Productive Use of Energy in Uganda's Refugee Response

Uganda Learning, Evidence, Accountability, and Research Network

About the USAID Uthabiti Activity

The USAID-funded Uthabiti Activity is implemented by Save the Children, in partnership with Uganda Response Innovation Lab (U-RIL), Swisscontact, and Grameen Foundation. It is facilitating diverse resilient and sustainable livelihood strategies for refugees and host communities in Isingiro and Lamwo districts. Uthabiti focuses on promoting livelihood opportunities in primarily off-farm activities while also addressing critical gaps in the selected value chains that limit economic activity, including access to skills, energy and financial services.

About U-Learn

The FCDO-funded U-Learn consortium is led by U-RIL, in partnership with IRC and IMPACT Initiatives. Its objective is to generate and encourage uptake of evidence and insights for the Uganda refugee response.

This publication was done in collaboration with numerous refugee response actors. Special thanks goes to the WorkGrEEn working group, CRRF secretariat, and GIZ Uganda.

Cover page image: Save the Children International August 2023.

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Acronyms

CRRF	Comprehensive Refugee Response Framework
EnDev	Energising Development
ERA	Electricity Regulatory Authority
GoU	Government of Uganda
LPG	Liquified petroleum gas
MSME	Micro, small, and medium-sized enterprises
NR-PUSE	National Road Map on Scaling Up Productive use of Solar Energy
PAYGo	Pay-As-You-Go
PLWD	Persons living with disabilities
PUE	Productive use of energy
SACCO	Savings and Credit Cooperative Society
SHS	Solar Home Systems
SERP	Sustainable Energy Response Plan for Refugees and Host Communities
VSLA	Village Savings and Loans Association

Executive Summary

Energy is increasingly recognised as a driver for social and economic development. Uganda has made considerable progress expanding its population's access to electricity over the past decade. Between 2013 and 2023, access to electricity increased from 15% to 57% nationwide. This report provides background information on the productive use of energy (PUE) and summarises PUE developments and challenges to promoting PUE in refugee and host communities in Uganda.

PUE is the use of electrical, thermal, and mechanical energy to increase income or productivity. It is not the electricity that leads to development, but the application of electricity to generate income. Energy can increase revenue by creating new activities or business opportunities, extending working hours, and lowering production costs. There is a wide range of applications of PUE in the agricultural, industrial, and commercial sectors, such as cooling, heating, drying, and cooking.

In Uganda, access to PUE is promoted within the Third National Development Plan, the Revised Energy Policy, and the Sustainable Energy Response Plan for Refugees and Host Communities 2022-2025. Access to clean off-grid energy has expanded in rural areas and refugee settlements in recent years. Nineteen mini-grid projects have been completed and over 60 are planned, most of which are solar-powered. Mini-grids have been installed in at least four refugee settlements (Palabek, Nakivale, Bidibidi, Rwamwanja).

There is great potential for PUE to make inroads in the agricultural sector, though uptake remains low. The use of solar water pumps for irrigation and cold storage for dairy products is on the rise; however, PUE adoption in dairy processing and agro-processing of top crops, such as for milling and shelling maize has been slow. In the commercial sector, the main PUE is in the use of standalone systems (e.g., solar home systems) to power small retail shops or services. In refugee settlements, energy kiosks are a budding industry that provides services such as phone charging, printing, and computer training. Refugees are also using energy to establish small businesses, such as hair salons and entertainment halls.

The main barriers to the widespread adoption of PUE by refugee and host communities are affordability, unwillingness or inability to pay out of pocket, and limited access to flexible financing. There are also challenges from the supply side, including scarce availability of PUE products in the settlements, low quality products in the market that have lowered consumer confidence, and insufficient technical support for product installation and repair.

Energy can help refugee and host communities achieve self-reliance. To accelerate the promotion of PUE, key recommendations for actors involved in the refugee response are to increase awareness of existing technologies, facilitate access to flexible finance options, strengthen the supply chain, integrate PUE into livelihood programming, and encourage PUE through incentives, standards, and coordination.

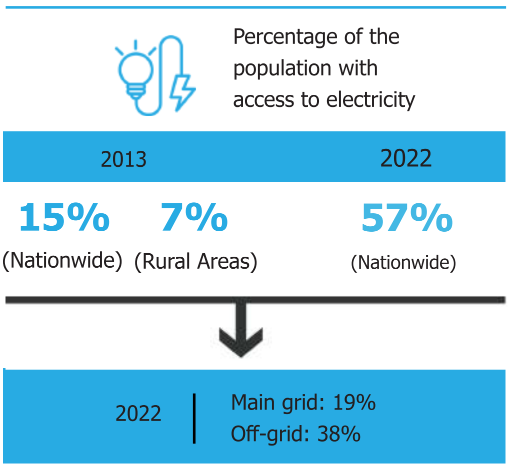
Introduction

Energy is increasingly recognised as a driver for social and economic development. It is believed that access to a source of energy – either electrical or non-electrical - is necessary for sustainable development because it enables people to engage in new or improved income generating activities.[12]

In Uganda, one-third (33%) of the population is considered severely energy poor, defined as being unable to meet their basic needs due to the absence of sufficient access to energy. Severe energy poverty is higher in rural areas and among female-headed householdss.[3] Biomass, or renewable organic material from plants or animals, is a staple source of energy in Uganda, accounting for 89% of the total final energy consumption. This is primarily in the form of firewood used for cooking.[4] The high demand for wood fuels is resulting in the depletion of forests and risks overwhelming the natural regeneration rates of forests.[5]

Electricity accounts for only 1.5% of total energy consumption, following oil products at 9.5%.[6] However, Uganda has made considerable progress in expanding the population's access to electricity in the last decade. In 2013, the percentage of the population with access to electricity was 15% nationwide and only 7% in rural areas.[7] By 2022, electricity access had increased to 57% of the population nationwide (the majority in urban areas),[8] with 19% of people connected to the main power grid and 38% having access to off-grid electricity.[9] Central Uganda has the highest grid electrification rate of the country and Northern Uganda has the lowest rate and relies primarily on off-grid energy sources.[10]

Figure 1: Percentage population access to electricity in the different areas of Uganda



Uganda hosts more than 1.5 million refugees, who primarily live in rural settlements in the north and west of the country. The presence of refugees has intensified energy demands, particularly for biomass. The majority of refugee households rely on wood fuels for cooking and very few have access to electricity.[11] Refugees' lack of access to energy limits their opportunities for education, protection, communication, and income generation.

Until recently, access to energy was not prioritised in interventions with displaced populations, as securing food and shelter was a more pressing need.[12]

1 Mayer-Tasch, L., Mukherjee, M., and Reiche, K. 2013. Productive Use of Energy – PRODUSE: Measuring Impacts of Electrification on Small and Micro-Enterprises in Sub-Saharan Africa. GIZ. Germany
2
3 Ministry of Energy and Mineral Development (MEMD). 2022. Sustainable Energy Response Plan for Refugees and Host Communities (SERP) 2022-2025. Uganda.
4 Energypedia. 2023. https://energypedia.info/wiki/Uganda_Energy_Situation
5 Centre for Research in Energy and Energy Conservation (CREEC). 2020. Final Report: Baseline Assessment for Market-based Energy Access for Scale up Projects in Refugee Settlements in Uganda. GIZ
6 Ministry of Energy and Mineral Development (MEMD). 2020. 2020 Statistical Abstract. https://energyandminerals.go.ug/wp-content/uploads/2020/07/2020-Statistical-Abstract.pdf.
7 Energypedia. 2023. Uganda Energy Situation. https://energypedia.info/wiki/Uganda_Energy_Situation. Page edited May 15, 2023.
8 Ministry of Energy and Mineral Development. 2023. National Road Map on Scaling Up Productive Use of Solar Energy. GOGLA. Netherlands.
9 Power for All. 2022. Going Beyond Access: Financing of Assets and Appliances Stimulates Energy Demand in Uganda. June 13, 2022. https://www.powerforall.org/insights/finance/going-beyond-access-financing-of-assets-and-appliances-stimulates-energy-demand-9uganda#:~:text=According%20to%20a%20recent%20household,off%2Dgrid%20power%2C%20respectively.
10 Uganda Off-Grid Energy Market Accelerator (UOMA). 2019. Reaching unserved populations. Insights and strategies to increase access in Northern Uganda.
11 GIZ. 2022.
12 CREEC. 2020.

However, increasing access to energy for productive use is now considered a key part of achieving longer-term resilience and self-reliance within the refugee and host populations, which is one of the main pillars of Uganda's Comprehensive Refugee Response Framework (CRRF).[13]
This report is based on a desk review of secondary sources. It provides background on the concept of the productive use of energy (PUE) and its applications. The report summarises the national policy framework, details the expansion of access to energy, and highlights advances in PUE, particularly within refugee settlements. It also summarises the main challenges to promoting PUE in Uganda – namely financing and market constraints - and concludes with recommendations that address the diverse dimensions of PUE integration, including creating awareness of PUE benefits among small businesses and households and increasing the availability of high-quality PUE products in settlements.

Background on Productive Use of Energy

Box 1: Defining Productive Use of Energy

PUE is not a new concept, but it is gaining increasing traction as a key measure for progress towards the achievement of the Sustainable Development Goals. There are several definitions of PUE (see Annex 1), but most simply put, PUE is **"uses of energy that increase income or productivity."[14]** Within this definition, it is recognised that the provision of energy itself is not the end goal. Rather, energy is an input for activities that enable economic development.

The concept of PUE comes as a response to the realisation that many rural electrification programmes did not directly result in improved economic development. It is not the electricity that leads to development, but the application of electricity to generate income.[15]

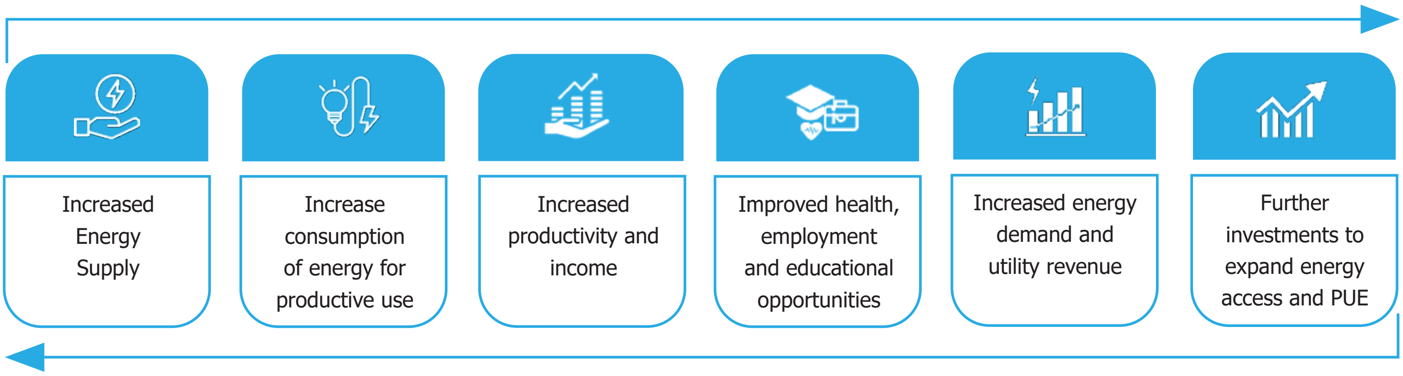
With improved energy services, including electrification, income can be generated in various ways:[16]

1. Improving the productivity of an existing production process.
2. Reducing the time needed for a production process.
3. Creating new types of profitable productive activities for an existing business.
4. Creating value-added products.
5. Lowering the cost of production.
6. Improving the quality of goods and services.
7. Extending business operating hours.
8. Creating opportunities to establish new enterprises.
9. Reducing the time spent on non-productive activities, releasing time for new income generating activities .

In theory, PUE increases income, which can then be used to employ others, bolster educational opportunities, or improve family health.[17] These outcomes can increase the energy demand and accelerate the ability to pay for energy. The revenue from increased energy demand can then be used to further expand energy supply in the country.

13 MEMD. 2022.
14 Havinga, M., and Tuele, R. 2021. Productive Use of Energy: Moving to scalable business cases. Energising Development (EnDev). Germany.
15 Kapadia, Kamal. 2004. Productive uses of renewable energy: A Review of Four Bank-GEF Projects.
16 Brüderle, A., Diembeck, K., Hartmann, J., Rammelt, M., and Volkmer, H. 2014. Productive Use of Thermal Energy: An Overview of Technology Options and Approaches for Promotion. Energy for Development. GIZ; Mayer-Tasch, L et. al. 2013.
17 Energising Development (EnDev). 2022. Productive Use of Energy. https://endev.info/approach/productive-use-of-energy/

Figure 2: Cycle of PUE application to generate income



Types of Energy for Productive Use

Modern energy services for productive use include three main types of energy: electrical, thermal, and mechanical.

Electrical

Electrical energy results from the flow of electrical charge. There are three main options for electrical energy:

a) **Grid:** A connection to the national grid. National grids are powered by non-renewable (fossil fuels) and/or renewable (e.g. solar, wind, hydropower) sources.

b) **Mini-grid:** A A connection to a local mini-grid. Mini-grids have one or more small power generation units and supply electricity to a small area, such as a village.

c) **Decentralised off-grid or standalone systems:** These are used by a single user or household and include solar home systems (SHS), household biogas plants, and solar lanterns.[18]

Thermal

Thermal energy is energy carried by a heat flow. Thermal energy includes solar heat and the burning of biomass (organic material). Biomass energy is often derived from wood, agricultural residues, animal by-products, fuel crops, and agro-industrial by-products.[19]

Mechanical

Mechanical energy is the result of an object in motion and can create electrical or non-electrical power. Examples include pumps, electrical and hydraulic motors, wind pumps, hydro-turbines, and biogas and diesel engines.[20]

18 Utz, V. 2011. Modern Energy Services for Modern Agriculture: A review of smallholder farming in developing countries. GIZ
19 Just Energy. 2023. Thermal Energy: What it is, How it Works, and its Environmental Impact. https://justenergy.com/blog/thermal-energy-what-it-is-how-it-works-environmental-impact/
20 Utz. 2011.

Box 2: Combined Heat and Power

A new promising technology is **combined heat and power,** also known as cogeneration, which uses a heat engine (an engine that converts heat to usable energy) to simultaneously generate electricity and useful heat from a single source of energy. In the sugar industry, for example, the pulp from sugarcane processing is burned to produce steam, which goes through a generator to produce electrical power. The excess heat from this process is captured and can be used for heating.

Applications of Energy for Productive Use

A wide range of applications transform energy sources into productive uses in the agricultural, industrial, and commercial sectors, as described below.[21,22]

Lighting

Lighting is the most common application of energy. Lighting provides illumination to improve working conditions and extend opening hours for businesses and markets. Public lighting improves security in trading centres and other public areas. Illumination in schools and training centres facilitates learning.

Cooling

Cooling can help preserve perishable goods. Cold storage and refrigeration can reduce loss, increase food safety, and add value to products. Refrigeration is also used to sell cold beverages. Solar or biomass-fuelled refrigerated barns and storage facilities can regulate temperature and ventilation.[23]

Heating

Energy is used for heating water and buildings, as well as egg incubators. Water is also heated as part of cooking and for industrial purposes.[24]

Cooking and baking

Different forms of biomass are often used for cooking and baking (e.g. firewood, charcoal, agricultural residues, or dung).[25] Other energy sources light liquified petroleum gas (LPG), ethanol, biogas, and electricity can also be used with different cookstoves and appliances.

Drying

Many agricultural products are dried prior to storage and transportation to reduce spoilage. Solar dryers (or hybrid dryers) use solar energy and ventilation to maintain a constant temperature in the drying process, which improves the drying time and preserves the quality of the product.

21 Energypedia. 2022. Productive Use Portal. Page edited September 5, 2022. https://energypedia.info/wiki/Portal:Productive_Use.
22 Kapadia, Kamal. 2004..
23 GIZ. 2021.
24 Bruderle, et.al. 2012.
25 Energypedia. Improved Cookstoves and Energy Saving Cooking Equipment. 2022. Page edited May 2, 2022. https://energypedia.info/wiki/Improved_Cookstoves_and_Energy_Saving_Cooking_Equipment

Smoking
Smoking preserves food for storage or creates value-added products, such as smoked fish or meat. Thermal energy can be used for smoking using, for example, efficient stoves or smoke generators.[26]

Water-related
Mechanical energy can be used to pump water for irrigation, to achieve better yields and plant higher value crops, and to pump water for drinking and washing. Technologies to pump water include solar- or wind-powered water pumps, diesel pumps, hand pumps, and river turbines.

Crop production
The use of mechanical energy during planting and harvesting (e.g. the use of diesel or gas-powered tractors and harvesters, power tillers, and seed drills) saves labour and time. The bio-fertiliser generated from biogas plants can be used to fertilise soil.

Processing
There are several machines that use energy to improve productivity and the efficiency of processing goods, such as agricultural products. These machines can improve processes such as grinding, milling, threshing, husking, pressing, and milking.

Manufacturing
Energy can improve the efficiency of manufacturing processes, including those in sewing, woodworking, weaving, and brickmaking.

Lifting and transportation
The manual lifting, extraction, and transportation of goods and resources is physically demanding. Mechanical power technologies, such as hoists, gravity ropeways, powered drills, hydraulic pumps, and engines reduce the effort needed to move goods to markets.

Communication
Electrical energy can improve access to information and communication technologies, which can be used to improve business operations; access information; facilitate communication with suppliers, distributors and consumers; and access online education and entertainment.

Provision of energy services
A common energy service is charging batteries and phones. 'Energy kiosks' provide energy and computing services.

For each of these applications, various technologies exist that use thermal, mechanical, or electrical energy (see Table 1). Many of the technologies rely on renewable energy sources, such as those found in the catalogue Photovoltaics for Productive Use Applications.[27]

26 Bruderle, et.al. 2012.
27 GIZ. 2016. Photovoltaics for Productive Use Applications: A Catalogue of DC-Appliances. Germany.

Lighting, heating and cooking are the most common applications of energy. Photo credit: Save The Children

Table 1: Examples of productive use applications and technologies

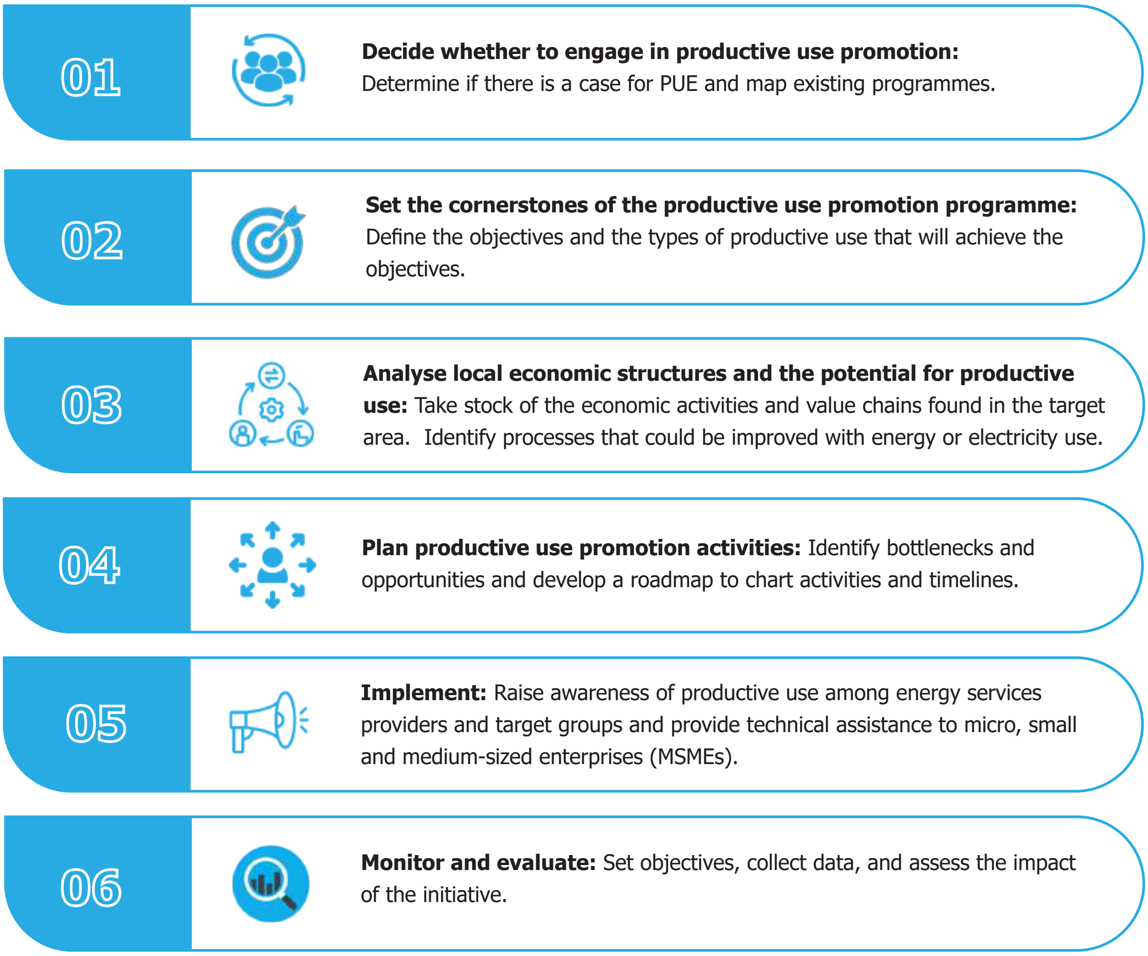
Heating	Cooling	Processing	Drying and smoking	Cooking and baking	Production
Water • Solar water heaters **Livestock** • Egg incubators	**Refrigeration** • Solar refrigerators • Coolers fuelled by solar or biomass • Solar-powered cold storage and cold rooms • Portable cooling systems • Milk chillers • Milk-can cooling blankets **Icemaking** • Standalone freezers • Solar icemakers **Air-conditioning** • Biomass-fuelled barns with controlled temperature and ventilation	**Milling** • Mechanised milling • Wind and micro-hydro-powered mills • Solar hammer mills • Grain mills **Oil extraction** • Hydraulic presses • Motorised expellers • Solar oil seed presses **Husking, hulling, and grating** • Solar grinder for groundnuts • Rice hullers • Maize shellers • Cassava graters **Value addition** • Solar juice processors • Butter makers • Tea fermenters	**Drying** • Solar thermal dryers • Flatbed dryers fuelled by rice hulls • Electric heaters *Smoking* • Brick-based furnaces • Biomass or solar efficient smokers • Smoke generators	**Cooking** • Biomass cookstoves • Improved cookstoves • Solar-powered pressure cookers • Heat-retaining bags • Electric cookers • Household biogas stoves • LPG cookstoves **Baking** • Biomass baking ovens **Briquettes** • Bamboo briquettes • Biomass briquettes	**Planting and harvesting** • Row planters • Seed drills • Power tillers • Harvesters • Tractors and harvesters **Fertiliser** • Biofertiliser by biogas plants **Milk** • Milking machines • Pre-digestors **Livestock** • Solar fencing

Energy services	Water-related	Lighting	Lifting and transportation	Lifting and transportation Communication	Manufacturing and other
Phone and battery charging • Solar chargers **Energy kiosks** • Phone chargers • Printers • Selling energy products	**Irrigationand pumping** • Solar or wind-driven water pumps (surface or submersible) **Purification** • Solar-powered water filters • Household water purification device **Desalination** **Hydroponic production**	**Lighting** • Solar lanterns • Solar home systems • Low-capacity solar lamps • Poultry lighting **Public use** • Lights in schools and training centres • Lights in health centres and clinics • Street and market lighting	**Lifting and crossing** • Chain and rope hoists • Gravity ropeways **Mining** • Powered drills • Engines **Trans-portation** • Electric motorbikes • Biofuel-powered vehicles • Electric vehicles Charging tations	***Information and communication technologies*** • Televisions • Computers • Radios • Internet-enabled devices • Solar-powered phones • Distance education courses	**Tailoring** • Sewing machines • Solar weaving looms • Treadle looms ***Manufacturing*** • Drills • Welding equipment • Saw mills • Paper presses • Pulp mills • Briquette presses **Other** • Pottery wheels • Solar barber kits • Solar hair dryers

Approaches to Promoting PUE

The promotion of PUE can be planned as part of projects that aim to increase energy access or rural electrification, as well as integrated into livelihood and other development projects. A systematic approach to promoting PUE can be used to identify processes that can potentially be improved through the use of energy.[28] The PRODUSE Manual for Electrification Practitioners outlines these main steps : [29]

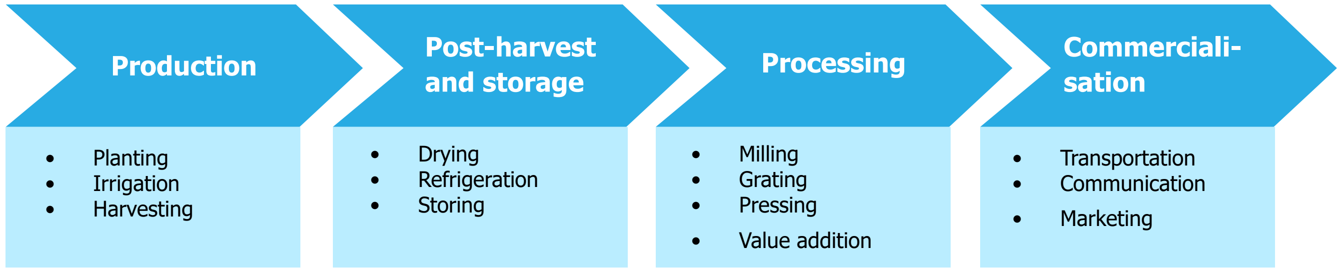
Figure 3: Steps to increasing energy access or rural electrification



In the agricultural sector, there is potential for PUE at all stages along the value chain, from production and post-harvest, to processing and commercialisation (see Figure 2). Various applications of electrical, mechanical, and thermal energy can be used throughout the value chain to increase productivity, prevent losses, boost product quality, add value, and reach markets.

28 De Gouvello, C., and Durix, L. 2008. Maximizing the Productive Uses of Electricity to Increase the Impact of Rural Electrification Programs. Energy Sector Management Assistance Program (ESMAP).
29 Bruderle, A., Attigah, B., Bodenbender, M. 2012. Productive Use of Energy – PRODUSE: A Manual for Electrification Practitioners. GIZ and Energy for Development (EUEI PDF); De Gouvello and Durix. 2008.

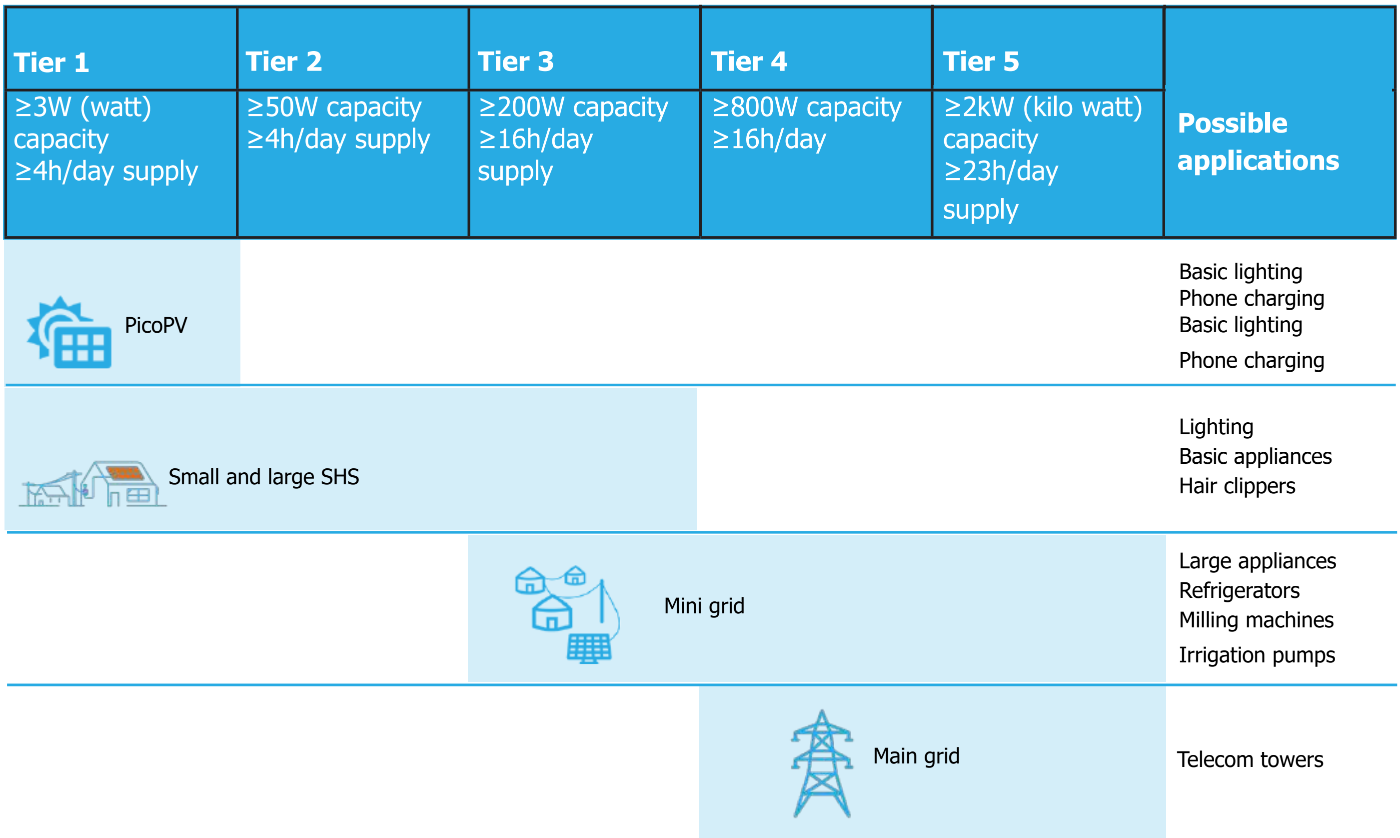
Figure 4: Processes within the agricultural value chain that could be improved with energy (Adapted from Utz, V., 2011)



When considering the technical feasibility of an application, one important aspect is the energy requirement of the proposed solution. Energy requirement is measured on a five-tier scale (see Figure 3). Pico-PV systems (i.e. low-capacity standalone devices, such as solar lanterns) are the lowest-tier off-grid technology and provide basic lighting and phone charging. SHS can range between 20 Wp (watt peak) and 800 Wp, generally providing between Tier 1 and 3 access to electricity - enough for small to large appliances. Larger appliances and equipment for milling, woodworking, freezing, and other commercial applications require Tier 3 to 4 access, which can be provided by mini-grids.[30] Tier 5 applications such as telecom towers, which have large power draws, generally need connection to the national grid.[31]

There are many small appliances (e.g. hair dryers and clippers) that can provide income generating opportunities for MSMEs. However, many other businesses and industries would require energy from larger SHS and micro-grids to power larger productive use appliances and equipment, such as refrigerators, woodworking equipment, and mills.[32]

Figure 5: Productive use technologies by energy tier (Adapted from Energising Development [EnDev] 2021)



30 EnDev. 2021. Tiers, Markets, Sustainability: Trends in Rural Off-Grid Electrification. EnDev. Germany.
31 Uganda Off-Grid Energy Markey Accelerator (UOMA). 2020. Productive Use of Energy in Uganda. Learnings from the Uganda Off-grid Energy Market Accelerator. UOMA, USAID, PowerAfrica
32 Open Capital Advisors (OCA). 2017. Promoting Productive Uses of Energy in Uganda.

Productive Use of Energy in Uganda

There have been numerous projects implemented in Uganda to improve access to clean energy and to accelerate the uptake of off-grid energy (see Annex 2). This section summarises the main policy frameworks governing PUE in Uganda, developments to expand off-grid energy, and the potential of PUE in the agricultural and commercial sectors.

National Policy Framework

There are several government policies and strategies in Uganda that foster expanded access to and the productive use of energy.

The **Third National Development Plan** recognises that access to a reliable energy supply is a critical issue for economic growth and poverty reduction. The **Revised Energy Policy for Uganda, 2023** has the goal "to meet the energy needs of Uganda's population for social economic development in an environmentally sustainable manner." The policy promotes increased access to electricity and enhanced utilisation of energy-efficient technologies and biomass.[33]

The **Electricity Act** (amended in 2022) governs the electrical power sector. The original act established the Electricity Regulatory Authority (ERA) to regulate the generation, transmission, sale, export, import, and distribution of electrical energy in the country. The amended act grants power to the ERA to classify licences according to the size and technology to be used, and that ERA may invite open and competitive applications for licences.[34]

To achieve its objective of meeting energy needs, the Government of Uganda developed the **Rural Electrification Strategy and Plan (2013-2022)** as part of its broader efforts to promote national economic and social development. This strategy aims to accelerate the national geographical coverage of and consumer access to energy by supporting the planned growth of off-grid electrification service technologies and on-grid electrification services. The strategy mentions special assistance programmes to support the promotion of PUE and economic development related to electrification.[35]

The **Biomass Energy Strategy** was developed in 2013 following the recognition that there is inadequate data on and a lack of a comprehensive plan for the biomass energy sector. The vision of the strategy is: "To secure a stable biomass energy supply for long-term social and economic development of Uganda including poverty reduction." Three of the main objectives are to: a) improve fuel efficiency and cooking environments; b) provide efficient technologies (fuel substitutions), and c) increase biomass supply.[36]

The **National Road Map on Scaling Up Productive use of Solar Energy (NR-PUSE)** provides an analysis and strategic direction to leverage solar energy for productive uses. The NR-PUSE's vision is "to have a vibrant and competitive productive use of the renewable energy ecosystem for food security and economic empowerment." The strategy proposes actions to improve the enabling environment, increase awareness about PUSE, enhance financing opportunities, and support research and development.[37]
The **Sustainable Energy Response Plan for Refugees and Host Communities 2022-2025 (SERP)** was developed to contribute to the achievement of the CRRF's long-term goal to transition and integrate humanitarian-based services into Uganda's national service delivery system. The SERP envisions that "all host and refugee communities attain universal access to affordable, reliable, and clean energy for socio-

33 Ministry of Energy and Mineral Development (MEMD). 2023. Revised Energy Policy for Uganda.
34 ALP EAST AFRICA. 2022. Proposed Amendments to Electricity Law in Uganda. February 4, 2022. https://alp-ea.com/proposed-amendments-to-electricity-law-in-uganda/
35 Rural Electrification Agency (REA). 2013. The Government of the Republic of Uganda Rural Electrification Strategy and Plan (2013-2022). Ministry of Energy and Mineral Development
36 Ministry of Energy and Mineral Development (MEMD). 2015. Biomass Energy Strategy (BEST) Uganda. Uganda
37 MEMD. 2023.

economic transformation in an environmentally sustainable manner." The first key result to be achieved is increased access to energy for household and productive uses. The strategy promotes PUE for MSMEs, farmers and associations, and includes the provision of business development support and training in PUE technologies.[38] The main energy solutions the SERP promotes are:

1) Standalone solar-powered off-grid solutions
2) Energy-efficient appliances for grid and off-grid use
3) Smart financing, subsidies, and supplier incentives
4) Solar kiosks and solar power hubs/centres
5) Solar thermal systems (e.g. for cooling or drying fruits, vegetables, and herbs)

The SERP is linked to the **Final Water and Environment Sector Refugee Response Plan** by contributing to the achievement of this plan's objectives to reduce the overexploitation of resources, improve access to sustainable energy, and improve the sustainable management of water supply in refugee settlements. The SERP also overlaps with the **Jobs and Livelihoods Integrated Response Plan for Refugees and Host Communities** by supporting an increase in affordable on-grid and off-grid energy solutions to increase business competitiveness in refugee settlements and host communities.

Electricity Access

Uganda's energy policies and strategies promote increasing access to clean, renewable energy. To reach 'last-mile' households in rural areas and refugee settlements, the strategies focus on expanding access to off-grid solutions, including mini-grids and standalone systems, as well as to clean cooking fuels.[39]

Mini-grids: As of 2021, there were 19 mini-grid projects providing electricity to households and small businesses (see Table 2).[40] These projects include solar-powered, bio-gas, hydro-powered, and solar-diesel mini-grids. There are also 62 mini-grid projects planned, most of which are solar-powered.

Table 2: Number of existing and planned mini-grids in Uganda (Source: UOMA, 2021)

Type of mini-grid	Existing	Upcoming
Biogas	3	1
Hydro-powered	6	10
Solar-powered	9	51
Solar-diesel	1	0
Total	**19**	**62**

Several of the projects are in refugee-hosting districts. Twenty-five solar-powered photovoltaic (PV) mini-grids were completed or commissioned for Lamwo district in Northern Uganda, under GIZ's Pro Mini Grids project, and 15 more are planned for Rakai and Isingiro districts in Southern Uganda.[41] Two of the solar mini-grids are planned for Palabek refugee settlement.[42]

UNHCR has commissioned a 10.8 kW solar-powered PV mini-grid in the Nakivale Refugee Settlement in western Uganda.[43] The Smart Communities Coalition awarded grants to local energy providers to install four solar-powered mini-grids in refugee settlements (see Box 3).[44]

38 Ministry of Energy and Mineral Development (MEMD). 2022. Sustainable Energy Response Plan for Refugees and Host Communities (SERP) 2022-2025. Uganda
39 De Gouvello and Durix. 2008.
40 Uganda Off-Grid Energy Market Accelerator (UOMA). 2021. Off-Grid Energy in Uganda. Market Map. https://uoma.ug/wp-content/ uploads/2021/12/2021-UOMA-market-map-vFinal.pdf
41 Banura, B. 2022. Promotion of Mini Grids for Rural Electrification (Pro Mini Grids). GIZ.
42 Tumwesigye, A., 2021. A report on end-user finance and payment systems to improve access to reliable, sustainable, and modern energy products in displacement settings (Uganda). GIZ. Uganda
43 UOMA. 2021.
44 Power Africa. 2022. USAID/Power Africa Awards $840,000 in Grant Funding to Install Mini-Grids and Promote Productive Uses of Energy in the Rwamwanga Refugee Settlement in Uganda. Sun-Connect. https://sun-connect.org/usaid-power-africa-awards-840000-in-grant-funding-to-install mini-grids-and-promote-productive-uses-of-energy-in-the-rwamwanja-refugee-settlement-in-uganda/

Box 3: Clean Energy in Refugee Settlements

The Smart Communities Coalition, with support by USAID's Power Africa, awarded grants to five Ugandan companies to bring clean energy to refugee camps.

1) Solar Today: Solar systems for businesses in Rwamwanja Refugee Settlement
2) Power Trust Uganda Limited: Stand-alone business hubs in Kiryandongo Refugee Settlement
3) Aga Great Work Limited: Solar-powered mini-grid in Bidi Bidi Refugee Settlement
4) Aptech Africa and Winch Energy: Installation of three solar mini-grids in Rwamwanja Refugee Settlement and the promotion of PUE, providing equipment such as cold storage, grain mills, welding machines, and computers.
5) Moban Savings and Credit Cooperative Society (SACCO), BiziSol, and OffGridBox: Solar-powered solutions providing clean and affordable energy, drinking water, and connectivity in Nakivale Refugee Settlement.

The Government of Uganda (GoU) has ambitious plans to continue installing mini-grids throughout the country. The following projects will support the GoU in achieving its ambition:

- The Uganda **Energy Access Scale-Up Project (EASP)** to scale up access to electricity and clean cooking for households, refugee and host communities, commercial enterprises, and health and education facilities.
- The **GET ACCESS** programme to install more than 120 solar-powered mini-grids in five regions starting in 2024.
- The **Beyond the Grid Fund for Africa** (BGFA) is providing funding to incentivise private companies – Energy Service Providers (ESPs) – to scale up access to off-grid solutions, either through stand-alone solar systems, mini-grids, or the productive use of energy.[45]

Although solar-powered mini-grids are currently the most common type of mini-grid in Uganda, the biomass gasification (bio-gas) plants have been beneficial in agricultural areas. The Pamoja biomass gasification power plant and mini-grid in Kamwenge district uses local maize crop residue to generate clean energy. The 52MW (megawatt) Kakira Biomass Power Plant in Jinja district is a combined heat and power project using bagasse, a by-product of sugar cane processing, to power the project.[46] At Gotngur, in Nwoya district, a 32kW **biomass gasification** plant was constructed that runs on rice straws and husks collected by farmers.[47] The waste from the plant, known as biochar, is used for fertiliser by local farms and to make clean cooking fuel in the form of pellets.[48] There are plans to build a 20MW biomass gasification plant in Gulu town in 2025. This plant will use rice husks to generate electricity, and the biochar produced will be sold as cooking and boiler fuel.[49]

Standalone Solar systems: Uganda has a strong and growing market for solar products. There are nearly 4 million solar products in use in Uganda (e.g. solar lanterns, multi-light systems, and SHS).[50] Between 2018 and 2019, there was a 9% increase in the number of off-grid solar lighting products sold (from 368,000 units to 400,000 units). SHS are compatible with DC (direct current) appliances, which are more energy efficient than AC (alternating current) appliances.[51] However, the productive use of solar products is only in its early stages, particularly for agriculture. Various off-grid products exist, such as small off-grid refrigerators, but the market is limited. Initiatives in rural and refugee-hosting districts are

45 Beyond the Grid Africa (BGFA). 2023. BGFA5 – Funding Lot #12: Up to EUR 6.3 million. https://beyondthegrid.africa/funding-rounds/bgfa5-uganda/
46 Power Technology. 2021. Kakira Biomass Power Plant, Uganda. December 17, 2021. https://www.power-technology.com/marketdata/kakira-biomass-power-plant-uganda/#catfish
47 Dokotho, E. 2022. How Nwoya residents turn farm waste into electricity. Monitor. https://www.monitor.co.ug/uganda/news/national/how-nwoya- residents-turn-farm-waste-into-electricity-4053308
48 DW. 2023. Turning farm waste into clean energy in Uganda. https://www.dw.com/en/turning-farm-waste-into-clean-energy-in-uganda/vid-eo-65452790
49 Sustainable Energy Fund for Africa (SEFA). 2016. Project Summary Note SEFA Project Preparation. Uganda Earth Energy Syngas Biomass.
50 Uganda Off-Grid Energy Markey Accelerator (UOMA). 2020. Productive Use of Energy in Uganda. Learnings from the Uganda Off-grid Energy Market Accelerator. UOMA, USAID, Power Africa.
51 OCA. 2017.

promoting access to standalone systems.[52] The promotion of Pico-PV products, such as solar lanterns, has been primarily for household uses lighting and phone charging. The promotion of SHS and solar appliances has resulted in some productive uses in the Commercial Sector (see below).

Cooking fuels: There are also efforts to improve access to cleaner cooking fuels to reduce or replace the use of biomass (firewood) for cooking. The cleaner fuels promoted are briquettes made from different forms of biomass (e.g. bamboo, agricultural residues), LPG, or electricity. The focus has been largely on household cooking and is described in more detail in the desk review of **Household Use of Energy.**

Productive Use of Energy in Agriculture

There is great potential for PUE technologies to drive economic growth in the agriculture sector, given the sector's importance to Uganda's population and economy. USAID's Uganda Off-Grid Energy Market Accelerator estimates there is the potential to increase farmers' income by 30% through value addition and efficiencies gained through PUE.[53] However, the adoption of PUE technologies by the agriculture sector has so far been limited, with even less uptake among refugee households. Generally, the mechanisation of Uganda's agriculture is low, and farmers continue to use human power for farming activities.

There are several PUE technologies with prospects for growth among farmers generally in the country, described below. Some of these are already being piloted with smallholder farmers (see Box 4).[54] There is little evidence that any of these technologies are being used within refugee and host communities currently, but there is opportunity to explore their potential adoption.

Box 4: Supporting Smallholder Farmers with PUE

The Sustainable Energy for Smallholder Farmers in Ethiopia, Kenya and Uganda programme from EnDev supports the scalable use of renewable energy services and technologies to improve productivity and the livelihoods of smallholder farmers (at least 25% women and 30% youth) in the dairy and horticultural value chains. The programme aims to increase interest in four priority PUE:

1) Solar irrigation for horticultural and livestock value chains
2) Solar drying for horticultural products
3) Solar cooling for horticultural and dairy products
4) Renewable energy community hubs

The baseline study in eight districts of Uganda confirmed opportunities for solar power to be used for water pumps, cold storage, milk processing, and the processing of horticultural products.

52 Efficiency for Access Coalition (EAC). 2021. Off- and Weak-Grid Solar Appliance Market Uganda.

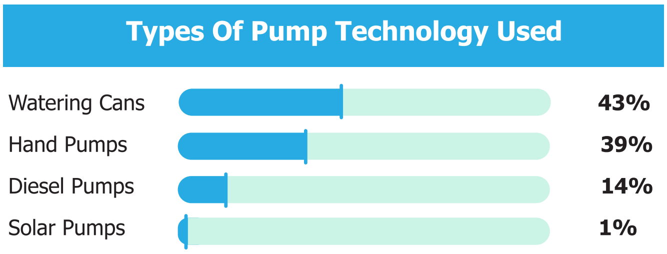
53 Uganda Off-Grid Energy Market Accelerator (UOMA). 2019. Productive use of off-grid energy. The business case in Uganda's dairy value chain.

54 Energising Development (EnDev). 2022. Sustainable Energy for Smallholder Farmers in Ethiopia, Kenya and Uganda (SEFFA).

Solar-powered irrigation: Solar water pumping for irrigation is one of the more widely adopted PUE, though it is still limited.[55] There is great potential and a strong business case for solar water pumps for irrigation. The capital cost of solar water pumps is decreasing, which makes them a clean and sustainable alternative to diesel pumps and rain-fed systems. Due to the low operating costs of solar water pumps, the capital cost of buying a solar pump to replace a diesel pump can be recouped within two years.[56] Pilots projects using solar water pumps have shown great benefits for farmers, especially those producing horticultural crops – the pumps enable farmers to have an additional growing season, improve productivity, and save time.[57] However, uptake is slow; only 395 small-scale solar water pumps (less than 3kW) were sold in 2019.[58]

A study of smallholder farmers found that the majority make an effort to irrigate their horticultural crops, but only 1% use solar pumps compared to 14% using diesel pumps, 39% using hand pumps, and 43% using watering cans.[59] In addition to the high upfront cost of a solar pump system (between USD1,000 and 3,000 per acre needing irrigation), the main challenge of solar water pumps is the need for available water sources and water infrastructure (e.g. boreholes). A significant number of smallholder farmers surveyed by EnDev (38%) did not have access to readily available water.[60]

Figure 6: Type of pump technology used by smallholder farmers (EnDev, 2021).



Similarly, solar irrigation may be able to offer farmers in Northern Uganda a means to improve food security in a region prone to drought.[61] However, given the upfront costs of solar irrigation, it is not economically viable for the majority of smallholder farmers. The adoption of solar irrigation makes more economic sense for farmers who grow high value crops, have more than one acre of land, come from higher-income households, or run medium to large scale commercial operations.[62]

Cold storage: The agricultural sector in Uganda would significantly benefit from access to and the use of cold storage, such as refrigerators, freezers, walk-in cold rooms, and portable cooling boxes, to prolong the shelf life of fruits and vegetables. Yet currently, cold storage is even less frequently used than solar-powered irrigation. A study of smallholder farmers found that only 8% had access to cold storage, and most of this access is by dairy farmers who jointly own electricity-powered cold storage units. Smallholder horticulture farmers showed limited demand, interest, and awareness in cold storage as refrigerators are perceived as a luxury item for higher income households.[63]

In the dairy industry, a reliable dairy cold chain can reduce milk losses and stimulate energy demand. It is estimated that in Uganda between 22% and 37% of milk is spoiled due to inadequate cooling and temperature-controlled transportation. There is a good business case for solar-powered cooling solutions for milk (such as refrigerators and milk coolers). Although there is a high upfront cost, the

55 NEFCO. 2023. Scaling Productive Use of Energy Solutions in Sub-Saharan Africa: Market Scoping and Design of a Results-Based Financing Window for the PUE Sector. Tetra Tech.
56 Power For All. 2020. Power For All Fact Sheet: Leveraging decentralized renewables for Uganda's agricultural sectors
57 Uganda Off-Grid Energy Markey Accelerator (UOMA). 2020. Productive Use of Energy in Uganda. Learnings from the Uganda Off-grid Energy Market Accelerator. UOMA, USAID, Power Africa
58 UOMA. 2020.
59 EnDev. 2021. Sustainable Energy for Smallholder Farmers (SEFFA) in Ethiopia, Kenya and Uganda Baseline Study and Market Assessment. GIZ. Germany
60 EnDev. 2021.
61 OCA. 2017.
62 Utz, V. 2011.; UOMA. 2020.
63 EnDev. 2021.

original investment in the equipment is recovered within two years.[64] Small and medium-sized cooling units are particularly viable in regions where farmers experience high spoilage, and work particularly well forcooperatives.[65]

Dairy production and processing: Technologies such as solar milking machines can increase speed and quality of the milk. However, it is mainly viable for farmers with a large herd. Solar products - including milk chillers, churners, and pasteurizers - can catalyse dairy processing. Dairy products that are increasingly produced by small-scale producers are yoghurt, ghee, cheese, and bongo (a traditional cultured milk drink). More than one-third of smallholder dairy farmers (35%) surveyed by EnDev used solar energy to process their products, such as for cheese and ghee production. Women participate throughout the dairy chain but are primarily involved in processing. A survey found that some women are already using SHS and solar-powered freezers to produce yoghurtg.[66]

Milling: There is a significant demand for milling services to produce products like posho, porridge, and cereal from maize and cassava. Most districts have limited milling capacity, and there is a heavy reliance on diesel milling. Smallholder farmers generally face high costs to transport goods to millers in distant trading centres.[67] Given that crop values can be tripled through milling, there is potential for standalone solar mills with capacities of at least to 500kg per day to be used instead of diesel machines. The main challenge of solar mills is the high upfront capital cost of the machine and its accessories (such as solar panels, batteries, and frames). Additionally, solar-powered mills are currently perceived to be technically inferior. Small-scale solar mills have a capacity of around 300kg per day, compared to diesel mills with a capacity of 1000kg. The solar mills available in the country also do not have a 'huller' to remove the hull and provide a fine flour used to make posho. However, solar mills could be employed to grind feed for poultry. Refugee settlements, where access to milling services is low, are also a potential market for solar milling.[68]

Maize shelling: Maize is one of the top crops in Uganda by tonnage and is grown in all parts of the country. Many smallholder farmers are involved in maize production, but are unable to invest in post-harvest handling or agro-processing. PUE could be implemented in maize processing to increase efficiency. The Uganda Value Added Maize Alliance project provided mechanised maize shellers to young operators in the Busoga region as part of a larger livelihood project.[69] These motorised shellers reduce the percentage of broken maize grain and increase productivity from two bags of grains per hour to 30 bags per hour, using the traditional technique of beating the maize grains from the cob with sticks. Over three years, the farmers doubled their incomes. This mechanisation was successful because it was part of a broader initiative to strengthen the maize value chain in Busoga so it could supply large brewing and milling companies in the region.

Coffee pulping: Coffee constitutes 18% of Uganda's exports and is mostly farmed by smallholders. Many coffee-producing areas are currently without grid access, but are in areas of projected grid or PV mini-grid extension.[70] Coffee pulping can increase farmers' income opportunities through value addition, separating the bean from the skin and pulp. Solar and on-grid coffee pulpers exist and are available in Uganda. However, the high capital cost of solar pulpers (USD2,000) makes them inaccessible for most smallholder farmers.[71]

64 Power for All. 2020.
65 UOMA. 2019.
66 Energizing Development (Endev). 2021. SEFFA.
67 Power For All. 2020. Power for All Fact Sheet: Leveraging decentralized renewables for Uganda's agricultural sectors.
68 Open Capital Advisors. 2017. Promoting Productive Uses of Energy in Uganda.
69 Tegendhat, E. 2017. Transforming the Uganda Maize System. Positive Impact Case Study. Palladium.
70 Shirley, R., Liu, Y., Kakande, J., Kagarura, M. 2021. Identifying high-priority areas for electricity services in Uganda through geospatial mapping. Journal of Agriculture and Food Researh 5: 100172
71 Power for All. 2020.

Oil seed processing: There is growing domestic demand for vegetable oil. Uganda produces many oil crops (groundnuts, soya beans, simsim [sesame], and sunflower), yet imports the majority of its vegetable oils. Solar oil seed processing machinery exists, but it is expensive (around USD21,000) and it is not widely available in the country.
As a result, there has been little uptake of this machinery so far. Considering the growing domestic demand of this largely imported product, processing seed crops into oils would be a lucrative industry for commercial farmers.[72]

Ice production for the fish industry: PUE-based ice production would provide economic advantages, particularly for the three fishing regions around Lakes Kyoga, Albert, and Kyoga. Improper storage and transportation of fish result in significant losses. Solar icemakers require a high capital investment (USD7,000) but would reduce inventory loss and the fish industry's dependency on ice suppliers.[73] Mini-grids enable greater potential for local ice production and reduce the cost of purchasing ice from middlemen. Ice production would have other uses in other businesses, such as restaurants.

There are few examples of PUE technologies being used by smallholder farmers in refugee settlements or host communities to date. Two pilot projects were identified (see Box 5) that showcase the potential to use PUE to increase refugee households' income.[74,75]

Box 5: Supporting Farmers in Refugee Hosting Districts

The EnDev programme supports refugees in Uganda. To promote PUE by refugees, a demonstration site was established to allow a women's agricultural group to pilot the use of a solar pump irrigation system for their horticulture garden.

PHB Development, Yelekeni Farmer's SACCO, BrightLife, and UltraTech won a grant from the Smart Communities Coalition Innovation Fund to develop a solar-powered hatchery and individual SHS for small-scale poultry farmers in Kiryandongo. It aims to provide income and electricity to more than 2,000 young and women farmers.

Productive Use in the Commercial Sector

The overall adoption of PUE within the commercial sector is limited in Uganda. The main PUE has been to use low-tier SHS and solar lights to run shops, charge phones, and power small appliances.[76] Generally, women tend to operate enterprises using PUE with lower energy consumption in service sectors, such as food vending, while men are inclined towards economic activities in agriculture, fisheries, and manufacturing - which require higher levels of energy consumption.[77]

PUE initiatives in refugee settlements have supported MSMEs to access and use off-grid technologies to generate income. A survey in 11 refugee-hosting districts found that most businesses engaged in small-scale activities that were not energy intensive. Nearly half of the surveyed businesses (46%) had access to electricity from the grid, followed by solar energy (39%). An additional 7% lacked access to any energy source.

72 OCA. 2017.
73 OCA. 2017.
74 EnDev. 2021.
75 EnDev. 2021ª. Creating a Brighter Future for Refugee-hosting Communities: SCCI announces grant winners. February 2, 2021. https://endev.info/ creating-a-brighter-future-for-refugee-hosting-communities-sccif-announces-grant-winners/
76 UOMA. 2020.
77 Africa Clean Energy. 2021.

The businesses using solar energy predominantly used either larger SHS (>100Wp) or low capacity (>10Wp) Pico-PV products (see Figure 3).[78] Businesses with larger-capacity systems were generally phone-charging points, video halls, and barbershops and salons. The most common appliances used by business were predominantly phone charging units (20%) and shavers (10%) (see Figure 5).[79] The majority (58%) of businesses, however, did not use any appliances for productive use.

Figure 7: Percent of business in 11 refugee-hosting districts using solar technology by type and capacity (IFC, 2022)

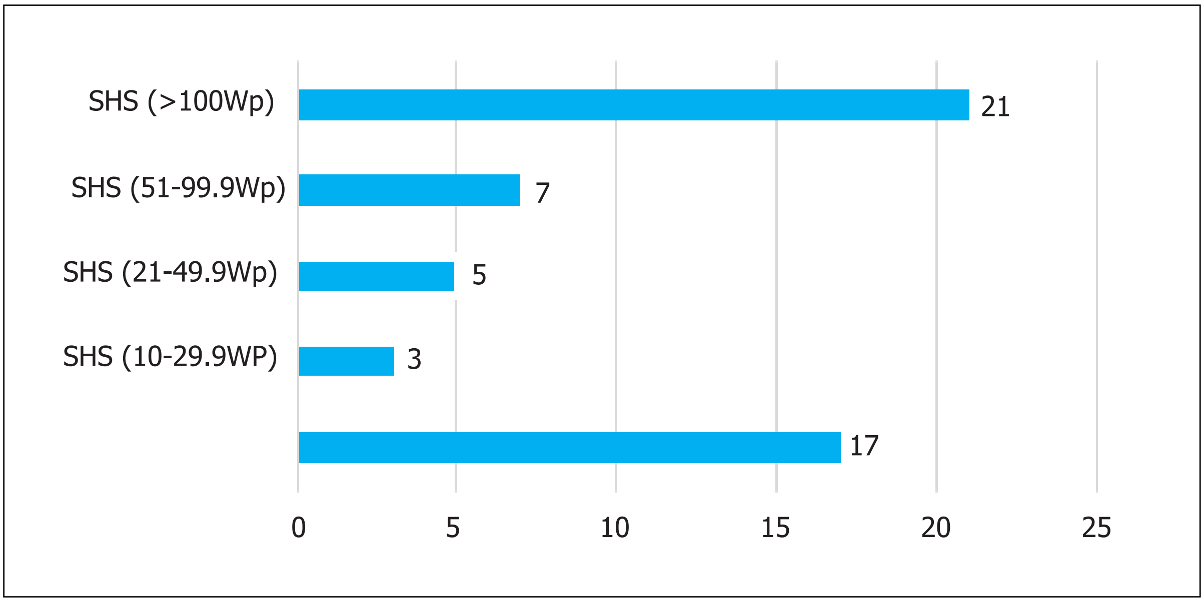
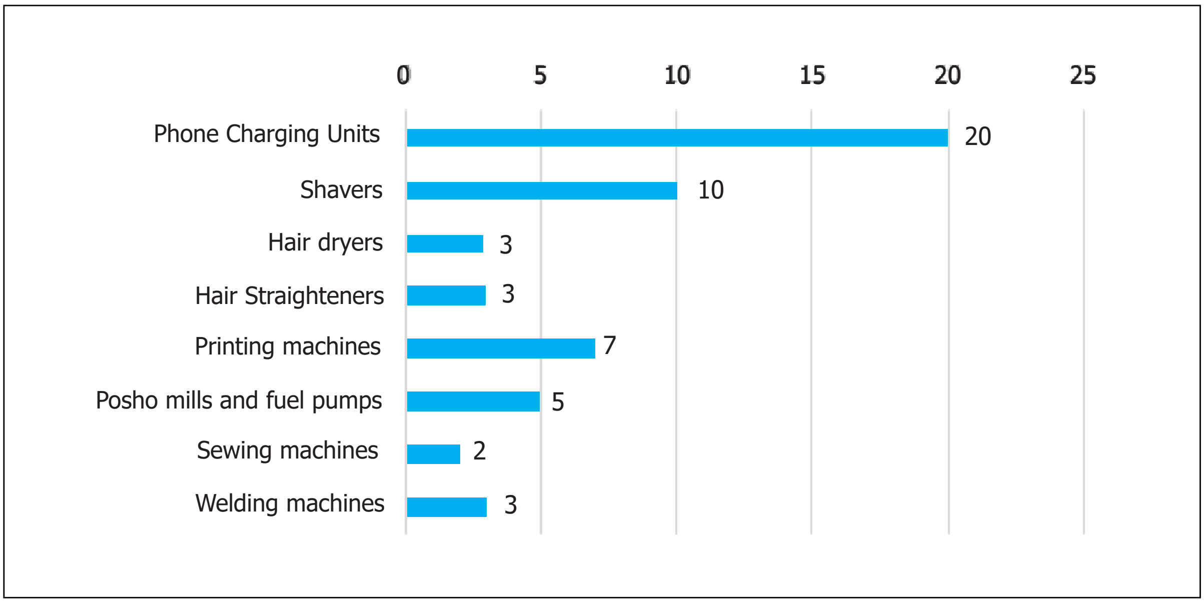


Figure 8: Percent of business in 11 refugee-hostingdistricts using electrical appliances by type (IFC, 2022)



78 International Finance Corporation (IFC). 2022. Energy Access Baseline Study in Uganda's Refugee-Hosting Areas. Washington, DC. November 2022.
79 IFC. 2022.

The following are the predominant PUE in the commercial sector found in refugee-hosting districts.

Energy kiosks: Energy kiosks have been established in several refugee settlements (Rhino Camp, Kiryandongo, Maaji, Imvepi, Bidi Bidi, Nakivale, and Palorinya) and Kampala. These kiosks provide services, such as phone charging, as well as printing, secretarial services, cold beverages, internet access, and computer training. The computer training offered at some kiosks is successful, with high demand and added community benefits. Additionally, several kiosks (around 14%) sell solar products such as solar lanterns, though very few sell improved cookstoves.

Two energy kiosks with solar-powered electricity were constructed in Ofua 3 and Siripi Zones in Rhino Camp Refugee Settlement by the Energy Solutions for Displacement Settings project[80] The EnDev programme supported the establishment of four solar-powered energy kiosks in adapted shipping containers in the Rhino Camp and Imvepi Refugee Settlements. Three of these were set up as for-profit businesses run by youth.[81] Village Savings and Loans Association members came together as cooperatives to set up energy kiosks in Kiryandongo and Yumbe.[82] Well-established kiosks have expanded to include internet cafés and banking services. The energy kiosk is a successful business model that can be replicated in more settlements.

Business hubs: Power Trust Uganda Ltd has supported the establishment of five solar-powered business hubs in Kiryandongo and Bweyale Refugee Settlements.[83] The hubs are 40-ft solar-powered containers that contain a milling service, a hair salon, a small energy kiosk for phone charging and computer access, and a space for training. The hubs are run by groups of residents.[84] Furthermore, the business hub has facilitated the establishment of women-owned businesses.[85]

Small retail and service businesses: The businesses most likely to use energy in the refugee-hosting districts are in retail and services. This includes food and beverage sellers, general retail shops, barbershops and salons, printing and computing shops, phone-charging points, posho mills, electronics shops, discos and cinema halls, garages, and welding.[86] Women and youth entrepreneurs, in particular, are using solar energy for these types of retail and service businesses.[87]

There are initiatives to support refugee and host communities to start businesses using solar energy. The EnDev programme has set up PUE demonstration sites in Rhino Camp and Imvepi refugee settlements showcasing three businesses (hair salon, restaurant, and a carpentry workshop). In Rwamwanja and Kamwenge districts, 122 SHS were installed for small businesses to refrigerate produce and milk and provide beauty salon services.[88] Solar Today supported youth in Rwamwanja Refugee Settlement to use solar energy to create small businesses, including hair salons, internet centres, and phone charging stations.[89]

Clean cooking: There are many initiatives to support clean cooking through the use energy efficient stoves or alternative fuels, such as LPG and electricity, to reduce dependence on firewood. Most of these efforts aim to improve the household use of energy, which is discussed in more depth in the desk review Household Use of Energy. For the PUE, GIZ promoted 'rocket' baking ovens for MSMEs in north-western and south-western Uganda. The rocket oven is more efficient, has shorter preheating times, and consumes

80 GIZ. 2021. The Uganda Energy Kiosk Model in Refugee Settings.
81 Moncada, A., Ruiz, L., Meyer, M., Surya, R., Wanyahoro, W. 2022. Assessment of Market-Driven Solutions: Energy Access in Refugee Settlements in Sub-Saharan Africa. Smart Communities Coalition. Smart Communities Coalition
82 Tumwesigye, A., 2021.
83 Smart Communities Coalition (SCC). 2019. 2019 Year in Review.
84 Lamb, H., 2022. Kigali conference can power up refugee incomes – with benefits across society. https://ashden.org/news/kigali-conference-can-power-up-refugee-incomes-with-benefits-across-society/. Page updated May 16, 2022.
85 Africa Clean Energy. 2021. Productive Use Potential and Sales of Off-Grid Solar to Women and Youth in Uganda. Tetra Tech International Development.
86 IFC. 2022.
87 Africa Clean Energy. 2021.
88 GIZ 2022. An Intermediate Outcome Study After the Electrification of Six Health Centers. Uganda
89 CREEC. 2018.

one-tenth of the firewood of a traditional oven. It also has a higher capacity, baking between 32kg and 256kg of bread in one cycle, or 100 to 800 buns. The increased productivity of the oven has enabled owners to employ more staff and increase their income.[90] Scaling up the use of efficient stoves and electricity for cooking (including grid- or solar-powered electric pressure cookers) for businesses preparing and selling food could significantly ratchet up productivity and sales.[91]

The refugee response has included initiatives to bolster the local production and sale of improved cookstoves. UNHCR, for example, has trained refugee and host community members to manufacture portable rocket cookstoves using locally available materials. Briquetting groups in the settlements are working to produce carbonised briquettes - using materials such as maize, cereals, roots, coffee residue and organic waste – to provide a cleaner alternative to firewood and charcoal.[92] The Raising Gabdho Foundation supported community members in Bidi Bidi Refugee Settlement to construct locally-sourced energy efficient solutions, such as clay stove bases, briquettes, and bio-waste fertiliser, and sell products through a commercial outlet.[93]

Box 6: PUE innovations: The Energy Solutions for Displacement Settings project supports PUE innovations in refugee settlements. The project established an innovation lab in Rhino Camp Refugee Settlement. At the lab, participants learn about the design process and build prototypes of an energy-driven technology to solve a specific problem. The lab holds lessons on energy, including solar photovoltaics, heat conservation methods, and biomass. Lab participants invent technologies using various forms of energy, such as a laundry machine with a hand-crank mechanism, a portable light with rechargeable phone battery, a large phone charging kit, and a table-top juice blender with string-drive technology to spin the blender.[94]

Beyond programs to expand access to and productively use energy, there are initiatives that aim to improve access to energy products in refugee settlements by addressing common barriers, namely, access to goods and finance. The Uganda De-Risking Pay-As-You-Go (PAYGo) Solar Home Systems grant, under EnDev, helped SHS companies to establish sales offices in Kiryandongo and Rwamwanja Refugee Settlements. Three companies (BrightLife, Fenix International, and SolarNow) opened storefronts, hired refugees as sales agents, and have had success selling energy products.[95] In Bidi Bidi Refugee Settlement, the AMPERE project worked with solar energy provider Village Power to create flexible financing options that increased the ability of refugee and host communities to pay for SHS and solar lanterns and reduced credit risks.

Challenges to PUE in Uganda

There have been significant advances in expanding energy access and promoting PUE in Uganda, as described in the previous sections. However, there are several common barriers on both the demand and supply sides that limit uptake of PUE technologies (see Table 3).[96]

90 GIZ. 2013. Bakeries with Efficient Ovens Uganda
91 MEMD. 2023.
92 UNHCR. 2022. Access to Clean Energy for Refugees: Uganda Case Studies.
93 Response Innovation Lab. Strengthening the Community's Resilience to Environmental Challenges. 2021. Edited on January 12, 2021. https://www.responseinnovationlab.com/innovations-marketplace/raising-gabdho-foundation-ltd
94 GIZ. 2022. Creating Energy Solutions in Rhino Camp.
95 Moncada, A., et. Al. 2022.
96 EnDev. 2021.

Demand-Side Barriers

The greatest barrier is the low affordability of the PUE technologies. There is a high upfront cost to many of the technologies, particularly larger appliances like refrigerators and biomass-fuelled baking ovens. Some products have additional costs for solar panels, batteries, and installations. Even though many of the technologies may be cheaper in the long run compared to diesel alternatives, the initial investment makes them cost-prohibitive.

There is reluctance and/or the inability to pay for energy products. Many refugee households have low, irregular, or seasonal incomes, which affects their ability to pay for off-grid solutions or electricity bills. On average, 60% of their monthly income is spent on food expenditures, followed by other necessities. Women, young people, and persons living with disabilities (PLWD), in particular, have low income levels.[97] The irregularity of household incomes makes taking out a loan – with the obligation of regular monthly payments – largely unfeasible for many families.

There is also limited awareness of the available PUE technologies and the benefits they can provide. While there is recognition of the utility of energy for lighting, there is less understanding of the advantages and range of energy-driven technologies available for the agriculture sector.

Refugees have limited access to flexible financing options for PUE. Most refugee households are unable or unwilling to pay for energy products in one lump sum.[98] One of the main financing options is Pay-As-You-Go (PAYGo), which allows Off-Grid Solar companies to sell products on credit to customers by splitting the payments over a longer period of time. However, providers are wary of extending credit due to the risk of consumer default.[99] Mobile money is a commonly used payment method for PAYGo, but this option is challenging in areas with limited connectivity.[100] A study in Bidi Bidi Refugee Settlement found that less than 5% of buyers could use mobile money, and that mobile money agents were located far away from the settlement.[101]

The use of energy is not profitable for some MSMEs. Studies have shown that connections to mini-grids or installation of SHS do not automatically trigger local economic activity.[102] Even when electricity is used by businesses, it does not necessarily result in greater profitability. A study commissioned by GIZ, BMZ and the Energy Sector Management Assistance Program (ESMAP) in 2013 sought to measure the impact of electrification on MSMEs. It examined how MSMEs that had recently gained grid access use the electricity and its effect on production and profitability. It found that although electrification improved the working conditions or productivity for some businesses, the increased cost of energy resulted in some cases reduced profits overall.[103] The findings point to the importance for MSMEs to receive support in business planning to consider energy costs as part of its financial planning to ensure its use improves profitability.

97 Africa Clean Energy. 2021.
98 Energizing Development (EnDev). 2019. The State of Sustainable Household Energy Access in Refugee Settings in Uganda. Survey Findings in Rhino Camp Settlement and Imvepi Settlement, Arua District, West Nile Region. GIZ. Uganda
99
100 NEFCO. 2023. Scaling Productive Use of Energy Solutions in Sub-Saharan Africa: Market Scoping and Design of a Results-Based Financing Window for the PUE Sector. Tetra Tech
101 Moncada, A., et.al. 2022
102 Africa Clean Energy (ACE). 2019. Uganda Solar Water Pumping Report. Kenya.
103 Mayer-Tasch, L., et.al. 2013.

Table 3 : Demand-side barriers to PUE uptake

Demand Side
• Limited consumer awareness • Low affordability • Low willingness and ability to pay out of pocket • Limited access to credit or financing • Limited or seasonal incomes • Lack of connectivity to pay providers by mobile money • Lack of the technical knowledge needed to operate PUE technology

Supply-Side Barriers

Few products and services are available near refugee settlements. There are scarcely any solar companies located near the refugee settlements where residents can purchase quality solar products or receive after-sales services.
PUE products do not meet demand. Some products, such as solar mills, require customisation to produce the right end product or sufficient output. Many of the PUE products are manufactured outside of the country and may have limited availability or spare parts in-country.

Low-quality products are flooding the market. There are many counterfeit energy products in circulation that spoil the market through their low cost and low quality. A 2019 study in Rhino Camp and Imvepi, Refugee Settlements found that 60% of the energy products on the market were counterfeit.[104] As consumers buy products that break or stop functioning, it lowers consumer confidence.[105]

There may be insufficient energy to run the appliances. For example, cold storage technologies are large and need a constant supply of energy to run.[106] The low quality and irregularity of the power supply limits the ability of operators to provide consistent energy services.[107] Some solar products are also less reliable in certain seasons. While there are many standalone solar products that require little energy input, such as solar clippers, heavier equipment requires energy from a mini-grid to operate.

The tariffs for energy from mini-grids are not affordable for many. The construction of mini-grids opens up many opportunities for PUE within the refugee settlement, particularly for the use of technologies with a higher energy requirement. However, even in areas with available electricity from mini-grids, their use has not been adopted by all community members due to factors such as low affordability, the high cost of connection, and high tariffs.[108] There is particularly low uptake among households that are not using the energy to generate income. However, if the tariff is set too low to encourage adoption, the mini-grid may not be economically viable and it can discourage potential investors.[109]

There is insufficient data on effective PUE. There are numerous initiatives to pilot PUE in refugee-hosting districts or in different value chains; however, greater aggregate data on successes and pitfalls would facilitate more evidence-based investment decisions.

104
105 IFC. 2022.
106 NEFCO. 2023
107 Energizing Development (EnDev). 2019. The State of Sustainable Household Energy Access in Refugee Settings in Uganda. Survey Findings in Rhino Camp Settlement and Imvepi Settlement, Arua District, West Nile Region. GIZ. Uganda
108 Eder, J., et.al. 2015.
109 IFC. 2022.

There is a paucity of trained technicians for PUE products. There are very few technicians available to provide training on the use of the product or to perform maintenance and repairs (see Box 7).[110,111] In rural areas, the availability of technicians is even more limited, estimated at approximately one technician per 1,800 households.[112]

Table 4 : Supply-side barriers to PUE uptake

Supply side
• High up-front costs • Lack of trained technicians for after-sales service, installation, and repair • Limited availability in or near settlements • Weak supply chain • PUE companies have limited access to finance • Products not manufactured in-country • Low quality or counterfeit products flooding the market

Box 7: Training for Technicians

To accelerate access to and use of energy, there is a need to have trained technicians in the sector. There is a demand for solar services and there are jobs available as solar technicians. A market study found that to meet the current off-grid sector targets, there needs to be 5,500-9,200 new jobs created related to SHS and 3,000-5,400 related to mini-grid operation and maintenance. The study found a significant gap between market demand and supply across all off-grid energy services.[113]

There are few training programmes available for solar technicians, including those offered by Makerere University, the Nakawa Vocational Training Institute, and by the training centre Youth Alive Uganda. The solar operator Village Energy has trained young men and women to be solar electricians and sales agents through a travelling solar academy. The Directorate of Industrial Training offers a Domestic Biogas Technician assessment and training package but not one for solar technicians.[114] The Pro Mini Grid project developed a solar and mini-grid training curriculum and a Renewable Energy Training Centre for solar and mini-grid technicians.

Conclusions

The adoption and use of energy in its different forms can provide a transformative opportunity for refugees and host community households to increase income and achieve self-reliance. Policies and strategies to promote energy access have created a positive enabling environment to expand access to clean energy. In line with the SERP, there have been advances in developing access to off-grid solar-powered solutions in

110 Stewart, J., and Trace, S. 2021. Market Scoping for a Job Creation Agenda for the Beyond the Grid Fund for Africa (BGFA) Window in Uganda. Oxford Policy Management. United Kingdom.
111 International Labour Organization. 2022. Occupations and skills assessment for youth in selected refugee settlements of Isingiro, Arua, and Madi Okollo districts in Uganda. Geneva.
112 Abbott, R. Scaling Off-grid Energy in Uganda: A Mid-Level Landscape Analysis of Issues and Stakeholders. FHI360.
113 Stewart, J., and Trace, S. 2021.
114 Directorate of Industrial Training Assessment and Training Package for Domestic Biogas Technicians. Uganda.

refugee-hosting districts, mainly through mini-grids and standalone systems. There has been less focus on solar thermal energy (e.g. for cooling or drying of produce).

The use of energy and available technologies for income generation among refugee and host communities is limited but growing. In the refugee settlements, the most common PUE is in the commercial sector through the establishment of energy kiosks that offer multiple services like phone charging and printing. Additional uses of energy are seen in retail shops, hair salons and entertainment halls. PUE in the agricultural sector has been sparse in the country, with even fewer examples present in refugee settlements. However, it is a sector where there is wide scope for growth, as there are many technologies available that can be applied throughout various steps of value chains. Annex 3 highlights the advantages and barriers of the main PUE included in this review.

To encourage greater adoption of PUE in refugee settlements, there is a need to address key constraints on the demand and supply side, such as affordability and availability.[115] The following are ten recommendations for actors involved in the refugee response to advance PUE in refugee-hosting districts.

1. Awareness: Increase target groups' awareness of PUE technologies.

There are many renewable energy and electricity-based technologies available that can help improve productivity or services. Refugee response actors can:

- Promote awareness about the existing technologies among men, women, and youth in the refugee and host communities.
- Provide demonstrations to show how it can be used and explain the potential benefits, such as long-term cost saving, improved health, or increased income, will contribute to the breadth of knowledge on this subject.

2. Financing: Facilitate access to flexible finance options

- Enable refugee and host communities to be able to pay for the cost of the technology, the connection fees, and/or electricity bills by providing flexible payment options. Examples of the models include PAYGo (via mobile money, airtime, or cash), VSLAs, lease-to-own schemes, subsidies, and loans from financial service providers.
- Provide combined financing and payment options, such as by linking VSLAs to financial service providers to allow VSLA members to acquire the more costly PUE technologies. Users could also leverage VSLAs to cover the initial deposit for the equipment (e.g. 15%-20% of the cost) and cover the remaining balance using PAYGo.[116] Financial institutions could also set up special financing products specific to renewable energy.[117]

3. Availability: Strengthen the supply chain of PUE technologies in refugee settlements

- Incentivise the suppliers of quality energy products to set up sales and service operations in or near refugee settlements.
- Support the establishment of inventory hubs for distributors to easily access high quality energy products and spare parts.
- Provide backing for the development of more energy kiosks in refugee settlements and facilitate connections between these kiosks and quality solar product suppliers.
- Encourage the training and employment of refugees to promote the use of the PUE technologies and/or to repair products. Support local artisans to manufacture energy efficient cookstoves using local materials to be sold at sales points or kiosks in the settlement.

4. Technology: Pilot and scale up successful PUE technologies

Several PUE technologies are considered to have a good business case in Uganda, particularly in the agricultural sector. There is potential to pilot and to scale up successful technologies and their productive uses in other refugee-hosting districts. Therefore, it is recommended to:

115 CREEC. 2018.
116 Tumwesigye, A., 2021.
117 IFC. 2022.

- Scale up technologies such as include solar-powered irrigation, cold storage in the dairy value chain, energy efficient ovens, small refrigerators for the sale of cold beverages, and SHS to be used for various business ventures, including energy kiosks and entertainment halls.
- Explore and pilot other technologies using solar power, electricity, or thermal energy such as solar millers, egg incubators, solar dryers, and electric pressure cookers.
- As more mini-grids are installed, help businesses use technologies with a higher (Tier 3) energy demand in areas such as woodworking and welding.

5. Capacity: Build the capacity of end users to optimise the PUE

- Provide technical training to owners of MSMEs and farmers on PUE technology so they can incorporate energy sources into their work and maximise their use. Work with them directly to understand their specific needs to identify and adapt the technology to meet requirements (e.g. desired output or quality of product).
- Provide business planning support to entrepreneurs, MSMEs, and farmers to help ensure that the cost of energy is offset by improved productivity and income over the long term.
- Support the organisation of cooperatives to collectively purchase more costly PUE technologies, such as cold storage equipment.

6. Training: Scale up training opportunities for technicians

- Develop training programmes related to the energy sector, particularly for solar technicians, and facilitate access to training for refugees.
- Train local technicians and youth on how to repair solar products, which would create a potential income stream for them.[118]

7. Programs: Integrate PUE into livelihood programming using a market-based approach

- Integrate PUE into the design of livelihoods programs. Consider the points in the entire value chain where PUE can optimise impact, productivity, and income.
- Take a market systems approach to project design, by analysing the local economic context, assessing the demand for PUE, and considering the availability of inputs, qualifications of the local workforce, conditions of infrastructure, and access to markets.[119]
- Support women, young people, and PLWD to start up or improve businesses using PUE technologies.

8. Data: Collect data on successful PUE cases

- Monitor the results of initiatives piloting PUE technologies.
- Support national efforts to aggregate data into a one stop centre to support governments, development partners, and private sector.

9. Strategy: Integrate PUE into a broader energy approach

- Strategies to increase energy access should be designed with PUE in mind to enhance income generation.
- Consider the productive, household, and public use of energy in a holistic strategy to maximise the effect of energy on the community as a whole. Promote the use of the same fuel source or stove type in households, businesses, and institutions to reduce reliance on biomass and optimise the supply chain.
- Review the indirect effects of energy access as part of income generation strategies. The improved public uses of energy - such as lighting for streets, markets, and health and education centres - can lead to the improved health and well-being of a community and increased training opportunities, which can have indirect impact on productivity. The improved public infrastructure can also attract more residents, businesses, and investors to the area, which would lead to greater economic development in a community or region more broadly.

118 IFC.2022.
119 Brüderle, A., et.al. 2014.

10. Policy: The Government can encourage PUE through incentives, standards, and coordination.

- The GoU has a pivotal role to play to accelerate the adoption of renewable energy by creating an enabling environment for private sector participation. This can include providing financial incentives, such as tax waivers and subsidies.[120] A special fund could be set up to lower risks for investors of mini-grids that would allow operators to charge an affordable rate to generate sufficient demand.[121]
- The GoU and partners can develop standards for quality solar products and their productive use, as well as guidelines for handling electronic waste.[122] Similarly, standards and guidance can be created for the promotion of energy efficient cookstoves and clean fuels.
- Greater coordination with development partners, private sector and other actors through the energy working groups of CRRF to align strategies and share information.[123]

120 NS-PUSE. 2023.
121 IFC. 2022.
122 NS-PUSE. 2023.
123 IFC.2022.

Annex 1: Definitions of Productive Use of Energy

Definitions

"Activities that involve the utilization of energy – both electric and non-electric energy in the forms of heat, or mechanical energy – for activities that enhance the income and welfare in rural contexts."[124]

"Projects that aim at enhancing income generation opportunities and productivity in rural areas […] to improve quality of life and increase local resilience and self-reliance." [125]

"Activities that involve the application of energy […] to create goods and/or services either directly or indirectly for the production of income or value."[126]

Productive uses of electricity are "agricultural, commercial and industrial activities involving electricity services as a direct input to the production of goods or provision of services."[127]

"Productive uses of energy are those uses of energy that increase income or productivity."[128]

"PUE is defined as any income generating activity involving electricity or thermal energy as a direct input in the production of goods or provision of services."[129]

PUE is "any income generating activity involving electricity as a direct input to the production of goods or provision of services."[130]

PUE is "use of energy services as a direct input in the transformation of goods and services within agricultural, commercial and industrial activities that enable value addition and the enhancement of incomes/revenues."[131]

124 Kapadia, Kamal. 2004
125 Etcheverry, J. 2003. Renewable Energy for Productive Uses: Strategies to Enhance Environmental Protection and the Quality of Rural Life. University of Toronto
126 White, R. 2003. GEF-FAO Workshop on Productive Uses of Renewable Energy – Synthesis and Report. Washington, D.C.
127 Bruderle, A., et.al. 2013.
128 Havinga, M., and Tuele, R. 2021.
129 Havinga, M., and Tuele, R. 2021.
130 Africa Clean Energy (ACE). 2019
131 Tumwesigye, A., 2021.

Annex 2: List of Projects Enhancing Energy Access and Productive Use in Uganda

Project	Donor	Description	Partners	Location	Year
Energy Solutions for Displacement Settings (ESDS)	Germany	ESDS pilots and promotes market-based solutions for access to sustainable cooking energy and electricity for households, social institutions, and small businesses, benefitting both refugees and host communities.	GIZ, Kulika Uganda, Youth Social Advocacy Team	Rhino Camp	2018-2022
Energising Development (EnDev)	Germany, the Netherlands, Norway, Sweden, the United Kingdom, Switzerland, Ireland, EU	Provides modern energy services for 15,700 social institutions and 28,300 small and medium-sized enterprises. Trains 32,000 stove builders, craftsmen, vendors and solar technicians.	EnDev Uganda	Rhino Camp and Imvepi	N/A
Promotion of Mini Grids for Rural Electrification (Pro Mini Grids)	BMZ, EU	Installed 40 mini-grids in three districts; promoted productive use of energy; and built technical capacity of solar and mini-grid technicians.	GIZ	Lamwo, Rakai, and Isingiro districts	2016-2022
GET ACCESS Mini-grid Solar Programme	European Union and Germany	Provides access to modern, affordable, and clean electricity to households, institutions, and businesses in remote rural areas by installing more than 120 solar mini-grids.	BMZ, MEMD	Palorinya-Maaji settlement, Kalangala and Wakiso, Buvuma Island, and Lake Albert Shores	2023-ongoing
Uganda Value Added Maize Alliance (UVAMA)	USAID	Involved in PUE in the maize value chain.	Palladium, Agroways	Ibanda and Kamwenge	2013-2017
Energy Access in Refugee Settlements	DFID	Piloted an integrated approach to improve access to energy with improved cookstoves	EnDev Uganda	Imvepi and Rhino Camp	2017-2018
De-Risking Pay-As-You-Go (PAYGo) Solar Home Systems in Uganda Refugee Settlements Project	USAID/Power Africa	Encouraged private PAYGo SHS companies to consider refugee communities as a viable market.	Smart Communities Coalition, BrightLife, Fenix International, Solar Now	Kiryandongo and Rwanwanja	2018-2020
Energy Access Scale-Up Project (EASP)	World Bank	Scale up access to electricity and clean cooking for households, refugee and host communities, commercial enterprises, and health and education facilities.	Sustainable Energy for ALL (SE4ALL) Uganda Solar Energy Association (USEA) Uganda Energy Credit Capitalization Company Limited (UECCC)	N/A	2023-2028
Accessing Markets through Private Enterprises for Refugees' Energy access (AMPERE)	Netherlands Enterprise Agency (RVO)	Increased affordability of consumer products and partnered with private solar energy providers to create flexible financing options.	Mercy Corps Netherlands, SNV, Response Innovation Lab Village Power	Bidbibi	2019-2020
Uganda Off-grid Market Accelerator (UOMA)	USAID/Power Africa, DFID, Shell Foundation	Accelerated off-grid access through coordination and research		N/A	2017-

Project	Donor	Description	Partners	Location	Year
Energy Access Scale-Up Project (EASP)	World Bank	Scale up access to electricity and clean cooking for households, refugee and host communities, commercial enterprises, and health and education facilities.	Sustainable Energy for ALL (SE4ALL) Uganda Solar Energy Association (USEA) Uganda Energy Credit Capitalization Company Limited (UECCC)	N/A	2023-2028
Accessing Markets through Private Enterprises for Refugees' Energy access (AMPERE)	Netherlands Enterprise Agency (RVO)	Increased affordability of consumer products and partnered with private solar energy providers to create flexible financing options.	Mercy Corps Netherlands, SNV, Response Innovation Lab Village Power	Bidbibi	2019-2020
Energy Access programme	UNCDF	Supporting the expansion of clean energy through policy and regulation, consumer protection and awareness, and consumer and supply chain finance.			2021-
Uganda Off-grid Market Accelerator (UOMA)	USAID/Power Africa, DFID, Shell Foundation	Accelerated off-grid access through coordination and research		N/A	2017-
Beyond the Grid Fund for Africa (BGFA)	Multi-donor Nefco Nordic Green Bank Sweden, Norway, Denmark, Germany	Scaled up off-grid stand-alone SHS energy solutions	BrightLife Uganda FINCA Plus LLC Uganda SunKing	N/A	2019-ongoing
Scaling–up rural electrification using innovative solar photovoltaic (PV) distribution models	European Union	Provided solar PV systems at schools, health clinics, and business levels in the district. Provided SHS, mini-grids, and cookstoves.	WWF	Kasese district	N/A
Electricity Access Impact Maximization Campaign (E-AIM)	EU	Involved in PUE training, identification of opportunities, and grants for appliances with a productive use.	GIZ	N/A	N/A
Promotion of Renewable Energy and Energy Efficiency Programme (PREEEP)	Germany, EU	Supported the process of increasing the amount of electricity from renewable sources and improves its accessibility as well as energy efficiency. Provided irrigation using PV pumping and technical training Promoted grid extension and electrification of social institutions	GIZ, Ministry of Energy and Mineral Development, REA	West Nile	2007-2023
The Sustainable Energy for Smallholder Farmers in Ethiopia, Kenya and Uganda (SEFFA)	IKEA Foundation	SEFFA supports scalable, innovative business cases using renewable energy services and technologies for irrigation, cooling, and drying, as well as renewable energy hub to improve production and livelihoods.	GIZ, Netherlands Development Organization (SNV) and the Netherlands Enterprise Organization (RVO)		2021-2023
Market-based Energy Access in Refugee Settlements and Host Communities		Supported set up of solar-powered energy kiosks, energy services, and improved cookstoves.	GIZ, ICRAF	Rhino Camp	
Inclusive Markets for Energy Efficiency in Uganda (IMEU)	Sweden	Providing capacity strengthening of energy service companies and businesses.	SNV, Makerere University	Bushenyi, Buhweju, Kanungu, and Kabarole, Lira, Oyam, Kole & Dokolo, Wakiso, Kampala, Mukono	2021-2025

Project	Donor	Description	Partners	Location	Year
Sustainable Use of Natural Resources and Energy in the Refugee Context in Uganda	DFID	Plotted an integrated approach to natural resource management by creating sustainable solutions to improve access to energy and creating a market-based system to deliver cookstoves and energy products.	GIZ World Agroforestry Centre (ICRAF) EnDev Uganda	Imvepi and Rhino Camp	2017-2018
Emergency Response to the Deforestation Crisis of the Kyangwali Refugee Settlement	Danish Novo Foundation, Danish MFA	Distributed SolarSacks (water purification device) for water treatment.	Solar Sack, Caritas Denmark, Community Integrated Development Initiatives.	Kyangwali Refugee Settlement	
Strengthening Resilience and Promoting Inclusive Governance (STRENPO)	European Trust Fund Program	Provided livelihood and value chain strengthening for women and youth, clean energy cookstoves and plastic recycling. Made briquettes for energy-saving stoves.	CARE Rural Initiative for Community Empowerment West Nile (RICE)	Rhino and Imvepi Arua, Kyegegwa and Kyenjojo.	2018-2021
Response to Increased Environmental Degradation and Promotion of Alternative Energy Sources in Refugee Hosting Districts (RED Project)	EU Germany	Improving access to sustainable sources of energy and agroforestry interventions along with a more efficient use of energy for cooking and charcoal production.	World Agroforestry (ICRAF), Center for International Forestry Research (CIFOR)	Arua (Madi-Okollo, and Terego), Yumbe, Adjumani and Kiryandongo	2021-2024
Remote-Controlled Solar Systems for Businesses in Rwamwanja Refugee Settlement	USAID	Worked to increase access to energy provided by African-owned enterprises. Installed solar PV systems.	Solar Today	Rwamwanja and Kamwenge	2019-2021
Renewable Energy Powering Agriculture and Rural Livelihood Enhancement (REPARLE)	USAID/Power Africa	Off-grid rural electrification using hybrid solar and gasification solutions to turn agricultural residues into electricity, as well as pelleting facilities.	ACTED, Mandulis Energy	Northern Uganda	
Access to energy services in rural and peri-urban areas in Northern Uganda	EU	Worked to increase energy security of rural households in Uganda through increased availability of biomass, energy-efficient stoves, and PV solar unit.	Church of Sweden	Northern Uganda	
Milking the Sun and Harvesting the Sun	Netherlands	Provided dairy and crop farmers with affordable solar lighting systems and appliances.	Solar Now Barefoot Power Uganda Crane Creameries Cooperative Union	Nation wide	
Energy and Environment Partnership/Southern and East Africa	Finland, DFID, Austria	Aimed to improve energy security and funding projects in fields of renewable energy and energy efficiency. Provided clean energy for dairy industry, including biogas for milk cooling.	KPMG Finland	Kamwenge	

Annex 3: Advantages and barriers of select PUE in Uganda

PUE	Advantages	Barriers
Solar-powered irrigation	• Improves crop yields and income • No operational costs • Lower lifetime cost than diesel pumps • Business case for farmers with high value crops and with >1 acre of land • Willingness of farmers to invest • Relatively affordable	• High capital cost of pump and irrigation system • Needs an available water source • Limited consumer awareness • Lack of targeted support to farmers; sales agents lacking agronomy experience • System configuration is not standard and needs to be customised
Cold storage	• Reduces spoilage of milk and crops • Improves milk supply chain • Business case for dairy farmers with large herd or for cooperatives • Some demand for cold storage among horticulture cooperatives • Refrigeration units of varying sizes (small to large) and portable options.	• High cost of refrigerators, cold storage and milk coolers • Logistical challenge to transport bulky refrigerators • Low awareness • Perception that it is a luxury item • Market is flooded with poor quality systems • Needs to run constantly
Dairy processing	• Solar energy can be used for processing cheese and ghee • High interest among farmers • Rationale for processors to use solar energy for milk churning to save costs • Possible with a household SHS • Women predominantly are involved in processing dairy products	• Low quality of raw milk • Inadequate feeding of cows • Milk churning technology not locally available • Seasonal variability in milk prices
Solar drying	• Adds value to fruit, particularly for export	• Low quality of raw milk • Inadequate feeding of cows • Milk churning technology not locally available • Seasonal variability in milk prices
Solar milling	• Milling of top crops like maize and cassava • Solar-powered standalone technologies exist • Can reduce reliance on diesel-powered mills • No operational costs • Reduce contamination caused by diesel spills and air pollution • Can be used in poultry value chain to grind feed	• High capital cost of the solar mill and components (solar panel, batteries, frames) • Perceived as technically inferior • Lower output capacity than diesel mills • Current technology not suited to make local products (does not have a 'huller') • Modifications required to have end product that meets demand.
Coffee pulpers	• Solar and on-grid coffee pulpers exist • Coffee is farmed by smallholders • Potential for value addition and increased income • Coffee is top agricultural export • Pulpers available in-country	• High capital cost • On-grid pulper requires Tier 3 energy • High altitude areas where some coffee is grown is inaccessible by the grid
Oil seed press	• Opportunity for commercial farmers • Growing domestic market • Large in-country production of groundnuts, soya beans, simsim, and sunflower • Solar press exists	• Very high capital cost • Not widely available in-country
Ice-making for fish	• Improve storage and transportation of fish • Reduce loss • Reduce cost of buying ice from middlemen at a mark-up • Solar icemakers exist	• Smoking and drying fish is cheaper • No small-scale ice making powered by standalone power • Investment in an ice-making plant is too high • Solar icemaker not yet available in country

PUE	Advantages	Barriers
SHS	• Powering entertainment, service and retail shops • Provide energy for phone charging, internet, printing and copying, business hubs, and energy kiosks • Willingness to pay • SHS of varying capacities from Tier 1-3	• Affordability is a constraint • Low-quality off-brand SHS are prevalent and lower consumer confidence
Small refrigerators	• Solar refrigerators are available • Can be powered by SHS • Selling cold drinks, restaurants, bars • Business case for small, energy efficient refrig-erators	• High upfront cost • High energy costs (grid or mini-grid) • Needs continuous power supply • Low willingness to pay • Logistically difficult to transport

Annoted Bibliography

Abbott, R., **Scaling Off-grid Energy in Uganda: A Mid-Level Landscape Analysis of Issues and Stakeholders.** FHI360.
https://pdf.usaid.gov/pdf_docs/PA00W5JT.pdf

This analysis identifies key actors in the off-grid energy market in Uganda and considers their interest, relationships, and flow of resources through their networks. There are seven interconnected issues: solar operators lack access to capital; consumers lack access to finance; high-quality products compromised by imitations and limited service; solar home system products suffer from distribution and scaling challenges; new taxes and uncoordinated policies threaten a new industry; workforce training opportunities exist but have limited reach; greater need for advocacy and coordination. It concludes that the supply of solar home systems is the limiting factor, not demand. There are existing training programs, but it is a matter of getting more of the right people trained and implementing them in rural areas.

Africa Clean Energy (ACE). 2019. **Uganda Solar Water Pumping Report.** Kenya.
https://www.ace-taf.org/wp-content/uploads/2019/10/ACE-TAF-UGANDA-SOLAR-WATER-PUMPING-REPORT-SCREEN-1.pdf

Off-grid technologies, such as standalone systems and mini-grids, have struggled to reach consumers in Uganda. The Government of Uganda expressed interest in promoting productive use of energy as a strategy for energy access. However, it is yet to implement strategies to promote their uptake. The main benefits of solar water pumping are increasing productivity and incomes for farmers, and it is a cheaper alternative to diesel-run pumps. The main challenges are that the system configuration is not standard, there is limited consumer awareness of the products, there is limited technical expertise to support farmers in its use, there is low affordability and limited access to finance, inconsistent aftersales support, and unavailability of data on access to water. The recommendations are to increase coordination with government agencies and other stakeholders, develop a fiscal policy such as tax incentives and subsidies, and provide awareness and training.

Africa Clean Energy. 2021. **Productive Use Potential and Sales of Of-Grid Solar to Women and Youth in Uganda.** Tetra Tech International Development.
https://www.ace-taf.org/kb/productive-use-potential-and-sales-of-off-grid-solar-to-women-and-youth-in-uganda/

The objective of the study was to establish the uptake and identify opportunities for the use of stand along solar (SAS) products for PUE by women, youth and Persons Living with a Disability (PLWD) in Uganda. The study reveals that the level of awareness of off-grid systems (OGS) is high. Awareness of SAS products is higher in urban areas than rural areas. At the micro-level, households are using solar home systems (SHS). PLWD are using solar for lighting but less for business. There is limited awareness of PUE among PLWD. Some agricultural processors have installed solar panels in their coffee production facilities, powering the hulling system. Coffee organizations use OGS solar water pumps for irrigation. OGS is increasingly used for water heating in urban areas in both homes and businesses. Women dominate the service sectors, such as food vending, which consume low energy. Men dominate agriculture, fisheries, and manufacturing which are heavy energy consumers. Electricity use was associated with better outcomes for mainly male business. Female enterprises had lower profits and lower electricity consumption. Low income levels of PLWD, women and youth affect their ability to pay for OGS. There is increased use of OGS in many refugee settlements, including the use of solar for home lighting and PUE like fridges for cold storage and phone charging. One local solar company designed business hubs powered by solar to enable the establishment of women-owned businesses like hair salons and kiosks. Youth-run business in OGS PUE include barber shops, phone charging, small printing and computing shops, discos and cinemas.

Booth, S., Li, X., Baring-Gould, I. 2018. **Productive Use of Energy in African Micro-grids: Technical and Business Considerations.** National Renewable Energy Laboratory and Energy for Impact.
https://www.nrel.gov/docs/fy18osti/71663.pdf

The report is a resource to understand the technical and business model challenges related to PUE in smaller micro-grids, focussing on agricultural processing and small industrial and commercial loads. It examines best practice for promoting PUE and key considerations for productive use. In a value chain analysis case, it is important to look at existing products, services and activities and how value can be derived from the supply of electricity. It is important to analyze the value chain in the four areas of inputs, processing, outputs and end use. A second consideration is enterprise development and training. This includes training on the use of electrical appliances and training on how to run a business with the product. Equipment financing is the third consideration. In remote areas there may not be a financial institution close by. Some micro-grid developers set up their own financing schemes to bridge the gap (e.g., concessionary loans, lease-to own model of equipment). The business case for PUE must consider both the cost of electricity and the monthly repayments. The study provides businesses cases for five different types of PU: ice making, milling, carpentry, egg incubation and water treatment. When designing a micro-grid, the characteristics of loads such as timing, magnitude and seasonality can have a large impact on the financial viability of the overall system. For this reason, the power requirements of a PU business may positively or negatively impact the design, operation, and resulting costs of power.

Brüderle, A., Attigah, B., Bodenbender, M. 2012. **Productive Use of Energy – PRODUSE: A Manual for Electrification Practitioners.** GIZ and Energy for Development (EUEI PDF).
http://www.produse.org/imglib/downloads/manual/euei_productive_use_manual_med.pdf

The manual provides a background on the productive uses of electricity. It provides a step-by-step guide to promoting productive use of electricity in four phases. The first is feasibility and planning to determine if there is a case for productive use promotion, defining the objectives, and mapping stakeholders. The second phase is the analysis and design of the intervention strategy, analysing the local economic structures in the target area, planning productive use by identify key bottlenecks, and assessing the scale on which opportunities are replicable. The third phase of implementation is to raise awareness of productive uses, encourage energy service providers to act as technology facilitators, provide technical assistance to MSMEs, and facilitating access to financing. The fourth phase is monitoring evaluation, assessment the impact and feeding lessons learned into future planning.

Brüderle, A., Diembeck, K., Hartmann, J., Rammelt, M., and Volkmer, H. 2014. **Productive Use of Thermal Energy: An Overview of Technology Options and Approaches for Promotion.** Energy for Development. GIZ
http://www.produse.org/index.php?lang=eng&page=14/

This booklet provides information on the technology options and approaches for productive purposes of efficient thermal energy appliances for micro, small and medium enterprises (MSME). It summarizes the ways that thermal energy can be used in agricultural, industrial and commercial value chains. It provides examples of the main applications of cooking, drying, baking, smoking, cooling, and heating water. It also provides practical guidance on how to promote the distribution of efficient biomass and solar thermal appliances for productive uses for energy and private sector. It summarizes the opportunities and challenges and the key criteria for the adoption of an appliance and energy supply: the key criteria that the reliability, quality, affordability, and adequacy.

Buyinza, J., Okia, C., Medum, R., Acanakwo, E., Kyomuhendo, P, Kabasindi, H., and Njenga, M. 2023. **Response to increased environmental degradation and promotion of alternative energy sources in refugee hosting districts in Uganda. Reducing Environmental Degradation (RED) in refugee context in Uganda.** Brief Series No. 1. CIFOR-ICRAF: Bogo, Indonesia; Nairobi, Kenya.
https://reliefweb.int/report/uganda/response-increased-environmental-degradation-and-promotion-alternative-energy-sources-refugee-hosting-districts-uganda-brief-series-no-1-february-2023

The RED project aims to contribute to increasing environmental protection and forest restoration and to improve sustainable energy and alternative livelihoods for displaced populations and host communities. It is being implemented in refugee settlements in 5 districts (Yumbe, Leju, Madi Okollo, Kiryandongo, Adjumani). The expected outputs of the project are inclusive market systems assess for alternative energy sources, alternative green livelihood opportunities are created, energy-efficient stoves and heat retaining bags are constructed and/or distributed, and alternative sources of energy are accessed.

Centre for Research in Energy and Energy Conservation (CREEC). 2018. **The environmental impact of settling refugees in refugee hosting areas in Uganda.** Uganda.
https://www.mwe.go.ug/sites/default/files/library/Presentation%20-%20OPM_WFP_CREEC_Sept%202018.pdf

The study aimed to assess the impact of settling refugees and their energy use on the environment, to assess the impact of environmental changes on their energy use and well-being and examine potential mitigation measures. It surveyed refugee and host communities (51% female) from 13 settlements. In the 13 settlements, the majority of fuel consumption was firewood, ranging from 57% in Oruchinga to 97% in Palorinya. The rest use charcoal. The majority (62%) reported that the distance walked to collect firewood had increased, with the highest percent reported in Adjumani and Lobule. Due to the scarcity of fuel, 51% report skipping meals. Proposed interventions are 'stove for work', tree growing, alternative fuels, market-led solutions (PAYGo), and promoting energy efficient cookstoves.

Centre for Research in Energy and Energy Conservation (CREEC). 2020. **Final Report: Baseline Assessment for Market-based Energy Access for Scale up Projects in Refugee Settlements in Uganda.** GIZ.
https://reliefweb.int/report/uganda/baseline-assessment-market-based-energy-access-scale-projects-refugee-settlements-uganda

CREEC conducted a baseline survey to assess the energy market supply and demand situation in four refugee settlements and host communities in Uganda. The study was designed to prioritize the settlements and host communities for their appropriateness to implement market-based energy access interventions. The energy market is underpinned by three factors: availability, accessibility and cost. The demand gaps in all four settlements present opportunities to increase coverage of one stop energy kiosks. The adoption of improved cookstoves (ICS) is low due to lack of awareness of benefits. Solar is the only available lighting option in the settlements, but in Palabek it is in limited supply. Nakivale and Kiryandongo are the most willing and appropriate settlements to adopt market-based approaches. In Maaji and Palabek, the incomes of the residents are lower as well as a slower uptake and appreciation of ICS was noted.

De Gouvello, C., and Durix, L. 2008. **Maximizing the Productive Uses of Electricity to Increase the Impact of Rural Electrification Programs.** Energy Sector Management Assistance Program (ESMAP).

Rural electrification programs may have some natural trickle-down effects, but spontaneous positive effects on social and economic development are generally limited. Two deterrents to the productive use of electricity are the lack of technical knowledge and skills of potential users, and the financial means to acquire the equipment. To be successful, a rural electrification program should target the direct impact on livelihoods and revenue generation beyond the provision of connections. A systematic approach to doing so analyzes the technologies used in the production process of goods and services and identifies bottlenecks. The five steps are: identifying the productive activities taking place in a project area; analyze the production processes involved and identifying possible improvements and limitations; review the contribution of electricity to these expected improvements and what equipment is required; analyze the technical and economic feasibility and the social viability of the electrically based solution proposed; targeted promotion campaign to potential users about the potential benefits.

Eder, J., Mutsaerts, C., Sriwannawit, P. 2015. **Mini-grids and renewable energy in rural Africa: How diffusion theory explains adoption of electricity in Uganda.** Energy Research and Social Science,

5:45-54.
http://dx.doi.org/10.1016/j.erss.2014.12.014

The study analyses the factors that influence the adoption of renewable electricity in the household. It is based on a case study of a Swedish energy service company, Pamoja Cleanteach AB, operating a small-scale biomass gasification power plant in rural Uganda. Three critical dimensions are identified as crucial to adoption: technology; economic requirements and the social dimension. The study found that higher income households adopted electricity. There were conflicts in the village as a result of the division between those who could and could not afford electricity. Income was cited as the main reason for not adopting. There was high awareness of the technology's relative advantages and had a positive view that it was sustainable energy. However, the company could not always provide electricity service every day from 5pm till midnight as promised, so it was viewed as unreliable. Other factors affecting adoption were affordability, payment system (how to pay), investment costs, and appropriate tariffs. When entering a new social system with a disruptive innovation, the firm should collaborate with local actors. A lack of understanding of local communities can lead foreign companies to fail.

Efficiency for Access Coalition. 2019. **Use and Benefits of Solar Water Pumps: Kenya, Tanzania and Uganda Consumer Research.**
https://www.clasp.ngo/wp-content/uploads/2021/01/Use-and-Benefits-of-Solar-Water-Pumps.pdf

The report outlines findings from the solar water pump sector in East Africa. Most solar water pump uses have higher incomes relative to the average off-grid consumer. Irrigation related expenses decreased by 91% on average with the use of solar water pumps. However, this excludes the repayment costs for pumps that were financed. Consumers reported increased agricultural productivity. Satisfied customers also reported time savings, decreased intensive physical labour, and cost efficiencies. The most common challenges they faced was equipment malfunction. This could be due to lack of training or misuse.

Efficiency for Access Coalition. 2021. **Off- and Weak-Grid Solar Appliance Market Uganda.**
https://efficiencyforaccess.org/publications/off-and-weak-grid-appliance-market-uganda

Uganda's electrification rate is growing rapidly, but the majority (59%) still do not have access to electricity. There is high potential for off-grid appliances in the country. Many development programmes have supported the deployment of off-grid solutions. Consumer financing is one of the main barriers to growth. Televisions have become the key driver of off-grid solar energy system uptakes and most in-demand appliance for off-grid households. The off-grid refrigerator market is new, with only 2% of the rural population owning a refrigerator. Solar water pumps are the most commercially viable productive use appliances, but the market is nascent.

Energising Development (EnDev) – Uganda. 2018. **Piloting Energy Access in Refugee Settlements and Host Communities to Create Evidence for Market-Based Approaches.** GIZ. Germany.
https://data.unhcr.org/en/documents/details/64605

The factsheet summarizes the pilot activity Energy Access in Refugee Settlements. EnDev Uganda carried out a baseline in Rhino and Imvepi camp, finding that the majority of households (85%) use firewood for cooking and heating, 76% use three-stone fire for cooking, and households use 10-12kg of firewood/day. Based on the findings, the project will carry out awareness raising activities, train local stove artisans, support local vendors of energy products, set up energy kiosks, which will be equipped with high quality cook stoves.

Energising Development (EnDev). 2019. **The State of Sustainable Household Energy Access in Refugee Settings in Uganda. Survey Findings in Rhino Camp Settlement and Imvepi Settlement, Arua District, West Nile Region.** GIZ. Uganda.
https://data.unhcr.org/en/documents/details/69808

The aim of the pilot project "Sustainable Use of Natural Resources and Energy in the Refugee Context in Uganda" was to pilot an integrated approach to natural resource management by creating sustainable solutions to improve access to energy, water, and other ecosystem goods. The objective was to find evidence to which extent market-based approaches can provide access to sustainable energy in refugee settlements and host communities. The findings show that firewood and charcoal are the main sources of fuel in the settlements. On average, two meals a day are prepared by women from inside shelters, which has negative health impacts. Most residents are aware of the benefits of improved cooking technology and would be willing to pay for it. The provision of electricity and lighting devices has been both advantageous and retrogressive. Solar lamps received as handouts increase access to solar products but stifles the free market. There are hardly any businesses that provide improved cooking stoves or good-quality solar products nearby.

Energising Development (Endev). 2021. **Sustainable Energy for Smallholder Farmers (SEFFA) in Ethiopia, Kenya and Uganda Baseline Study and Market Assessment.** GIZ. Germany
https://endev.info/countries/sustainable-energy-for-smallholder-farmers-in-ethiopia-kenya-and-uganda/

This report presents the findings of the Baseline Study and Market Assessment commissioned by the Sustainable Energy for Smallholder Farmers in Ethiopia, Kenya and Uganda (SEFFA) project. The study aimed to inform the design of SEFFA by i) conducting a baseline survey of horticultural and dairy producers to provide a diagnostic of current production systems and energy needs, ii) conducting a market assessment of PUE technology demand and supply in the target countries, iii) developing business cases for each country, iv) establishing key indicators to measure project performance. In Uganda, the main opportunities for PUE technologies among horticulture and dairy farmers are: solar powered water pumps, solar powered cold storage for horticulture (especially for co-operatives), cold storage for dairy (with at least 20 cows), milk processing, solar powered horticulture processing to produce dried fruits, through there are no drying technology suppliers in Uganda. The main constraints of PUE are limited awareness, high capital costs, low access to consumer financing, and pay-as-you-go (PAYGO) companies have struggled with repayment rates.

Energy4Impact. 2017. **Grid Powered Refrigeration for Productive Use.**
https://energy4impact.org/file/1946/download?token=2Li0aJN0

A survey about on-grid refrigeration was carried out to understand the context of how Ugandan micro-enterprise owners use refrigeration as part of their operations to inform the potential use of off-grid refrigeration. There is a clear business case for micro-enterprises to acquire fridges for selling drink, to diversify products sold, and provide additional revenue streams. The main challenges are the high energy cost related to high energy consumption of the fridges, power supply interruptions, and appropriateness of the products to their business needs. Solar refrigerators at their current cost do not make sufficient economic argument for a microbusiness. However, there could be a 3-year payback period for the power supply of a $546 170L fridge. There is a business case for energy efficient refrigerators (AC powered for on-grid enterprises, and off-grid users.

Etcheverry, J. 2003. **Renewable Energy for Productive Uses: Strategies to Enhance Environmental Protection and the Quality of Rural Life.** University of Toronto.
http://www.martinot.info/Etcheverry_UT.pdf

Most renewable energy projects in rural areas of less industrialized nations have concentrated on residential applications. A growing number of projects are being implemented to use renewable energy for productive uses. The study analyses the linkages between energy and productive uses and the potential benefits of sustainable energy options. It illustrates how new initiatives evolving from a traditional focus on satisfying residential needs towards a community development approach. Emerging evidence suggest that carefully designed productive-use projects can contribute to the enhancement of rural sustainability and improvements in rural quality of life.

Geofrey, K. and Tumwine, F.R. 2023. T**he impact of Refugee Settlement on Landscape and Green Environment in Yumbe District West Nile Sub Region, Uganda.** Advances in Social Sciences Research Journal – Vol. 10, No. 4. 139-152.
https://journals.scholarpublishing.org/index.php/ASSRJ/article/view/13682

Little information is available on impacts of refugees and host communities on land use changes. The study used GIS software to determine the current and past spatial areal extent of changes from 2010-2020. Findings showed a rarefied increase in areas under subsistence farming, with losses in grasslands and woodlands. These were primarily attributed to unending activities of deforestation, bush-burning, high refugee population, and land conflicts with host communities. There is a need to promote a shift from the use of non-renewable energy sources like charcoal to renewable sources like biogas and briquettes.

GIZ. 2013. **Bakeries with Efficient Ovens Uganda.**
http://www.produse.org/imglib/downloads/energy_sources/PRODUSE-Factsheet-Uganda.pdf

This fact sheet highlights good practice from the EnDev Uganda project Promotion of Renewable Energy and Energy Efficiency Programme (PREEP). It promotes the productive use of thermal energy for baking. PREEP promoted the use of efficient biomass baking ovens. It has also provided technical training for oven builders to construct and market efficient rocket baking ovens themselves. The firewood rocket baking oven comes in three sizes with a capacity of between 32 and 256 kg of bread in one cycle (between 12-760 loaves of bread), saving a baker time and money. Entrepreneurs need to invest between UGX 4 and 18 million to purchase the improved baking ovens. It considerably reduces firewood consumption and fuel wood costs.

GIZ. 2016. **Photovoltaics for Productive Use Applications: A Catalogue of DC-Appliances.**
https://www.preo.org/photovoltaics-for-productive-use-applications-a-catalogue-of-dc-appliances/

The catalogue provides an overview of various productive use applications and associated aspects. It describes technical issues of the development of DC mini grids. It provides the factsheets for 10 categories of appliances: Livestock breeding; Food Production – Water pumping; Food processing- Milling; Food storage- Cooling; Food for Sale; Tailoring; Workshop Tools; Media and Entertainment; Energy Services; Haircutting and Other Services.

GIZ. 2021. **Electrification of Six Health Centres in Rhino Camp and Imvepi Refugee Settlements. Baseline Assessment Report.** Uganda.
https://energypedia.info/images/6/65/Baseline_Assessment_Report_on_the_Electrification_of_Six_Health_Centres_in_Rhino_Camp_and_Imvepi_Refugee_Settlements_.pdf

The aim of the baseline assessment is to describe the status of health centres, service provision, and electrification prior to the intervention of the ESDS and ENDev projects. It took place in the Rhino Camp and Imvepi Refugee Settlements. All the six facilities studied have a maternity ward and in-patient ward. They have a limited capacity for blood transfusion as a result of unreliable electricity. All health facilities have emergency services, and basic diagnostic testing. None offered liver function tests. Two had imaging equipment. One has an ultrasound machine. Only one facility had a solar fridge for vaccines. All facilities send samples to a regional laboratory with more advanced diagnostic capacity. The facilities do not have electricity to store blood and so do not offer blood transfusion. Recommendations are to ensure adequate sizing of solar systems to fully function for health service delivery and develop a sustainability plan for each facility.

GIZ 2022. **An intermediate Outcome Study After the Electrification of Six Health Centers.** Uganda.
https://energypedia.info/wiki/File:An_Intermediate_Outcome_Study_After_the_Electrification_of_Six_Health_Centers.pdf

The intermediate outcome report is based on a field study of six electrified health centres in Imvepi and Rhino Camp Refugee Settlements. Its purpose was to provide information on the status of the health centres ten months after the solarisation of the centres. Findings show that the catchment population increased for 4/6 health centres. The number of patient visits reduced progressively. The number of services provided increased in all centres. Additional services include, for example, a pediatric ward, CD4 cell count lab services, urine microscopy, onsite ambulance, and serology testing. Operation and maintenance of the solar PV systems were low, and only one centre had a professional technician who could operate fault in the system.

GIZ. 2021. **The Uganda Energy Kiosk Model in Refugee Settings.**
https://energypedia.info/images/6/69/Factsheet_Energy_Kiosk_Model_in_Uganda_ESDS.pdf

This is a case study of the construction of two energy kiosks with solar-powered electricity in the Rhino Camp Refugee Settlement from the project Energy Solutions for Displacement Settings (ESDS). Before the kiosks, it was hard to find a place to buy energy products or buy a phone. Members of the refugee and host community are now making use of the services offered, such as phone charging, secretarial services, sale of cold drinks, purchase of energy efficient cookstoves and solar lights. The kiosks were achieved with support from private sector financing through results-based financing. There is a need to carry out awareness raising campaigns in local languages to promote the use of energy products.

GIZ. 2022. **Creating Energy Solutions in Rhino Camp.**
https://energypedia.info/images/9/9f/Creating_Energy_Solutions_RhinoCamp.pdf

The case study summarizes good practices from the project Design Lab financed by the German Federal Ministry for Economic Cooperation and Development (BMZ) and implemented in the Rhino Camp Refugee Settlement. In partnership with MIT D-Lab, Kulika Uganda and the Youth Social Advocacy Team, and GIZ's Energy Solutions for Displacement Settings (ESDS), an innovation center was established in the camp. The participants of the Creative Capacity Building (CCB) trainings learn about design process and building prototypes of technologies to address a specific problem. They learned specifically about clean energy technologies. Through the process, the participants built machines to help solve a problem, such as a laundry machine with a hand-crank mechanism, a portable light with a rechargeable cell phone battery, and a table-top juice blender with a string-drive technology to spin the blender.

Habersbrunner, K., Mirembe, A., Ruhlemann, A. 2018. **Affordable, Empowering and Sustainable Decentralised Renewable Energy Solutions: Potential of energy communities in Uganda.** New Energy for Uganda. Kampala.
https://www.wecf.org/de/wp-content/uploads/2018/10/Report_Ecommunities_Uganda_2018.pdf

Small scale renewable energy community projects will boost rural development and provide multiple benefits. If local people are close to the energy grid, the financial conditions may not enable them to access the energy. Thus, energy projects also need to follow bottom-up approaches. Cross-sectional samples in terms of renewable energy sources (solar, wind, biomass, hydro), user needs (electricity, food preparation, lighting, PUE) can be organized in community management models considering local context. The main challenges are the high initial investment, lacking quality assurance, and lacking awareness of potential business models and technologies. A roundtable discussion in Uganda concluded that 'energy' should be part of the solution, rather than the solution itself. There are several projects in Uganda for community energy fun by GIZ, KfW, SNV, ARUWE, FINCA, Solar Sisters, Climate Justice for Women and Children, and the Ugandan Solar Energy Associations. They range from mini-grids, household biogas, selling clean energy technologies, and solar home systems.

Havinga, M., and Tuele, R. 2021. **Productive Use of Energy: Moving to scalable business cases.** Energising Development (EnDev). Germany
https://endev.info/wp-content/uploads/2021/03/EnDev_Learning_Innovation_PUE.pdf

The report provides background on productive use of energy (PUE), technologies and initiatives. Multiple factors support the use of energy for productive uses, such as increased energy access, payment models like Pay-As-You-Go (PAYGO), technological innovation, and lower costs for solar technologies. The report maps PUE initiatives by categories (Target group, Value Chain Approach, PUE approach, Focus on supply side and technology). Key challenges identified in the analysis of initiatives are the lack of availability of appropriate products and business cases, and lack of an enabling market environment to facilitate the scaling of PUE. Key success factors are a detailed analysis of demand, an integrated market development approach, continued support to businesses adopting PUE and detailed monitoring using tailored PUE indicators. The analysis shows that PUE promotion requires a more holistic or 'ecosystem' approach to PUE promotion, addressing the key barriers and integrating the key success factors.

International Bank for Reconstruction and Development. 2019. **Rapid Assessment of Natural Resource Degradation in Refugee Impacted Areas in Northern Uganda.**

The report summarizes the findings and recommendations of the assessment of natural resource degradation around refugee settlements in northern Uganda. The main findings are: the refugee influx led to an increase in the rate of degradation and tree loss; land cover change analysis shows an increase in tree cover loss in and around refugee settlements; refugee and host households are highly dependent on forest and other woodlands; total cooking fuel demand in the 14 settlements is about 345,000 metric tons of wood per year; refugee woodfuel consumption at Bidibidi settlements has significantly reduced; refugees and host communities have a tradition of building improved mud-stoves from locally available materials; households need additional wood to build and maintain living structures; there are few organizations working on environment and energy-related activities in refugee-affected areas. It is recommended to develop agroforestry systems on household plots and farmland, establish woodlots for energy and other purposes, rehabilitate degraded forests, enhance energy efficiency of cooking practices.

International Finance Corporation. 2019. **The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa.**

Productive use leveraging solar energy (PULSE) represents the next frontier of off-grid solar (OGS). The use cases are diverse and encompass activities that can be mechanized across agriculture, industry, and commerce. PULSE appliances are increasingly available in African markets. The products are generally small-scale applications of 1 kW of below. The most common appliances are solar-powered water pumps and refrigerators. The PULSE sector faces traditional constraints, that individual farmers do not have the resources to expand their operations or reach a scale to benefit from mechanization. Affordability constrains uptake of all appliances. Growing the sector requires policy action, market development and coordination between energy and agriculture sectors.

International Finance Corporation (IFC). 2022. **Energy Access Baseline Study in Uganda's Refugee-Hosting Areas.** Washington, DC. November 2022.

Energy access is a challenge for refugee and host communities. The main source of lighting in households is solar energy and torches. The solar products used are pico-PV products and solar home systems (SHS). Both refugee and host communities rely on firewood (85%) and charcoal (14%) for cooking. Many of the refugee households using charcoal do so because the host communities restrict access to the forest. Most host community and half of refugee households use a three-stone fire, followed by mud stoves. More than half of businesses do not use any energy. Those that did use high capacity SHS. To increase private sector engagement, promote the use of energy-efficient stoves and alternative fuels, help local enterprises in trading solar products, incentivize suppliers of solar products to offer credit, and strengthen the supply chain.

Kapadia, Kamal. 2004. **Productive uses of renewable energy: A Review of Four Bank-GEF Projects.**
http://www.martinot.info/Kapadia_WB.pdf

The paper analyses the World Bank's approaches to promoting productive uses of renewables, with a view to providing recommendations. It provides a background on what is the productive use of energy (PUE) and the rational to promote it – to maximize the economic and social benefits that access to energy can catalyze, and to improve the economic sustainability of rural electrification projects and renewable energy markets. It analyzed the approaches of four projects, including the Uganda Energy for Rural Transformation (UERT) project. The project focusses on productive uses and aims to address issues of scale-up of rural energy services by focussing on developing appropriate policy, institutional, and regulatory capacity. All projects demonstrate that multi-sectoral projects are essential for promoting productive uses of renewables. There can be problems with the selection of technology, such as path-dependency which may lead to sub-optimal technology choices and lead to negative impacts on productivity and welfare.

Mayer-Tasch, L., Mukherjee, M., and Reiche, K. 2013. **Productive Use of Energy – PRODUSE: Measuring Impacts of Electrification on Small and Micro-Enterprises in Sub-Saharan Africa.** GIZ. Germany.
https://www.esmap.org/sites/default/files/resources-document/esmap_giz_bmz_aei_produse_study_fulltext_optimized_0-1_0.pdf

The study aims to gain insight on the interaction between electrification and productive use of energy by examining the impact on micro-enterprises, based on field surveys in Benin, Ghana, and Uganda. Stark differences between industries show up. While service firms tend to get connected to the grid, uptake in the manufacturing sector was low in rural areas. Connected firms in both sectors used electricity mostly for lighting and phone charging. Some rural manufacturing firms used electric appliances. In the three studies, electricity usage hardly translated into higher firm profits in a measurable way. The financial burden from the investment in the connection and subsequent electricity bills can even reduce profitability. There was, however, evidence that electrification can lead to the creation of new business and in a few cases can attract larger firms to the area, contributing to economic development. One conclusion is that project managers should be realistic in their expectations with regard to the measurable economic impact of electrification projects.

Ministry of Energy and Mineral Development (MEMD). 2015. **Biomass Energy Strategy (BEST) Uganda. Uganda.**
https://www.undp.org/uganda/publications/biomass-energy-strategy-best-uganda-0#:~:text=Biomass%20is%20used%20in%20all,Strategy%20for%20Uganda%20(BEST).

The biomass energy sector is flawed, having and inadequate scanty data. There is a dependency on the use of tree biomass, estimated at 44 million tonnes per annum, which could rise if no interventions are put in place. There are options to increase efficiency through improved charcoal and improved stoves, using other type of biomass, or using modern forms of clean energy. The strategic objectives of the BEST are to create a Biomass Information System, enhance institutional capacity to regulate the use of biomass resources, increase fuel efficiency and clean cooking environments, promote efficient technologies, increase the biomass supply, and improve financing mechanisms for efficient technologies and renewable energy.

Ministry of Energy and Mineral Development (MEMD). 2020. **Sustainable Energy Response Plan for Refugees and Host Communities (SERP) Inception Report**

The inception report outlines the process to develop the SERP. It summarizes the main energy sector context in refugee hosting districts. There are insufficient levels of access to energy for the needs of households, PUE, and social institutions; primary reliance on biomass for cooking on inefficient stoves and low access to alternatives; protection risks for women and children while collecting firewood, and limited access to on- and off-grid solutions. To develop the SERP, a participatory, inclusive and evidence-based approach will be taken. Promoting the use of innovative financing will be an important component, as well as institutional strengthening.

Ministry of Energy and Mineral Development (MEMD). 2022. **Sustainable Energy Response Plan for**

Refugees and Host Communities (SERP) 2022-2025. Uganda.
https://energypedia.info/wiki/File:The_Sustainable_Energy_Response_Plan_for_Refugess_and_Host_Communities_2022-2025.pdf

Uganda hosts over 1,582,892 refugees. The SERP aims to support the implementation of emergency response and longer-term interventions for effective transition and integration of humanitarian-based services into Uganda's national service delivery system. The SERP vision is for refugee and host communities to attain universal access to affordable, reliable and clean energy for socio-economic transformation in an environmentally sustainable manner. The SERP is a three-year plan and the main results to achieve are: increased access to energy for household and productive uses; decreased reliance on biomass for cooking; enhanced awareness and increased adoption of clean energy solutions; and reduced impact on the environment.

Ministry of Energy and Mineral Development (MEMD). 2023. **National Road Map on Scaling up Productive Use of Solar Energy.** Uganda.
https://www.gogla.org/wp-content/uploads/2023/07/Gogla_PURE-Roadmap-Report-Uganda.pdf
The National Road Map on Scaling Up Productive use of Solar Energy (NR-PUSE) provides an analysis and strategic direction to leverage solar energy for productive uses. The NR-PUSE's vision is "to have a vibrant and competitive productive use of the renewable energy ecosystem for food security and economic empowerment." Barriers to promoting PUSE are limited access to financing, lack of affordability, limited technical and human capacity, presence of low-quality products on the market. The strategy proposes actions to improve the enabling environment, increase awareness about PUSE, enhance financing opportunities, and support research and development.

Ministry of Water and Environment. 2019. **Water and Environment Sector Response Plan for Refugees and Host Communities in Uganda (WESRP).** The Republic of Uganda.
https://www.mwe.go.ug/sites/default/files/library/Final%20Water%20and%20Environment%20Sector%20%20Refugee%20Response%20Plan.pdf

The WESRP provides a comprehensive planning for both refugees and host communities within the context of the Water and Environment Sector Development Plan. Uganda's population is heavily reliant on natural resources to meet basic needs and is seeing forest cover quickly diminish. Some of the expected outputs of the plan are to raise 18 million seedlings, and to provide alternative and renewable energy for cooking and/or fuel wood from licensed providers. It aims to shift Water Resource Management to a deconcentrated system where planning and management is done at the lowest level. Refugee settlements have low sanitation coverage. Hard ground conditions, and limitations on construction materials mean latrines are poor and serve for a shorter duration. Challenges in implementation are inadequate coordination between refugee hosting district and sub counties, low community involvement and little behaviour change, and inadequate planning for emergency, humanitarian, integration and repatriation phases.

Moncada, A., Ruiz, L., Meyer, M., Surya, R., Wanyahoro, W. 2022. **Assessment of Market-Driven Solutions: Energy Access in Refugee Settlements in Sub-Saharan Africa.** Smart Communities Coalition. Smart Communities Coalition.
https://www.mastercard.us/content/dam/public/mastercardcom/na/global-site/public-sector/other/scc-whitepaper.pdf

The report summarizes findings from 13 projects that target increasing energy access in refugee camps and settlements in sub-Saharan Africa. In Uganda, the project De-Risking PAYGO Solar Home Systems in Refugee Settlements encouraged private PAGO SHS companies to consider refugee communities as a viable market. Three companies were granted awards to stimulate market activities in refugee settlements. This included subsidizing sales office. The three grantees are continuing sales and are seeing acceptable repayment rates. The lack of mobile money penetration impedes repayment. The AMPERE project used market-based interventions to enhance long-term investments in BidiBidi. Funding was used to provide a 60% subsidy for clients buying power from two partner solar energy provides. It showed how more

flexible financing options to accommodate inconsistent income streams can strengthen market systems. It concludes that Direct Supplier Financing to set up operations can stimulate market development and works well for productive uses as the revenue streams can support ongoing operations after. Projects should start with comprehensive market surveys. Demand-side interventions generally carry more long-term risk as they do not fundamentally alter the economic landscape or income of refugees.

NEFCO. 2023. **Scaling Productive Use of Energy Solutions in Sub-Saharan Africa: Market Scoping and Design of a Results-Based Financing Window for the PUE Sector.** Tetra Tech. https://beyondthegrid.africa/wp-content/uploads/Nefco-PUE-Market-Assessment-March-2023.pdf

Beyond the Grid Fund for Africa (BGFA) provides results-based financing (RBF) for companies selling solar home systems and developing mini0grids, including those that incorporate PUE appliances and applications. The report summarizes applications that generate income and create employment for socioeconomic developing. Numerous PUE initiatives have had successes, but they are relatively small and not at scale. Challenges to deploying PUE are significant, including th high cost of equipment, affordability, risks in providing financing to entrepreneurs, fewer potential sales in rural areas, complications in the supply chain and after-sale servicing, the need for customization, competition with incumbent technologies, and consumer awareness. The PUE that are starting to scale are solar water pumping; refrigeration and cold storage, agricultural processing and e-mobility are starting to show promise. Initiatives should be co-designed with government, donors, and private sector and maximize flexibility.

Open Capital Advisors. 2017. **Promoting Productive Uses of Energy in Uganda.** https://shellfoundation.org/app/uploads/2018/10/SF-OCA-Uganda-Accelerator-_-Productive-Use-Technology.pdf

There is opportunity to accelerate energy access by reducing market barriers. One of the core accelerator initiatives is enhancing business case for productive use technologies. The agricultural sector in Uganda provides the highest potential for impact. DC appliances are more energy efficient and are compatible with many solar home systems, mini-grids and other off-grid technologies. Technologies should be adapted to power generation, production quantities and local technical capacity to install, maintain, and repair. Solar irrigation has high potential in the North with appliances locally available. Ice production has potential in fishing communities near Lakes Kyoga, Victoria and Albert but requires high capital investment. Cold chain for dairy would reduce milk losses. Grain milling is an opportunity to benefit farmers throughout Uganda, which can triple the crops value by weight, but there is limited option to purchase energy efficient mills in the country. Oil seed processing presents an opportunity to meet growing demand but is not widely available locally. PUE projects are difficult to implement due to lack of funding, reliable machinery, awareness, and good data.

Power For All. 2020. **Power For All Fact Sheet: Leveraging decentralized renewables for Uganda's agricultural sectors.**
https://www.powerforall.org/application/files/5016/0275/8163/FS_DRE_and_Ag_in_Uganda-1-1.pdf

The fact sheet highlights how decentralized renewable energy (DRE) has the potential to bridge the energy access gap in the agricultural sector. DRE technologies have had successful use cases in various agricultural value chains in Uganda, such as solar irrigation and milk chilling. Solar irrigation has a large potential, as it has low operating costs and can achieve payback in 2 years when replacing diesel. Milk coolers and refrigerators have a 2-year payback period from the reduced spoilage, and a positive 5-year return on investment.

Rural Electrification Agency (REA). 2013. **The Government of the Republic of Uganda Rural Electrification Strategy and Plan (2013-2022).** Ministry of Energy and Mineral Development. https://s3-eu-west-1.amazonaws.com/s3.sourceafrica.net/documents/119217/Strategy-and-Plan-2013-2022.pdf

This document presents the Government's Rural Electrification Strategy and Plan (RESP) for the ten-year period 2013-2022. This RESP is aligned to the Government vision of universal electricity access by 2040. the primary objective of the RESP 2013-2022 is: "To achieve an accelerated pace of electricity access and service penetration to meet national development goals during the planning period and beyond". A secondary objective is to ensure that, progressively, the program facilitates access to all forms of modern energy services to replace kerosene lighting and other forms of traditional cooking and heating by 2030. During this 10-year period, the Government aims to achieve a rural electrification access of 26%. It will be implemented on a model of scaled, multi-technology electricity service territories. Off-grid electrification services shall be offered in tandem with on-grid electrification services.

Shirley, R., Liu, Y., Kakande, J., Kagarura, M. 2021. **Identifying high-priority areas for electricity services in Uganda through geospatial mapping.** Journal of Agriculture and Food Researh 5: 100172
https://www.sciencedirect.com/science/article/pii/S2666154321000740

The study explores the opportunities to improve electricity mapping with electricity access. Using maize and coffee farming as a case study, the study compares data on electrification infrastructure and crop statistics. The study finds significant areas of underserved staple and cash crop farmland that can be served through grid and mini-grid electricity to improve productivity. Some key maize growing areas in the Northern region are unlikely to be reached by extended grid infrastructure. There are many coffee producing areas without grid access, limiting local processing activities like pulping or grinding.

Solar Sack. 2021. **Impact Evaluation Report for the Project: "Emergency Response to Deforestation Crisis of the Kyangwali Refugee Settlement."** CIDI, Caritas Denmark and SolarSack.
https://reliefweb.int/report/uganda/impact-evaluation-report-project-emergency-response-deforestation-crisis-kyangwali-refugee-settlement

The report presents findings from the impact evaluation of the project which aimed to distribute 25,000 SolarSacks to reduce the prevalence of waterborne diseases and reduce deforestation. Household surveys found a 98% adoption rate. The percent of respondents reporting diarrheal diseases reduced from 32% to 9%. Beneficiaries are practicing good hygiene reducing the risk or recontamination. Charcoal consumption has gone down, whereas firewood consumption has gone up. However, most say they use less wood fuel to boil water.

Stewart, J, and Trace S. 2021. **Market Scoping for a Job Creation Agenda for the Beyond the Grid Fund for Africa (BGFA) Window in Uganda: Final Report.** Oxford Policy Management. United Kingdom.
https://beyondthegrid.africa/wp-content/uploads/Market-scoping-for-a-job-creation-agenda-for-the-Beyond-the-Grid-Fund-for-Africa_Oxford-Policy-Management_Final-report_2021.pdf

The report assesses the potential for off-grid jobs in Uganda to 2030 ad assesses the off-grid skills development sector. It projects that the direct jobs needed in the off-grid sector are 5,500-9,200 in Stand-alone/SHS; 3,000-5,400 in mini-grid operation and maintenance; and 600-2,000 in mini-grid construction. There is opportunity for growth of off-grid with a huge unserved market, particularly in electric-cooking and productive use. There are challenges in the low standard of SHS is damaging public perception, limited access to capital holds back off-grid companies, low willingness to pay, and companies struggle to achieve scale and profitability.

Sustainable Energy Fund for Africa (SEFA). 2016. **Project Summary Note SEFA Project Preparation. Uganda Earth Energy Syngas Biomass.**
https://www.afdb.org/en/documents/uganda-uganda-earth-energy-syngas-biomass-sefa-project-summary-note

This summary note provides a description of the development and operation of a 20 MW baseload Biomass Gasification plant at the outskirts of Gulu Town. The technology will generate electricity via gas engine and

added production of biochar to be sold as cooking and boiler fuel.

Tegendhat, E. 2017. **Transforming the Uganda Maize System. Positive Impact Case Study.** Palladium
https://thepalladiumgroup.com/news/Transforming-the-Uganda-maize-system

This case study looks at a proof of concept for modernising the traditional small farmer system and bringing it into the supply chain of a sophisticated company, Nile Breweries Ltd (NBL). There was a large gap between the requirements of NBL and the traditional maize system. Improvements were made in the supply chain infrastructure, technology and financing to improve productivity and efficiency. Village Aggregation Centres were constructed, operated by farmer associations. The VACs have the equipment and facilities for proper shelling, temporary storage and protection from pests. Mechanized maize shellers were provided to young operators. The equipment reduces the amount of broken maize and can shell 30 bags an hour compared to two bags an hour using traditional methods. The project improved productivity, increased household incomes, and women and youth.

Tumwesigye, A., 2021. **A report on end-user finance and payment systems to improve access to reliable, sustainable, and modern energy products in displacement settings (Uganda).** GIZ. Uganda.
https://energypedia.info/images/e/e0/ESDS_End_User_Finance_Report_Uganda.pdf

The lack of sufficient quality energy products and services for cooking and lighting, communication and productive use grossly limits opportunities to meet basic needs and strive for self-reliance. The report examines how End-User Finance (EUF), and Payment Systems improve access to energy solutions. The predominant EUF options are PAYGo, Village Savings and Lending Associations (VSLA) and Financial Service Providers (FSP). There are many factors that enable and hinder their usage. PAYG via mobile money is an ideal option but is limited by unreliable connectivity and low literacy. FSPs can provide subsidized loans, but limited reach, unclear policy, and lack of physical collateral are barriers. VSLAs are locally owned and managed and are the most ideal savings and borrowing mechanisms, but they have short repayment periods and disbursement amounts that are too low to acquire PUE. Options are to link VSLAs to FSPs to acquire more costly PUE or borrow from VSLA to cover an initial deposit and pay the rest through PAYGo.

Uganda Off-Grid Energy Markey Accelerator (UOMA). 2018. **Mapping the Ugandan off-grid energy market.** UKAID, Power Africa, USAID, Shell Foundation, Open Capital Advisors.
https://shellfoundation.org/app/uploads/2018/10/2018-UOMA-Market-Map.pdf

The market map seeks to provide a holistic and objective description of the off-grid industry in Uganda. It provides an industry overview, industry insights, and barriers to scale. Off-grid ecosystem is divided by Pico lamps, solar home systems, & mini-grids. Distribution of solar home systems is driven by the private sector offering credit, with the majority from PAYG operators. Mini-grids in Uganda are mainly driven by public sector but managed by private sector or communities. Government-led projects enable clearer planning to ensure economies of scale, de-risks projects, and makes utility cheaper for end-users through subsidies. There is a strong market potential for productive use solar products like water heaters, refrigerators, hair clippers, sewing machines, water pumps, and oil seed press. In order to reach unserved populations, it is critical to address the themes of affordability, distribution and awareness.

Uganda Off-Grid Energy Markey Accelerator (UOMA). 2020. **Productive Use of Energy in Uganda. Learnings from the Uganda Off-grid Energy Market Accelerator.** UOMA, USAID, PowerAfrica.
https://uoma.ug/wp-content/uploads/2020/10/UOMA-PUE-white-paper.pdf

Off-grid solar energy has become a major success story, accelerating energy for millions of Ugandans. Over the last decade, off-grid solar products have become commonplace in Uganda, with over 4 million products currently in the market. Productive use of energy (PUE) technology, powered by standalone solar systems, is emerging as a new market in the off-grid solar sector and a major opportunity to drive energy demand and increase income levels. The study found that there are several key challenges that cut across all technologies. End users, particularly smallholder farmers of staple crops, have low affordability and willingness to pay; companies are still tailoring products for consumer demand, and other products require heavy customization that prevents scalability, there is limited access to finance for PUE companies, limited consumer awareness means that consumers don't yet fully appreciate the potential benefits of PUE technology, and market spoilage due to low quality products has discouraged consumers from purchasing quality systems. Recommendations to accelerate PUE in Uganda are: private companies can accelerate PUE by continuing to develop scalable business models and relevant technologies, donors and investors can promote PUE by providing the right forms of finance to scale early-stage business models, development parts can develop the right enabling environment so that PUE companies can flourish.

Utz, V. 2011. **Modern Energy Services for Modern Agriculture: A review of smallholder farming in developing countries.** GIZ
https://energypedia.info/images/f/fd/Energy_Services_for_Modern_Agriculture.pdf

Modernising agricultural production systems can increase productivity and energy plays a key role in this. Energy for transport (fossil fuels of biofuels) is needed for many services in the supply chain. Energy for production, processing and commercialisation can be provided in different forms – from the grid, renewable decentralized power, and hybrid systems. It can be used to provide irrigation (pumps), post-harvest treatment (cooling), or processing (drying, milling, pressing). The requirements of mechanical energy are also of critical importance, and this can include human and animal labour as well as fuels for mechanisation, pumping, and the production of fertilisers and agrochemicals.

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