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Shell Foundation

Promoting Productive Uses of Energy in Uganda

Status and Potential for Growth

October 2017

Contents

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Background and context

Open Capital has partnered with the Shell Foundation to increase off-grid energy access & reduce market barriers

Substantial progress to-date

- Uganda has seen considerable growth in off-grid energy access through innovative products, strong investor and donor interest, & growing political will
- Many stakeholders have invested time & resources to advance access across tiers
- Substantial research has been conducted to identify barriers to continued growth

Our goal is to facilitate further growth

- Partnership has been formed between Shell Foundation & Open Capital Advisors (OCA), in close collaboration with DFID/Energy Africa & USAID / Power Africa
- Goal is to support stakeholders to reduce market barriers through direct initiatives & improve energy access across tiers
- Accelerator will build credibility as a neutral party to coordinate resources and provide support to current & future initiatives

There is an opportunity to accelerate energy access by reducing market barriers

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Based on strong market feedback, one of core accelerator initiatives is enhancing business case for productive use technologies

The market accelerator is working on 4 high impact initiatives:

Initiative 1: Scaling access to finance for PAYG solar, unlocking local debt	**Initiative 2:** Segment unserved pops, analyze opportunities to serve	**Initiative 3:** Evaluating and promoting ability of productive use technologies	**Initiative 4:** Provide support for communication and coordination

- Potential value of productive use technologies is acknowledged by key players in the Ugandan market, however, there has not been a centralized, consolidated effort to describe the opportunity and assemble the relevant stakeholders across the sector
  - In addition, few examples of productive use exist across the region, with fewer still in Uganda; selection of available case studies are included at the back of this document
- By combining targeted research and analysis with stakeholder coordination we can meaningfully advance the off-grid space, increasing industrial productivity and residential connectivity
- We are continuously working with partners to articulate and develop initial planning for pilots targeting productive use technologies, including defining timelines and necessary incentives

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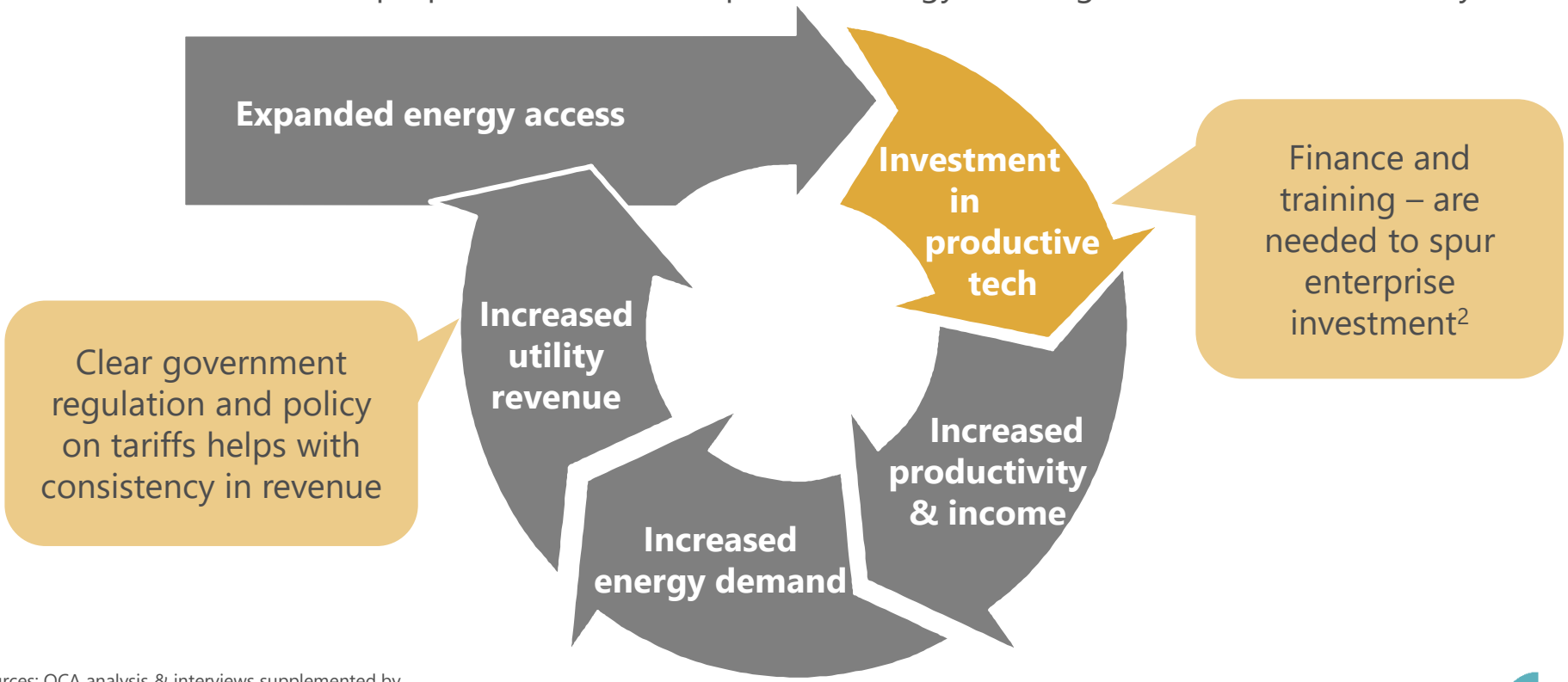
The cycle to increase energy access requires external support

Investment in productive use tech will increase incomes & expand energy access

According to GIZ, **productive use can be defined as**[1]: *"Agricultural, commercial and industrial activities involving electricity services as a direct input to the production of goods or provision of services*

Through increased productivity, energy access can be stimulated by private sector revenue

- In the long term, increased energy access stimulates economic activity in communities, which in turn increases income and proportion of income spent on energy, creating a continuous virtuous cycle



Sources: OCA analysis & interviews supplemented by

1. GIZ's "Productive Use of Energy – PRODUSE A Manual for Electrifi cation Practitioners": https://www.giz.de/fachexpertise/downloads/giz-eueipdf-en-productive-use-manual.pdf
2. ESMAP "Maximizing the Productive Uses of Electricity to Increase the Impact of Rural Electrification Programs": https://www.esmap.org/node/714

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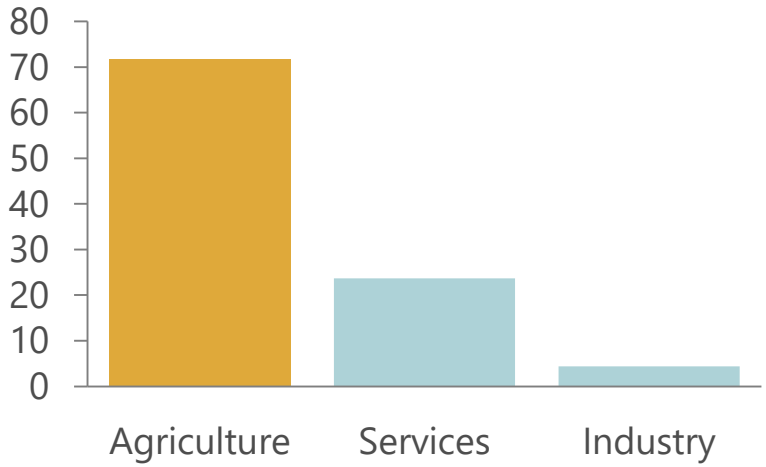
Prod use tech has potential to boost overall demand; agricultural applications most relevant to building an economic case in UG

Productive use technologies have the potential to supplement demand, lower costs & drive growth

- Residential demand and growth is often insufficient to make the business case for high capacity generation tech; results into either high tariff structures or long capex payback
- Productive use technologies – if properly targeted – have the potential to significantly and perhaps sufficiently supplement overall demand, boost productivity and lower cost

Agricultural sector in Uganda employs the majority and provides the highest potential for impact

Employment by sector
Percentage



- Agricultural sector employs over 70% of Uganda's work force and has the significant potential for value addition across the country[1]
- Productive use equipment in agriculture could potentially increase individual monthly incomes by 30%[2]

Sources: OCA analysis & interviews supplemented by
1. CIA World Fact Book: https://www.cia.gov/library/publications/the-world-factbook/fields/2048.html
2, National Survey and Segmentation of Smallholder Households in Uganda

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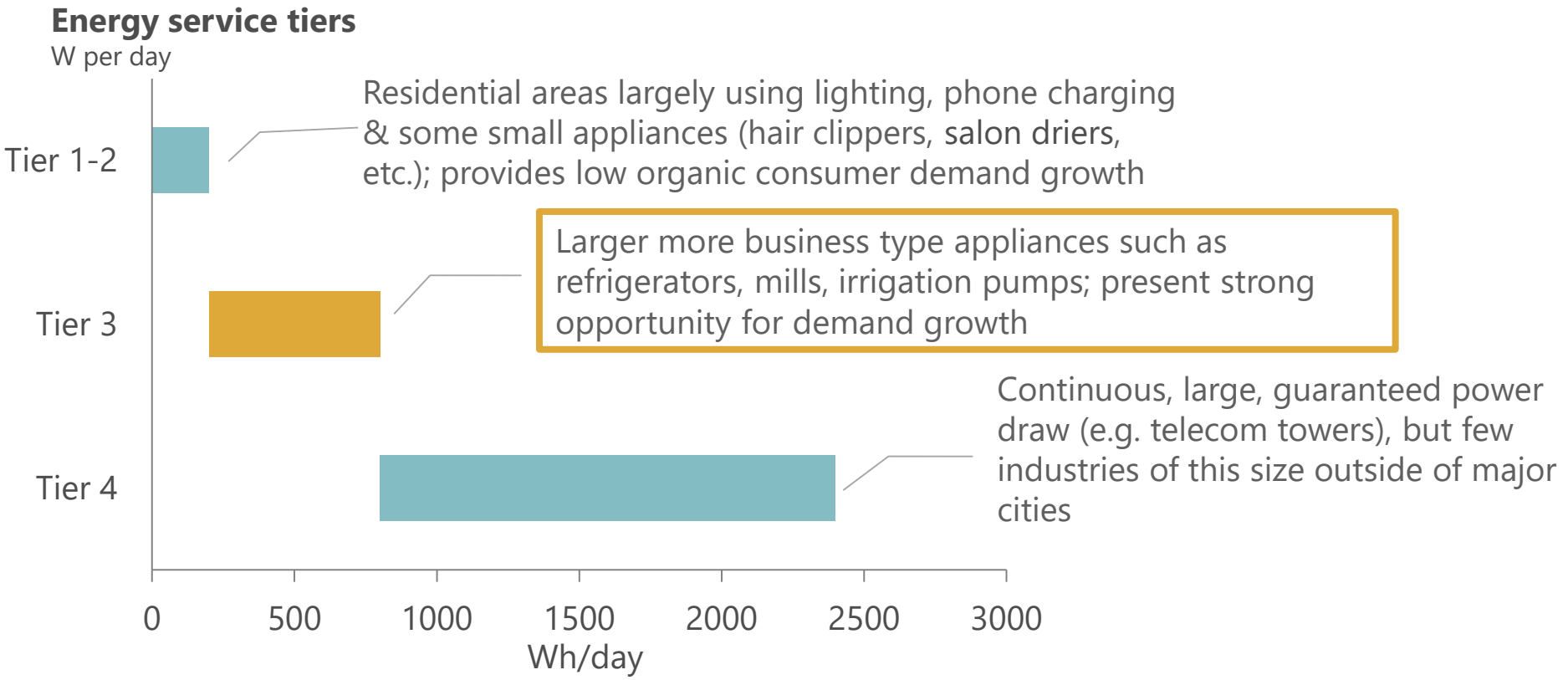
Focus of report is on SME business level; these have potential to generate significant demand and reach large customer base



- Access programs have typically overlooked tier 3 uses of power because they require substantial capital expenditure[1,2]
- However, businesses using tier 3 technology have potential to generate significant energy demand and positive externalities

Sources: OCA analysis & interviews supplemented by
1. Tier categories are based on the International Renewable Energy Agency's 2015 definitions, described in "Off-grid Renewable Energy Systems: Status and Methodological Issues":
2 Overview of access programs in Uganda from Open Capital Advisor's "Ugandan off-grid energy market accelerator":

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This report highlights the opportunity for productive use technologies across various stakeholders

SHS operators	• Support expansion – cross subsidizing operations in rural areas by diversifying product range to include higher tier appliances / prod use tech • Provide the opportunity to support existing customers to move up the energy ladder and own larger value assets
Utility & mini-grid developers	• Have the potential to significantly, and perhaps sufficiently, supplement residential energy demand, enabling shorter payback periods on capital invested; and as a result accelerating residential connectivity
Government	• Can be used as a solution to generate increased off-grid energy awareness and sustainable uptake in rural areas where supply is expensive & communities are predominantly agrarian • Can increase constituents' income and improve standard of living
Development partners	• Can increase synergies across various programs currently supported, (e.g. agriculture value chains, financial inclusion and energy), enabling great impact in consumer income, productivity and economic growth

Methodology: **Report informed by extensive review of available local and int'l materials supported by several stakeholder interviews**

Interviews & research were tailored to assess the state & potential for productive use in Uganda

Desk research*

Over 40 materials reviewed

- 4 catalogues on productive use appliances & technologies available globally
- >30 reports on productive use related manuals, business models, and impacts
- Uganda industry data including agricultural census and district profiling records
- Case study materials from local and international implementers

Stakeholder interviews

Over 25 consultations held

- >10 private sector operators
- >5 government agencies
- >5 development organizations
- >5 other stakeholders

* Links for relevant publicly available materials are provided in the 'Additional Resources' section of this report (page 30)

Industries & technologies for productive use in Uganda

Demand map focuses on agricultural categories with high potential for value addition and impact

Industries

Technologies

Where possible, sample solar and DC productive use technology are highlighted

- DC appliances are more energy efficient than AC appliances
- DC appliances are directly compatible with many solar home systems (SHS), mini-grids, and other renewable off-grid electrification technologies although we see a trend to AC as eventual integration with the grid becomes more plausible

However, these technologies merely demonstrate pricing and capacity

- Specific technologies should be adapted to power generation, production quantities, and local technical capacity to install, maintain, and repair

Note: Industries selected based on Uganda Ag Census (2009), UBOS Business Census (2011), UBOS Agriculture by District report (2011), and qualitative reviews

Rationale: Solar irrigation presents many benefits if systems are tailored to unique needs of farm

Solar irrigation proves a reliable and cost effective option over diesel

Rural areas with no access to both power and water mostly have the choice between solar and diesel pumps

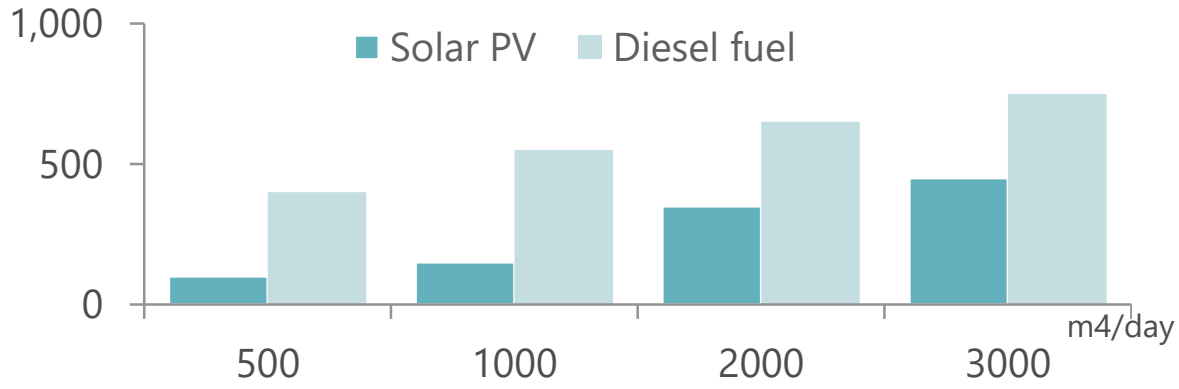
- Diesel pumps have a lower initial cost but have high maintenance costs in addition to the possibility of fuel shortages in these areas
- Solar pumps have a higher initial cost (1,000-3,000 USD per acre) but are proving the more cost effective option

Studies show that solar pumps are cheaper on a life cycle cost basis than diesel pumps[1]

- Cost estimated at between 22-56% of diesel pumps; can achieve payback in a as few as 2 years

Lifetime cost of pump, by size[1]

$ Thousands



Sources: OCA analysis & interviews supplemented by

1. Solar Electric Light Fund "A Cost and Reliability Comparison between Solar and Diesel Powered Pumps" https://www.self.org/SELF_White_Paper_-_Solar_vs_Diesel.pdf

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Use-case: **Solar irrigation has potential to serve a large majority of Uganda with appliances available locally**

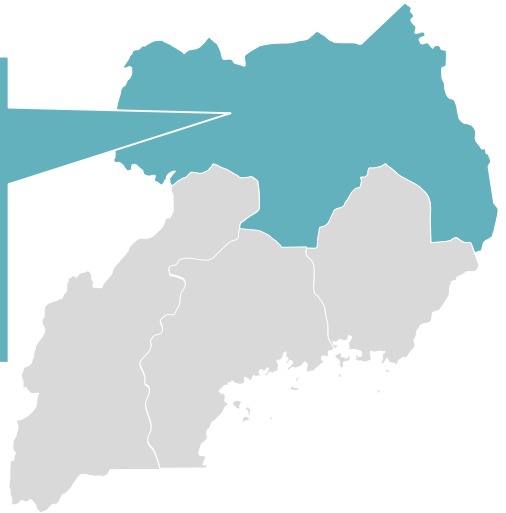
Example product

Future Pump SF1	
Power required	*80 W (solar and manual back up)*
Capacity	*2,000 liters per hour at 1 meter lift*
Approximate cost	*USD 725 for pump and 4 sprinklers to cover half an acre*
Available in UG	*Yes*

- *Note:* cost and specifications of systems are highly variable and need to be adapted to the needs of the crop, irrigation system, plot, and local water assets

Geographic focus

The north is particularly high potential for increasing irrigation and food security[1,2]



- While irrigation could serve a large majority of Uganda, access in the North will be transformative
- Due to the increasing bouts of drought last year across the country, access to solar irrigation has been noted as a government priority & is rapidly being included as a business line for a no. of SHS operators

Sources:
Product information and photo source: Solar Now and https://futurepump.com/wp-content/uploads/2016/06/SF1-Technical-Specification.pdf
1.Future Water's map of irrigation potential in Nile Countries: http://www.futurewater.eu/projects/irrigation-potential/
2.FAO report on food security in the Horn of Africa: https://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article_id=72

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Rationale: Ice production relevant for islands to support fishing communities and increase productivity

Ice production reduces fishermen losses

- Over 460 million tonnes of fish are caught each year in Uganda – but significant losses due to improper storage and transportation keep fishing communities from reaching their full potential[1]
- Localized ice production helps ease the scarcity of ice for preservation of fish and enables the fishermen to favorably compete
- In addition to reducing inventory losses, localized ice-production facilities can reduce dependency on middlemen supplying ice at an extreme mark-up -- a sack of ice costs between UGX 300-350K on the island in addition to the cost of transport & time, compared to UGX 100K on the mainland[2]

Utilities on islands using ice making as anchor

- Some mini-grid operators and other utilities setting up in island communities are using ice production as an anchor for energy demand
- Presence of these ice plants on the islands has allowed for cross utilization in businesses such as restaurants, hotels, juice making, etc.
- Previously, processing plants have been commissioned at Mwena and Kitobo landing sites to serve the 84 islands of Kalangala in the Lake region – however these are still not sufficient to serve all fishing communities especially with the limited access to power and poor transport network[3]
- Clear need exists to set up ice plants in these communities

Sources: OCA analysis & interviews supplemented by
1.Uganda Bureau of Statistics Statistical Abstract 2015: http://www.ubos.org/publications/statistical-abstract/
2. https://ugandaradionetwork.com/story/kalangala-gets-ugx-8-billion-ice-processing-plant
3..Kalangala Ice Plant to Start Production" http://allafrica.com/stories/201509110075.html

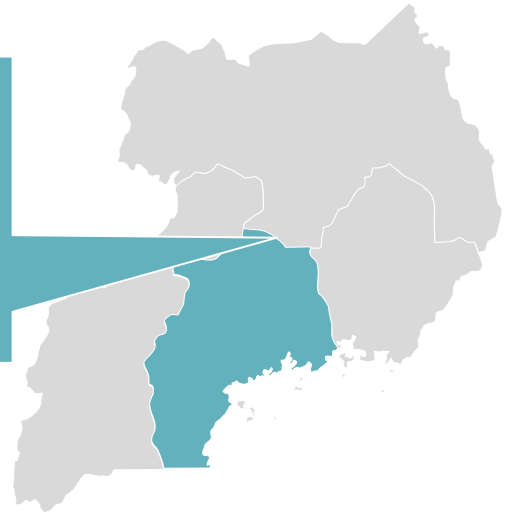
Use-case: **Significant potential exists in ice production but requires substantial capital investment in order to serve larger communities**

Example product

ISAAC Solar Icemaker	
Capacity	*50-60kg per sunny day*
Approximate cost	*USD 7,000*
Available in UG	*Pilots in Kenya – not yet in Uganda*

Geographic focus

Lake Kyoga is one of largest fishing regions by catch – with limited grid access



- Uganda's top 3 fishing regions are high potential for ice production: Lakes Victoria, Albert, and Kyoga

Sources:
http://www.energy-concepts.com/_pages/app_isaac_solar_ice_maker.htm
Product information and photo source: http://solaricemaker.com/

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Rationale: **Reliable cold chain for dairy could reduce milk losses in regions with dairy surpluses, while stimulating energy demand**

Cold chain in the dairy sector is divided into two: frozen & chilled

- Frozen includes processed products like ice-cream, yoghurt, etc.
- Chilled incudes milk, cheese, ghee and other dairy products – focus for this research

Chilled products' main challenge is in transportation, as they require controlled temperatures

- It's estimated that 20-40% of all milk production in Uganda is wasted due to lack of timely cooling[1] - the lack of cooling capacity is a potential deterrent to farm expansion

Due to these notable losses and potential for dairy, a number of innovations in milk chilling exist

- DC fridges are widely available in-country compared to other energy efficient products; presents a valuable opportunity
- Solar refrigeration provides cold storage consistently for areas with no or unreliable energy access
- More widely available data on quality for refrigeration exists than for other productive use applications, e.g., resources on brand quality from WHO/PATH for vaccine-storage applications, and research is forthcoming from Global Leap on recommended household and productive use systems

Strategically placed collection centers can service processing points, increasing dairy farmer income by >20%[2]

- These improve access to town and export markets, providing higher income for the dairy farmers

Sources: OCA analysis & interviews supplemented by
1, 2 Biogas-Powered_Evaporative_Cooling_for_Uganda's_Dairy_Industry#Overview, Dairy Cattle and Dairy Industry in Uganda: Trends and Challenges , http://www.ifcnnetwork.org/media/pdf/AN-milkproductionUganda.pdf, National Survey and Segmentation of Smallholder Households in Uganda

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Use-case: **Increased innovation means a no. of solar fridges available locally, but distribution possibly limited by relatively high cost**

Example product

SunDanzer DCR225 refrigerator	
Power required	*198 Watt-hrs/day at 32°C (solar or on-grid)*
Capacity	*225 liters*
Approximate cost	*USD 1,349*
Available in UG	*Yes*

- *SunDanzer* adapted this fridge for the East African dairy market providing a portable cooling system
- Also developed milk-can blankets to aid in transportation to collection site[1]

Geographic focus

- Many dairy communities could benefit; particularly in North & South West regions
- Communities in Central North & South West have both milk surpluses & variable grid access[2]

Sources:
1. Powering Agriculture: An Energy Grand Challenge for Development catalogue
2. International Livestock Research Institute map of milk surpluses and poverty levels: https://www.ilri.org/ilrinews/index.php/archives/3256
Product information and photo: http://www.sundanzer.com/product/dcr225-dcf225-2/

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Rationale: **Grain milling presents an opportunity to benefit farmers throughout Uganda**

Increase in grains and cereal grown due to growing demand for related biproducts

- Maize and cassava constitute Uganda's top crops by tonnage grown due to the increased demand for biproducts such as porridge, posho and cereal
- Despite the increase in crops grown, farmers are rarely able to benefit from value addition[1] yet processing and milling grains can more than triple the crops' value by weight[2]

One of the key barriers to value addition is high milling costs

- Farmers face high milling costs due to the cost of transportation to the trading centers and the limited or no access to reliable electricity

In addition, the quality of milling machinery available in rural areas is highly variable and inefficient

- Most milling machinery is made by local "fundis"; typically inconsistent, and energy inefficient
- Energy efficient machinery available at a more localized level would allow producers to reduce their largest expense in production while empowering farmers
- A number of farmers with limited access to electricity greatly depend on relatively low speed water cooled diesel engines[3]

Sources: OCA analysis & interviews supplemented by
1.Uganda Bureau of Statistics Statistical Abstract 2015: http://www.ubos.org/publications/statistical-abstract/
2.World Vision on impact of maize mills: http://www.wvi.org/uganda/video/3-maize-milling-machines-kiboga-district
3.FAO engineering working documents on small mills in Africa selection, installation and operation equipment"

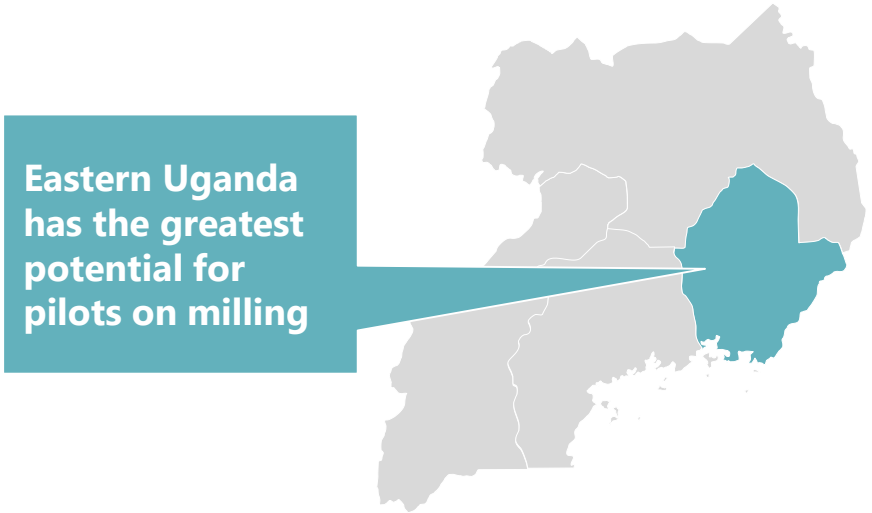
Use-case: **Despite high potential, limited options exist for purchasing energy efficient mills in the country**

Example product

Project Support Services Hammer Mill	
Power required	*750 W (solar)*
Capacity	*40 to 60 kilograms per hour*
Approximate cost	*USD 3,250*
Available in UG	*No (some parts locally-made)*

- Hammer mills' power requirement ranges between 2-50 kW
- About 1 kW can mill 25–30 kg of produce per hour
- Spare parts often made locally although some components will need to be imported[1]

Geographic focus



- Eastern Uganda leads production of grains as the top grower of millet, cassava, and maize[1]

Sources:
1.FAO engineering working documents on small mills in Africa selection, installation and operation equipment"
2.Uganda Bureau of Statistics Statistical Abstract 2015: http://www.ubos.org/publications/statistical-abstract/
Photo and product information: http://psspng.com/

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Rationale: **Oil seed processing presents an opportunity to meet growing demand with local value addition**

Domestic demand for vegetable oil continues to increase

- Uganda's top oil crops are groundnuts, soya beans, simsim, and sunflower[2]
- Despite growing many oil crops, Uganda imports the majority of its vegetable oil[1], there is now increased domestic demand – presenting an opportunity for farmers to benefit from investments in processing equipment

Increased sector focus through numerous initiatives led by private, public & civil society

- Oil seed farming, production and processing has been an increased focus area for private- and public-sector market interventions, including:
  - Promotion of sunflower farming and creation of Vegetable Oil Development Project (VODP) in Northern Uganda
  - National Agricultural Advisory Services (NAADS) extension programs funded by government, World Bank, IFAD, EU & Danida
  - DFID program, Northern Uganda: Transforming the Economy through Climate Smart Agribusiness (NU-TEC)[4]

Sources: OCA analysis & interviews supplemented by

1.Opportunities and Challenges in Uganda's Vegetable Oil Industry http://asigmacapital.com/insights/opportunities-and-challenges-in-ugandas-vegetable-oil-industry/
2.Uganda Bureau of Statistics Statistical Abstract 2015: http://www.ubos.org/publications/statistical-abstract/
3.SNV report on "Oil Seeds in Uganda: Combining business led development and multi-stakeholder dynamics in boosting a diverse national sub-sector "
4.iati.dfid.gov.uk/iati_documents/5079902.od

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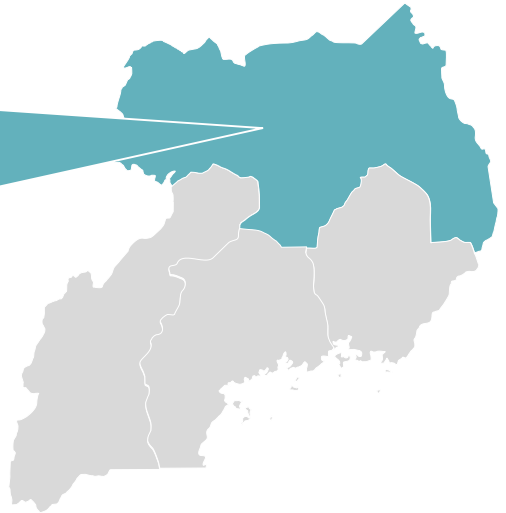
Use-case: **Oil seed processing machinery is expensive and not widely available locally, but can potentially serve a large market**

Example product

Phaesun Boss Kit Pro Press	
Power required	*380-810 W (solar)*
Capacity	*20 kilograms per hour*
Approximate cost	*USD 21,600*
Available in UG	*No*

Geographic focus

Northern Uganda has been the focus of most initiatives in oil seed growing



- The North leads in oil seed production, with high potential for the expansion of productive use services

Sources: OCA analysis & interviews supplemented by
1. Opportunities and Challenges in Uganda's Vegetable Oil Industry http://asigmacapital.com/insights/opportunities-and-challenges-in-ugandas-vegetable-oil-industry/
Photo and product information from: http://order.phaesun.com/

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Rationale: **Coffee, Uganda's top export, can provide higher incomes for farmers if potential for value addition is explored**

Most profit from the coffee value chain is from value-added products

- Uganda grows both premium Arabica coffee and Robusta coffee
- Premium Arabica coffee grows best in high altitudes while Robusta is more widely grown in the lower central and northern regions
- Coffee is historically Uganda's top agricultural export, constituting over 18% of formal exports in 2014 at $410M USD[1]
- Sector is dominated by private sector aggregators buying coffee beans for further processing; means farmer incomes remain low

Coffee-growing households are significantly less poor than others[2] – and may be capable of paying for additional energy services if local productive use can further increase incomes

- Coffee pulping is a first level of value addition that can increase farmer incomes and enable them to expand their income base
- Pulpers process coffee cherries separating the bean from the skin and pulp, enabling value addition at local level

Sources: OCA analysis & interviews supplemented by
1 Uganda Bureau of Statistics Statistical Abstract 2015: http://www.ubos.org/publications/statistical-abstract/
2 Information on coffee-growing households: http://kyagalanyi.co.ug/our-coffee/uganda-coffee/

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Use-case: **Coffee pulpers present attractive opportunity to promote local value addition for Uganda's top export**

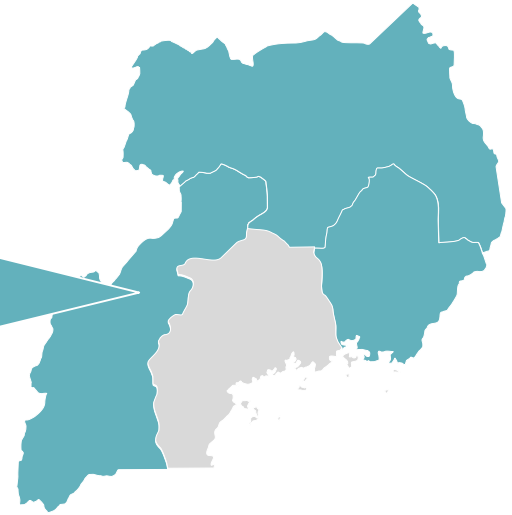
Example product

Penagos DH-2 Coffee Pulper	
Power required	*370 W (solar or on-grid)*
Capacity	*200-300 kilograms per hour*
Approximate cost	*USD 2,025 (engine + pulper)*
Available in UG	*Yes*

- Pulpers process coffee cherries – separating the bean from the skin and pulp and allowing for value addition at a local level

Geographic focus

Coffee is grown widely but high altitude areas are least accessible



- Premium Arabica coffee grows best in high altitudes while Robusta is more widely grown in the lower central and northern regions
- High altitudes like slopes of Mt Rwenzori and Elgon are favorable for growing coffee and are currently inaccessible by the grid[1]

Sources: OCA analysis & interviews supplemented by
1.Map of Uganda's coffee production: http://kyagalanyi.co.ug/sustainability/sustainable-coffee-schemes/
Photo and product information from local vendor and: http://www.penagos.com/eng/product/horizontal-coffee-pulper-dh-2/

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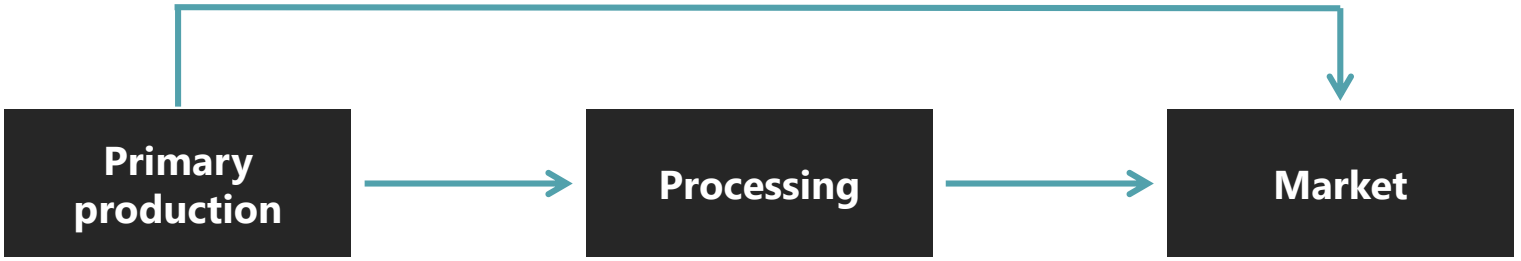
Challenges & recommendations

Vital to consider entire value chain to optimize impact of productive use technologies

In order to have an impact on farmer livelihoods & increase energy demand, we must consider the value chain holistically, from efficiency at primary production stage to access to secondary markets



	Primary production	Processing	Market
Example technologies	• Irrigation pumps • Post harvest storage & transport	• Grain mills • Coffee pulpers • Seed pressers	• Ice machines • Refrigerators • Storage silos
Challenges	• Lack of awareness • Limited business training • Limited access to finance	• Lack of awareness • Limited local supply of tech • Limited access to finance	• Limited capacity to meet demand • Lack of information
Potential interventions	• Awareness campaigns • Consumer financing • Technical training for farmers	• Incentive programs for increased supply • Consumer financing	• Business incubation • Investment in post harvest programs

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Productive use projects are difficult to implement in Uganda due to a lack of: funding, reliable machinery, awareness and good data

Lack of funding for productive use projects

Financiers (donors, banks, other FIs) focus largely on access to energy – not building energy demand

- Local implementers acknowledge that anchor clients and productive uses of energy are key to economics of increasing access through more reliable demand; however, off-grid projects overwhelmingly focus on household access

Absence of appropriate machinery locally

Industry experts report that locally available machinery is inefficient and of poor quality

- Few suppliers of DC machinery locally
- Inaccurate labels on products about power draw
- Most SHS companies do not currently provide productive use products
- Government policy doesn't yet address energy efficiency in the agricultural sector

Lack of awareness & data on opportunities

Absence of consumer acceptance about tech, and lack of coordinated data, means farmers' potential to seek value add opps is limited

- Farmers require targeted training to understand opportunity and increase uptake of prod use tech
- Coordinated research on rural ag value chain would allow better market sizing & increased long-term benefit to farmers

High maintenance cost of imported machinery

The costs of supplying and risks of repairing foreign machinery are high

- Lack of technically skilled mechanics in-country to repair imported machinery

Sources: OCA analysis & interviews

In order to scale and promote productive use tech, important to prioritize awareness, pilot execution & gov't policy development

1. **Boost demand through consumer awareness, particularly through increased roll out of more established and tested technologies like solar irrigation and pumps**

   Raising awareness would lead to a rise in demand, and in turn encourage existing and new companies to utilize productive use technologies

2. **Running pilots and incentive programs to encourage innovation for high-potential industries identified such as coffee, nuts & oil seeds**

   There is room to better understand and potentially work with industry players and manufacturers to test opportunity within significant agricultural sub-sectors; opportunity exists to encourage manufacturers through challenge competitions & local testing

3. **Further market research needed to help identify investment gaps and explore value creation**

   More information in this nascent sector will help operators and investors fully understand and take advantage of potentially large market, and stimulate innovation of financing mechanisms for lower income households

4. **Lobbying government to consider specific tariff and trade policies to encourage investment**

   At present, there are no specific policies that provide incentives for investment into the sector - consistent dialogue with gov't is required to consider attractive policy development for high-potential opportunities; in conjunction, opportunity exists to prove to public sector the potential for prod use in increasing energy demand, expanding energy access and improving standards of living

Sources: OCA analysis & interviews

Market Accelerator is working to convene stakeholders to identify opportunities to test and pilot productive use technologies

Disseminating productive use findings to reach all relevant stakeholder groups

- Distributing to 100s of stakeholders to build awareness, and contribute to discussion on opportunities for productive use technology in Uganda
- Holding targeted sessions with various groups to receive feedback on ability to bring these technologies to market; including workshops and 1:1 consultations with private sector, development partners, and government agencies

Subsequently, identifying stakeholders that have demonstrated interest and capacity to partner, pilot and test necessary proof-points to take the technologies to market

- Market Accelerator is seeking to identify and bring together partners (operators, donors, other stakeholders) who have interest and capacity to pilot productive use technologies in Uganda
- Team will work directly with identified partners to articulate and develop initial planning for productive use programs, including defining timelines and necessary incentives
- Targeted support will be offered to stakeholders to accelerate their work and increase the adoption and investment in productive-use technologies, including the design of pilots and the development of Terms of Reference to seek project funding, as relevant

Productive use pilots can test hypotheses around capital payback, impact to consumers & optimal partnerships

Potential to cross subsidize expansion & operations in rural areas for SHS operators

- What is the marginal contribution of incorporating appliances into product range?
- What is the increase in investment in terms of technology, personnel & after sales services? Is this increase justified by a proportional increase in uptake?
- What models of financing will be most effective and affordable for the farmers? Cash sales versus PAYG versus asset financing from microfinance institutions?
- What strategic partnerships will aid distribution? Working with farmer cooperatives?

Potential to strengthen business case for mini-grid development

- What business models make sense in incorporating these appliances and prod use tech? Will they be sold by the mini-grid developer or stand alone operators?
- If mini-grid developers, will it be on a lease to own or service model? How much further investment will be required for maintenance, training for consumers, personnel?
- If other operators, how will we ensure appliances are energy efficient and will the increase in consumption translate to higher costs to the consumers?
- What is the actual reduction in capital payback period? Does it justify this kind of investment?

Potential to aid government and donor programs to improve welfare

- What is the actual impact on individual incomes for the various value chains?
- Does productive use technology stimulate economic activity and create a hub for entrepreneurship?

Additional resources

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Additional resources currently available online and in-country for productive use projects; several related initiatives also in pipeline

Online tools

- GIZ's PRODUSE portal: http://produse.org/
- GIZ's Catalogue of PV Appliances for Micro Enterprises:https://collaboration.worldbank.org/docs/DOC-20766
- Global Leap buyers' guides and awards for TVs and fans http://globalleap.org/awards/
- WHO and PATH approved solar refrigerators http://www.who.int/immunization/programmes_systems/supply_chain/optimize/direct_drive_solar_vaccine_refrigerator.pdf

Local resources

Select energy auditors:

- AOT Consulting
- Baseline Africa
- Centre for Research in Energy and Energy Conservation (CREEC)
- ELM

Shell Foundation is working with **China Impact Ventures** to review & source available technology for productive use in Uganda

Forthcoming initiatives

- Odyssey Energy web-based market place for the off-grid sector (Q4 2017)
- One Lamp is introducing Pay-As-You-Go freezers for fishermen(Q4 2017)
- Global Leap's refrigeration buyer's guide (Q1 2018)
- Productive use is a planned and current priority for UNIDO's work with East African Centre for Renewable Energy and Energy Efficiency (EACREEE)
- Ugandan government has voiced support for energy efficient and productivity, particularly for solar irrigation – opening the door to other productive use applications[1]

Sources: OCA interviews supplemented by

1 News coverage and press releases on government initiatives http://www.monitor.co.ug/Business/Govt-moves-to-promote-sustainable-energy-use/688322-4022856-15ed6y9z/index.html and http://www.statehouse.go.ug/media/press-releases/2017/03/24/drip-irrigation-museveni-puts-critics-shame

APPENDIX: Regional case studies

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1 *Hydropower plant in Mawengi, Tanzania:* **ACRA utilized selective grants to stimulate productive use**

Key facts

- **Launch:** 2014
- **Type & quantity of power:** 300 kW run-of-the-river hydro
- **Connection strategy:** Extremely low cost connections in favor of higher tariffs, run by local non-profit LUMAMA currently serving 1,700 connections in 8 villages
- **Tariffs:** Monthly membership fee + pre-paid kWh rates that are lowest for households. Businesses pay nearly double household rate – but prices are slightly lower for milling machines

Stimulating larger productive investments in milling, oil-seed pressing, and carpentry was a driver for the Mawengi plant's strong results

ACRA created a grant for businesses to purchase machinery for value addition

- Entrepreneur submitted an application and agreed to pay at least 50% of the machine's cost
- ACRA carefully spaced businesses and chose not to sponsor businesses like bars, restaurants, hair dressers, etc. where capital expenditures required were lower but offered fewer positive externalities

Results to date are impressive

- 30% of customers are businesses, accounting for 58% of electricity sold
- Cost of milling for local farmers dropped by nearly 50%
- LUMAMA reached breakeven in 2015

Sources: OCA analysis & interviews supplemented by Project data from IIED's "Remote but Productive": http://pubs.iied.org/pdfs/16627IIED.pdf, IIED's "Making mini-grids work: productive uses of electricity in Tanzania": http://pubs.iied.org/16632IIED/

Photo source: https://europa.eu/capacity4dev/public-energy/blog/inauguration-solar-powered-mini-grid-ukara-island

2 *Mini grid on Ukara Island, Tanzania:* **JUMEME utilized partnerships for value chain analysis to boost demand**

Key facts

- **Launch:** 2016
- **Type & quantity of power:** Modular 60 kWp solar plant, 33kVA diesel genset, and 240 kWh battery bank
- **Connection strategy:** Incentivized entrepreneurs to quickly make the switch to electricity by offering 1 month of free energy – served as an opportunity to assess power draw and pricing
- **Tariffs:** Variable prepaid tariffs that charge households, SMEs, and industrial loads differently at different times; incentivizes businesses for daytime use

Partnerships allowed JUMEME to understand local value chains to build demand for productive use

- *Energy 4 Impact* and *Excel Hort Consult* analyzed existing production, transportation, and production methods. They utilized existing small industries to promote electricity usage
  - For example, *Energy 4 Impact* successfully partnered with diesel vendors to identify businesses that owned generators and approached entrepreneurs to make the switch to electricity
- Additionally, JUMEME set up their own shop on the island to sell appliances and increase consumer education about technology
- Partnerships with SACCOS helped consumers and small businesses close on purchases

Sources: OCA analysis & interviews supplemented by Project data from IIED's "Remote but Productive": http://pubs.iied.org/pdfs/16627IIED.pdf, IIED's "Making mini-grids work: productive uses of electricity in Tanzania": http://pubs.iied.org/16632IIED/, and interviews with Energy 4 Impact

Photo source: https://europa.eu/capacity4dev/public-energy/blog/inauguration-solar-powered-mini-grid-ukara-island

3 *Biogas system in Gulu, Uganda:* **PAMOJA partnership with CREEC and UNCST focused on community fit technology**

Key facts

- **Launch:** 2014
- **Type & quantity of power:** 30 kW to 10 kW modular gasification system
- **Connection strategy:** Project sponsored purchase of milling equipment
- **Tariffs:** No direct tariffs. Mainly powering productive use equipment—from business model under the research; avg. price for milling a kg of grain is 150 UGX & the price for purchasing already milled flour is 1250 UGX / kg

CREEC's team focused on localized assessment of economy, energy resources, and human capital for a productive use milling project

The Centre for Research in Energy and Energy Conservation (CREEC) ran pilot facility employing a full ecosystem approach:

- Technology was carefully selected for nearby farming capacity, available power supply, and local technical skill to repair and maintain
- Local mechanics were trained to manage the machinery
- In order to ensure farmers saw income growth, the project also supported the construction of grain storage

While this model is still is under research for viability, local communities have expressed significant interest to adopt and replicate the project in other areas

Sources: OCA analysis & interviews supplemented by Project data from CREEC

Photo source: http://creec.or.ug/creec-to-install-gasifier-systems-for-productive-use/sam_1362/

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