CrossBoundary

Mini-Grid Innovation Lab

Innovation Insight

Electric grain milling – a USD $2.5 billion opportunity across Sub-Saharan Africa (SSA)

March 2024

About the CrossBoundary Mini-Grid Innovation Lab

CrossBoundary's Mini-Grid Innovation Lab, part of CrossBoundary Group, is Africa's first R&D fund exclusively focused on testing new business model innovations for mini-grids, designed to close the gap on the 618 million Africans who do not have power. The Mini-Grid Innovation Lab works with developers across the continent to test innovations to make mini-grids a more reliable and commercially viable solution. For additional information, visit **www.crossboundary.com/labs**.

Governments across SSA could add USD $2.5B/annum to their economies by incentivizing electric milling

Grain milling is one of the most **common agro-processing activities across SSA** – an estimated 90M tonnes of maize is processed annually. We estimate this maize is milled across **~500-750k maize mills**, the majority of which are diesel powered posho mills.

Switching to electric mills is beneficial to mini-grid developers, consumers and the broader economy. Profitable mini-grids are needed to provide energy access to ~260M people across the continent. Mini-grid sites with grain-mills have higher utilization than those without, and grain mills can contribute **~10% of total site consumption at peak harvest season improving site profitability**.

For consumers, electric mills are already competitive with diesel mills in terms of capex and opex, while standalone solar mills require the highest upfront investment. Electric mill uptake is constrained by inconsistent electricity supply, mill operator inertia and ancillary costs.

1. **Inconsistent electricity supply:** operators need a reliable power supply to run their businesses, and grid power can be inconsistent in supply and be variable in terms of quality
2. **Mill operator inertia:** electric mills deviate from the embedded perception of what grain mills are – operators are accustomed to large hammer-mills with high throughputs
3. **Ancillary costs:** installation of electric mills attracts additional costs arising from three-phase supply / variable frequency drives (VFDs) / soft starter requirements

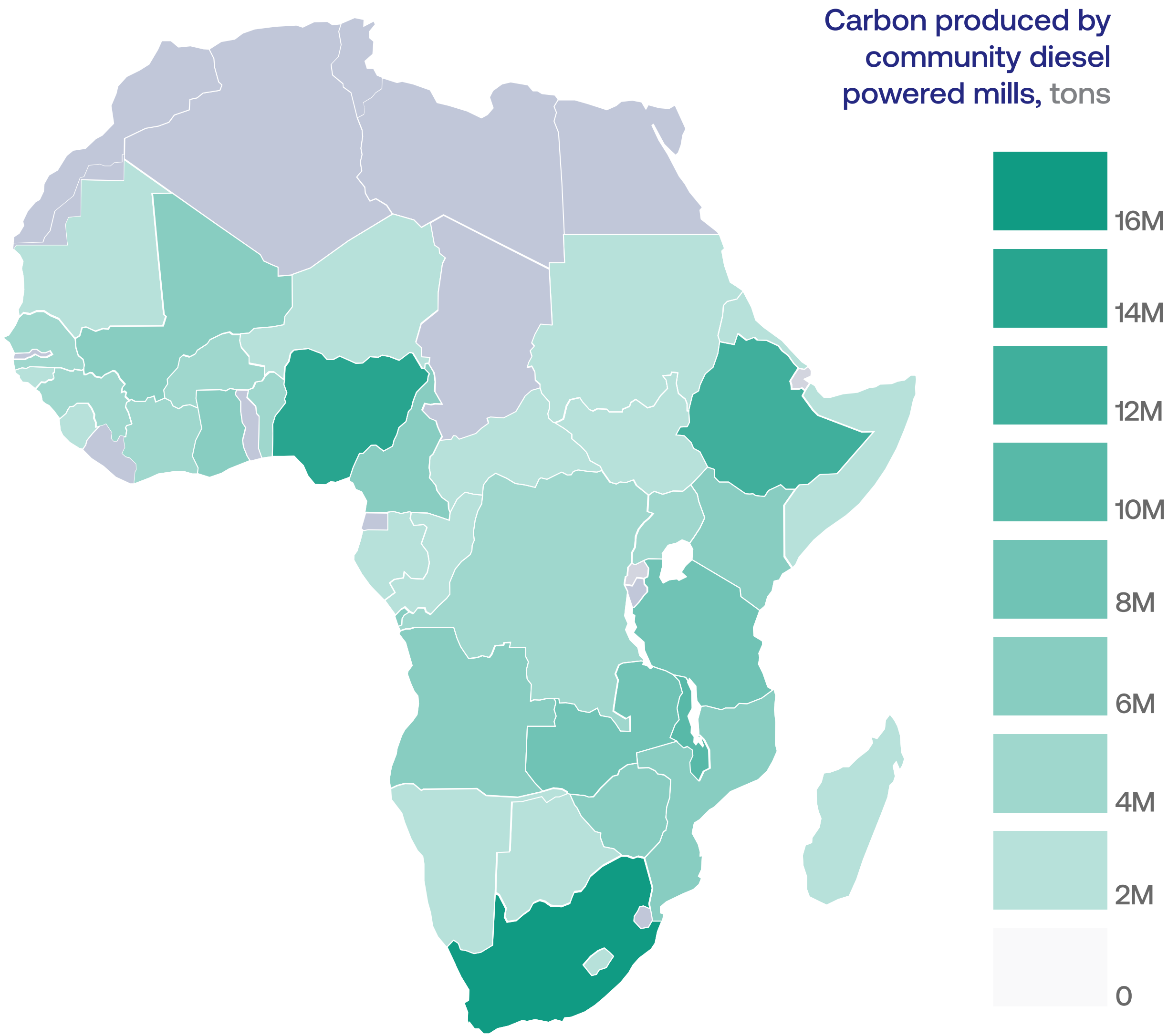
Converting diesel mills to electric could be an option to accelerate uptake. However, conversions can cost $2000-$2800, with VFDs/soft starters constituting >40% of the cost. More generally, **reliable power, financial incentives for switching and a concerted marketing/education campaign**, are the key interventions for scaling electric milling. These could be supported by strong links to national agricultural programs in economic clusters for maximum impact.

For the broader economy, converting to electric mills by 2030 could **add $2.5B of value across SSA, saving 5M tons of carbon per annum**. However this is not achievable without universal electricity access, which is not a reality for 75% of rural communities – buttressing the need for **governments, development partners and the private sector to accelerate the deployment of mini-grids** and least cost electrification technologies in these communities.

01

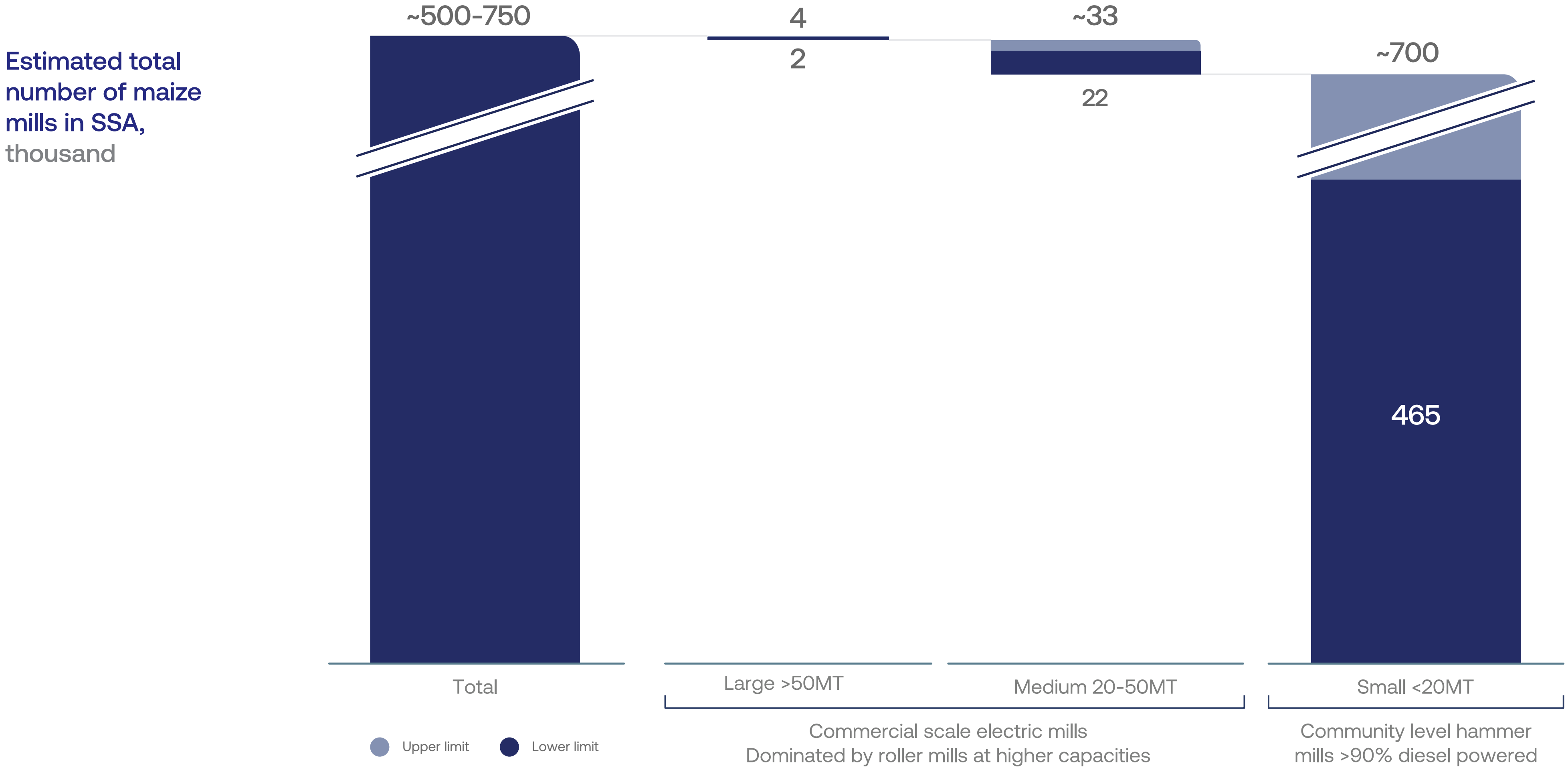
90M tonnes of maize is processed in ~0.5-0.75M mostly diesel powered mills in SSA annually

Grain milling is one of SSA's most common agro-processing activities. An estimated **~90M tonnes of maize** are processed annually across the continent.



1. Maize production is from: https://www.fao.org/faostat/en/#home
2. Maize imports and exports are from: https://wits.worldbank.org/trade/comtrade/en/country/ALL/year/2021/tradeflow/Imports/partner/WLD/product/100590
Any gaps signify incomplete data from the FAO in the plot above, showing where data is unavailable

Maize is milled across **~500-750k maize mills**, the majority of which are diesel powered posho mills

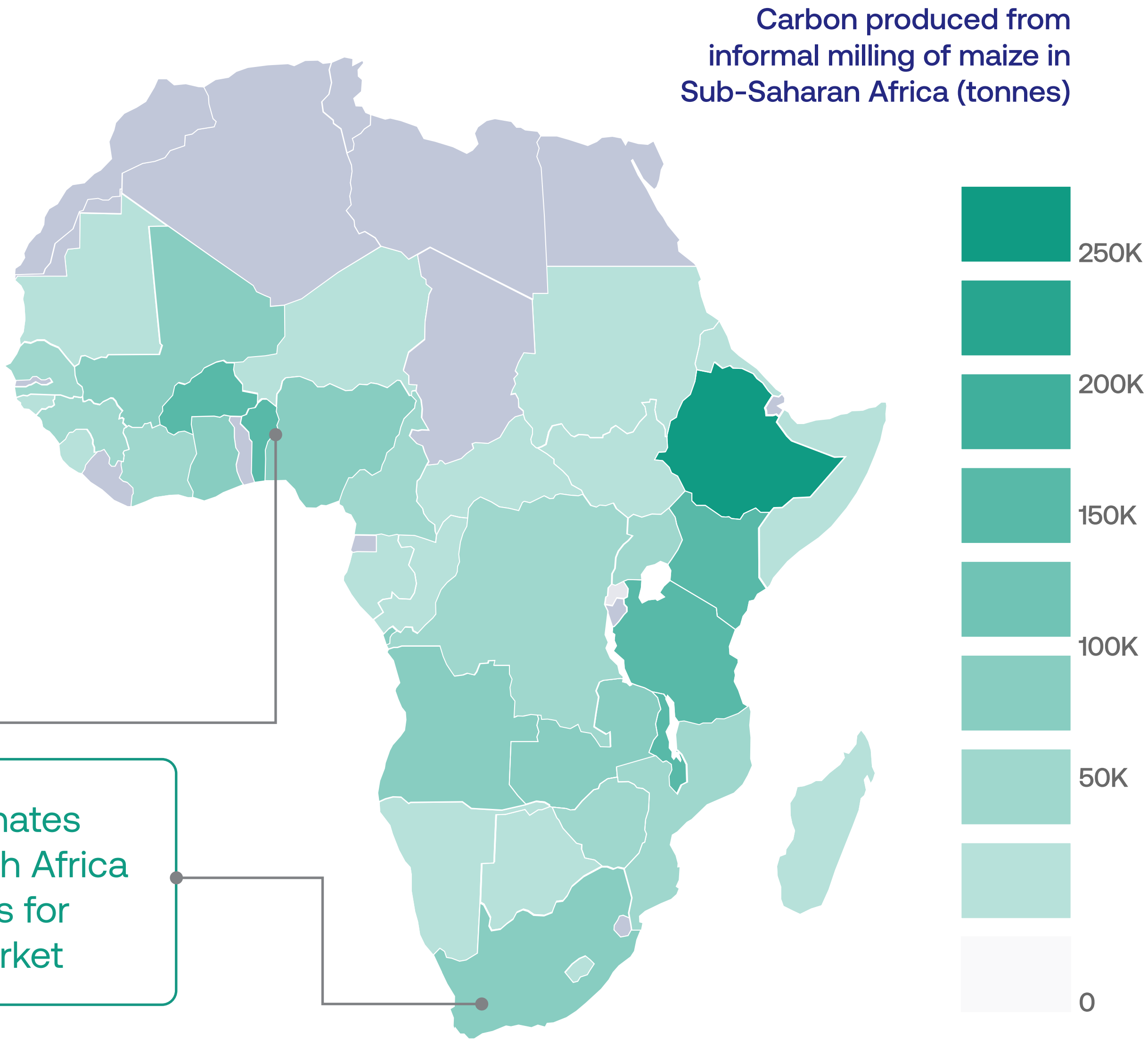


Assumptions: One mill per 200-300 households, as derived from empirical data from 2 countries and applied across SSA in accordance to household size. Commercial milling: Large mills: >50MT/day consists of ~34 million tons of installed commercial cereal grain milling capacity installed in SSA, Medium commercial electric mills serving peri-urban population assumed to be 4.5% of total mills
Sources: Press search, stakeholder interviews https://www.theafricareport.com/10511/african-flour-mills-fight-for-market-share

Our analysis suggests that this requires up to ~900M litres of diesel per year – translating to **~2.3M Tonnes of carbon per year** for maize alone.

This figure does not include other cereals milled across SSA including rice, millet, wheat or sorghum, meaning the **total carbon impact of grain milling is even higher**.

Switching to electric milling across the continent could provide a clean, viable alternative to diesel mills.



Commercial milling dominates cereal processing in South Africa and Nigeria, and accounts for 75-80% of the milling market

Assumptions: 50 Kg of Maize milled per litre of diesel, Carbon produced consuming litre of diesel is 2.68 kg
Source: Survey data. Press Search, DCLA LOG clutser

02

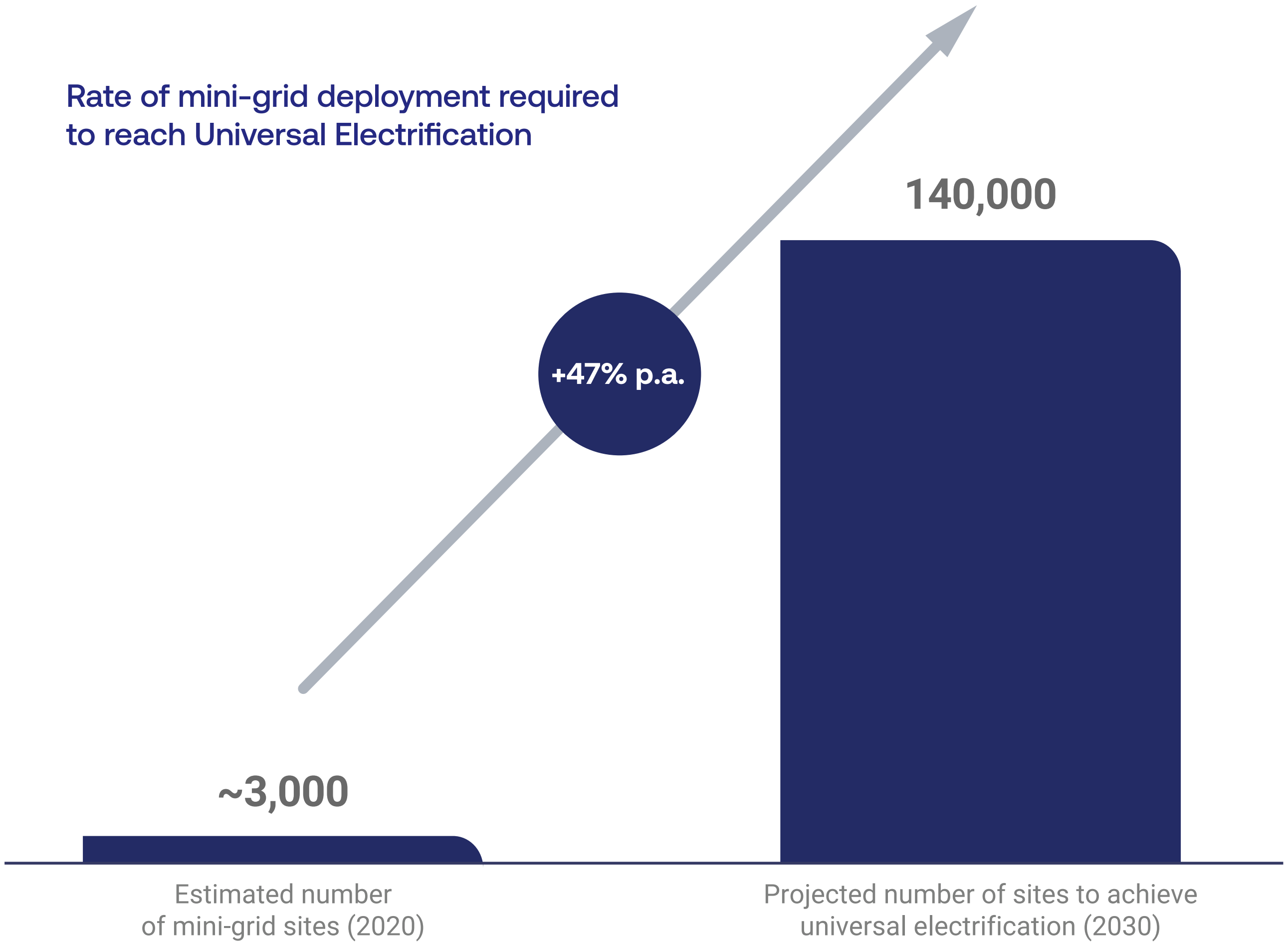
Switching to electric mills is beneficial to both mini-grid developers and consumers

Profitable mini-grids are required to provide energy access to at least 260 million people across SSA

Mini-grids are the least cost technology for providing electricity to homes and businesses for ~260 million people across SSA

However, mini-grid deployment has not yet scaled up sufficiently to meet electrification targets, partly due to challenging economics that inhibit private sector investment

Innovations aimed at increasing electricity consumption and capacity utilization, such as electric milling, could enhance their profitability and drive much needed investment in the sector



1. Only 600-1000 of these are private minigrids. Others are owned by the government
Source: BNEF Mini-grid database, AMDA Benchmarking Report (2020)

Mini-grid sites with grain mills have higher capacity utilization than those without, making them more profitable

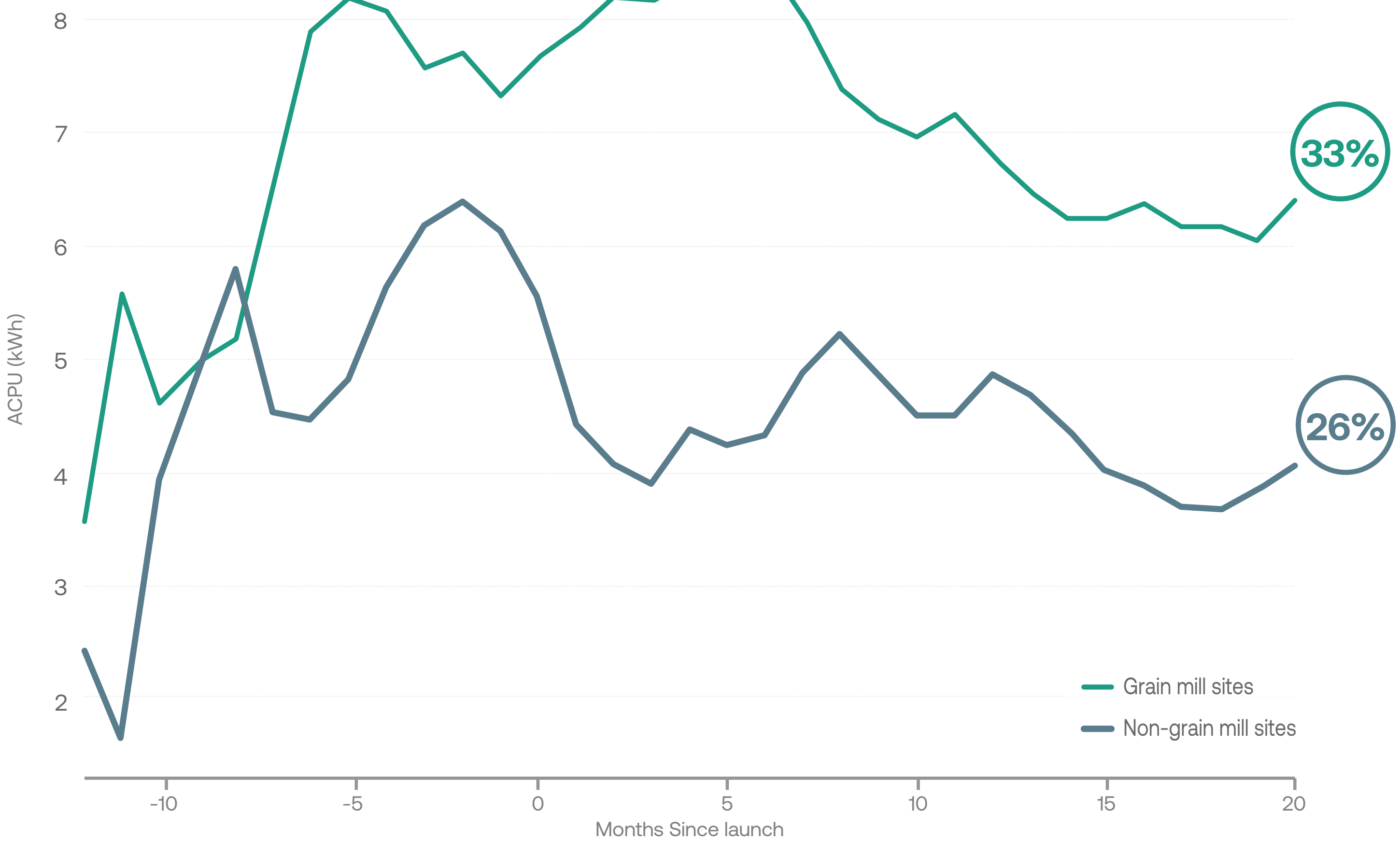
Low utilization is a major loss contributor across minigrid sites

Data from sixteen sites show mini-grid sites with grain mills on them have a **higher utilization factor** than those without

Scaling the use of electric mills on mini-grid sites improves capacity utilization factor, which means more revenue is derived from higher consumption and fixed costs are spread over a greater number of units sold. This improves mini-grid unit economics and profitability.

ACPU[1] across sites in Kenya, Tanzania and Nigeria, kWh

Average site utilization factor



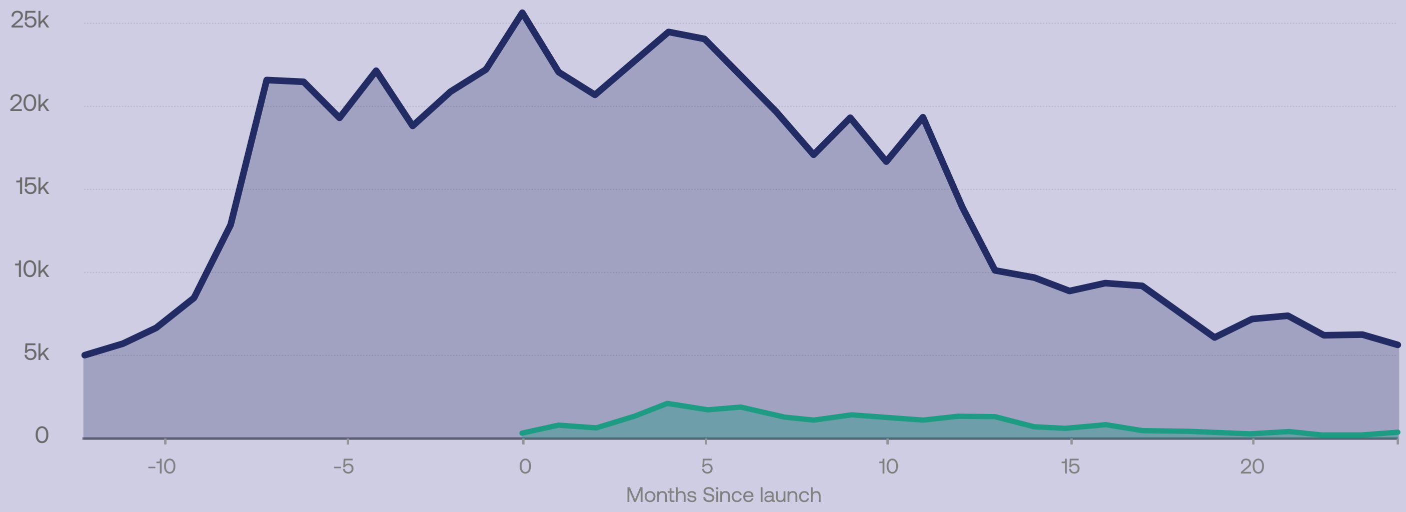
1. Average Consumption per User
Data from 11 Grain Milling Sites and 5 non-Grain Milling Sites

Case study: Grain mills can contribute up to 12% of a site's total consumption, depending on seasonality

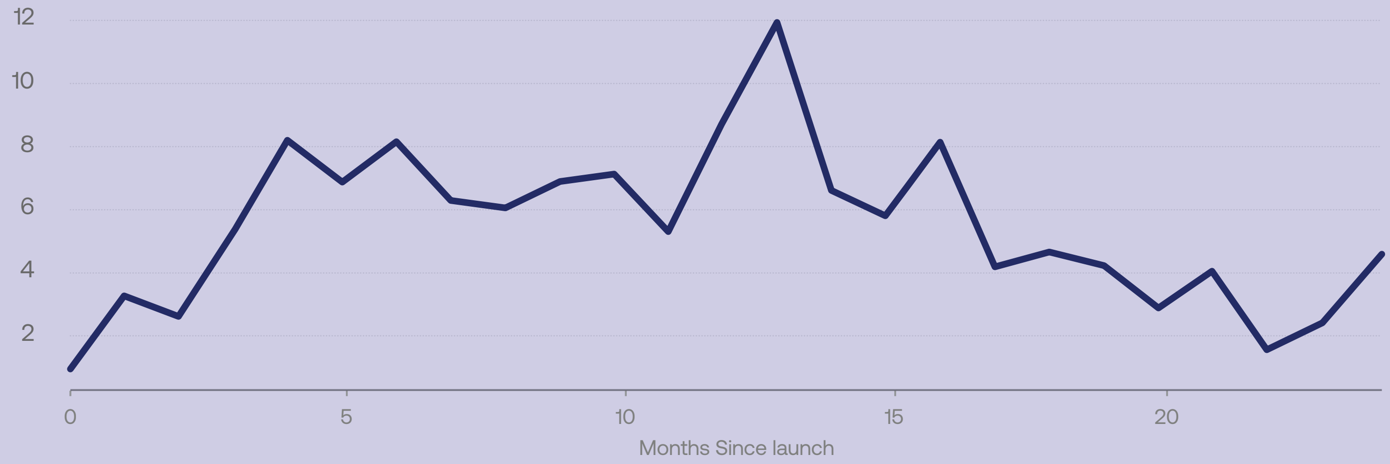
Grain mill usage is highly seasonal, and at peak can contribute up to 12% of total consumption across during harvests sites

This consumption is an incentive for mini-grid developers to ensure electric mills scale across their sites

Grain mill total consumption throughout the year, kWh



Grain mill consumption as a proportion of total consumption, kWh



● Grain mill consumption
● Total consumption

Data from 11 Grain Milling Sites and 5 non-Grain Milling Sites

For millers, the purchase and installation of electric mills is cost competitive with diesel today

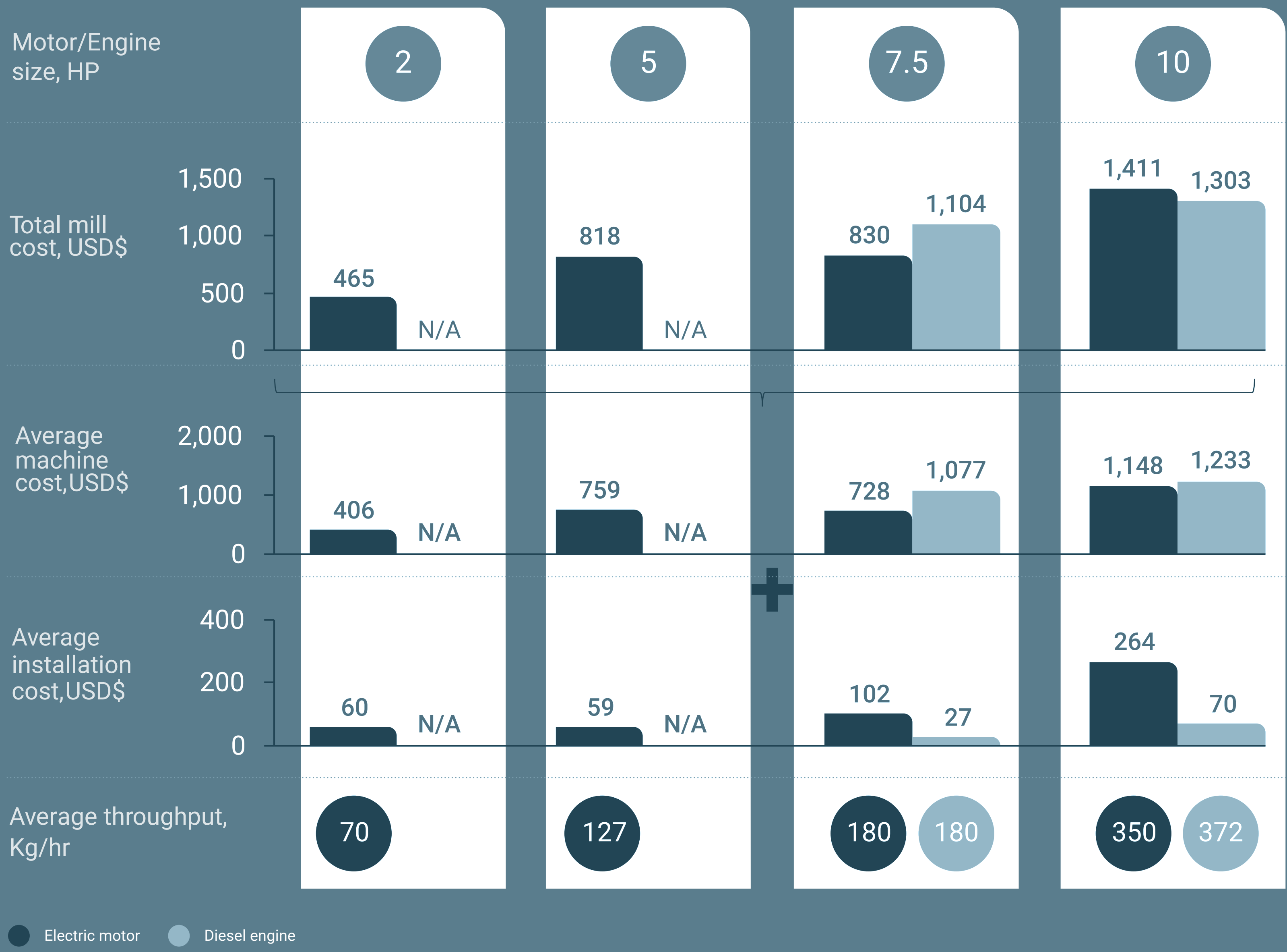
A survey of 17 suppliers across Kenya showed all suppliers stocked both electric and diesel mills, though only electric motors were available at smaller power ratings (2HP, 5HP)

Electric motors were cheaper on average than diesel engines, but had higher installation costs

- Accessories and materials costs for the electric mills typically included soft starters, isolators and electric cabling
- The associated cost for the diesel engine was typically only the ballast, sand and cement required for plinth civil works

Electric mills approximately matched throughput for 7.5 and 10HP power ratings

Suppliers reported they also provided retro-fitting services to fulfill client requests for hybrid mills with both electric motors and diesel engines

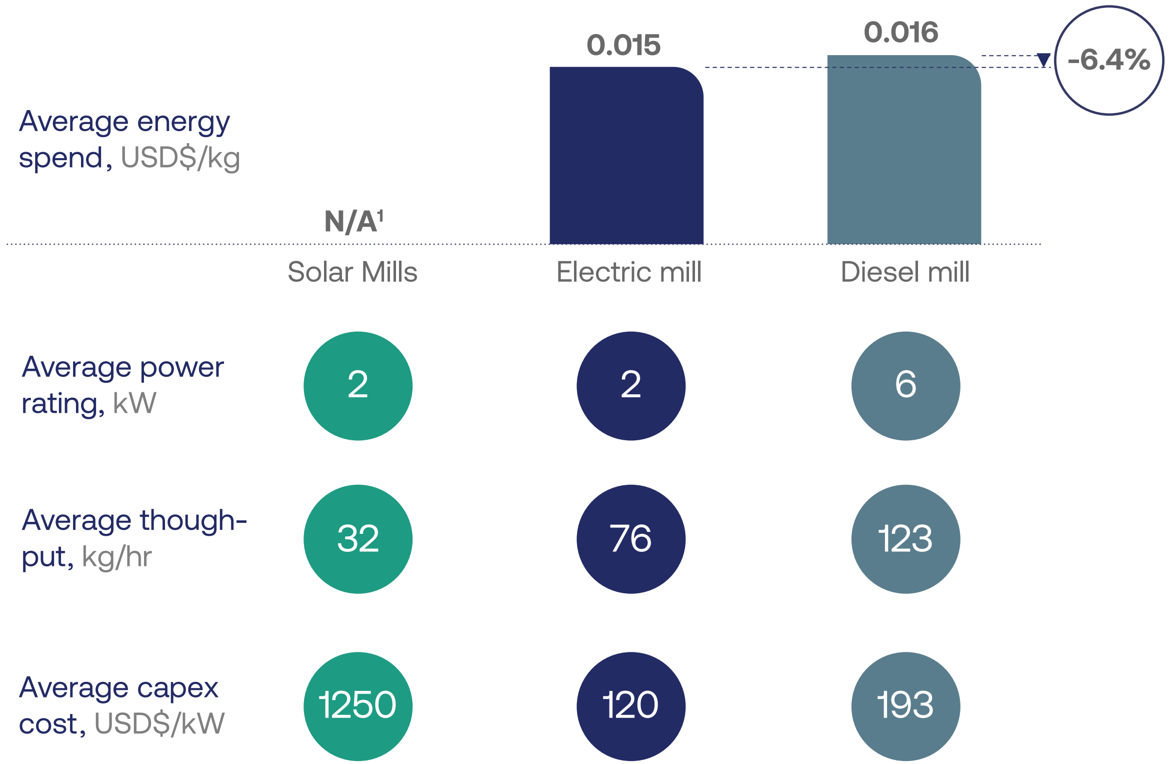


Source: Kenya supplier survey data. Data was collected for 31 different mills available in their inventories, sourced mainly from China and India

While stand-alone solar-powered mills have the lowest recurring energy costs, their substantial upfront capital expenditure renders them economically less viable compared to diesel or electric-powered mills.

Solar mills have the advantage of dedicated energy supply and reliability, however, their high average capex cost makes them uncompetitive to diesel or plug-in electric mills

Plug-in electric mills deployed from Lab prototypes across sites in communities in Kenya typically have low power rating, low throughput compared to diesel mills, but their efficiency makes them competitive on an energy-spending basis

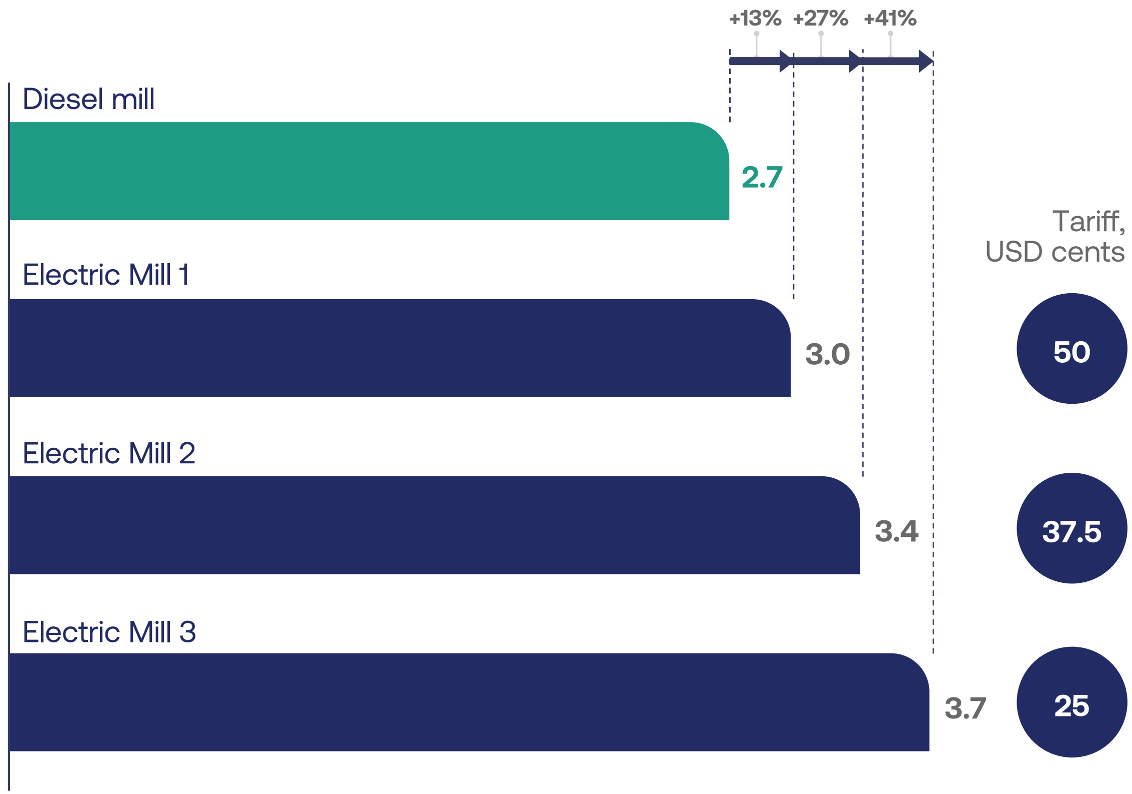


1. Assumed to have no external energy cost as solar panels are built into the mill and covered in CapEx

Source: Solar milling: Exploring market requirements to close the commercial viability gap by efficiency for access

Mini-grid developers can further incentivize electric milling by reducing tariffs – implementing a 25 cent tariff can increase profits for electric millers by 41%

Profit per day per 100kg milled, USD$



Our data shows millers process **~100kg per day** on average throughout the year, with peaks in harvest season and troughs throughout the rains

This can translate to **USD 30/day profit** for electric millers, 13% more than their diesel mill counterparts today

Developers can incentivize adoption of electric millers by further reducing tariff – **a 25% and 50% tariff reduction increases profit by 27% and 41% respectively**

While lower tariffs may reduce mini-grid profits, the additional load and increased consumption from more affordable rates has been shown to offset those losses across different sites

Assumptions: Price per kg maize 5 KES/kg, Overheads as a proportion of revenue: Labour and other general (5%), Maintenance (9% - diesel only)
Source: Diesel mill survey data

03

Electric mill uptake is constrained by inconsistent electricity supply, mill operator inertia and ancillary costs

Consistent electricity supply, mill operator inertia and additional costs are the three most common constraints hampering electric mill uptake

Theme	Challenges	
Inconsistent electricity supply	• Mill operators require a reliable power supply to ensure business operations: power cuts and fluctuating voltages hamper efficiency and consistency in service • Where there is no access to power, electric milling is not possible in any case (unless it is an individually powered solar powered mill)	*Electricity is on and off, I am not changing from diesel* – Eunice Sarano, Diesel mill operator
Mill operator inertia	• Electric mills deviate from the embedded perception of what grain mills are – operators are accustomed to large hammer-mills with high throughputs • 18-20HP mills are common for most businesses as they are well understood technically and operationally by their operators, and fulfill a “fast service”	*I can do one gorogoro[1] fast – I will use less fuel compared to paying for electricity* – Dennis Wafula, Diesel mill operator
Ancillary costs	• Three-phase supply is required to connect larger electric mills, which can attract an additional distribution line cost • Variable frequency drives and/or soft starters can also be required to connect smaller electric mills to ensure grid stability	*Electricity services can be expensive, I am more comfortable sticking to what I know* – Nicholas Wekesa, Diesel mill operator

1. One gorogoro = One ~2kg tin

Source: Stakeholder interviews, miller interviews (Kenya)

Without reliable electricity supply, scaling electric milling is a non-starter – millers opt for the service provision predictability of diesel mills

Inconsistent electricity supply

Electricity access is low across SSA, and more acute in rural areas...

>500M do not have access to electricity in SSA

The majority of these unelectrified communities are in rural areas – the most current data puts the rural electrification rate at 30%

...and where there is electricity, it is unreliable and unstable...

The majority of SSA countries experience >100 hours of outages per year

Power cuts coupled with fluctuating voltages affect electric motor driven milling service availability, machinery performance and machinery efficiency

...so millers opt for the predictability of diesel mills

Mini-grids provide a cheaper, more reliable alternative than grid extension for many rural communities, but they are not yet scaled across the continent

Solar powered mills provide a stand-alone option to address these challenges, but require 10x additional CapEx investment[1]

As a result, millers opt for tried and tested diesel powered machines, preferring predictability and control over their businesses

“I prefer diesel - as long as I have my diesel and surplus stored somewhere I can operate”
- Dennis, Mill Operator

1. Taking $120/kW for electric mills against $1250/kW for solar mills

Sources: World Bank, IEA (Power outages act as a handbrake to economic development, 2019)

Community millers are accustomed to using hammer mills connected to highly rated engines – electric mills do not meet this expectation

Rural communities commonly utilize readily available hammer mills connected to 10-20HP diesel engines

As a result there is a large legacy stock of these mills across SSA, further perpetuated through familiarity:

- Technical operation and performance well understood by millers
- Local technicians are able to service engines and trouble-shoot any arising issues
- Pricing per kg can be set confidently for profit, taking into account past performance and expected lifespan of the machinery

Millers are reluctant to switch from these large hammer mills to smaller, quieter, less prevalent electric mills despite operational challenges:

- Breakdowns and regular periodic maintenance costs
- Under-utilization

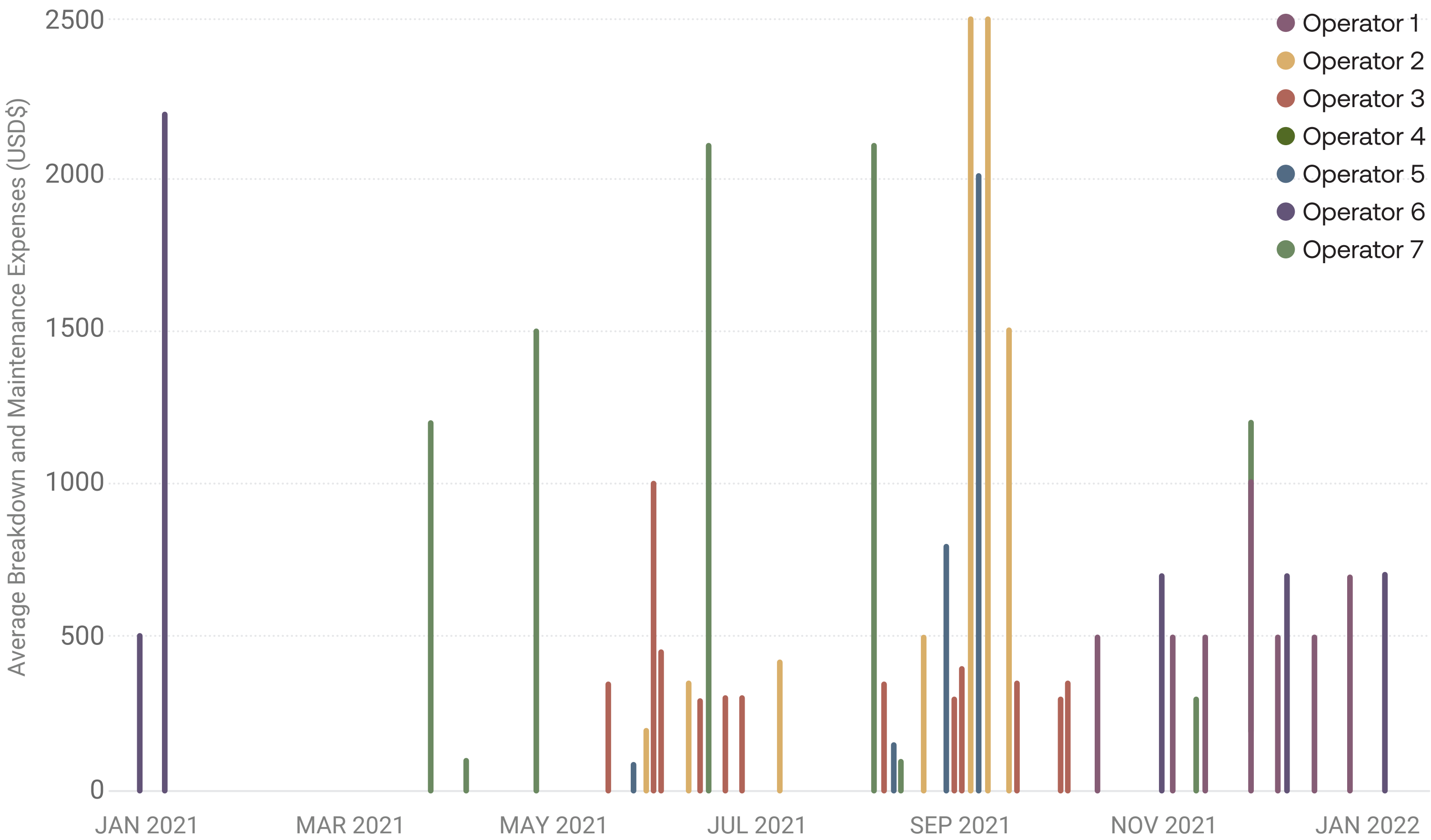
Source: Stakeholder interviews, press search

On average, diesel mill operators experience a breakdown or conduct maintenance on their diesel engines at least once a quarter, spending up to USD$20 each time

This maintenance cost is ~9% of total revenue and typically includes labour costs for servicing and servicing oil

Electric motors in comparison, have minimal maintenance and breakdown costs

Average Diesel Grain Mill Operator Breakdown and Maintenance expenses, January 2021 to January 2022

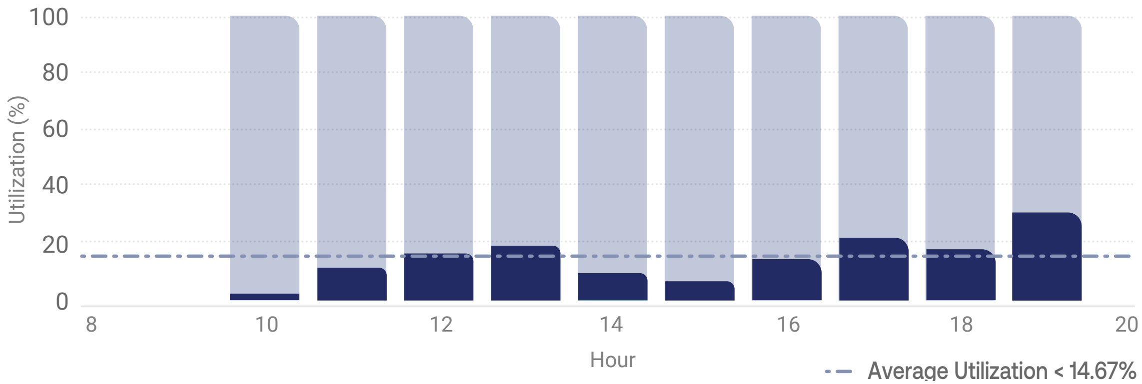


Based on 14 Diesel Grain Mill Operators in Kenya

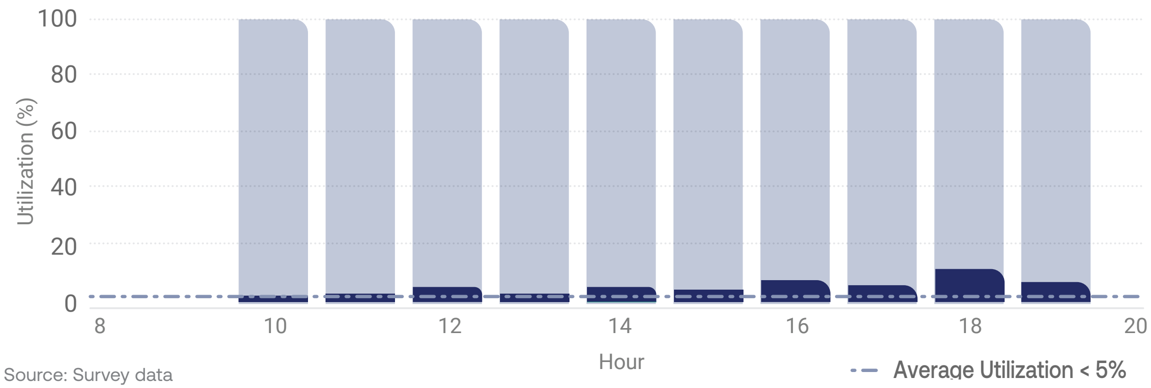
Diesel mills are often grossly oversized – they hardly achieve 20% utilization throughout an entire day of milling during peak harvest season

Ancillary costs

Median utilization of Diesel Grain Mills by the hour of the day, peak harvest season



Median utilization of Diesel Grain Mills by the hour of the day, over the year



Source: Survey data

Data from 25 diesel mills in Kenya shows the extent to which diesel mills are over capacity

On average, the mills have throughput of 133kg/hr rated at ~9HP, and mill ~100kg of grain per day

During peak harvest season, the data showed that these millers barely utilize 20% of the capacity

Over the course of the year, this picture is even worse, utilization is less than 5%

"It's like using a Massey Ferguson tractor to go buy some groceries"

- Matt Carr, Agsol CEO

However, to connect electric mills or convert legacy stock, ancillaries such as three phase supply, VFDs or soft starters are often required.

Three phase supply requires an upgrade of the distribution network

Most existing grain mill operator businesses have **single phase supply** to their premises, sufficient for lighting and other small electric appliances

Highly rated electric mills can require **three phase supply for safe operation**, which often necessitates an **upgrade of the distribution cables and distribution board** connecting the premises at additional cost of USD 200-300[1]

For mini-grids, a VFD or soft starter is required to stabilize the mini-grid network

Motors with power rating >5kW can **trigger an in-rush current** upon starting, which can trip/de-stabilize an entire mini-grid network if inverters cannot match ramp up time

This mean additional investment in **Variable Frequency Drives (VFDs)** or **soft starters** of USD1000-1500 to maintain normal electricity supply:

- VFDs control ramp up and ramp down of motors during start-up or powering off by varying frequency and voltage driving the motor
- Soft starters perform a similar functionality limiting the torque of the motor through voltage regulation, for a smoother progression of current

1. Cost data averaged across 4 Nigerian and Zambian sites

Source: Stakeholder interviews. Press search

04

Rewarding reliable power and financially incentivizing millers are key to driving electric mill uptake

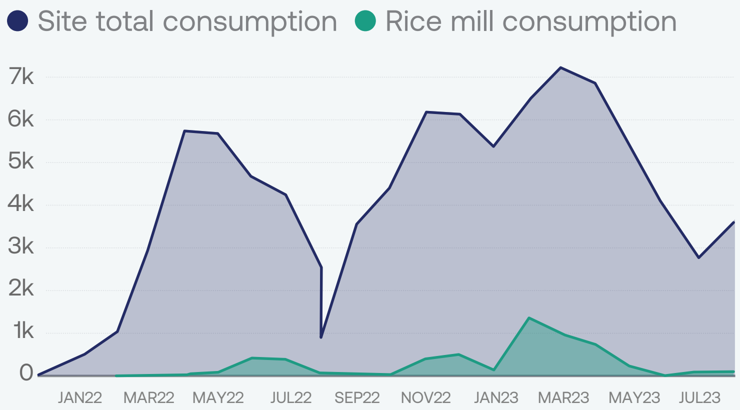
Converting diesel mills to electric addresses the challenge of the sunk cost of the existing milling stock, but requires significant investment

Converting mills addresses sunk cost concerns...

- Converting or retrofitting existing diesel mills could be an attractive option for convincing existing millers reluctant to forego their diesel mill investment to switch to electric milling
- Converting involves replacing the diesel engine driving the milling head with an electric motor
- A variable frequency drive or soft starter is required to protect the electric motor from high in-rush current and stabilize the grid upon start-up

...and can result in significant consumption across sites...

Grain mill total consumption throughout the year, kWh



Case study example (further detailed in the appendix)

- At one mini-grid site a converted rice mill contributes to up to 20% of consumption at peak harvest time
- The conversion is also lucrative for the miller who saves ~40% on energy costs compared to their prior diesel spend

...however significant upfront investment is required

- Spend per conversion typically ranges from USD$2000 to USD$2800, with >40% attributable to soft starter/VFD costs
- This investment can be prohibitive were there is no external financing

Source: Site data. Developer, operator and technician interviews

Reliable power, coupled with financial incentives for switching, are the key interventions for scaling electric milling. These should be supported by strong links to national agricultural programs in economic clusters

1. Reliable power

Expanding Distributed Renewable Energy (DRE) such as minigrids, and rewarding reliable connections

2. Financial incentives

Tax exemptions/ rebates for electric mills

Financing or conversions

Low tariffs

3. Links to national agricultural programs

Anchoring on economic clusters to maximize economic gain

In addition to promoting reliable power, governments and development partners have roles in implementing financial incentives and links to agricultural programs

	1. Reliable power	2. Financial incentives	3. Links to national agricultural programs
Governments	Recognize reliable connections as core to rural economic development (cross-cutting agriculture, health, education, water and sanitation) Utilize integrated resource planning and least cost modelling to identify and install DRE as part of national electrification planning Implement tax exemptions for DRE components Reward reliable connections through service level linked RBF or grants	Introduce tax exemptions/ rebates /subsidies for purchasing electric mills Design programs to enable millers to exchange their diesel mills for electric mills of similar capacity for free or at minimal costs Introduce Government policy prioritizing electric mills be purchased for governmental program or agency usage	Identify economic clusters where complementary activities such as irrigation and agricultural mechanization are supporting high yields and productivity Provide market linkages for surplus yields Provide demonstrations during agricultural promotional activities to highlight: • Financial and operational advantages to be gained by switching to electric mills • Opportunities for fortification and aflatoxin quality control
Development partners	Recognize reliable connections as core to rural economic development, make central theme across all development programs Support/create electrification programs that reward reliable connections in line with national priorities	Provide financing to subsidize electric mills/conversions Support R&D to reduce cost of conversions and electric mills Facilitate carbon credit accreditation for electric mill OEMs/operators	Support/create programs linking electric milling to agricultural economic clusters in line with national priorities

Source: Stakeholder interviews. Press search

Mini-grid developers, financiers and equipment suppliers from the private sector. Also have a role to play across all three interventions for scaling electric mills

Private sector	1. Reliable power	2. Financial incentives	3. Links to national agricultural programs
Mini-grid developers	Implement and adhere to minimum service levels at mini-grid sites	Introduce time or use/ milling tariffs to increase competitiveness vs diesel Provide conversion services for local millers through trained technicians	Prioritize roll-out of mini-grids at agricultural economic clusters
Financiers	Provide concessional local currency local debt to finance mini-grid development	Provide seasonality linked financing for conversions, electrical reticulation and accessory (VFD/soft starter) costs	
Equipment suppliers		Supply affordable, fit for purpose electric milling machinery Design and supply multi-crop processors (e.g., maize/millet/ rice) with fortification capability (dosifiers)	Provide technical and financial information on electric milling during government roadshows/independent roadshow Supply complementary agro-processing equipment to communities where electric milling is offered

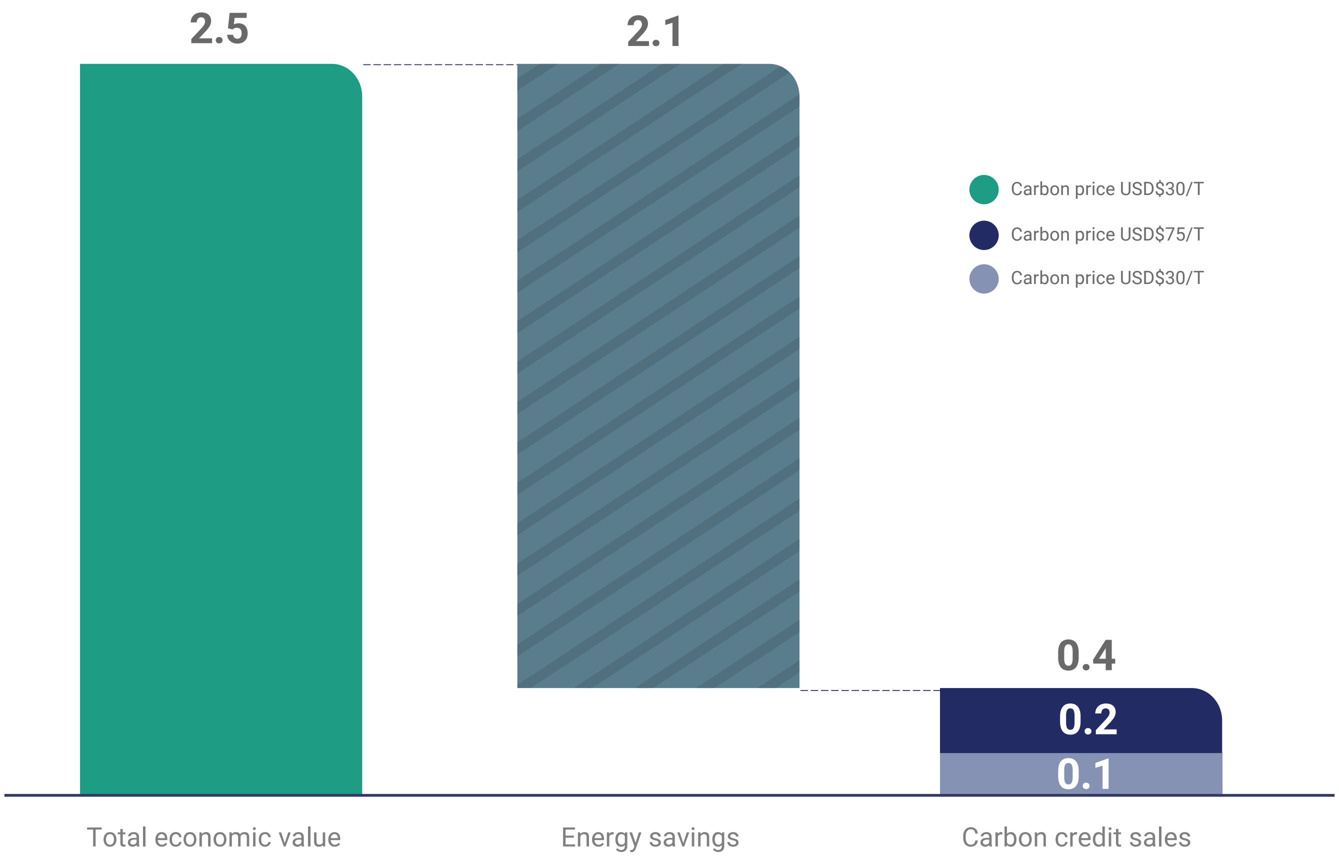
Source: Stakeholder interviews. Press search

05

Switching to electric milling could generate African economies > USD$2.5 billion per annum

Switching to electric grain mills by 2030 could be a $2.5B/annum opportunity through carbon credits, savings on fuel imports and spending on local electricity alone

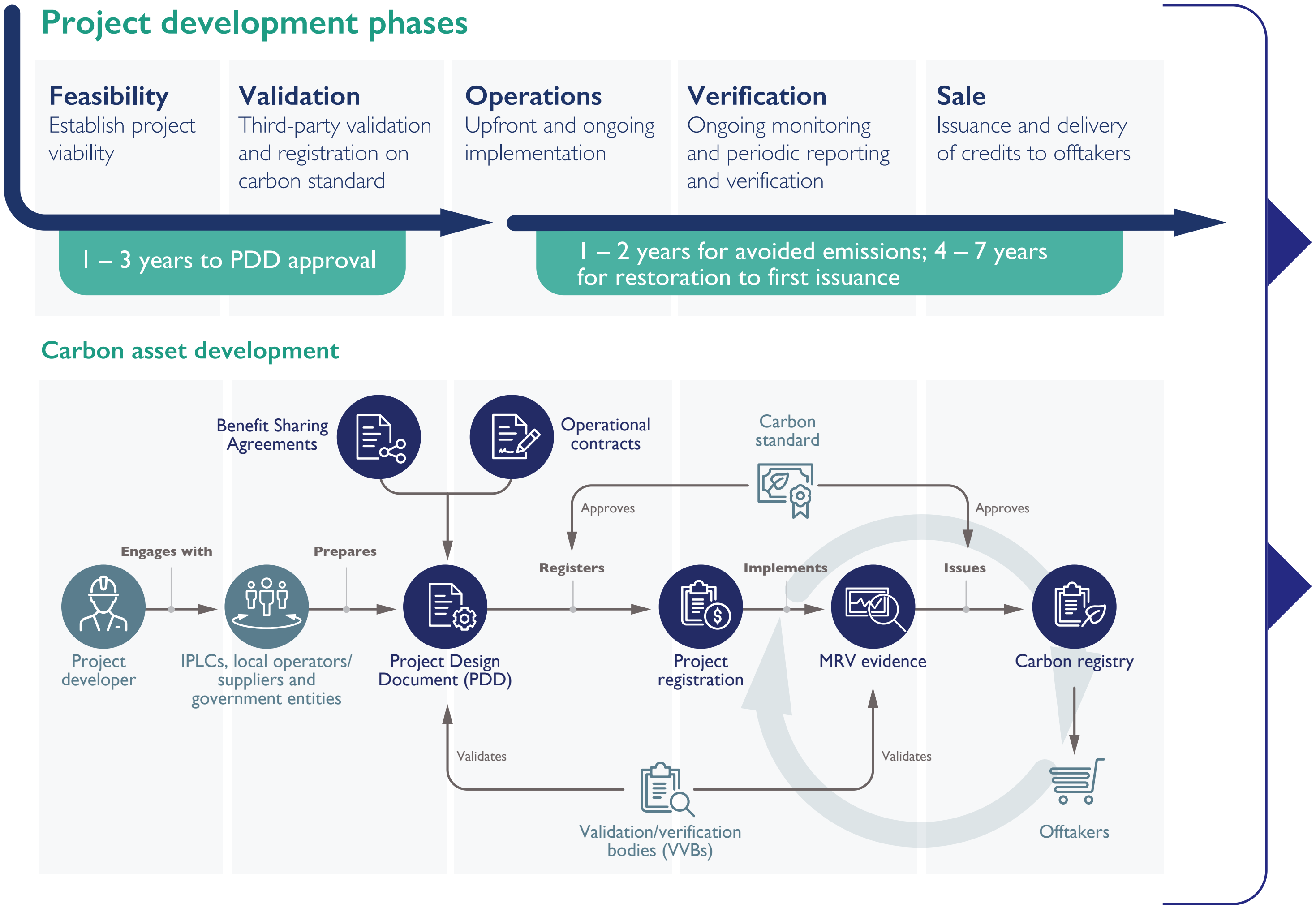
Potential economic value per annum from energy savings and carbon credits from 2030, USD$



Assumptions: 90M tons of maize and rice to be milled in SSA by informal millers in 2030, growing from ~60M today at 6% CAGR. 40% of grain milled at large commercial scale. Average electricity tariff of 20c, and diesel price of S1.4/litre (not taking into potential carbon taxes or other increases in price driven by supply). 95% of electricity sources powering mills are renewable by 2030. Upper limit carbon price of $75/ton in 2030 as stipulated as required price for climate obligations. Lower limit carbon price of $30/ton as projected by Africa Climate Markets Initiative

Source: Press Search, expert interviews

Accessing carbon credits requires significant resourcing and time commitment. However, this presents presents an opportunity for cost reduction of electric mills and financial incentive for operators.



Source: CrossBoundary Natural Capital Practice

Benefitting from carbon credit sales involves a **2-5 year project development process**, which can be resource and time intensive

Third parties operating in the space, potentially de-risked/enabled through development partner interventions, could unlock money through these carbon credit sales, which could in turn be used as a **financial incentive for operators and OEMs**

The carbon price is a significant factor that will influence activity – the price today (~$5/T) **may not justify investment**

However, the price is projected to increase – the Africa Climate Market Initiative projects **a price of $30/T by 2030**, while the IFC project that **a price of $75** is required to meet global climate targets

Next steps...

CrossBoundary Innovation Lab is working with developers, governments, technology providers and implementation partners on:

1

Introducing programs that reward energy access reliability, and not only connections

2

Testing financial models to improve diesel mill conversion economics

If you would like to collaborate on these or related projects eg., scaling electric milling through agriculture programs, please contact us on:

minigridslabs@crossboundary.com

The Innovation Lab's work is made possible by the following funders:

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Disclaimer and acknowledgements

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The Lab's Innovation Insight series provides ongoing, early insights on the prototypes so mini-grid developers, governments, and funders can act on the results as they emerge. All results and analysis in these series is therefore shared as actionable business intelligence rather than scientific evidence.

While these series are not intended to meet the standards of an academic paper, the Lab will publish more complete reports at the end of each prototype, and has partnered with University of Massachusetts Amherst, Rochester Institute of Technology, and Duke University to publish academic papers on certain prototypes.

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Appendix

Converting diesel mills to electric could be an option to accelerate uptake

Converting diesel mills to electric addresses the challenge of the sunk cost of the existing milling stock, and adds considerable load to mini-grids

Why should we do it?

Converting or retrofitting existing diesel mills could be an attractive option for convincing existing millers reluctant to forego their diesel mill investment to switch to electric milling

How do we do it?

Converting involves replacing the diesel engine driving the milling head with an electric motor

A variable frequency drive or soft starter is required to protect the electric motor from high in-rush current and stabilize the grid upon start-up

What is the impact?

Converting one 5HP diesel powered mill can add 20% total consumption on a typical mini-grid

However, conversions require substantial investment from mini-grid developers, ranging USD$2,000 to USD$2,800 per mill, where external financing is unavailable

Installations in rural areas also pose challenges — high quality electric motors are hard to source, and inexperienced technicians struggle with proper sizing and specification of VFDs/soft starters.

Case study: A converted rice mill in Nigeria contributes to up to 20% of consumption at peak harvest time

Overview

The Lab partnered with a developer to electrify milling in one of their sites

This included conversion of a 20Hp rice milling machine from diesel to electric and financing one new 5Hp electric mills to replace a smaller diesel mill

Methodology

Conversion was conducted by a technician identified by the developer

Financing was offered to the mill operators, along with a time of use tariff to improve the business case for switching

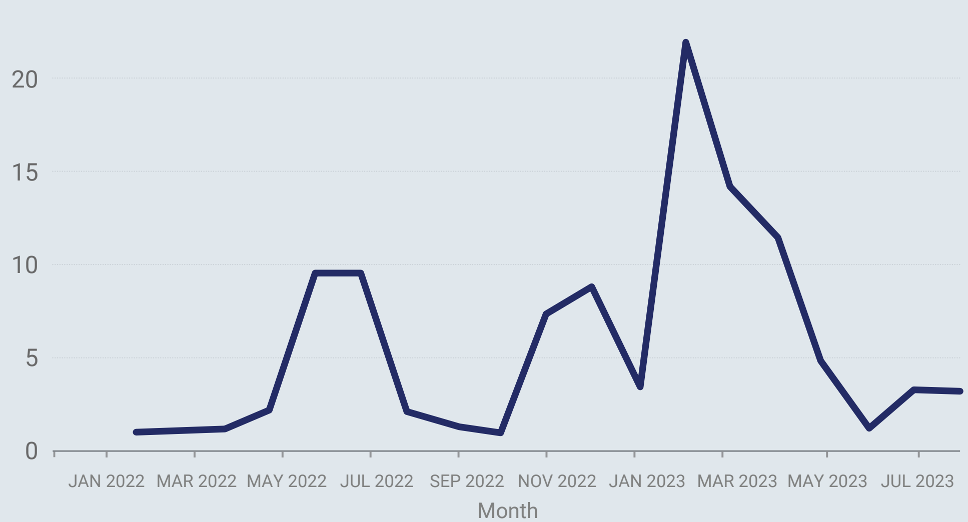
Results

The conversion was successfully implemented – the electric mills contribute up to 20% of total site consumption at peak harvest time

The developer is looking to systematically incorporate conversions across all sites given the impact of the intervention

Grain mill total consumption throughout the year, kWh

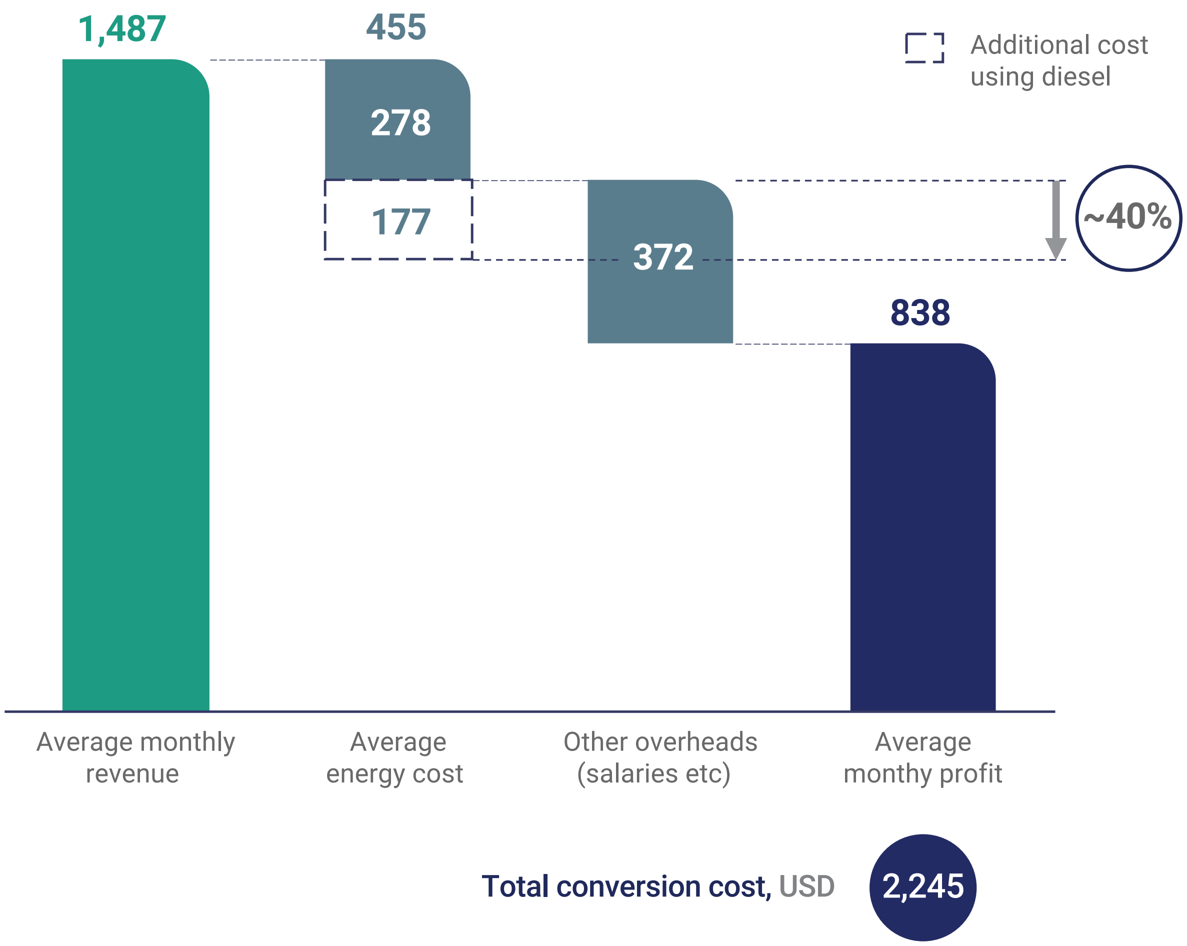
Corresponding percentage of consumption throughout the year, %



Source: Site consumption data

Time of use tariffs mean savings of 40% on energy costs..

Peak monthly profit for a converted 20HP rice miller, USD



Source: Mill operator surveys

..making the business case of conversion viable for millers

During peak harvest season, this miller processes up to 20 bags of rice per day, earning **N1,000 per bag ($2.50)**

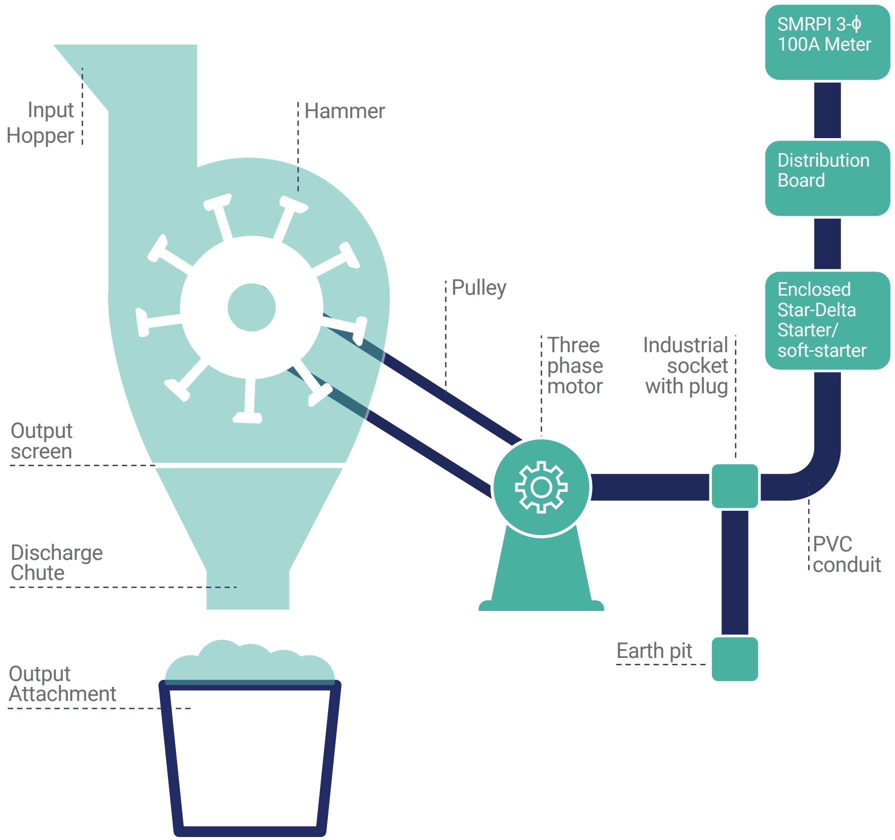
The miller **saves ~40% on energy costs** compared to their prior diesel spend (savings have since further increased following the removal of diesel subsidies)

Assuming 25% of revenues are spent on overheads and 50% on repaying conversion financing costs, this could translate to a **six-month payback period**

However, **revenues are heavily impacted by seasonal variations** and other events, financing needs to be flexible to take this into account

The conversion process requires design across motor size, motor protection, power supply type and metering

Schematic of a three-phase conversion



Source: Developer and technician interviews

1. Motor sizing

An electric motor size is selected to match the original diesel engine

2. Power supply type

Motor size and customer location are used to determine connection to single or three phase supply

3. Motor Protection

A variable frequency drive or soft starter is selected to match selected motor and power supply

4. Metering

A meter is specified according to the power supply type and expected base current (meters are often oversized to ensure meter protection)

Typical installation steps for a three-phase motor

1. Construct concrete base and fabricate metal base-plate for motor
2. Mount distribution board and install meter
3. Install motor and accessories and confirm alignment of grinding head and motor
4. Draw load cable from industrial socket to the motor and terminate load cable
5. Power on motor and test performance checking for leakages, vibrations etc

Due to reliability concerns, millers prefer to retain the diesel generator as back up. This requires a configuration where the grinding head is placed in between the electric motor and the diesel generator to allow power switching.

VFDs/soft starters typically contribute >40% the cost of a conversion

Typical bill of materials for conversion of a 16-20HP engine

Item	Typical cost (USD)	
Motor and pulley	700-850	30%
Cables/control switches/meters	160-230	8%
VFD/soft starters	1000-1200	43%
Motor base Fabrications	50-60	2%
Transport	70-350	13%
Labour	50-100	4%
Total conversion cost	**2000-2800**	**100%**

Source: Developer and technician interviews

Conducting conversions in rural settings can be challenging – high quality motors can be difficult to procure and VFD/soft starters require careful specification and sizing

1. Sourcing high quality electric motors

- Developers in rural communities experience difficulties sourcing high quality motors from suppliers in their vicinity
- Multiple instances of burnt windings occurred during testing across sites – this was attributed to contaminants/sub-par copper in the motors
- This then required replacement of the faulty motors, attracting additional cost and increasing implementation time

2. VFD/soft starters operations

Incorrect specification/sizing of VFDs/soft starters can lead to performance issues:

- One developer purchased two VFDs that were too sensitive - the resultant rapid decrease and increase in frequency affected the torque of the motor, which in-turn affected the power and throughput of the mill
- Other developers have experienced faults with VFDs or soft-starter where under/over sizing has led to overcurrent and overvoltage conditions, causing stress on the VFD or soft starter components

Proposed Solutions

- **Purchase motors from reliable suppliers that offer warranties**
- **Consider use of contractors that will supply and service purchased motors**

- **Work with experienced technicians to size and specify VFDs or soft starters**
- **Select simple, robust devices that can be troubleshooted by local technicians**

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