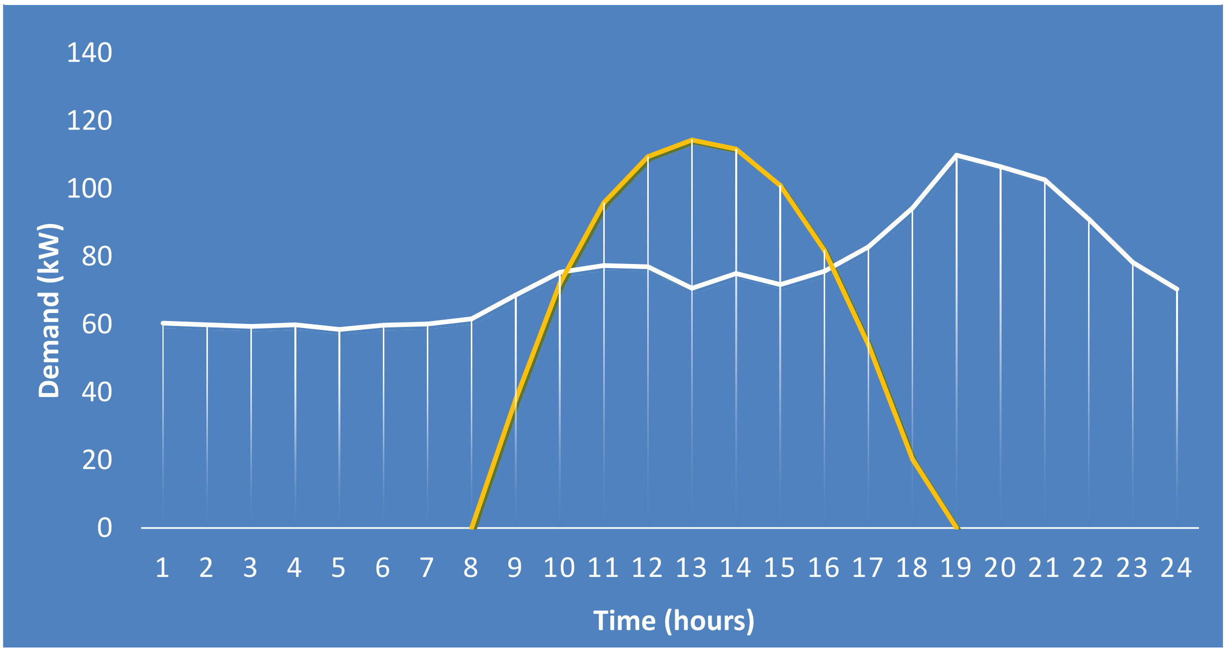


Figure 6: Typical load curve for a small town and production of a PV plant

Since most of the solar energy is available during daytime, even in case of increased demand during the day, a mismatch between demand and supply is not commonly seen during sunlight hours. However, if most of the energy is used during the daytime, the batteries may not be sufficiently charged to cover the evening peak.

The easiest technical way to control the consumption patterns of customers is to use meters which can limit:

- power (expressed in kW): only a certain number of appliances can be used simultaneously and
- energy (expressed in kWh): appliances can be used only a certain duration, until a kWh limit set by the provider.

With the use of smart meters, these parameters can be set remotely and can vary throughout the day or the week.

Again, the easiest way to ensure there will always be sufficient energy in the evening peak, even if the batteries are unloaded is to provide a back-up diesel generator.

A battery bank does not generate energy: it displaces energy stored in times of excess production to time of excess demand. The addition of battery therefore requires incremental solar power in order to account for sufficient energy.

- If the demand of the PU is during daytime hours, there is a good match between demand and supply and therefore a large battery will be needed.
- If the demand of the PU is during evening or night, the energy produced during the day will need to be displaced to the demand time: a large battery bank will be needed.

In the case of milling, there is a good match between high power and energy demand, since use is principally during daytime. However, as commented above, since the energy demand is very punctual, solar is less of a viable solution.

Case Study: Milling Conversion Model

Let us assume Developer Y has identified a potential entrepreneur wishing to use a maize mill.

For Developer Y's existing mini-grid, monthly consumption is 600 kWh. The mill therefore represents a significant share of consumption (180 kWh per month when running 1 hour a day), but could potentially be covered. The cheapest and fastest way to provide incremental power is to do so with the help of a diesel generator, particularly if it is to provide power over a short period of time per day.

Currently, the mini-grid of Developer Y has a rated capacity of 7.5 kW so it will not be able to start the mill. No milling business should be integrated with the mini-grid before the planned capacity uograde that Developer Y is implementing. The consequence is that if the mill starts up before the upgrade it will collapse the grid which will probably have to be manually reset. Similar considerations are to be made for the other new mini-grid sites identified for development.

Grid upgrade cost calculation example

Taking into account the above example, one should account for about 26,000 USD, on the distribution only, in order to upgrade a 3km single-phase grid to a 3-phase grid as broken down below.

Item	Price
Equipment	
2 x single-phase inverters (if compatible) or 1 x 3-phase inverter	$10,000.00
Electrical equipment at generation (LV Panel)	$5,000.00
Recabling grid into 3-Phase (assuming 3 km)	$3,000.00
Other cabling at consumers level	$3,000.00
Installation	
Mechanical / Electrical installation	$5,000.00
Grand total	**$26,000.00**

Table 4: Grid upgrade cost calculation

Incremental power supply cost calculation example

There are two main ways to provide incremental power. The solar + battery option is much more costly as shown in the table below. If the mill requires power (especially if it's a high power compared to the baseload of the grid) for a short time or seasonally, a diesel generator will by far remain the cheapest option. One should note that such hybrid mini-grid is still regarded as "green", since no more than 5% of the overall power supply is generated by diesel.

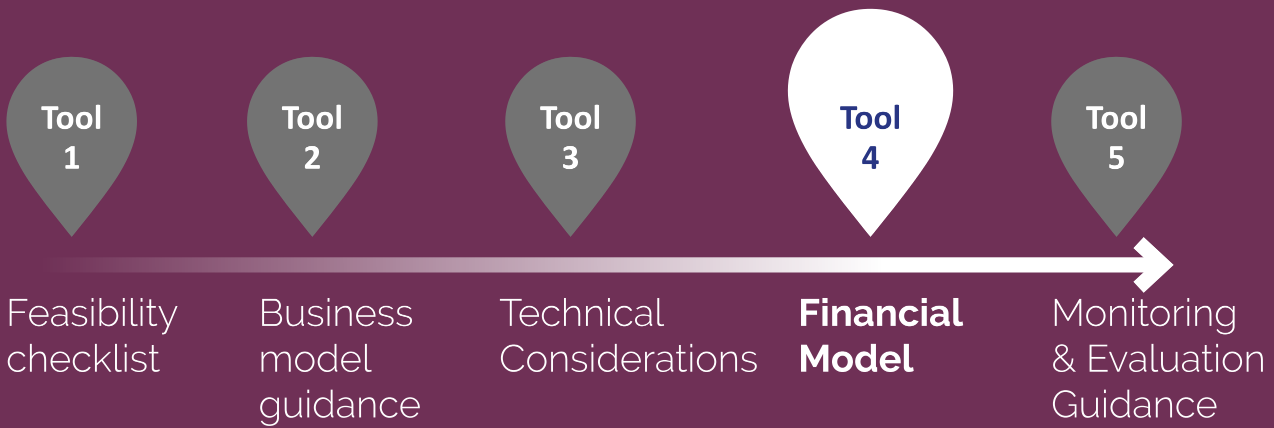
Item to provide incremental power with Solar	Price
Equipment	
PV Panels and equipment 7kW	$15,000.00
Inverters 10kW	$10,000.00
Batteries 20 kWh	$10,000.00
Other cabling at consumers level	$3,000.00
Mechanical / Electrical installation	$5,000.00
Grand total	**$ 43,000.00**

Item to provide incremental power with a diesel generator	Price
Equipment	
Diesel Generator 20 kW	$10,000.00
Mechanical / Electrical installation	$2,000.00
Grand total	**$ 12,000.00**

Table 5: Incremental power supply cost calculation

'All costs/prices reflect typical averages, based on experience in the region in similar sized projects'.

Tool 4: Financial Model



Purpose

The purpose of Tool 4 is to assist mini-grid developers and mill owners to determine the financial feasibility of milling as a PU activity.

Tool 4 is best viewed and understood in its original Microsoft Excel Workbook Format (www.gmgfacilitykenya.org). The tool provides a general overview as well as detailed user instructions and guidance throughout. This written section of the guide should be used as a high level reference only to understanding the intent, design and potential applications of the Tool 4.

The Financial Model is built from perspective of both the mini-grid developer and the mill owner, with the understanding that the milling equipment must deliver positive returns to both parties to be a financially feasible enterprise.

Mini-grid Developer's View

The mini-grid developer has to consider the overall economic impact of upgrading the mini-grid system to accommodate the mills. This is best reflected in the Levelized Cost of Energy (LCOE) calculation, which is a measure that reflects the overall cost to the developer for each unit (expressed in kilowatt hours) of energy produced from the mini-grid system. LCOE is expressed in the following formula:

LCOE = (Capital Expenditures + Present Value of Lifetime Operating Expenditures) / (Lifetime Energy Production)

Furthermore, to evaluate project economics, the mini-grid developer should consider typical investment metrics such as internal rate of return (IRR) and payback period.

The model calculates the LCOE under two default scenarios. The 'Base Case' scenario calculates the LCOE for a mini-grid system without mills. Whereas the 'Upgrade Case' scenario calculates the LCOE incorporating the additional investment and energy production to accommodate the mills.

A decreasing LCOE between the two scenarios is an indication of the positive marginal benefit of adding milling equipment to the economics of the mini-grid system. Furthermore, it is noted that the LCOE (with a profit margin for the developer) becomes the basis for the Tariff that is paid by the end-user. As such, a decreasing LCOE results in lower electricity bills and therefore cost savings and increased financial returns for the mill owner.

This analysis can be performed in the ***Mini-grid Developer's View Worksheet*** of the excel model and is organized as follows:

Reference	Calculation
1	LCOE Analysis
2	Key Investment Metrics
3	Cash Flow Analysis
4	Assumptions and Calculations
4.1	Capital Expenditures
4.2	Operating Expenditures
4.3	Energy Production

Table 6: Organisation of online excel worksheets (Developers view)

The purpose of this tool is to assist mini-grid developers and mill owners to determine the financial feasibility of milling as a PU activity.

Mill Owner's View

The mill owner has to consider the investment, cash flow generation profile and perform sensitivity analysis of key value drivers in assessing the economic viability of the PU activity. The key investment metrics to be assessed are the internal rate of return (IRR), net present value (NPV) and payback period.

The model allows the user to build a detailed cash flow forecast, which provides the basis for the calculation of the investment metrics. The cash flow forecast is developed using key financial, commercial and market assumptions related to the operations of the productive use activity.

For a given set of inputs, if the IRR is greater than the cost of capital, NPV is positive, and payback period is within an acceptable range, the mill owner should proceed with the project.

The mill owner should assess the impact of changes in key variables such as the retail price for the product or the electricity tariff. The model facilitates this analysis through a sensitivity analysis calculator that shows the impact on the NPV based on changes to the assumed values for key variables.

The model has two default scenarios. The 'Conversion Scenario' refers to the case where the mill owner owns/operates a mill already and is looking to either convert it from diesel to electric or transport it to the mini-grid site from another location. The 'New Enterprise Scenario' refers to the case where a mill owner intends to build and operate a new mill at the mini-grid site.

These analyses can be performed in the Mill Owner's View Worksheet of the excel model and is organized as follows:

Reference	Calculation
1	Key Investment Metrics
2	NPV Sensitivity Analysis
3	Cash Flow Analysis
4	Assumptions and Calculations
4.1	Revenue
4.2	Energy Consumption/Flour Processing
4.3	Operations & Maintenance (O&M)
4.4	Depreciation
4.5	Interest and Principal Loan Repayments

Table 7: Organisation of online excel worksheets (Mill owners view)

The model allows the user to build a detailed cash flow forecast, which provides the basis for the calculation of the investment metrics.

Case Study (Developer Y)

The financial model template has been used by Developer Y to understand the financial viability of upgrading the mini-grid system in Busia County to accommodate electric mills and for assessing the feasibility of having existing milling enterprise (i) convert diesel mills to electric or (ii) purchase and install new electric mills.

Developer Y used the ‘Developer View’ worksheet to understand the economic impact of integrating the milling equipment on a planned mini-grid system by calculating the LCOE (Category 1), Tariff (Category 1) and investment metrics (Category 2) under the ‘Base Case’ and ‘Upgrade Case’ Scenarios. To perform this analysis, Developer Y estimated the key inputs associated with upgrading the system including system size (Category 4.3), energy production (Category 4.3), operating expense (Category 4.2) and capital expenditures (Category 4.1).

Developer Y used the ‘Mill Owner’ worksheet to calculate the return on investment (Category 1) associated with (i) the conversion of 1 x 7kW existing diesel powered mills at the mini-grid site and (ii) purchase, installation and operation of 1 x 3kW electric mills.

Developer View Results

The table below demonstrates the key output of the ‘Mini-grid Developer View’ worksheet for Developer Y. It is noted that the LCOE decreases between the ‘Base Case’ and the ‘Upgrade Case’ indicating the marginal benefit of adding mills is greater than the costs associated with upgrading mini-grid system. In mathematical terms, this is due to the magnitude of increase in total energy production being greater than the associated increase in capital and operating expenditures over the lifetime of the mini-grid system. Furthermore, as the profit margins to the developer are assumed to remain the same under both scenarios, the lower LCOE could support a lower electricity tariff that can be passed on to the mill owner and other residential and commercial end-users connected to Developer Y’s mini-grid system.

It should be noted that while there is a decrease in the LCOE between the two scenarios the impact on overall cash flows from adding the mills is negligible. This is primarily driven by the limited demand for milling processed flour in the mini-grid community due to competition amongst mills, which results in low machine capacity utilization and energy consumption.

	Units	Base Case	Upgrade Case
System Size	kW	23	26
Capital Expenditures	$	313,422	320,679
Present Value of Operating Expense	$	69,269	75,143
Total Energy Production	kWh	877,217	995,771
LCOE	**$/kWh**	**0.44**	**0.40**
Profit Margin	%	35%	35%
Tariff	**$/kWh**	**0.59**	**0.54**
IRR	%	10%	10%
Average Annual Cash Flow	$	17,237	17,392

Table 8: Mini-grid developer view worksheet for Developer Y

Mill Owner View Results (Conversion Scenario)

The table below demonstrates the key input and output values using the worksheet 'Mill Owner View'. The analysis indicated that for 1 x 7kW mills with a production capacity of 300 kgs / day and approximately 0.5 hours of usage (which translates to 150 kgs processed flour per day) over 10 year period, the mill owner can expect a positive NPV and IRR and should therefore proceed with the investment. It should be noted that in practice this would be difficult to implement, as the mill owner would be able to generate a better outcome by retaining the existing diesel configuration (which results in lower tariffs) and may not want to incur the additional investment of approx. $1,500 associated with converting the diesel-powered mill to electric.

Key Input	Units	Conversion
Mill Power Rating	kW	7kW
Production Capacity	kgs /hour	300
Utilization	hrs/day	0.5
Processed Flour	Kgs / Day	150
Useful life	Years	10
Unit Retail Price (Service)	$	Maize = 0.05, Sorghum = 0.10
Unit Retail Price (Product)	$	Maize = 0.35, Sorghum = 0.60
Mix (Service)	%	Maize = 50%, Sorghum = 50%
Mix (Product)	%	Maize = 50%, Sorghum = 50%
Tariff	$/kWh	0.54

Output	Units	Conversion
Total Investment	$	1500
NPV (Service)	$	14,413
NPV (Product)	$	48,557
Payback Period	Years	<1
Annual Production (Service)	kgs	45,000
Annual Production (Product)	kgs	33,750
Energy Consumption	kWh	1,125

Table 9: Mill Owner's view for Developer Y

Mill Owner View Results (New Enterprise Scenario)

The table below demonstrates the key input and output values using the worksheet 'Mill Owner View'. The analysis indicated that for 1 x 3kW mills with a production capacity of 70 kgs/hr and approximately 2.1 hours of usage over 10 year period, the mill owner can expect a positive NPV and IRR and can proceed with the investment. It should be noted that this would be difficult to implement for mill owners with existing milling operations as they would be able to generate a better outcome by retaining their existing diesel configuration (which results in lower tariffs) and may not want to incur the additional investment of approx. $900 associated with the purchase and installation of new electric mills.

Input	Units	New Enterprise
Mill Power Rating	kW	3kW
Production Capacity	kgs /hour	70
Utilization	hrs/day	2.1
Processed Flour	kgs/day	150
Useful life	Years	10
Unit Retail Price (Service)	$	Maize = 0.05, Sorghum = 0.10
Unit Retail Price (Product)	$	Maize = 0.35, Sorghum = 0.60
Mix (Service)	%	Maize = 50%, Sorghum = 50%
Mix (Product)	%	Maize = 50%, Sorghum = 50%
Tariff	$/kWh	0.54

Output	Units	New Enterprise
Total Investment	$	900
NPV (Service)	$	12,753
NPV (Product)	$	54,558
Payback Period	Years	<1
Annual Production (Service)	kgs	45,000
Annual Production (Product)	kgs	33,750
Energy Consumption	kWh	1,929

Table 10: Mill Owner's view (New Enterprise Scenario)

While the above calculations indicate that converting a milling machine is economically profitable over a 10 year period. Mill operators, for several reasons including the comparatively cheaper cost of a diesel and issues accessing finance, can be resistant to converting or purchasing an electric milling machine.

It should be noted that the cost of power supplied by a diesel generator is lower (0.37 $/kWh) than the prevailing mini-grid tariff. While the mini-grid tariff may be higher than equivalent diesel cost, the PU activity may still be profitable and therefore additional factors need to be taken into consideration:

- Reliability: An electric grid may be more reliable in the long-term with fewer outages than diesel generator set which needs frequent maintenance and exposes the mill owner to fuel supply delays / shortages.
- Cost savings: For a new enterprise, connecting to the grid can provide upfront cost savings on diesel generation equipment or stand-alone solar PV system.
- Operations & maintenance: The operations and maintenance costs of the power supply are borne by the mini-grid developer.
- Value-add services: The mini-grid developer needs to ascertain whether they have the capacity to offer the value add services such as capacity building, financing and/or access to inputs/markets to incentivize integration of existing milling activities with the mini-grid.
- Mission-based motivation: Some PU owners may have a personal preference for selecting a generation source that is eco-friendly.

- Safety perception: Consumer perception that flour processing with electric mills is safer and more hygienic than diesel powered mills.

- Efficiency: Diesel-run mills are efficient at very high capacities hence the presence of 7 kW mills in areas where mills are operating way below capacity. However electric mills that are half the size 3kw are available in the market and run more efficiently than the larger diesel mills hence would be ideal for most rural villages.

Mini-grid developers seeking to improve productive use load as part of their installed mini-grids can pursue a range of catalytic strategies to encourage operators to make this switch in the first instance, leveraging the insights gained from the financial model. Such strategies include:

- **Encourage value addition:** The developer should promote the additional potential returns from Milling as a Flour Product (when using a converted mill to providing milling as a product rather than just a service, the 10 year NPV increases to $48,557 from $14,413 for the mill owner). While this value addition is clearly the most promising milling opportunity, it can represent a challenge for milling operators who previously have only offered milling as a service. Therefore, it is equally important that the developer can provide sufficient support to the milling operator to help them transition

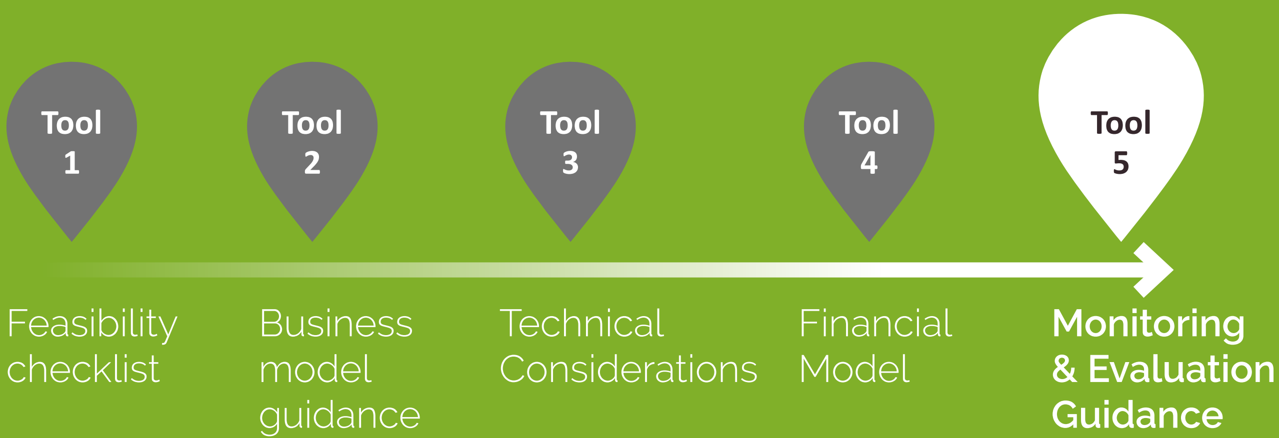
- **Facilitate access to appropriate financing** for the capital expenditure required to convert or purchase an electric mill, by linking with financial institutions or provide credit guarantees to facilitate lending

- **Pilot tariff subsidies to be more competitive with diesel** such that mill operators see electric mills as less onerous from an operating expenditure perspective

- **Flexible Tariff Structures:** Developers can promote variable tariff structures that incentivize mill owners to operate the mill during specified periods during the day. The mill owners in turn can incentivize their customers to mill during specified hours by passing on the lower service fees. Furthermore, a drop and pick strategy can be employed where customers are encouraged to drop their grain in the morning and pick in the evening hence allowing the mill owner to process the flour when tariffs are lowest during the day and reduce operating expenditure. The same point can be made in a demand management context where this practice will contribute to mini-grid viability by promoting maximum use of power during non-peak times and mitigate the risk of grid under-utilization.

In many instances, a combination of the above strategies will likely be the most effective for supporting a milling operator, however with different combinations and relative emphasis based on the need of the milling operator and capacity of the Developer.

Tool 5: Monitoring & Evaluation Guidance



Purpose

Introducing milling into a rural community can have a number of impacts, in particular it can provide increased income for a community if community members reduce their travel costs/time travelling to other mills and/or can mill and sell surplus product. However these impacts cannot be assumed to happen; they need to be validated. In addition there may be unexpected outcomes or impacts from introducing milling into a community and these also need to be understood.

The purpose of this tool is to provide guidance on how to undertake monitoring and evaluation (M&E) on a milling business, introduced as a productive activity attached to a mini-grid. The focus of this tool is on the social impacts of the milling business rather than the impact on energy demand / mini-grid profitability, as it is assumed this is tracked using existing business indicators.

Why is M&E important?

This tool should be integrated into a wider M&E strategy that monitors and assesses the impact of the mini-grid as a whole. Having an M&E strategy in place enables accurate and reliable data to be collected and analysed into useful insights, which can enable effective decision-making. It demonstrates accountability to customers, partners and if relevant donors – it is also important for donors to assess the social return on investment. Finally, M&E allows for lessons learnt to be communicated, and ideally shared across the sector to improve quality and innovation in mini-grid business models.

For broader guidance on developing an M&E strategy please see the M&E toolkit developed for mini-grid practitioners by University of Strathclyde, Practical Action and Carbon Trust (2018). https://pureportal.strath.ac.uk/en/persons/aran-eales/publications/

The purpose of this tool is to provide guidance on how to undertake monitoring and evaluation (M&E) on a milling business, introduced as a productive activity attached to a mini-grid.

Steps in developing M&E framework

Step 1. Decide what to measure and develop a Theory of Change

A theory of change is a useful tool to think through how and why a desired change is expected to happen in a particular context. A theory of change generally includes four levels:

1. Impact level: What impact(s) do we wish to achieve?
2. Outcome level: What conditions are needed to achieve this(these) impact(s)?
3. Output level: What outputs are needed to achieve these outcomes?
4. Activity level: What activities must be undertaken to achieve these outputs?

Having a theory of change in place provides a clearer picture of desired outcomes/impacts and therefore what should be measured as part of an M&E strategy. Not every possible outcome/impact needs to be measured (nor is this possible), so the theory of change should reflect the social impact priorities of the community, developer and partners.

The theory of change should not be a static one-off tool but a 'living document' that can be refined as understanding of an intervention's impact increases.

A sample theory of change for Developer Y for a milling business is outlined in Figure 7.

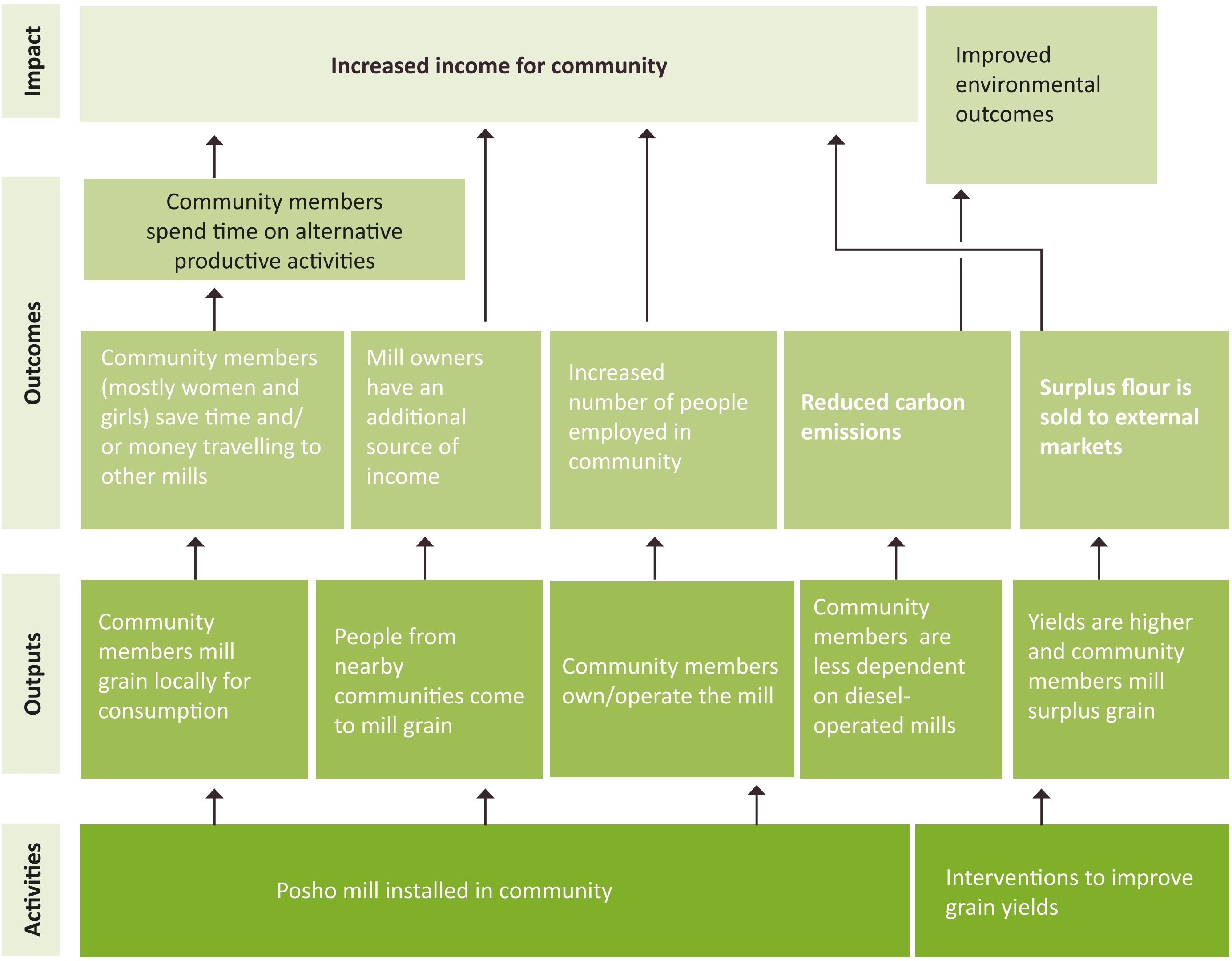


Figure 7: Theory of change

Step 2. Develop indicators

Once a theory of change has been developed, the next step is to design indicators. These are used to track and quantify progress of activities linked to outputs, outcomes and impact.

Below is a menu of indicators that can be used to assess outcomes and impacts of a milling business. Practitioners can select indicators depending on the context as well as the priorities established in the theory of change, and adapt and expand indicators as needed to create a tailored M&E approach. The closer the indicators are aligned to company-wide Key Peformance Indicators (KPIs), the easier they will be to track and the more useful they will be.

Outcome/impact to measure	Indicator	Notes
Time/money saved travelling to mill grain	Increase in % of grain milled locally	
	Reduced % in time spent travelling to mill each day/week	Frequency should be determined based on milling frequency. Indicator should be disaggregated by gender to understand specific impacts on women and girls.
	Reduced % in money spent travelling to mill each day/week	As above. Indicator will not be relevant if travelling by foot.
	Increase in % of time spent on other productive activities	Indicator should be disaggregated by gender.
Additional income for community from sale of surplus grain	Increase in % of surplus grain sold in external markets	This will help to demonstrate whether income is simply being recycled within a community or whether additional value is being brought in from outside the community.
	% increase in income for grain farmers	
Increased employment opportunities and income for mill owner/operator	% increase in income for miller	Indicator can be broken down by income source (community members vs people outside the community) to assess whether additional value is being brought in from outside the community.
	% increase in people involved in milling business	May simply be the mill operator/owner but could also extend to aggregators/traders in the case of surplus grain being milled.
Reduced carbon emissions and improved environmental outcomes	Estimated tons of greenhouse gas emissions avoided through use of renewable energy instead of diesel.	Calculation based on litres of diesel consumed before and after mill was installed (either because original mill was diesel operated or because previously community depended on a different diesel-operated mill).

Table 11: Indicators that can be used to asess outcomes and impact of a milling business

Being aware of unintended consequences

It is possible that setting up a milling business has unintended negative consequences, for example, it might draw customers away from a nearby mill and therefore affect the income and livelihood of those mill owners/operators. While it is not possible to set up mechanisms to track these unknown factors in advance, having a robust M&E strategy and continuous community engagement should mean that there are communication channels and relationships in place to help identify and mitigate any emerging issues. Data collection should ensure people are being asked 'open' questions, not just specific questions designed to track pre-defined indicators: this will give space for responders to articulate any concerns/issues they may have which might not otherwise be captured.

Step 3. Develop tools and process to collect data

Data collection should as far as possible be integrated into existing processes and customer interactions.

Data collection methods

To collect data against the above indicators, the most likely data collection methods are the following:

1. Surveys of grain farmers (to capture income levels, milling usage patterns and travel time/costs)
2. Surveys of mill owner/operator (to capture quantity of mill maized, income levels, customer profiles and level of external sales)

Data collection should be participatory and done in collaboration with relevant community stakeholders.

Timing of data collection

Data should be collected at regular intervals (eg. quarterly, 6-monthly or annually) to track progress against indicators, with baseline data collection occurring before the installation/conversion of the milling equipment.

However since grain production is subject to significant seasonal variations, data taken at a particular time of year might not be comparable to a different season and therefore the timing of data collection should reflect the conditions at the time of the baseline survey and subsequent data collection periods.

Data collection tools

Sample tools for surveys and data monitoring are in Figures 8 and 9.

- Name of site
- Name of respondent
- How much grain do you mill per day/week?
- How many customers do you have per day/week?
- How much grain does the average customer bring to mill?
- How much do you charge per kg? (or other appropriate unit – ensure consistency across survey tools)
- What % of your customers are local vs outside the community?
- How much income do you make from milling per day/week? How does this vary throughout the year?
- Do you employ anyone else?
- Do you use any diesel? If so, how many litres per day/week?

Figure 8 - Sample survey for mill owners/operators.

- Do you harvest more grain than your household needs?
- How much surplus did you get in the last harvest?
- How much grain do you bring to mill on average? How does this vary throughout the year?
- How much do you pay to mill your grain per day/week?
- Where do you mill your grain? If not the local mill, why not? How far do you travel and are there any transportation costs?
- Do you mill surplus grain? If so, how much per day/week? Do you store it for later consumptionor sell it? If you sell it, where do you sell it and for how much?

Figure 9 - Sample survey for milling customers

Tips on effective surveying

Enumerators need to be able to speak the local language and understand local culture and context. Gaining community trust is essential to ensure accurate information. It is also important to consider having enumerators of both sexes to enable male and female members of the community to feel comfortable.

Consideration should be given to avoiding survey bias when designing the questions. Survey bias can occur by phrasing questions to elicit either a positive or negative reaction from the respondent, often termed 'leading questions'. The key is to keep the phrasing as neutral as possible.

Consideration should be given to sampling strategies. The purpose of sampling is to select individuals for interviews from the total population in the target region in a way that is governed by chance (or at least by clear, transparent purposive sampling), not by the researcher's or enumerator's choice/bias. The resulting randomness of sample selection is important for guaranteeing representativeness of the collected data. It is not always possible to have random samples and where this is the case purposive sampling is another option. Ultimately what is most important is to be transparent and clear about the sampling methodology used and associated constraints, and therefore any disclaimers on conclusions made.

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Milling as a Productive Application in Green Mini-Grid (GMG) Systems

Practitioner Guide

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