PREO Powering Renewable Energy Opportunities

Made in Africa: Impact of local manufacturing on profits, people and products

Insights from the off-grid energy sector in sub-Saharan Africa

IKEA Foundation
UKaid Transforming Energy Access
CARBON TRUST
ENERGY 4 IMPACT POWERED BY MERCY CORPS

Findings from the Powering Renewable Energy Opportunities (PREO) Value Addition and Employment Creation (VA&EC) challenge

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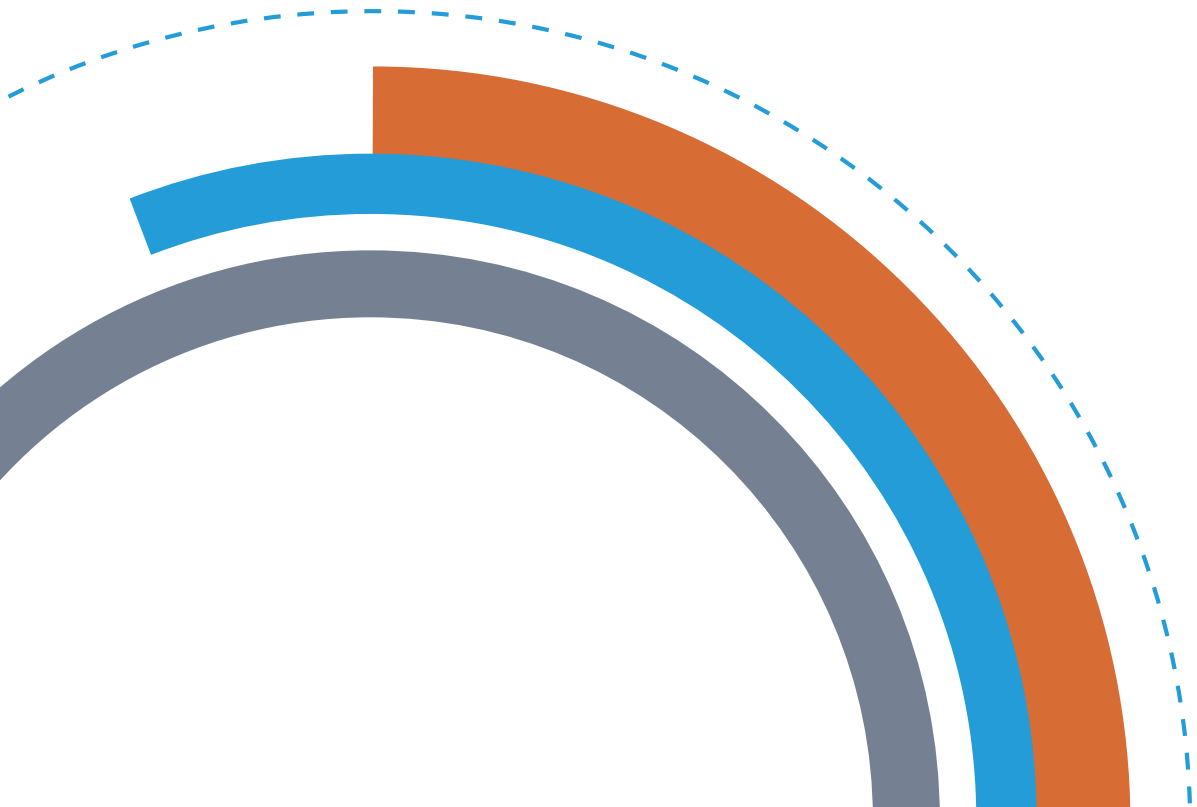


Abbreviations

ACE TAF	The Africa Clean Energy Technical Assistance Facility
FCDO	UK Foreign, Commonwealth and Development Office
IoT	Internet of Things
MCT	multi-crop thresher
OGE	off-grid energy
PAYG	pay as you go
PCB	printed circuit board
PCBA	printed circuit board assembly
PREO	Powering Renewable Energy Opportunities programme (UK aid- and IKEA Foundation-funded R&D programme; part of TEA)
PUE	productive use of energy
R&D	research and development
SHS	solar home system
SMT	surface-mount technology
TEA	Transforming Energy Access (UK aid-funded R&D platform)
VA&EC	Value Addition and Employment Creation challenge
VAT	value added tax

Students participating in a LAGAZEL solar home system workshop

1. Executive Summary

Through efforts to facilitate and drive energy access, there is opportunity to increase and capture the local "share of value" in the off-grid energy sector. As the sector is rapidly growing, existing policies and incentives around domestic manufacturing and supply can cultivate further growth. Increased local activity in this value chain is expected to improve the trade balance concerning these technologies and may reduce inclinations to apply heavy import duties that limit the sustainability of off-grid business models.

Over the course of two years the PREO programme ran a Value Addition and Employment Creation (VA&EC) challenge delivered with funding from UK aid's Transforming Energy Access (TEA) platform. The challenge supported five sub-Saharan African companies in assessing the viability of import substitution in the upstream segments of the off-grid energy value chain in their respective sectors. This included local research and development (R&D), testing, manufacturing and assembly of products. The five companies set out to explore what benefits could be realised from increasing their local manufacturing capacity and thereby demonstrate that this can lead to added value across the upstream value chain and create local sustainable jobs.

Table 1 PREO VA&EC challenge companies

Company	burn™ life · saving · stoves	IMARA TECH	INNOVEX Creating Technologies for Africa	LAGAZEL Lighting Everywhere	POWER
Sector	Clean cooking	Agricultural equipment	Smart grid and meters	Solar products	Smart grid and meters
Location	Kenya	Tanzania	Uganda	Benin and Burkina Faso	Lesotho

The five VA&EC-funded projects successfully demonstrated that greater local value addition in their respective areas of operation captured greater content by establishing or extending new upstream off-grid energy activities, and created new sustainable jobs. We have accompanied all five companies on this journey and, based on the data gathered during this time and interviews with the project leads and company heads, we have concluded five key insights that demonstrate the success of these undertakings:

- Products manufactured and assembled locally in Africa can be of higher quality than imported products, resulting in rejection rates falling by up to 70%
- Local manufacturing and assembly can increase profitability by 10% to 40% by avoiding import duties, retaining supplier margins and reducing shipping costs
- Locally manufactured products have much shorter lead times than imported products, opening up new revenue opportunities from "quick to market" contract manufacturers and product developers requiring shorter feedback loops to iterate product development
- Local manufacturing creates high-value technical jobs in the local labour force in R&D, manufacturing and management functions, while there are collaborative development opportunities with local universities
- The majority of the basic components for local manufacture and assembly of off-grid energy products still come from China, with all the commensurate risk that this involves, e.g. long lead times and supply bottlenecks, exposure to changes in import duties, and local taxes

2. Background and Context

Due to its large access deficit, there is a substantial international focus on delivering energy access in sub-Saharan Africa, with large volumes of international support and funding. The deployment of energy solutions is essential to conducting value-creating processes, including R&D, manufacturing, assembly, logistics, sales, marketing, installation, servicing, customer services and recycling/disposal. Amongst these, the processes that do not intrinsically require proximity to customers are conducted outside of sub-Saharan Africa.

In most cases the principal motivation for governments' investment in the off-grid energy sector is the access to energy that can unlock development of their economies. However, the lack of upstream value chain capacities such as design, development, manufacturing, assembly and quality control, as well as inaction on the downstream value chain related to market development such as distribution and after-sales services, results in missed opportunities to capitalise on the potential for economic and social benefits that could be captured across sub-Saharan African countries in scaling access to energy.

There is the possibility, therefore, to grow the local "share of value" in the off-grid energy sector, just as the off-grid energy sector itself is growing, and bolster existing incentives for governments to facilitate and drive energy access, building upon current policies around domestic manufacture and supply. Collectively this would also decrease the incentive for African governments to enforce heavy import duties on electricity equipment to recoup value from the off-grid energy sector, further improving the economics and therefore accelerating the scale-up of local off-grid energy industries. Greater political and policy support and certainty would induce increased investment in the off-grid energy sector.

Increased local activity in this value chain is expected to improve the trade balance concerning these technologies and may reduce inclinations to apply heavy import duties that limit the sustainability of off-grid business models. For example, when Kenya introduced 16% VAT and import duties of up to 25% for stand-alone solar products in 2020, ACE TAF estimated the impact of this could result in 650,000 fewer households having access to such products by 2025. Furthermore, even though the government stands to lose USD 19.6 million per year if the exemptions are continued, it was estimated that the government would gain USD 46 million in taxes per year from 250,000 households starting new businesses using SAS products[1].

Local industrialisation is a key socio-economic development priority in sub-Saharan Africa. Although earlier efforts at manufacturing renewable energy equipment in Africa have been mixed, it still is a sector worthy of attention due to the very local nature of the sector. Whilst much attention has been paid to developing other parts of the off-grid energy value chain in Africa with varied results, the manufacturing, assembly, service and recycling of equipment have been particularly overlooked. These are high-potential areas for greater value and employment creation across sub-Saharan Africa.

Access to energy, local revenue and employment are all highly politicised topics, and are strong drivers of government investment should the local benefits be clearly demonstrated. In addition to greater tax revenues, which could be channelled back into the energy sector, greater local ownership and employment in the off-grid sector would increase capacity building of local staff. This would limit the brain drain of highly qualified citizens through more, better-paid jobs, and indirectly stimulate the creation of further industries and services. Increased employment, especially in rural areas, would further benefit the economic and social standing of communities.

[1] Impact of VAT and Import Duty on the Stand-Alone Solar Sector in Kenya. A policy position paper presented by: The Kenya Renewable Energy Association (KEREA) and GOGLA

3. Purpose of this Report

The Transforming Energy Access Platform (TEA) funded by UK aid from the FCDO, is a research and innovation platform supporting the technologies, business models and skills needed to enable an inclusive clean energy transition. Specifically, TEA seeks to contribute to the de-risking of new business model innovation in sub-Saharan Africa, South Asia and the Indo-Pacific region. The PREO VA&EC challenge, which sits within the TEA platform, supported five companies that tested the viability of local upstream (R&D, testing, manufacturing, assembly) segments of the off-grid energy value chain spanning a wide variety of sectors and geographies. The overarching aim of this report is to supply insights from these projects.

Innovative business models are enabling off-grid energy equipment to be profitably manufactured, serviced and recycled in Africa, rather than relying on international companies, especially in China. The VA&EC challenge identified five high-value opportunities and supported them to: demonstrate greater local value addition in their existing local operations; capture greater local content by establishing or extending new upstream off-grid energy activities; and create new sustainable jobs.

This report presents the outcome from each project as a case study and summarises some of the shared challenges, opportunities and insights gained from across the portfolio.

Table 2 VA&EC portfolio

Project lead	Sector	Location
BURN Manufacturing	Clean cooking	Kenya
Imara Technology	Agricultural equipment	Tanzania
Innovex	Smart grid and meters	Uganda
LAGAZEL	Solar products	Benin and Burkina Faso
OnePower	Smart grid and meters	Lesotho

4. Key Insights

In the baseline scenario, most VA&EC portfolio companies viewed design capacity as integral to their business models and possessed preliminary design capacity locally, often within the founding team. However, all the companies lacked manufacturing capacity and were relying on suppliers in China, India or other Southeast Asian countries. Some of the key hurdles faced by these companies in pushing forward with local manufacturing were the high capital expenditure involved, the need to create a skilled workforce and an uncertainty of the degree of quality and savings that could be achieved.

With support from PREO, the VA&EC companies created domestic manufacturing infrastructure in six countries in sub-Saharan Africa spanning diverse end-use products with capacities listed below:

- 60,000 remote monitoring and control units for e-motorcycles, cold storage units, solar pumps and rooftop solar installations in Uganda by Innovex
- 90,000 solar lamps and 5,000+ solar home systems in Benin and Burkina Faso by LAGAZEL
- 25,000 clean cookstoves in-built with a fan powered by a solar panel to achieve forced draft cooking in Kenya by BURN Manufacturing
- 200 PV trackers, 2,500 smart meters and 1.5MW capacity equivalent powerhouses by OnePower in Lesotho
- 800 units per year of agricultural processing equipment such as peanut shellers, oil presses and flour mills in Tanzania by Imara Technology

On close analysis of the outcomes achieved, four key patterns emerged:

1. Domestic manufacturing in Africa can achieve high quality

All the VA&EC projects were able to achieve manufacturing quality[2] that was evaluated to be better than that of imported units in the baseline scenario (at the start of the PREO support). Where comparable data sets existed, rejection rates dropped from 30% in the baseline scenario to less than 10% through local manufacturing by the end of VA&EC projects. Rejection rate was measured as the number of units rejected during the quality control process as a percentage of the total units sampled. Some VA&EC portfolio companies also used the warranty claim rate[3] as a proxy for product failure because of manufacturing defects.

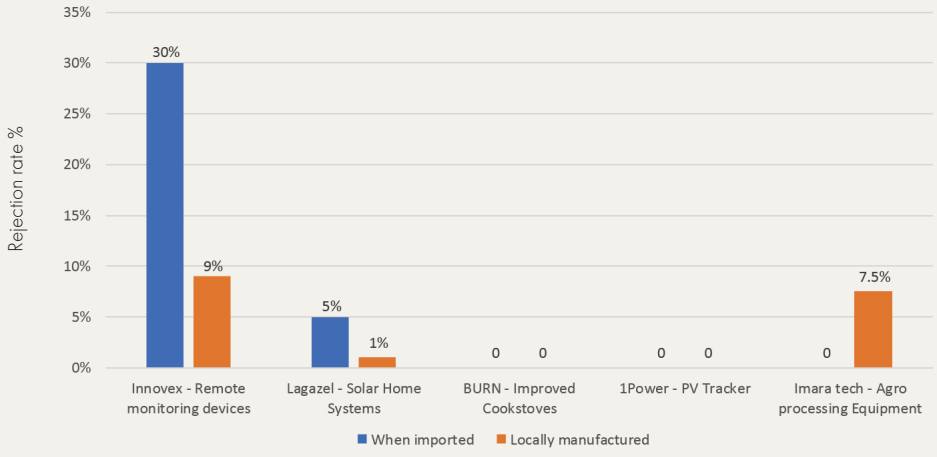


Figure 1 Rejection rate (baseline vs endline)

[2] Manufacturing quality was measured by VA&EC companies through rejection rates during the quality control phase or through the warranty claim rate. QC data was self-reported by VA&EC companies

[3] This measure calculates the total value of warranty claims paid in the 12-month period as a percentage of total business entity revenue for the period

2. Overall profitability increased across the board

All five VA&EC-supported companies witnessed an increase in profitability. The margin increase ranged from as low as 12% in the case of Imara Technology to as high as 38% in the case of Innovex. The top three drivers behind the increased profitability were identified as:

- Avoided import duties and taxes
- Avoided supplier margins
- Avoided shipping costs

Where data sets existed, it was observed that 53% of the increased margins were achieved from avoided import duties and taxes. Avoided shipping costs came as a respite for all VA&EC companies since their shipping costs on a per-20ft-container basis had increased by three to five times compared with pre-COVID-19 rates.

3. Lower lead time is unlocking new revenue streams

The most potent indirect benefit of increased local manufacturing is in the form of lower lead times. Lead time describes the time between the initiation (i.e. distributor places the order) and completion (i.e. distributor receives the order) of the production process.

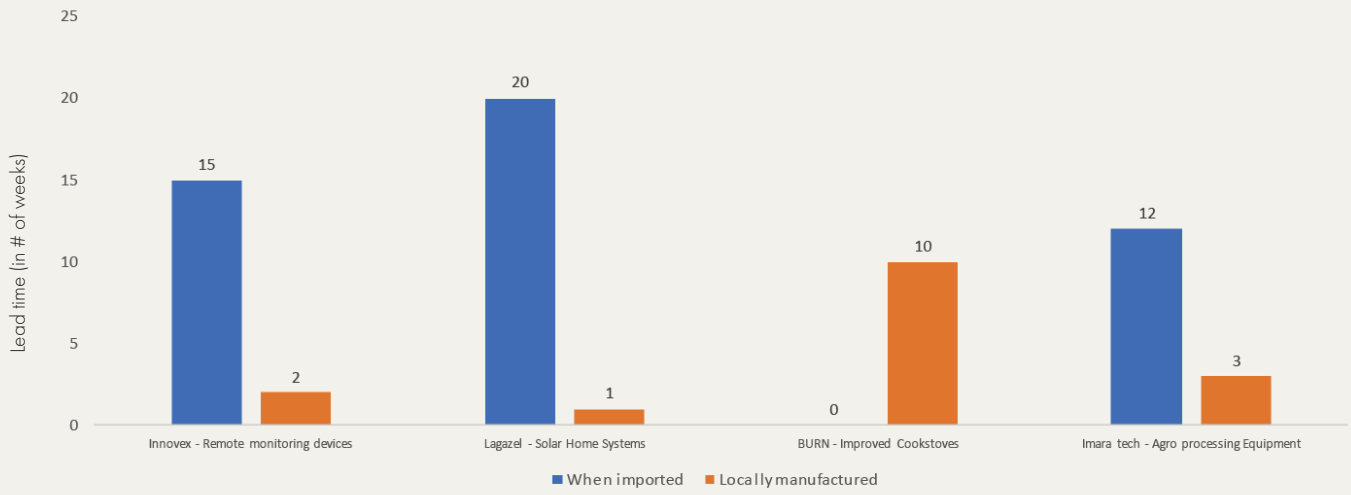
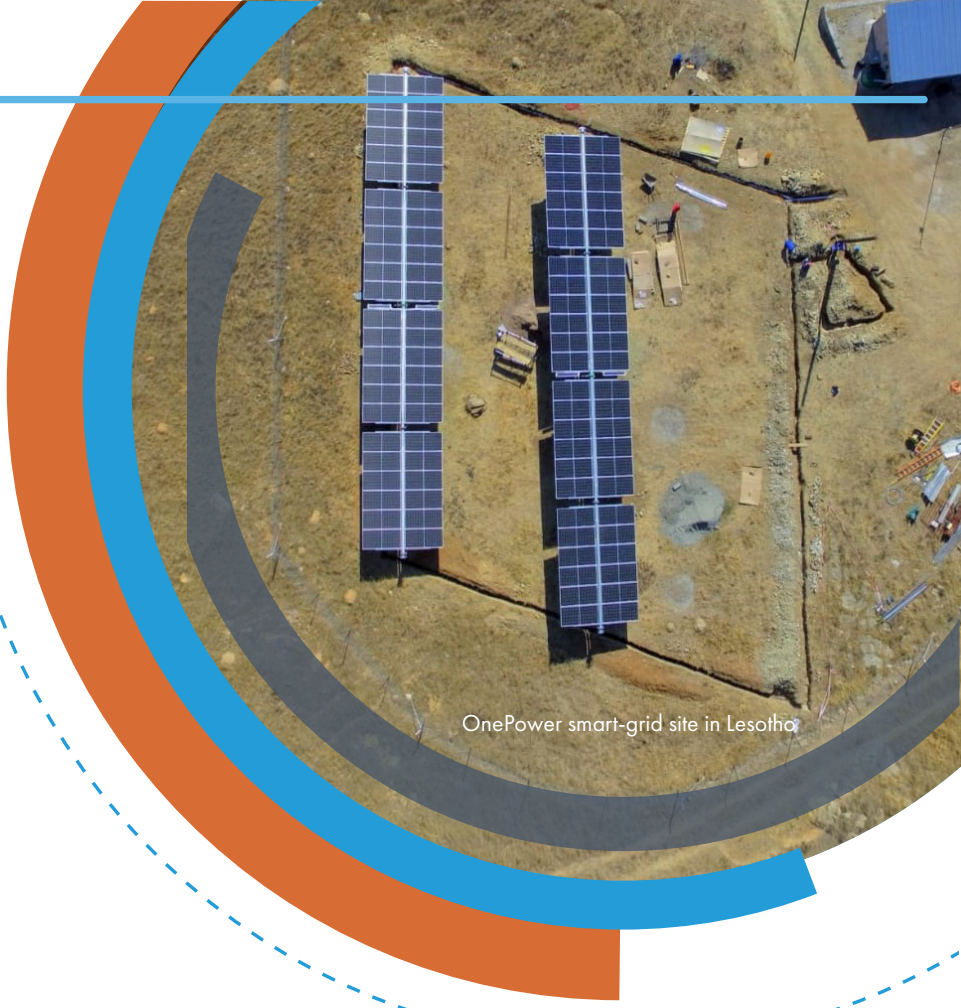


Figure 2 Typical lead time (in number of weeks)[4]

All VA&EC portfolio companies now have the capacity to meet in-house and market demand for their products in one to two weeks, as opposed to a few months in the case of importing units. Most VA&EC companies acknowledged that the lower lead times because of local manufacturing is now their biggest competitive advantage. This has resulted in three tangible outcomes:

- Lower lead time is unlocking new revenue streams for the companies, which are starting to receive contract manufacturing orders from companies interested in reducing their time to market by sourcing locally
- Manufacturing companies can shorten their feedback loops during the development phase by more quickly iterating their products in the field
- Product manufacturers that suffered from frozen supply chains during the COVID-19 pandemic are seeing value in de-risking their supply chains by including domestic manufacturing

[4] BURN baseline not applicable as TURBO cookstove (which is the subject of the VA&EC-supported project) is a new product. Similar data from OnePower was not available at the time of writing



OnePower smart-grid site in Lesotho

4. Local manufacturing contributes to increase in skilled labour force

In addition to the value captured locally, as presented in the three tangible outcomes, all VA&EC companies demonstrated the creation of sustainable jobs that were technical in nature. Across all five companies, 73 technical and 15 non-technical jobs (full-time positions) were created, of which most were in manufacturing, assembly, testing and R&D functions. The VA&EC companies, realising the need to create a technical workforce, collaborated with local universities and vocation training centres. For instance, Innovex is working closely with Makerere University in Kampala to create curriculum-based training on semi-conductor manufacturing, and OnePower is collaborating with the Energy Research Centre of the National University of Lesotho to establish an internship programme for students to develop hands-on skills applicable to developing and implementing off-grid energy projects.

5. Conclusion

Despite the achievements in quality, profitability, lead times and jobs from local manufacturing, it was observed that the majority of basic components needed for manufacturing and assembly continue to be imported from China and other countries. Particularly, all electronic components such as resistors, capacitors and microchips, irrespective of the product they go into, and solar generation components such as PV panels are imported.

The local value captured during the VA&EC challenge was primarily achieved by moving manufacturing and assembly processes that relied on capital expenditure equipment onshore. This was seen as a less-risky way of capturing value locally when compared to building a fully fledged design or a development team that required intense intellectual assets that were not readily available. The companies believe that the import of key components will likely continue unless a large-scale backward integration drive is executed by the manufacturing sector with support from government agencies. There were encouraging signs that the country governments (on a case-by-case basis) are already supportive of local manufacturing by creating an enabling policy environment and providing incentives such as duty exemptions, discounted electricity rates for domestic manufacturers, and easing of access to land parcels in industrial plots.

VA&EC-supported companies are already answering some pertinent questions on manufacturing in Africa: each achieved higher quality, increased profits and lower lead times, and created technical jobs for locals. We believe that the evidence generated by these companies, outlined in the subsequent case studies, will attract further donor, commercial and public capital to scale local manufacturing that PREO (via the VA&EC challenge) trialled as part of these action research projects.

Back view of an installed OnePower manufactured-in-Lesotho PV tracker system at Ha Makebe; PV tracker manufacturing processes supported by TEA-POP

6. Case Studies

An in-depth overview of the five VA&EC challenge projects:

Imara Tech team tending to a locally manufactured flour mill in Tanzania

Innovex staff testing and assembling agricultural processing equipment in Uganda

6.1 Innovex

Technology: IoT equipment
Value chain: Manufacturing and assembly
Country: Uganda
Project name: Manufacture and assembly of low-cost Internet of Things technology for monitoring and control of off-grid solar systems, solar equipment and appliances in the solar-for-productive-use industry.

About Innovex

Innovex, founded in 2016 by Douglas Baguma and David Tusubira, is a Uganda-based Internet of Things technology provider for energy applications. Its flagship product, REMOT, enables solar energy providers, PUE enterprises such as solar-powered water pumping companies, and energy infrastructure companies such as utilities to remotely monitor and control energy assets. REMOT is made up of an electronic hardware component (Davix) and a digital monitoring platform.

One of the biggest challenges faced by most solar energy application providers is selling their solutions at a price that is affordable to their consumers. Innovex addresses this challenge in the following ways:

- Through a PAYG model enabled by remote-control functionality, solar companies can sell their products, such as a rooftop solar system, to vital service providers including health clinics on payment plans allowing them to make monthly payments, failing which the installation can be turned off
- By integrating IoT-for-payment capabilities through Mobile Money, REMOT eliminates the need for capital expenditure investment in building last-mile infrastructure such as physical branches for collecting cash payments
- REMOT increases the utilisation rate of the energy application by reducing downtime through predictive maintenance, remote troubleshooting and data intelligence

Innovex has sold more than 1,500 REMOT units in the last three years to users from diverse sectors such as solar energy generation, solar PV water pumping and cold storage, and e-mobility.

Innovex's business model

With the support of PREO, Innovex has set up Uganda's first PCBA manufacturing facility meeting international standards. This allows Innovex to manufacture high-quality PCBs for in-house use and for use by third parties.

Innovex's current model involves design, manufacture, quality control and sales of its remote monitoring hardware, Davix, through upfront cash payments by its customers followed by service fee-based access to the performance data platform. Innovex, through this model, supports manufacturers and distributors of solar energy systems and PUE applications to acquire remote monitoring and control capabilities over their assets without having to reinvent the wheel by building their own hardware and software platforms. These manufacturers and distributors are also inclined to purchase off-the-shelf appliances so that they can stay focused on their core capacities of manufacturing and last-mile distribution. There are hundreds of solar and energy companies in Uganda and several thousand in East Africa alone, providing a long runway to grow for Innovex.

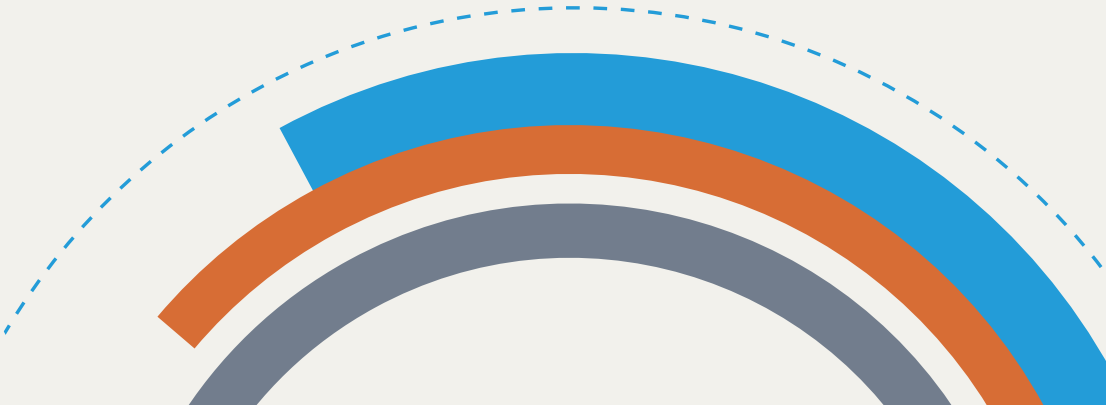
Acquisition of in-house manufacturing capacity is also opening a new business opportunity for Innovex to contract-manufacture electronics hardware for domestic companies seeking alternatives to procuring from China. Innovex is well positioned to capitalise on this demand since it can offer high-quality electronics at reduced prices and lower turnaround times. Innovex has staffed a business development team to pursue this opportunity and the initial traction is seen in products such as battery management systems for e-mobility companies, PCBs for ventilator equipment and remote tamper-proof energy monitoring meters for utilities.

Why did Innovex decide to manufacture domestically?

Prior to the PREO VA&EC challenge, Innovex designed its units in-country but had them manufactured in China. Innovex decided to invest in shifting the manufacturing of its electronics products to Uganda because:

- Forty percent of imported products were faulty, and although suppliers acted to resolve issues promptly, the fluctuating failure rate remained
- Poor workmanship and inferior quality of the components were identified as key reasons. Addressing this required Innovex to set up a quality control function in China that was considered expensive and operationally intensive for an early-stage company
- Lead times were increasing, from two months to as many as six months, impacted by supply chain challenges exacerbated by the COVID-19 pandemic
- Innovex identified that unlike high-volume manufacturing that requires large anchor customers from Europe or the US, low- to medium-volume manufacturing can be viable in Africa with the growing need for remote monitoring of energy systems
- There are improved policies and regulatory frameworks for local manufacturers, such as the establishment of the African Continental Free Trade Area, and the introduction of government incentives to substitute imports and promote exports

This made Innovex explore the possibility of just-in-time manufacturing, through which it could deliver orders in a week's time and at a lower cost.



Description of project

The PREO project aimed to enhance manufacturing and assembly capacity for low-cost Internet of Things technology for monitoring and control of off-grid solar systems, solar equipment and appliances in the solar PUE industry. Key objectives of this project included:

- Enabling Innovex to locally manufacture its remote monitoring products, which otherwise would have to be procured from China
- Testing and demonstrating that good quality can be achieved through local manufacturing
- Building human resource capacity for operating high-tech electronics manufacturing locally

With PREO's support, Innovex developed the following local manufacturing capacities;

Setting up a low-cost PCBA manufacturing site in Uganda

- The PCBA (printed circuit board assembly) manufacturing facility's role is to locally manufacture electronic circuit boards for Innovex's hardware
- Innovex floated a competitive tender to select the equipment supplier, conducted necessary due diligence and identified a site for setting up the manufacturing facility
- It successfully lobbied the Uganda government to achieve a waiver on VAT and import duties on the manufacturing equipment
- The Innovex team designed a manufacturing floor layout, set up the necessary electrical infrastructure, and developed standard operating procedures for equipment operations, maintenance, health and safety
- The low-cost PCBA manufacturing facility set-up has a capacity of 200 units per day

Setting up domestic casings manufacturing

- The PCBAs manufactured needed high-quality plastic casings that are produced using injection moulding technology
- Innovex underwent a similar competitive process to secure the equipment supplier for an injection moulding machine, but it also had to work with the supplier to develop the mould, which turned out to be time consuming
- The Innovex team developed standard operating procedures for the injection moulding equipment operation, maintenance, health and safety

Human resource investments

- Innovex developed resourcing needs specifications and concomitant job descriptions for the target technical and non-technical staff. The human resource manual was revised, and staff recruitment undertaken in line with the revised manual
- Furthermore, it recruited 10 consultants to support various aspects of the project's implementation. In total, Innovex recruited 17 technical staff (six of them female) and seven non-technical staff

Research and development

- Innovex improved its products through development and testing of new firmware and design-for-manufacture analysis as part of the PREO project
- It also developed two new product lines: the pump Davix, in collaboration with Aptech Africa, and the cold-chain Davix, supported by CLASP. Fifteen pilots have been installed in Kenya and a pilot in India is in the works
- Innovex performed a design-for-manufacture test on its products with imec, based in Belgium
- Innovex secured a pro bono consulting engagement with Enea Consulting to further collect data and study the long-term financial viability of local manufacturing of electronics and plastic products in Uganda

Key outcome – value addition: 37.9% cost savings achieved through domestic manufacturing

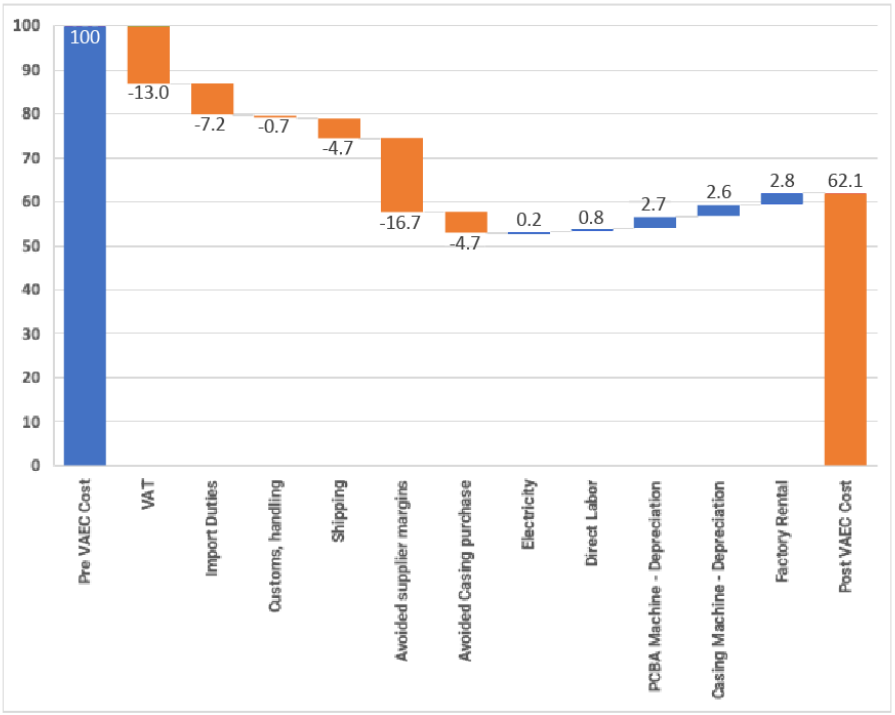


Figure 3 Cost increase and savings in manufacturing one unit of REMOT locally/ locally in Uganda

Shown above is the cost waterfall for one unit of REMOT on a base scale of n=100. The waterfall tracks the cost increases and savings associated with manufacturing the unit locally in comparison to importing the units from China. It also indicates the overall value that Innovex can capture on a per-unit basis.

- Innovex demonstrated cost savings of USD 40 and additional cost of USD 9 on every USD 100 worth of units that were previously imported but are now manufactured domestically
- The largest cost savings due to local manufacturing accrued from not having to pay import duties and VAT, totalling as much as USD 20 on every USD 100 worth of units previously imported
- The second largest cost savings (USD 16.7 of every USD 100 imported) accrued from no longer having to pay supplier margins on the inputs
- Of the additional cost of USD 9 incurred because of local manufacturing, 58% or USD 5.3 was incurred on the CAPEX required to import machinery and build the local manufacturing set-up
- The remaining 42% in cost increase can be attributed to labour involved, factory rental and other direct costs involved in manufacturing the units

Overall, the average landed cost of goods sold reduced by 37.9% because of local manufacturing, allowing Innovex to capture that value for itself or pass it on to customers in the form of competitive pricing. Our simulations also suggest that a potential decrease in vendor pricing due to supply chain normalcy could be matched by reduction in value of the raw materials procured, allowing Innovex to retain the 38% cost savings achieved.

In addition to achieving direct cost savings per unit, Innovex unlocked additional value and growth in the following ways:

- Ninety-one percent of end products manufactured as part of the project passed the quality testing, successfully demonstrating Innovex's capacity to manufacture high-tech electronics. This compares with a 70% success rate when imported from China
- Innovex is positioned to deliver orders in two weeks, compared with a lead time of at least three months when imported from China. The majority of businesses that explore contract manufacturing opportunities with Innovex regard this reduction as the strongest value proposition of working with Innovex
- Innovex successfully raised GBP 890,635 in scale-up funding, of which GBP 156,500 was raised from the Gaia Impact Fund in the form of direct equity and venture builder service; GBP 221,000 from Innovate UK; and GBP 208,029 in support from the Ugandan government
- Innovex was able to unlock business interest for its high-quality, low-cost domestic products from potential partners such as Kiira Motors, which required electronics for e-buses; Zembo and Bodawerk for energy management use cases in e-bikes; and even Umeme, the largest energy distributor in Uganda, for IoT-controlled metering devices for industrial consumers

Key outcome – employment creation

One of the key hurdles in setting up local manufacturing of PCBAs is the lack of technical capacity to operate the surface-mount technology (SMT) machines that are used to mount complex electronic circuitries to the surface of PCBs. Through PREO, Innovex not only achieved technical capacity to operate SMT machines, but also extended its capacity to create training modules and to standardise PCBA processes amidst travel restrictions due to COVID-19.

The Innovex team could not travel to China to attend the training on operating the SMT machine for manufacturing PCBAs and the injection moulding machine for manufacturing high-grade plastic casings. The technical manuals attached were in Chinese and the virtual interactions did not prove to be of much help since the technicians lacked English fluency. Innovex, through the Belgian non-profit OVO, received training and technical support from ED&A (manufacturer of electronic controllers) and imec (an international R&D firm active in nanoelectronics) to design training manuals and to standardise the manufacturing process.

Innovex, once it standardised the processes, recruited 17 technical staff and seven non-technical staff. It is also working closely with Makerere University to create curriculum-based training on semi-conductor manufacturing and employment-oriented internship opportunities.

Local manufacturers can benefit immensely by consistently persuading government authorities to create supportive policy frameworks, and by designing public capital-funded incentives. Innovex, by working closely with the government of Uganda, received exemption on duties worth **USD 40,000** to import manufacturing equipment. As a domestic manufacturer, Innovex's electricity tariffs are cheaper by **50%** compared with domestic consumers. Innovex also received USD 30,000 funding from the Ministry of Science, Technology and Innovation to invest in R&D activities.

Innovex learned that it is valuable for local manufacturers to establish in-country quality control teams and create on-the-ground partnerships in China for sourcing equipment or material. Innovex's partner played a critical role in conducting due diligence on the suppliers of manufacturing equipment and inspected the machinery pre-shipment.

KEY LEARNINGS

Innovex demonstrated that locally manufactured electronics hardware can be of high quality and can compete with imports. **Ninety-one percent of end products manufactured as part of the project passed the quality testing,** compared with only 70% when imported from China.

There is a need to invest in business development and create partnerships as a path to profitability by efficiently utilising the installed machinery. This can also unlock opportunities such as contract manufacturing through which product manufacturers such as Innovex can diversify revenues, achieve scale faster and create wider impact.

6.2 BURN Manufacturing

Technology: Cookstove
Value chain: Manufacturing and distribution
Country: Kenya
Project name: TURBO: Manufacturing a forced-draft biomass household stove bundled with solar home system to transform the rural energy sector

About BURN Manufacturing

BURN Manufacturing (BURN) designs, manufactures and sells affordable and energy-efficient clean cookstoves to low-income households in developing economies.

Since launching in 2013, BURN has sold more than 2.8 million cookstoves, providing economic, social and health benefits to over 15.4 million people in sub-Saharan Africa. BURN has established itself as the leading modern cookstove manufacturer and distributor in Kenya, with over 70% market share.

The Jikokoa Classic and the Kuniokoa are the most popular and best-selling stoves in the BURN catalogue. BURN owns and operates a manufacturing facility in Ruiru, Kenya, that currently produces 250,000 stoves per month, and aims to scale this production capacity to 600,000 units per month by the end of 2023. Seventy percent of the factory's power needs are supplied by a 120kW solar PV array. BURN employs over 2,500 people, 50% of whom are women.

BURN is led by founder and CEO Peter Scott, who has more than 22 years' experience in cookstove design and commercialisation in the developing world.

Kuniokoa multi-fuel stove

Description of project

BURN launched Kuniokoa, its popular fuel-efficient firewood rocket stove, for household use in 2017. The technology had its limitations, such as: reduced performance with wet wood; inability to burn agricultural waste briquettes; increased tending time as compared with a three-stone fire; and no reduction in time to boil compared with an open fire.

In this project and with matching grant funding from PREO via the VA&EC challenge, BURN aimed to begin production of the newly designed Kuniokoa TURBO Stove ("TURBO") at its factory in Kenya and launch distribution across rural Kenya through existing distribution partnerships. The TURBO is a forced-draft biomass stove that has a 2.5W fan, designed to be powered by either the grid or solar, making it more efficient and cleaner-burning than previous models of the Kuniokoa stove. With the manufacturing launch of the TURBO, BURN aims to:

- Continue to create local upstream value in sub-Saharan Africa's off-grid energy industry, including by adding electronics assembly to its existing manufacturing capabilities in Kenya
- Create over 60 new manufacturing, sales and support jobs in this 18-month project, and over 70 additional jobs in the next five years
- Provide world-class clean cooking solutions to an additional 10 million households in the next five years

Project outcomes

With PREO's support, BURN finalised the design of the TURBO to address these challenges. The final design has the following features:

- Addition of a 2.5W fan, which increases mixing above and below the fuel bed, allowing the stove to burn agricultural waste briquettes, wet wood and dry wood faster, cleaner and more efficiently
- Decreases the time to boil by ~60% and decreases the tending interval by 30%
- Wood fuel with up to 27% moisture content (wet basis) can be burned – as clean as liquid petroleum gas (LPG)
- On track to be a production household cookstove that achieves ISO/IWA "Tier 4" performance with agricultural waste briquettes

BURN initially produced 130 TURBOS as both demonstration units for prospective distribution partners and retail units. BURN was able to trial a limited number of TURBOS from this batch for a small pilot with platform users in rural Kenya. The response was positive, with users reporting high levels of satisfaction in terms of durability, useability and fuel efficiency of the stove. The clean-cookstove enterprise managed to scale its production of the TURBO stove from 150 at the start of the project to 2,500 per month.

BURN sought additional market data and partnerships during this period while also identifying efficiencies in manufacturing and sourcing. By identifying improved suppliers of critical components for the TURBO's fan system from China and addressing design-for-manufacture concerns, BURN was able to reduce the retail price from ~USD 50 to ~USD 30. A B2C pilot sale in Western Kenya validated that the new lower price would drive demand and put the TURBO within range of a limited market of cash buyers. Data from the study in Western Kenya illustrated that 96% of participants were unable to pay cash for the TURBO but would be interested in exploring financing options.

BURN was also able to create nine full-time jobs, including five women in the manufacturing process, and a new electronic assembly line that has five full-time staff.

Lessons learned

Initial attempts to secure a larger distribution with SHS distributors in 2020 and 2021 were not successful. Retrospectively, at the time there was an industry-wide move away from biomass towards more traditional financed assets, such as mobile phones and other electrical devices. Due to this reduced level of commitment from SHS providers in entering distribution relationships, BURN pivoted towards a B2C approach within sub-Saharan Africa, but outside Kenya, to generate additional interest and sales.

However, looking ahead through 2023 and beyond (the grant's implementation period) BURN expects demand to significantly increase, which is partially driven by a new framework agreement with a leading SHS distributor that will drive market uptake across multiple markets. Based on this successful partnership, BURN continues to seek distribution deals in the SHS sector. As high-volume sales drive manufacturing, BURN will be able to pursue other distribution channels and B2C sales. Besides sales-focused activities, BURN will seek further support to both drive manufacturing efficiencies and find innovative finance mechanisms, such as result-based financing schemes or carbon financing, to reduce costs for the customers.

BURN Manufacturing – Kenyan woman prepares a meal using a BURN cookstove

6.3 Imara Technology

Technology: Agricultural equipment
Value chain: Agricultural processing equipment
Country: Tanzania
Project name: Local lean manufacturing of off-grid, productive-use agricultural equipment

About Imara Tech

Imara Tech is a Tanzania-based start-up founded in 2016 that manufactures agricultural equipment. Imara Tech's first product was a mechanised multi-crop thresher (MCT) that fits on the back of a motorcycle and can be operated as a service business that generates income for the operator and saves time of post-harvest labour for smallholder farmers. In 2019, Imara Tech opened its first workshop in the industrial area of Arusha and is now implementing its lean manufacturing model, working with other small-scale workshops and utilising modern CNC (computer numerical control) equipment. The team also redesigned the MCT to accommodate additional crops, expanding its functionality to process beans, lentils and other legume crops.

Description of project

Of the six million smallholder farms in Tanzania, 97% lack mechanisation and less than 50% have access to electricity on a community level. This makes it difficult for farmers to add value to their harvests and leaves them dependent on laborious, time-consuming practices.

With PREO's support, Imara Tech sought to develop a portfolio of agricultural machines that can be powered by clean energy and used as profitable, income-generating businesses in off-grid areas. The portfolio consisted of three products: a flour mill, a peanut sheller and an oil press. Each product was to be operated as a business that provides value-addition services to off-grid farms, allowing them to capture more of the value chain and reduce time and labour.

To ensure the products successfully reached the market, Imara Tech sought to increase its local supply chain capacity with both capital equipment and a growing team. Each Imara Tech product was to be made locally using lean manufacturing principles, allowing the company to be agile in responding to market demand.

Each product was available in both AC and DC options to deploy them using existing off-grid energy systems or with new stand-alone systems.

The product specifications are as follows:

Peanut sheller

Motor specification	1.5kW, 3-phase motor
Throughput	110 kg/hr shelled
Target breakage[5] rate	10%
Unshelled output	<1%
Throughput efficiency	73 kg/kWh

Flour mill

Motor specification	4kW, 3-phase motor
No load power[6]	1.9kW
Load power	10%
Throughput	60 kg/h

Oil press

Motor specification	3kW, BLDC motor
Hydraulic cylinder	Double acting, 9 ton, 30 MPa-rated pressure
Pump specification	4.5 ml/rev, 29.7 MPa-rated pressure
Oil production	28 l/hr

Project outcomes

Prototypes were completed and fabricated for all three technologies – three oil-press prototypes, three peanut-sheller prototype units and a roller-mill prototype.

All prototypes were deployed to field sites for piloting. Two sites were constructed for the oil presses and solar systems, and prototypes were installed and partners trained in their operation. Three peanut-sheller prototypes were deployed to mini-grid sites in Central Tanzania and operators trained. The mill prototype was installed on an existing mini-grid site in Northern Tanzania and operators trained. Baseline data was collected for all pilots, and operators were given logs to begin collecting customer data during pilots.

[5] Breakage can be considered as a rejection rate since peanuts that are broken during the shelling process have poor market value

[6] No load power is the energy requirement when the mill is run with no grain – usually during idle times between servicing two customers, for instance

Table 3 Summary of activities and results of the pilots

	Summary of activity	Summary of results
Peanut sheller	• Three peanut-shelling machines were built and tested for use on mini-grid sites in Central Tanzania • Operators received the machines at no cost and agreed to repay through a revenue-sharing agreement. The mini-grid provided community contacts and facility space	• No major technical problems were detected, but minor changes recommended to improve user experience • Business productivity was low due to a low number of customers – this was in line with other local businesses of similar types • End users perceive that mechanisation reduces the difficulty of shelling and most of this benefit is expected to impact women as they do most of the labour
Flour mill	• One roller milling machine was built and tested on a mini-grid site in Tanzania • Operators received the machine at no cost and were encouraged to operate it as a business in return for collecting user feedback	• The mill design proved to be energy efficient, but the flour quality was not fine enough to meet community standards due to imprecision in roll machining that resulted in gaps between the lower rolls and a coarse flour grind • The mill produced white maize flour; however, whole grain was locally preferred
Oil press	• Three micro-grid facilities were constructed in areas with avocado farmer cooperatives • Oil presses were installed at each site and cooperative members were trained in their operation. The investment in the equipment is repaid through a revenue share from the oil produced by the cooperatives	• No major technical problems, but the pilot timeline was affected by procurement options and component quality • The business case demonstrated high-potential earnings but was novel and not fully understood by the community. The business requires a hands-on, top-down and patient approach to be successful • The oil-press business can result in reduced labour and higher income for cooperative members, but requires strong personnel capacity in the last mile to manage operations

Lessons learned

- Finding the right model is the most critical barrier to scaling these technologies. Difficulties and high costs of operation in the last mile weaken the investment case, and the multi-stakeholder model introduces further complexity. Commercialisation can be more viable if targeting different customer profiles and less remote, grid-connected communities
- B2B commercialisation models seem the most appropriate for potential scaling, but depend on successfully completing a robust product that can meet quality standards
- Significant collaboration challenges at the last mile resulted in an eventual change of model to have Imara Tech take responsibility for all pilot roles. The lesson learned is to vertically integrate required capacities under a single organisation and recruit suitable talent for managing different roles

6.4 LAGAZEL

Technology: Solar lighting equipment
Value chain: Research and development, assembly
Country: Benin and Burkina Faso
Project name: Strengthening and developing the local added value of LAGAZEL manufacturing facilities

About LAGAZEL

LAGAZEL is a leading manufacturer of high-quality solar lamps and solar home systems (SHS), and it is the first company to manufacture solar products in Africa on an industrial scale. The company has been manufacturing internationally certified solar lamps in Burkina Faso since 2016, and more recently SHS, sourcing quality-controlled components from reliable suppliers in Europe and China, which are then assembled, tested and packaged locally to be marketed in a B2B approach.

In December 2019, before the PREO project, the company had one workshop in Burkina Faso with the capacity to exclusively produce solar lamps, of which 66,500 units had been manufactured at that date.

LAGAZEL's mission is to industrialise the manufacturing of solar-powered products, bringing affordable and high-quality solutions to off-grid households while contributing to the local economy and creating sustainable local jobs.

Lagazel employee stands alongside a batch of locally manufactured and packaged solar products

Description of project

Through PREO funding, LAGAZEL implemented a pilot project aimed at strengthening and developing the local added value of its manufacturing facilities in Burkina Faso and opening a new facility in Benin, while creating sustainable local jobs and training opportunities. LAGAZEL designs and manufactures solar equipment in metal, which provides high resistance to impacts while facilitating recycling, so it can produce high-quality goods suitable for the African market. The solar lamps and kits have a life expectancy of five years and come with a two-year guarantee.

Most solar products in the available African markets are manufactured in and imported from China and India, diminishing the capacity to capture value locally. Additionally, most of the local distributors are often SMEs that lack sufficient financial means to exploit economies of scale. This has an impact on access to high-quality (non-certified) products and reliable after-sales services and hinders the creation of local jobs and contribution to the local economy.

For this project, LAGAZEL adapted its existing solar lamp business model for its new SHS product by sourcing components from reliable suppliers predominantly in Europe and Asia for its workshop in Dédougou, Burkina Faso. The company expanded its operations to Porto-Novo, Benin, starting to manufacture a first series of Sobox Power, its solar home system. Additionally, through a partnership with the research association IFSRA, an in-depth study was conducted to investigate the socio-economic impact of LAGAZEL's activity in these areas.

The project envisaged four phases:

- **Phase 1:** Manufacture the first series of solar home systems and increase production in Burkina Faso
- **Phase 2:** Finalise the development of subsections of off-grid solar products, manufacture the first series and replicate in Benin
- **Phase 3**: Conduct R&D and testing activities on new, innovative products
- **Phase 4:** Evaluate the viability of local production, impact on employment, and direct and indirect economic and social impact

Project outcomes

The PREO project supported the strengthening and development of local production at LAGAZEL'S manufacturing facilities in Burkina Faso and Benin.

Value addition

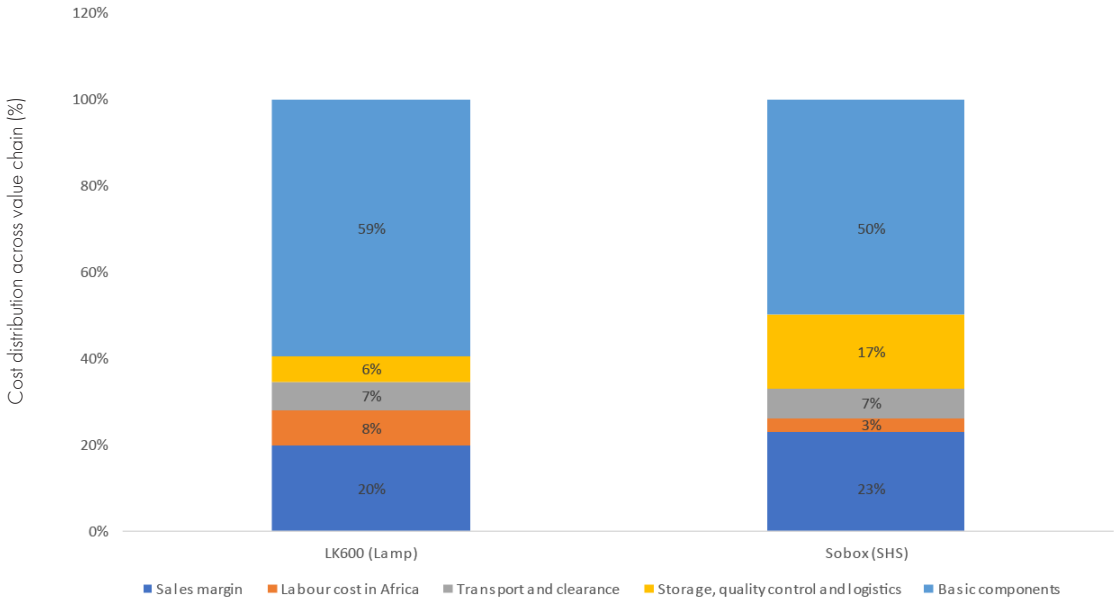


Figure 4 Cost contribution % of different parts of the value chain[7]

Figure 4 showcases the breakdown of the production costs of two LAGAZEL products: a solar lamp (LK600) and a solar home system (Sobox SHS). The main conclusions are:

- The cost of basic components and raw materials varies between 50% (Sobox SHS) and 59% (lamp) of its selling price (cash sale) to distributors
- The locally captured value including labour and minimum sales margin (excluding distribution) is 26% to 27%
- Labour share per unit is higher for small products such as the lamp (8%) than the Sobox SHS (3%)

In addition to the value captured locally, the project resulted in the following outcomes:

- Increased capacity to produce a range of quality-certified solar products locally. LAGAZEL expanded its production from solar lamps to solar home systems, including spare parts such as bulb lights and battery packs. As part of this capacity and despite supply and logistics challenges, 470 Sobox Power units and 950 bulb lights were manufactured and sold in Benin and Burkina Faso. The current capacity in each workshop (Burkina Faso and Benin) is 100 SHS per week, including three bulb lights, and 250 to 300 solar lamps per day
- Developed in-house tools for drilling and moulding bulb metal sheets and plastic parts. New software was implemented to improve purchase, stock and production management, as well as quality and traceability. As a result, a pre-series of 100 units of a new version of Sobox SHS were in progress at the end of project
- Set-up of a second manufacturing facility in Benin that was inaugurated in October 2021, creating 10 permanent jobs. The facility is already a reference for training in solar equipment production in Benin
- R&D activities were carried out and iterative prototypes were created in the field, including the assembly of weldless battery packs, a collective phone charging station and the case of a power bank. Preliminary studies and requirements to improve PV cell assembly were conducted, as well as creating a marketing and communications unit at a company level

[7] Source: LAGAZEL Project POP VA&EC Strengthening and developing the local added value of LAGAZEL manufacturing facilities (2020-2021) FINAL REPORT – January 2022

Employment creation

LAGAZEL partnered with IFSRA, a research association that conducted an in-depth study to assess the viability of local production and the direct and indirect socio-economic impact of the project on local communities. The study outlines the impact generated by the project as follows:

- Increased formal job creation, inclusive of vulnerable people
- The creation of training opportunities at local level, contributing to the national effort to increase the skilled workforce in the solar sector
- Improvement of living conditions for employees, retailers and end users by generating new sources of income and replacing highly polluting and harmful products
- The local supply of high-quality products and efficient after-sales services due to the proximity of facilities, and an R&D effort to evolve products and adapt them to local needs
- A local presence allows local demand to be met rapidly and reduces taxes and transport costs
- Consumers in both countries are proud to buy local products, which supports the regional initiative to promote "Made in Africa"

In each case, the facilities upgraded or set up by LAGAZEL had a direct impact on the creation of new jobs. According to the survey conducted by IFSRA, employee perception of quality jobs and work environment is satisfactory.

Dédougou facility (Burkina Faso)

Inaugurated in October 2016, the Dédougou workshop is in the Boucle du Mouhoun, ranked second poorest region of the country. This production unit currently employs 17 people distributed among various departments. The facility is organised in three departments: administration (five staff), a production workshop (11) and after-sales service (one).

In terms of direct impact on employment, 12 people were hired by the company: 10 on a fixed-term contract and two on a permanent contract. Two women have also been employed to work at the facility. According to IFSRA, the employees value their jobs because of the advantages linked to obtaining a formal job. This allows them to contribute to the National Social Security Fund and gain financial inclusion by accessing loan offers from financial institutions.

Porto-Novo facility (Benin)

Located in the Ouémé region (lake area) in Porto-Novo, the second LAGAZEL workshop was inaugurated in October 2021. LAGAZEL's Benin operations have two main departments: an administration office based in Cotonou and a production workshop in Porto-Novo.

So far LAGAZEL has hired nine operators, four administrative staff and three support staff for its Benin workshop. It is noted that efforts are made for an inclusive recruitment policy, resulting in 38% of employees being women and 6% people with disabilities.

Three students were offered the chance to complete their theoretical training, complemented by a practical internship in the workshop. This work experience supports the development of skills needed to access technical jobs and creates the possibility of future involvement, should the business continue to grow.

The impact on indirect job creation will be subject to further studies. During IFSRA's country visits evidence was collected, indicating the strengthening of retailers and the creation of small businesses through the commercialisation and use of LAGAZEL products.

Lessons learned

- Achieving local production is not a problem – LAGAZEL is able to manufacture high-quality products locally. The challenges are related to complex logistics and delays in supply chains and export across Africa
- LAGAZEL manufactures on demand, generating a fluctuation in the number of units produced and the number of employees required over certain periods of time. Nevertheless, there is a relevant market opportunity in West Africa that is expected to grow, and local manufacturers are well placed to respond quickly
- Although more value is being captured locally compared with importing a finished product, there is still a reliance on importing components for product assembly. This can lead to import delays, witnessed during COVID-19, and price fluctuations due to economy of scale and exchange rates
- It is feasible to assemble high-quality products that can compete with imported products. End users appreciate that manufacturing is locally "Made in Africa" and that faster after-sales service is available
- R&D activities were limited during the project lifetime and ended up being mainly conducted in France because of its proximity to LAGAZEL's technical partners and suppliers. Testing activities in the field were reduced due to travel restrictions during the COVID-19 pandemic and feedback was mainly collected through videoconferences
- Not only can jobs be created, and employees' living conditions improved, but there are also training opportunities created by the local facilities. In the case of LAGAZEL, both facilities regularly receive a significant number of trainees, which requires formalisation and visibility to gain support from government and other stakeholders

6.5 OnePower

Technology: Smart grid and meters
Value chain: Manufacturing
Country: Lesotho
Project name: Increasing renewable energy engineering and manufacturing capacity in Lesotho

About OnePower

OnePower (1PWR) is a renewable energy company providing electricity services to off-grid communities in rural Lesotho. 1PWR is vertically integrated with in-house capacities including technical design, manufacturing, engineering, and operations and maintenance (O&M) in the delivery of sustainable energy generation and distribution systems. In the manufacturing function, at the time of writing, 1PWR was Africa's only manufacturer of single-axis tracking frames for solar panels designed to orient the panels towards the sun, boosting power output by up to 20%[8]. The company is pioneering the use of these innovative structures in a portfolio of mini-grids in the Lesotho Highlands.

Description of project

With grant funding from PREO, 1PWR established and upgraded production and assembly operations at its manufacturing facility in Maseru, Lesotho. It developed local manufacturing capacity to deliver solar PV trackers ("One Tracker"), smart meters and mini-grid powerhouses that will be used for local mini-grid electrification projects – thereby reducing the country's reliance on panel imports due to efficient power utilisation from using fewer panels while increasing local value creation and employment.

A large proportion of equipment in mini-grids such as panels and batteries is commoditised or high-tech and requires importation. 1PWR analysed and engaged with key elements of the value chain and built local capacity in Lesotho to:

- Manufacture panel-mount structures including a single-axis PV tracker that boosts output by up to 20% and reduces quantities of panel imports
- Fabricate and integrate components into containerised mini-grid powerhouses with efficient layouts that are easy to operate and maintain
- Manufacture GSM-enabled smart meters for PAYG energy transactions with mobile-money platforms (e.g. Vodacom M-Pesa)

A OnePower employee in protective workwear accesses a solar-panel site

[8] Based on 1PWR's internal output performance

By localising the production of these critical components, 1PWR sought to demonstrate a roadmap for reducing the cost of off-grid electricity supply that is scalable to rural communities across Africa.

Moreover, 1PWR collaborated with the Energy Research Centre (ERC) of the National University of Lesotho (NUL) to establish an internship programme for students to contribute to project activities and learn about the applied side of developing off-grid renewable energy systems.

The goal of this partnership is to enable students at the ERC to learn cross-disciplinary and hands-on skills directly applicable to developing and implementing (off-grid) energy projects.

Key outcomes

The PREO grant funding enabled 1PWR to invest in manufacturing and testing equipment for local production of the PV trackers, powerhouses and smart meters, which included procurement of large machines such as a CNC plasma cutter, tungsten inert gas (TIG) welding facility, machine tools, high-throughput fabrication, assembly systems and test equipment. 1PWR also developed the necessary manufacturing processes, including standard operating procedure documentation.

PV tracker

1PWR upgraded its machinery, equipment and facilities, hired technicians, and validated its processes to set up a manufacturing capacity of 200 PV trackers a year. In doing so, 1PWR identified the following elements as the key influencing factors behind the overall pricing for PV trackers:

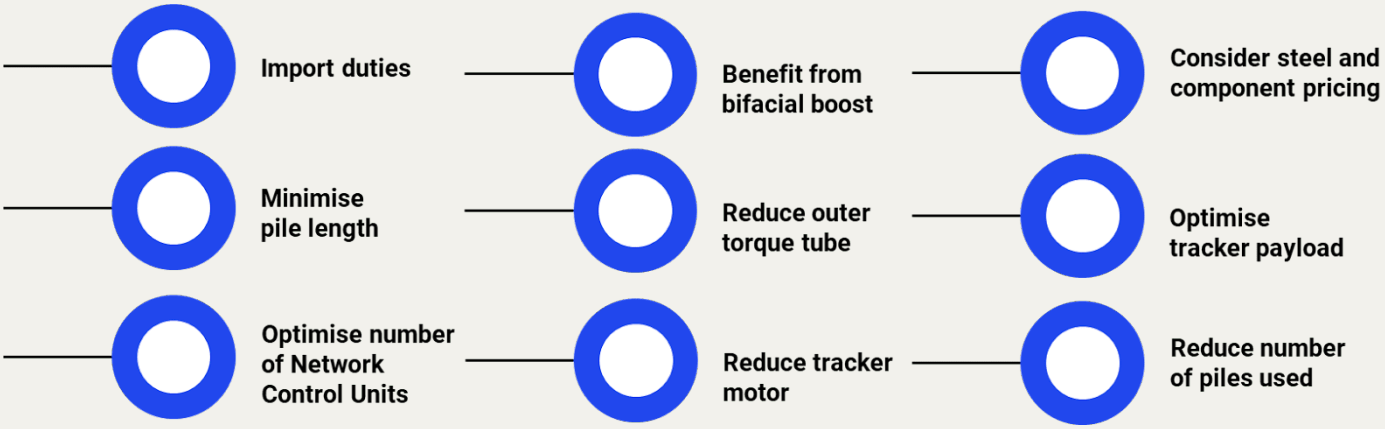
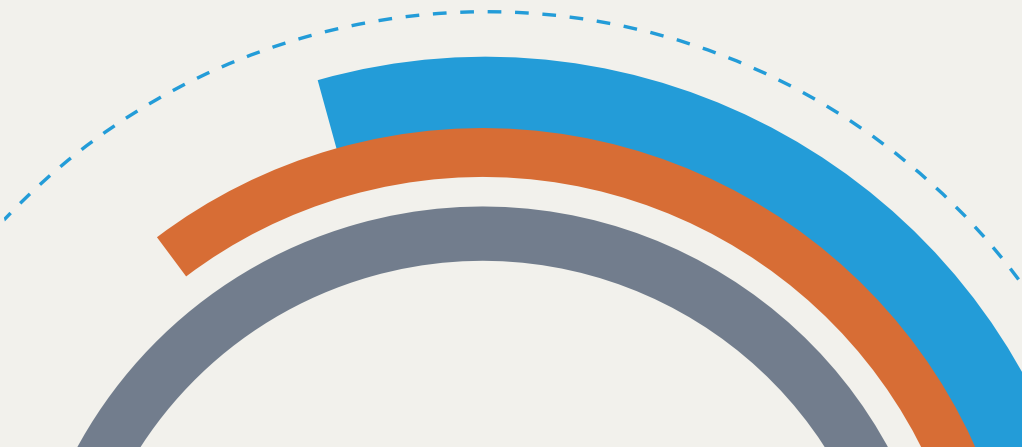


Figure 5 Major price elements influencing the overall cost of PV trackers



Mini-grid powerhouses

The powerhouse is the central component of a mini-grid that includes the power electronics systems and controls to monitor and manage the mini-grid autonomously. 1PWR procured a prefabricated powerhouse made from a shipping container, which was pre-installed with equipment and systems. These powerhouses were delivered to 1PWR's mini-grid site at Ha Makebe and rapidly connected as a plug-and-play installation.

In addition, to identify the most cost-effective powerhouse solution, 1PWR built a traditional powerhouse structure at Ha Makebe as well. The traditional powerhouse is a permanent and traditionally constructed building (concrete foundation and block wall, wood-trussed roof structure, and corrugated metal roofing) that is relatively expensive to build and maintain, and impossible to move from one site to another if an interconnection with the main grid requires the redeployment of mini-grid assets.

Following a cost analysis, 1PWR determined that prefabricated powerhouses are approximately 5% less expensive than using traditional structures. Installation of equipment in a traditionally constructed powerhouse is relatively time-, labour- and cost-intensive as it must be performed at a remote site with suitable laydown areas and access for construction vehicles, a worker camp, and logistics for staging the materials and labourers involved in the construction of the building and installation of the systems inside. These are the main cost drivers of the traditional powerhouse.

Employment creation

- At the start just one woman was employed in a non-managerial role, full-time in the company. This figure increased throughout the project's lifetime, resulting in nine women (out of 59 total staff) working for the company when the project concluded in December 2021
- Number of staff hired from local labour pool and NUL partnership – permanent employees, which comprise 28 males and nine females, are spread throughout the company operations: lead electrical engineer (x1), senior linesman (x1), linesman (x1), technician (x6), O&M lead (x1), O&M officer (x2), project manager (x1), associate project manager (x1), grant manager (x1), mechanic (x3), electrical engineer (x3), EHS manager (x1), EHS officer (x1), office manager (x1) and office assistant (x2). Interns/fellows (x11)
- A quantitative survey was conducted among all staff to learn about their experience and how they perceived the quality of the workplace. In an anonymous survey, staff were asked to assess employee satisfaction. Overall, satisfaction was high, with male candidates ranking the workplace quality as 4.3/5 and female colleagues as 4.8/5 (1 = not satisfied to 5 = highly satisfied)

Achievements

- 1PWR deploys mini-grids that maximise the output of solar panels through its One Tracker product, at the same time reducing dependence on imported products. The in-house design was built and led by the 1PWR team, which installed the first One Tracker system at Ha Makebe in 2021. It currently serves 200 households with solar mini-grid electricity
- Seven remote partners in health centres were also electrified, giving more than 44,500 patients 24/7 improved healthcare services
- 1PWR intends to replicate the mini-grid project portfolio approach validated by the PREO project in Lesotho, including localising the production of key components of the mini-grid supply chain. 1PWR is currently building a portfolio of mini-grids that will span 80 villages and serve more than 30,000 people, with a USD10 million debt and equity financing from REPP, EDFI and the UNCDF. Further grant funding secured from EEP Africa is enabling the company to introduce energy-efficient appliances to shops in the newly electrified communities and provide business development support for women entrepreneurs

PREO Powering Renewable Energy Opportunities

PREO is funded by the IKEA Foundation and UK aid (via the Transforming Energy Access platform), and is delivered by the Carbon Trust and Energy 4 Impact. To date, it has supported 27 productive-use-of-renewable-energy enterprises across 11 countries in sub-Saharan Africa.

https://www.preo.org/about/

Observation of OnePower's manufactured-in-Lesotho PV tracker at Ha Makebe by the Honourable Minister of Energy on 30 June 2021

IKEA Foundation

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