FACTSHEET GRAIN MILLING

Introduction

Grain milling is an important process for turning grains such as maize into flour for edible and/or animal consumption. This fact sheet centres around off-grid, solar-powered milling in Tanzania.

Key Facts of the Application Environment

80% of Tanzania's population is engaged in agriculture and 90% of these farms grow maize for edible consumption. This widespread agricultural practice has resulted in 93% of all maize being produced on small farms and 95% of all maize flour being milled at small-scale, decentralised hammer mills that are powered by grid electricity or diesel engines.

Technology	Hammer mills use spinning hammers to crush grain into powder for edible consumption. Flour quality is determined by a metal screen that limits particle size.
Application	The majority of households in Tanzania grow maize and mill their own grain for consumption at small-scale decentralised mills.
Technology Overview	Mills can utilise DC or AC motors that are powered by stand-alone solar systems or mini-grids. Matching voltage requirements of the motor and power system reduces the need for additional components such as inverters.
Economic and Financial Feasibility	Mills charge between 100–200 TZS ($0.043–$0.086) per kilogram of maize milled, with households milling between 9–18 kilogram of maize flour per week. Using these figures, the earning potential of a mill business can be estimated from the surrounding population. Standalone solar mills with brushless DC motors offer the best return on investment due to high efficiency and fewer components required.
Example Mill	The Agsol MicroMill is a BLDC mill that operates at 800W and produces 60 kg/hr of edible flour. It can be purchased with a stand-alone solar system or with an AC-DC converter. Financial models suggest the "MicroMill" can achieve break-even within one year if it has at least 25 customers per week.
Benefits and Outcomes	Solar mills save time and labour for women, who might otherwise travel up to 10km to access milling services. The presence of mills can complement existing local businesses and attract more customers to an area.
Constraints and Risks	Costs of customer acquisition, system distribution, installation, and after-sales services are high for decentralised mills. Due diligence on products, customers, and markets is important for ensuring mills deliver sustained benefits.
Future Perspectives	The market for off-grid milling can be supported with debt finance that helps companies achieve production runs of 2000 units and above and to support customers finance up to 50% of the product costs. Digital tools and data can reduce customer acquisition costs and enable business model innovation.

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95%

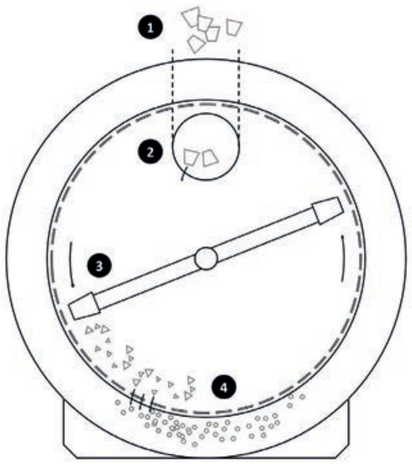
maize flour produced in Tanzania is milled at small-scale, decentralised hammer mills

Technical Information

The most common type of small-scale mill used in Tanzania is the hammer mill, which uses spinning blades/hammers to crush grain into fine particles. The flour exits the milling chamber through a replaceable metal screen that controls the flour quality by limiting the output particle size: screens with tighter meshes produce finer flour that is preferred for eating, whereas looser meshes produce coarser flour that is used for animal feed. Common hammer mill maintenance involves replacing the screen, which can be damaged by stones, or replacing the hammers, which degrade over time. Materials required for this common maintenance are locally available at relatively low costs.

There are no formal quality standards for small-scale mills in Tanzania. It is recommended that purchasers check whether a mill supplier has had their products tested by any 3rd party labs or if they were used in pilots in East Africa.

The milling mechanism is driven by a motor or engine that rotates the hammer blades and runs on a power system. Ensuring that the mill, motor, and power system have compatible voltages and power ratings minimizes the need for converters such as variable frequency drives, inverters, and AC-DC converters that reduce the system efficiency and increase the cost.



Steps for Milling Grain in a Hammer Mill

1. Maize is fed into the mill through a hopper
2. Maize enters the milling chamber
3. Rotating hammers hit the maize and break it into smaller pieces
4. Fine particles pass through the screen and exit the milling chamber to be collected

Graph 1: A diagram of a hammer mill (RENAC 2022)

Economic and Financial Feasibility

Mills are often located at markets or village centers and provide services to the surrounding community members in as much as a 10km radius. Households in Tanzania typically mill grain in 10–20 L (9–18 kg) quantities on a weekly basis with trips coinciding with local market days.

Milling services in Tanzania have typically been priced between 100–200 TZS ($0.043–$0.086) per kilogram of maize. Because of their high CAPEX investment for panels and batteries, solar mills tend to charge more than other mills, especially if they are serving small and remote communities. Recently however, rising fuel prices have caused diesel mill operators to increase their prices such that diesel and solar milling are currently cost competitive.

Diesel mills consume a large amount of fuel when starting and so operators typically prefer to wait until there are multiple customers to start the mill, resulting in long customer wait times. Conversely, solar mills can be used efficiently on small quantities of grain and thus can offer faster service times than diesel mills.

The feasibility of an off-grid milling business largely depends on the local population, which influences the earning potential of the mill. The local market size for a mill can be estimated by the number of households in the area. Assuming households consume 10kg of maize per week and pay 150 TZS ($0.064) per kg for grain milling, each household would spend 78,000 TZS ($33.46) per year on milling.

Mill efficiency directly impacts the profitability of a solar mill, as low efficiency increases energy consumption and thus raises costs. A stand alone DC system offers the greatest efficiency and profitability due to the minimal need for converters. A stand alone system would have higher fixed costs but lower variable costs compared to a mill being installed on an established mini-grid.

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Benefits and Outcome

Mechanised milling enables significant labour and time savings for women, who are often responsible for the milling and sometimes spend hours either pounding grain into flour by hand or walking to access the nearest diesel mills. As solar mills are well adapted to handle small customer volumes, they can reach remote communities that would otherwise not be served by diesel mills that need higher customer volumes to break even. As shown in Table 2, small decentralized solar mills could break even within one year if they serve a population of just 25 households.

The presence of mills also strengthens surrounding businesses by attracting customers to the area. Local businesses such as shop owners are ideal operators of solar mills, as they have an established customer base and revenue streams that are complemented by the mill.

Constraints and Risks

Relatively few companies specialise in solar mill production or distribution and existing firms face challenges to build their market and reach financial sustainability. Because solar mills are targeted at decentralised and remote customers, the costs of customer acquisition, mill distribution, system installation, and after-sales service are relatively high compared to the cost of the product. Selling to or partnering with businesses already operating in the last mile, such as mini-grids, will help to minimise these costs.

Due diligence when selecting products, customers and markets is critical. A recent project to deploy 2000 solar mills in Zambia has been criticised for failing to deliver: end-users have criticised the mills for being too slow, while operators complained that they were not profitable, and project developers have reported that panels are being stolen at many milling sites[2].

Future Perspectives

For companies, working capital is needed in order to achieve high volume production runs that would unlock economies of scale and bring down product costs. In the case of Agsol, the company estimates that it needs to reach production volumes of at least 2000 units before it achieves economies of scale. For customers, asset financing is needed to make the purchase affordable and Agsol expects that financing 50% of the system cost would help secure new orders while minimizing the risk of customers defaulting.

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Case study: Agsol MicroMill

Agsol is an early-stage start-up based in Kenya that develops high-efficiency mills for use with solar power. In 2022, Agsol launched the “MicroMill”, a compact mill that can produce edible-quality flour at a rate of 60 kg/hr while consuming only 800W of power. The mill runs on a BLDC motor and can be purchased with a standalone solar system or with an AC-DC converter to use on mini-grids. The business model for a MicroMill operator can be constructed from Agsol’s technical data and local market assumptions. Under the assumptions given below, the MicroMill can reach a simple break-even in one year.

Table 1: Agsol MicroMill Specifications

Mill	Motor	1.2kW BLDC motor operates at 800W
	Throughput	60 kg/hr for edible-quality flour
	Warrantly	2 years for the mill and batteries
	Price	$590 EXW Nairobi
	Maintanance	Replaceable screens cost $4 are replaced every year; hammers cost $4 and are replaced every 6 months
Standalone Solar System	Panels	600W solar panels PV power
	Battery	600Wh LSP Lithium-ion
	Charge controller	MPPT
	Price	$710 EXW Nairobi
AC-DC Adapter	Efficiency	98% efficiency
	Price	$100 EXW Nairobi

Table 2: Agsol MicroMill Simple Break-even Financial Model

Topic	Value
Number of Customers per Week (customers/week)	25
Average Customer Grain Volume (kg/customer)	13.5
Milling Price ($/kg)	$0.086
Revenue per Week ($/week)	$29.03
Variable Costs per Week (Screen and Hammers) ($/week)	$0.23
Gross Profit per Week ($/week)	$28.80
System Cost: Mill, Stand-alone System, and $200 Installation ($)	$1,500.00
Weeks to Simple Break-Even (weeks)	52

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