BUSINESS MODEL INNOVATIONS ADDRESSING ENVIRONMENTAL SUSTAINABILITY AND CIRCULARITY: CASE STUDIES

FEBRUARY 2021
EFFICIENCY FOR ACCESS COALITION
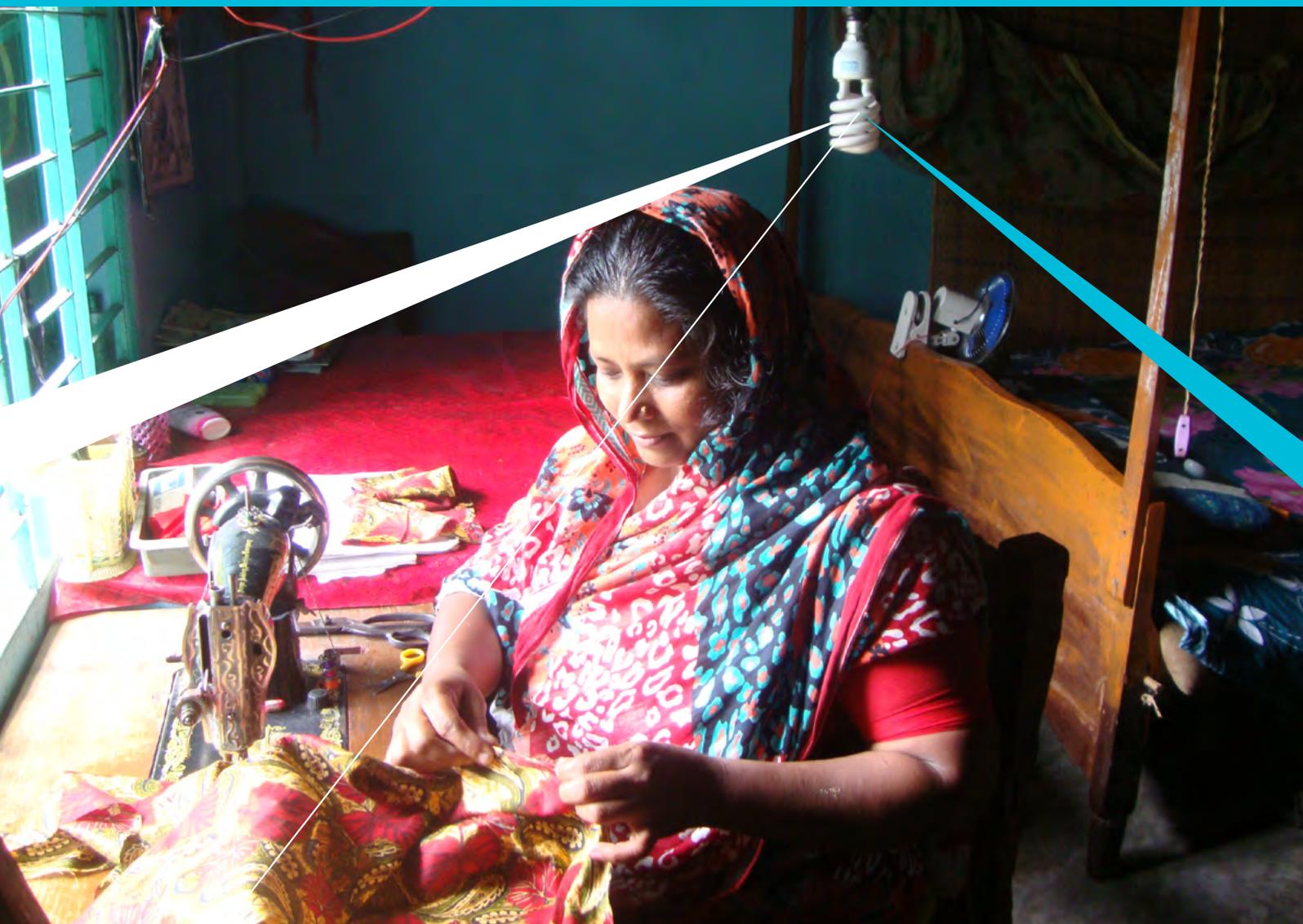
This report is part of a series of publications derived from the Business Model Innovations for Productive Use and Cooking Appliance Access research project. The research focuses on business model innovations that can help overcome challenges in providing rural, off-grid communities with productive use and electrical cooking appliances. It was commissioned by the Low Energy Inclusive Appliances (LEIA) programme. This particular report was authored by Raluca Dumitrescu of MicroEnergy International and Claudia Knobloch of Endeva.

Efficiency for Access is a global coalition working to promote high-performing appliances that enable access to clean energy for the world's poorest people. It is a catalyst for change, accelerating the growth of off-grid appliance markets to boost incomes, reduce carbon emissions, improve quality of life and support sustainable development. The Low Energy Inclusive Appliances programme is Efficiency for Access' flagship initiative.

Efficiency for Access consists of 15 Donor Roundtable Members, 10 Programme Partners, and more than 30 Investor Network members. Current Efficiency for Access Coalition members have programmes and initiatives spanning 44 countries and 22 key technologies. The Efficiency for Access Coalition is coordinated jointly by CLASP, an international appliance energy efficiency and market development specialist not for-profit organisation, and UK's Energy Saving Trust, which specialises in energy efficiency product verification, data and insight, advice and research.

About this report

This report includes four case studies examining companies pursuing innovative business model practices that support the goals of a circular economy and environmental sustainability in the off-grid appliance sector.

Other publications and tools derived from this research project include an **analytical report** summarising the research findings, a **database containing about 130 companies** engaged in innovative business models, a **report** documenting case studies on the theme of affordability, a **report** documenting case studies on the theme of resilience, and **three podcasts** featuring experts' views on the various innovation-related themes that have guided the research.

The research project overall explores **business model innovations (BMIs) relating to a variety of different themes,** thus featuring up to five case studies for each of the following thematic areas: 1) environmental sustainability and circularity, 2) affordability, and (3) resilience to regional and global shocks.

Title picture: Tailor in rural Bangladesh can work better thanks to more light (Bangladesh, 2019) Copyright: ME SOLshare Ltd

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ABBREVIATIONS

B2B .... Business-to-business
B2C .... Business-to-consumer
BMS .... Battery management system
CAYG .... Cash in as you go (opposite of Pay-As-You-Go, with revenue generated per each kWh sold)
DC .... Direct-current
Dena .... Germany Energy Agency
EBL .... Empower a Billion Lives
EV .... Electric vehicle
GSM .... Global System for Mobile Communications
IBB .... Investitionsbank Berlin
IDCOL .... Infrastructure Development Company Limited
IEA .... International Energy Agency
IEC .... International Electrotechnical Commission
IoT .... Internet of Things
IPS .... Integrated power system
kWp .... Kilowatt peak
LAB .... Lead-acid batteries
Li-ion .... Lithium-ion
M2M .... Machine-to-machine
Mesh grid .... Peer-to-peer grids for which there was no previous infrastructure
P2P .... Peer-to-peer grids
PAYGo .... Pay-As-You-Go
PV .... Photovoltaic
REA .... (Nigeria's) Rural Electrification Agency
REAM .... Renewable Energy Association of Myanmar
SaaS .... Software-as-a-service
SEforALL .... Sustainable Energy for all
SHS .... Solar home system
SHSes .... Solar home systems
SSA .... Sub-Saharan African
TNB .... Tenaga Nasional Berhad
UN DESA .... United Nations Department of Economic and Social Affairs
UNSD .... United Nations Statistics Division
UPS .... Uninterruptible power supply
WBG .... World Bank Group
WEC .... World Energy Council
WHO .... World Health Organisation

THE SUSTAINABLE DEVELOPMENT GOALS

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries – developed and developing – in a global partnership. They recognise that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – while tackling climate change and working to preserve our oceans and forests. Source: https://sdgs.un.org/goals

No Poverty
End poverty in all its forms everywhere

Reduced Inequalities
Reduce inequality within and among countries

Zero Hunger
End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Sustainable Cities and Communities
Make cities and human settlements inclusive, safe, resilient and sustainable

Good Health and Well-being
Ensure healthy lives and promote well-being for all at all ages

Responsible Consumption and Production
Ensure sustainable consumption and production patterns

Quality Education
Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Climate Change
Take urgent action to combat climate change and its impacts

Gender Equality
Achieve gender equality and empower all women and girls

Life below Water
Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Clean Water and Sanitation
Ensure availability and sustainable management of water and sanitation for all

Life on Land
Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Affordable and Clean Energy
Ensure access to affordable, reliable, sustainable and modern energy for all

Peace, Justice and Strong Institutions
Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
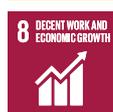
Decent Work and Economic Growth
Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Partnerships for the Goals
Strengthen the means of implementation and revitalise the Global Partnership for Sustainable Development

Industry, Innovation and Infrastructure
Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation

ENVIRONMENTAL
SUSTAINABILITY AND
CIRCULARITY IN THE
OFF-GRID APPLIANCE
SECTOR

KPay enabled solar devices lighten homes in rural Asia.

Today's industry practices are dominated by a linear economic model, in which resources are used once and then discarded. However, given the increase in the world's population and the growing complexity of the goods produced, each year, humanity consumes more ecological resources than the planet's natural ecosystems can regenerate within the same period. At the same time, the disposal of goods and other waste products is damaging the environment, further slowing the Earth's ability to heal and regenerate. In this context, environmental sustainability as well as circular production and consumption models are becoming increasingly relevant.

Circular economic models use resources more efficiently than linear models, thus maximising product benefits. Circular models seek to keep production and consumption within a closed-loop cycle. Consequently, raw materials are used and the products based on them reused or upcycled in such a way as to avoid as much waste and emissions as possible. Combined with a transition to renewable energy sources, the circular model helps to expand economic, natural, and social capital.[1]

Specially designed business models and practices can help facilitate the transition to a circular economy. In its 2015 Circular Advantage market study,[2] Accenture described

five types of innovative business models that, when applied individually or in combination, can help companies use resources sustainably, improve their customer experience, and reduce operational risk. These models included the following: 1) circular supplies, 2) resource recovery, 3) product-life extension, 4) sharing platforms, and 5) product as a service.

Creating circular economic systems should be regarded a global priority. This promises to help businesses unlock new economic opportunities, while making their activities more environmentally sustainable. Developing markets for circular business models will help companies and consumers leapfrog to a point of sustainability. However, concerted governance and regulatory efforts, as well as considerable work to develop appropriate business models, will be necessary to effect such a transition.

Circularity in the energy-access sector

Companies in the energy access sector can play an influential role in the development of a circular economy. Innovations in materials composition, energy efficiency, electrification techniques, biochemistry, and synthetic chemistry are just some of the many technological developments that fall into these companies' sphere of operations. Particularly first-time users of electricity, those with limited ability to pay for goods, and those living in geographically remote areas demand a paradigm shift,

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1   Ellen MacArthur Foundation. Concept: What is a circular economy? A framework for an economy that is restorative and regenerative by design, https://www.ellenmacarthurfoundation.org/circular-economy/concept. Retrieved 28/10/2020.

2   Lacy, P., Keeble, J., McNamara, R. et. al. Circular advantage: Innovative business models and technologies to create value in a world without limits to growth, Accenture Strategy, 2014, https://www.accenture.com/t20150523T053139__w__/us-en/_acnmedia/Accenture/

Conversion-Assets/DotCom/Documents/Global/PDF/Strategy_6/Accenture-Circular-Advantage-Innovative-Business-Models-Technologies-Value-Growth.pdf.

away from owning assests. Companies need business models based on sharing assets and servicing. In this regard, a circular approach frequently makes products less costly and leads to the localisation of supply chains. Consequently, circular business models can make products and services more affordable, while increasing companies and customers' resiliency to global shocks.

The number of energy-access business ideas based on circular and environmentally friendly practices is growing. In its 2020 Market Report,[3] the Energy and Environment Partnership Trust Fund (EEP Africa) noted that 30% of the 350 project proposals received that year in a funding round dedicated to energy access focused on circular business models. These fell into a variety of areas including agricultural innovation; waste-to-energy mechanisms for converting agricultural and human waste into electricity, heat and biofuels; and sub-sectors such as energy efficiency, recycling of non-biomaterials, battery refurbishment, and sustainable e-waste management.

Business model innovation in circular energy access

The business model innovations identified in this research category were placed in the following categories, based on their social, technical, and financial effects.[4] The companies associated with each business model innovation type are identified in brackets, and are described in more detail in the table at the end of this section.

- **Circular-design business models** (ZOLA Infinity, Solarworx) are intended to allow organisations to create, deliver, and capture value by focusing on product-design innovations that minimise ecological and social costs. Such business models allow for changes in product and process design; for example, Solarworx's light fittings are demountable and upgradable, with the aim of reducing the overall consumption of virgin resources. Over time, these business models can have significant financial benefits for end users, since both the products and underlying infrastructural elements are built for longer-term use. This obviates the need for repeated reinvestment in new assets. However, while this increases product longevity and extracts maximum value from the products being used, upfront costs remain high, which in many cases leads to customer resistance.

- **Circular-use business models** (SOLshare) seek to leverage previously unused residual value in existing assets or infrastructures, thus allowing for a more efficient use of resources. For example, peer-to-peer electricity trading allows households with solar panels to sell unused energy

DC fan usage improves poultry life quality (Bangladesh, 2019)

– which would otherwise be wasted – to their neighbours. These models optimise existing infrastructures, while also creating new customer, producer and "prosumer" (e.g. households that generate, consume and sell solar power) segments. They therefore hold the promise of contributing to long-term business sustainability. However, the operational risks associated with such business models remain difficult to assess.

- **Circular-recovery business models** (AMPERES) involve the collection and reuse of material that might otherwise be discarded or wasted, thus using the original raw materials more efficiently and reducing the need to consume more new resources. By employing reverse-logistics innovations to recapture used material, they extend products and services' usable lifetimes. However, regulatory uncertainty is perceived as a significant risk for these business models.

It is important to distinguish between technological and business model innovations. Whereas both can prove transformative, the former is much easier to replicate than the latter. For example, the research showed that technological innovations in product design and in data-analytics processes associated with IoT devices made strong contributions to circular processes. However, all of the business model innovations examined in the research entailed a shift from external control and global supply chains toward local enterprise and community ownership, which involves a much more complex set of processes.

3 The Energy and Environment Partnership Trust Fund (EEP Africa). 2020 MARKET REPORT Productivity and Circularity in the, Clean Energy Sector, Nordic Development Fund (NDF), 2020, https://eepafrica.org/wp-content/uploads/2020/11/2020-Market-Report_digital.pdf.
4 Carra, G., and N. Magdani. Circular business models for the built environment, Arup BAM, 2017, https://www.arup.com/perspectives/publications/research/section/circular-business-models-for-the-built-environment.

OVERVIEW OF CASE STUDIES IN THIS REPORT

The research on circular business models reviewed more than 30 appliance companies showing innovative practices within this area. The largest share was active in Sub-Saharan Africa or South Asia, with a smaller proportion based in East Asia and South-East Asia. From this group of companies, four examples were selected. They either apply an unique or very innovative approach to overcoming challenges or reach more clients than other companies. Table 1 gives an overview of the four case studies selected for this study.

Overview of cases studied under the circularity theme

Organisation	**AMPERES: The Australia–Mekong Partnership for Environmental Resources and Energy Systems**	**Solarworx GmbH**	**ME SOLshare Ltd**	**ZOLA Electric**
Business model innovation	Circular recovery – end-of-life management and upcycling through use of e-waste to power e-cooking solutions	Circular design and manufacture of modular and stackable solar systems for off-grid communities	Circular use – utility maximisation through interconnected, decentralised energy storage, renewable energy generation and peer-to-peer energy sharing	Circular design – optimising use of multiple electricity-generation sources
Productive appliance	Lithium-ion battery-based upcycled power packs for homes and businesses	Modular off-grid solar systems for homes and businesses	Large TV for village cinemas, hair trimmers for barbers, printers, photocopy machines and internet access for computer shops, fridge for pharmacies, motors for sewing machines	System enables integration of solar panels, battery power, grid power, and diesel generators for homes and businesses
Region	Myanmar	Cameroon, Senegal, Zambia, Kenya, Tanzania, Rwanda, and Uganda	Bangladesh, India	Nigeria

E-WASTE TO E-COOKING

Shift to electric appliances for cooking (Myanmar, 2020)

Key challenges

Nearly six million households in Myanmar have no connection to the electrical grid and even more are located in weak-grid settings. Many of these households use firewood or other biomass for indoor cooking purposes. However, the smoke from open indoor fires threatens women's and children's health, while the environmental impact of chopping firewood can lead to deforestation.

Empowering energy-poor households to cook with electric stoves has positive health, environmental and economic benefits. However, solar home systems (SHSes) currently deployed across Myanmar in off-grid areas have low storage capacity due to the high cost of batteries, which limits the use of electricity after daylight hours. Frequently undersized due to uncertainty in demand, minigrids fail to meet all the energy needs that arise once electricity is available. As many households prioritise the use of power for lighting purposes after sunset, women must complete their cooking activities during daylight hours, which restricts their ability to engage in income-generating activities during the day. While power packs based on lithium-ion (Li-ion) batteries offer greater storage capacity, these system have high upfront costs, presenting a significant barrier to uptake. Minigrids are frequently undersized due to uncertainty in demand and fail to meet all energy needs which often arise after electricity becomes available.

Seperately, the growing number of illegal e-waste dumps in Myanmar is burdening the country's waste management sector, posing both an environmental and social threat. Large amounts of waste are imported from China or Nepal,

entering Myanmar's waste value chain through the informal sector. Additional waste is produced in-country, particularly in Yangon.

Finally, the current lack of community-centric businesses, jobs and income-generating opportunities is inhibiting development in remote areas of Myanmar. This lack of opportunities results in limited jobs, a small market for local businesses, and low education and skills levels.

AMPERES' e-waste to e-cooking initiative addresses all three of these challenges. It promises to improve access to reliable electricity supply for households, reduces e-waste, and brings local manufacturing capabilities and jobs to villages.

About the innovation

The AMPERES-Switch Batteries partnership is based on a vision of facilitating electricity-powered cooking by making off-grid electricity truly accessible to communities. The e-waste to e-cooking initiative has developed an affordable,

reliable, dispatchable power source, based on upcycling and reusing Li-ion batteries. This technological innovation promises to help off-grid communities transition from traditional cooking methods to energy-efficient and healthier modern cooking practices. It also opens the potential for dispatchable power supply for other productive home and village uses. From the end user's perspective, this product will support the use of appliances such as induction hobs, rice cookers, and pressure cookers. The innovation aims to target off-grid areas and unlock the potential of affordable electricity for weak-grid households in Myanmar.

The intervention generates a reduction in environmental waste through the reuse of reconditioned Li-ion cells. The use of upcycled power packs reduces upfront costs considerably. The ability to close the waste-management loop allows the product to be cost-effective, with final energy costs comparable to current energy alternatives. The low supply-chain costs become an essential factor in determining the highly affordable price.

The partnership proposes a franchise-styled community-centric model that features co-ownership by locals and substantial local control over resource streams. The Li-ion cells will be repurposed at the local level, at local assembly sites, with testing taking place in decentralised locations. Local distribution channels will disseminate the power packs to end users.

The organisations currently offering cooking stoves on the market have not yet ventured into purely battery-driven products. Ordinarily, the high cost of new batteries makes this proposition unattractive, with batteries thus functioning only as starters or combustion enhancers for gas-based cookstoves. However, case studies (MECS, September 2020) have shown that the business case associated with a battery-based e-cooking intervention can be strengthened by increased benefits such as the ability to connect with other household appliances.

Upcycled lead-acid batteries (LABs) for industrial appliances are already offered in the market by Upcycled Batteries in the United States and Recylex in France/EU, for example. In Europe, a number of companies including General Motors, Nissan, BMW, and Daimler AG have provided incentives for companies which up- or recycle batteries thus unlocking the value inherent in used batteries. American companies such as Rivian and Protera are designing EV batteries so that they can be recycled from the beginning. While China, Europe and the state of California (United States) are heading in this direction, there is as yet no collective effort of this kind present in Myanmar or the South and South-East Asia region overall.

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Heat shrinking as part of battery upcycling from e-waste (Myanmar, 2020)

© AMPERES

Installation of upcycled batteries (Myanmar, 2020)

Installation of a community solar PV system (Myanmar, 2020)

Training session on cell grouping with local community on upcycling of batteries (Myanmar, 2020)

Transitioning away from lead-acid batteries

Presently, used LABs are widely used to power stationary electricity-storage applications. The popularity of solar home systems of this kind in Myanmar has contributed significantly to their presence in the market, despite LABs' lower efficiency, lower deep-charge capability, shorter lifetime (around 18 months), and higher operational cost as compared to lithium-ion batteries. These technical performance factors present the risk that consumers will be forced to take on more debt in order to operate and replace these batteries. In addition, LABs require more space than Li-ion batteries for systems with comparable capacities. Although SHSes currently rely mainly on LABs for storage, a shift is underway towards Li-ion batteries. This is being driven by declining prices for Li-ion-based storage, as well as this technology's higher performance

and expanding market presence in recent years. Moreover, the environmental and health risks associated with the disposal of lead-acid batteries at the end of their lives also make this a less attractive solution. An imminent transition to solar home systems based on Li-ion battery technology can be foreseen. Thus, given the influx of Li-ion batteries into the e-waste mix across the waste value chain, AMPERES seeks to unlock the potential of upcycled power packs based on these batteries.

Illustration of business model innovation
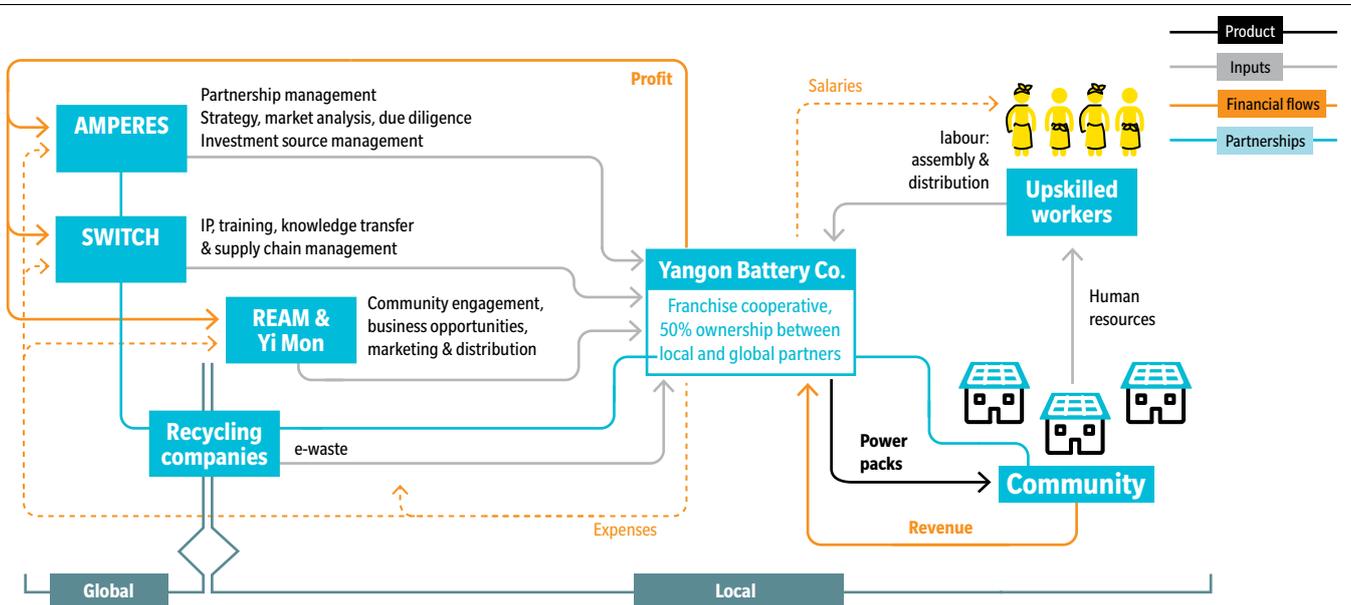
CASE STUDY

THE AUSTRALIA – MEKONG PARTNERSHIP FOR ENVIRONMENTAL RESOURCES AND ENERGY SYSTEMS (AMPERES)

Committed to finding integrated solutions for the sustainability challenges facing South-East Asia and Australia

Power pack assembly unit established by AMPERES-Switch Batteries, Pannyo (Myanmar, 2020)

AMPERES at a glance

AMPERES is a mission-driven enterprise focused on solving sustainability challenges facing South-East Asia and Australia by improving society's use of vital energy, water, and environmental resources. The e-waste to e-cooking project was conceived in collaboration with AMPERES technology partner Switch Batteries and implementation partners REAM and Yi Mon Electronics. As a technology innovator experienced in bringing high-quality standardised products to market, Switch Batteries played an essential role in the initiative's design and implementation stages, as well as in the process of transferring the technology from Australia to Myanmar. REAM and Yi Mon Electronics engaged local stakeholders and supervised the local manufacturing process during the project's pilot phase.

The focus of the innovation presented here is an affordable and portable power source designed to support underserved households' transition to modern cooking services, and eventually to other productive applications.

Currently, Myanmar produces a growing amount of Li-ion battery-appliance waste, generated by electronic goods (smartphones, laptops) and the increasing number of EVs. Only a small fraction of Li-ion waste is recycled at present.

Key figures

- Key geographies: Offices in Australia and Vietnam, with battery recycling projects being implemented or considered in Myanmar, Vietnam, Indonesia, and Bangladesh
- Team: 18 project staff members
- Turnover: 100,000 USD estimated for future e-waste battery-recycling activities
- Installed systems in prototype phase: 20 units in Myanmar (2020)
- No. of beneficiaries: 100 (2020)
- Year founded: While AMPERES was founded in 2015, the e-waste project began in 2018.

Business model innovation

- Product: Power packs based on upcycled Li-ion batteries
- BMI: Circular recovery – end-of-life management / upcycling of power packs for productive use applications
- SDGs addressed:

Contact details

- Website: https://www.amperes.com.au/home
- Tarek Ketelsen, director general

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"Remote off-grid communities in Myanmar stand to benefit the most from electricity access, yet they face the highest costs for electricity compared to all other consumer segments in the country. We sought to address this problem in two main ways: by innovating the technology of batteries to bring the costs of dispatchable electricity down, and by innovating the business model to share ownership and centre more of the whole electricity-services value stack with local communities. That means clean, affordable electricity, employment, and a shared mutual interest in the prosperity of the business."

Tarek Ketelsen, AMPERES

Demonstration of a rice cooker powered by electricity (Myanmar, 2020)

The value proposition associated with the proposed deployment for cooking functions encompasses a number of individual benefits, including:

- New village revenue and employment streams due to local manufacturing
- Reduction in e-waste in landfills
- Affordable power source
- Portable, dispatchable power sources
- Reliable, efficient on-demand cooking
- Healthy alternative to wood fuel, with improved air quality in the home

Following a pilot in the village of Pannyo, the project is considering expansion into locations like Yangon, Taunggyi, and Mandalay as a means of scaling up country-wide operations. Thanks to strong local networks, expanding distribution to Vietnam, Indonesia, and other Southeast Asian countries is also possible.

Innovation at AMPERES

The AMPERES-Switch Batteries circular e-waste to e-cooking business model is an example of a resource-recovery model that upcycles waste into secondary raw materials (power packs), thereby redirecting waste away from landfills. It displaces the need to extract and process virgin natural resources for the production of new units.

After mapping out the e-cooking problem context in Myanmar, this business model incorporated three key innovations, as detailed below.

The first innovation is the reuse of e-waste, through the development of standardised, modular and shareable batteries

based on open-source technology. These are built using upcycled e-waste streams, and incorporate existing battery management systems (BMS) built by Switch Batteries for high-performance electric vehicles. The design process included the standardisation and consolidation of methods developed by a global community focused on building so-called DIY Powerwalls using 18650-format[5] Li-ion cells recovered from e-waste. During the pilot phase, it was discovered that households used an average of 0.7 kWh per meal. The product design was subsequently based on this and other insights. While a 1 kWh battery can be used to cook an evening meal, heat water and provide light at night, the final product was increased to 2.5 kWh to allow households to add more appliances. Thus, cooking is no longer competing for electricity with lighting or entertainment needs. The power source was designed to be compatible with a range of cooking equipment commercially available in Myanmar, including induction hobs, pressure cookers, and rice cookers. The Li-ion upcycled power packs can thus be integrated as part of a single modular appliance. The system's built-in capacity for grid integration and grid charging provides flexibility, and the integrated BMS is vital to withstand voltage fluctuations. The open-source design will facilitate local manufacturing from locally sourced materials, including e-waste from e-bikes, computers and laptops, and mobile phones.

As an early step, the AMPERES-Switch Batteries partnership saw that technology transfer would be essential in sustaining a business model that included local assembly and human resources (see p. 11). Consequently, it pursued a novel

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5   Refers to rechargeable Lithium-ion batteries (18mm x 65mm), which have been used by individual innovators to develop small-scale battery storage systems. Collaboration is encouraged, free of cost, on open web-based platforms.

Consultation with village community members (Myanmar, 2020)

approach focused on decentralised, community-level micromanufacturing rather than large-scale corporate production. Switch Batteries organised the knowledge transfer and implemented the on-ground activities during the pilot in Pannyo village. An appropriate tool-and-literature set for battery micromanufacturing was developed for the purposes of transferring knowledge to the local level. This model promises to foster the creation of new small businesses and microentrepreneurs across the entire supply chain in target regions. A supply chain that combines the collection of e-waste, promotion, assembly of the power packs, and distribution close to the customer is a critical factor in building resilience as it is less prone to external shocks. For example, this strength became apparent during the COVID-19 pandemic in 2020, which undermined global supply chains, the flow of finance, and the purchasing power of consumers. However, the pilot was able to continue production despite interruptions in international trade, displaying the advantage of such an approach.

Lastly, the project uses an innovative co-ownership model that shares revenue with local entities. Unlike the typical corporate approach, in which conglomerates move secondary and tertiary industries to low-cost developing economies such as Myanmar, the AMPERES-Switch Batteries model shifts production to the the village to anchor more of the value-stack at the village level. In the next phase of the initiative, the partnership plans to establish a Yangon Battery Company, in which local companies will take ownership shares. The partnership has further collaborated with the Renewable Energy Association of Myanmar (REAM) and Yi Mon Electronics in Myanmar, successfully fostering community engagement. Local e-waste company RecyGlo helped the project engage with entities making up the local waste value chain.

AMPERES' use of Li-ion batteries for the purposes of e-cooking is unique. The organisation has been recognised for its business model innovation, and was a finalist for the Powering the Future We Want energy grant awarded by the United Nations Department of Economic and Social Affairs (UN DESA) in 2017.

Success factors for business model innovation

- High-quality product design based on global standards
- Open-source technology transfer and ecosystem, enabling decentralised dissemination of the products
- Community engagement in identifying productive use priorities
- Franchisee business model, with franchises co-owned by local enterprises
- Strong connection to e-waste supply chains
- Business franchise can adapt to an evolving regulatory environment

Spotlight on partnerships

The partnership's experience in Australia helps ensure technological consistency and high standards. The project will engage in local skills-development training, and help create local partnerships for power pack micromanufacturing. A related joint venture under consideration is the Yangon Battery Company, which is scheduled to feature 50% ownership by the AMPERES-Switch Batteries partnership and 50% by Yi Mon Electronics and REAM from the local business company.

Switch Batteries designed the high-quality, standardised, modular, open-source power pack and assisted with technology transfer to local entities.

 Yi Mon Electronics and **REAM** are in charge of sourcing, manufacturing, assembly, marketing and distribution.

The goal is to develop an in-country enterprise responsible for sourcing, assembly, distribution, and market development, and which leads all operational aspects of the business.

AMPERES is exploring new community partnerships, and is seeking to strengthen its links with the e-waste sub-sector, which could provide local expertise enhancing community engagement and buy-in, while helping to identify relevant challenges.

Spotlight on beneficiaries

The partnership has focused on identifying the needs of off-grid consumer segments. It is estimated that about 154 million households in South-East Asia and the Pacific are located in off- and weak-grid settings. Out of this number, it is estimated that 24 million households constitute an obtainable market. In Myanmar, this market includes about 1.3 million households and productive enterprises.

Myanmar's energy demand is outstripping generation capacity. This has negative social and economic impacts, but particularly for small consumers who cannot leverage their full economic potential. In the future, communities in weak-grid settings (about 15-20 million people) will also be assessed to identify suitable interventions.

Pannyo village: A six-unit pilot project, including a preliminary survey of household cooking habits and consumption needs, was used to study the prototype technology's performance and reception. Households assessed the power packs' performance and suitability by keeping a daily cooking diary.

Impact

Community: The benefits of electricity-based cooking include ease of use, a reduction in time spent cooking and preparing, reduced costs, a cleaner and smoke-free kitchen, a reduction in time spent collecting firewood, and the ability to multitask while cooking. The project encouraged users to maintain a daily cooking diary which increased the general knowledge about household fuel-wood consumption. More generally, the community benefits from the creation of new jobs, enhancement of local residents' skills through training programmes, and inflow of financial support for the establishment of new businesses.

Organisational: AMPERES has developed a business plan, and is establishing a local enterprise in Myanmar that will operate as a franchise cooperative. Community involvement will remain critical throughout all stages of the process.

Environment: Off-grid communities' reliance on firewood for fuel degrades local environments. The burden on Myanmar's forests and woodlands can be reduced by the elimination of biomass for cooking. The use of upcycled Li-ion cells also reduces the volume of e-waste flowing into landfills, which is partly generated in-country, but also comes from neighbouring countries.

Liberated spent Li-ion cells

Replication and scalability

The product sources recyled or reused components sustainably, which helps reduce the loss of non-renewable materials. This indicates growth potential decoupled from resource extraction.However, it must adapt to an uncertain and evolving regulatory environment with regard to waste management in Myanmar.

Shorter supply chains hold great promise in terms of achieving price parity. At the global scale, upcycled power packs reduce the price of electricity from renewable sources by 30% to 50% as compared to conventional lithium-ion storage. These lower prices are expected to accelerate the uptake in Myanmar.

The partnership is exploring financial avenues that will facilitate its establishment of the Yangon Battery Company in collaboration with local partners. Over the long term, the objective is to establish an open-source ecosystem that supports a network of related projects. For instance, this could include e-cooking stoves and home-storage power packs in Myanmar, electric sewage-collection tricycles in Bangladesh, and photovoltaic cold storage for fisheries in Vietnam.

MODULAR SOLAR SYSTEMS FOR ELECTRICITY POOR COMMUNITIES

© Solarworx

The SOLEGO 80/160 modular system (2020)

Key challenges

Whereas the global electrification rate reached 90% in 2018, over 800 million people worldwide still have no access to electricity (World Bank, 2020). Getting electricity to remote areas and people across Sub-Saharan Africa in particular, where 53% of the population still lacks access, is a major challenge.

The high up-front costs of energy systems today pose obstacles to efforts to serve this market. High costs are a barrier not only for the consumer, but also for solar product providers who have difficulties in creating financially sustainable business models. As the scale of customer demand for electricity is unclear, it is easy to over- or underestimate actual electricity consumption levels, adversely impacting the profitability of companies offering products and services in the off-grid space.

The products or services currently available in the market are not encouraging increases in appliance uptake and electricity demand. The reasons for this are the high upfront costs for the assets, the lack of knowledge on how to use or integrate appliances in existing business practices, and limitations of access to electricity. Rather, they are locking in end users through their high up-front costs and lack of modularity. Therefore, the demand for these products remains low, with the broader population seeing little ability to expand their consumption through the use of higher-capacity systems.

CASE STUDY COMPANY
Solarworx GmbH

PRODUCTIVE APPLIANCE
Solego: Modular off-grid solar systems for homes and businesses

SIMILAR BUSINESS MODEL INNOVATIONS
Fosera, Okra Solar, ME SOLhare, Solartechno, Unbound Solar

The lack of knowledge about the benefits of energy-system products can also constitute a barrier. Consumers are often averse to new technology, and are not aware of how it can increase income and/or quality of life by powering useful household or business appliances.

In some cases, energy-system providers fail to measure correctly energy demand and needs, and to accurately estimate potential growth in energy use. This disconnect from the community can result in products that are difficult for the consumer to understand and operate. A non-consumer-friendly interface may inspire resistance or indifference within its ostensible target market. As a result, training consumers to use the product becomes a challenge, limiting business model replicability.

The entire off-grid solar sector faces the challenge of disposing of products that have reached the end of their useful lives. Indeed, the contribution of solar products to e-waste streams is increasing every year in proportion with the increase in sales. Consumers are often ill-informed about

appropriate disposal or recycling opportunities (if available). Very few solar companies or distributors offer waste collection services, and the solar market is still viewed as having an overall negative recycling value.

About the innovation

The innovation featured in this case study is based on a state-of-the-art combiner box, itself part of Solarworx's Solego product range. The unique design of Solego's combiner box gives it the ability to intelligently interconnect solar panels, batteries, and appliances.

The solar systems included in the Solego product range all feature this integration technology, and support PAYGo billing structures. This ensures that the company's offerings for homes and businesses are affordable, modular and scalable. It allows users to adapt their stand-alone solar systems to serve their growing demand for electricity. The products' remote-monitoring function and easy payment features are designed to overcome high up-front costs, thus making the system more affordable for the end user.

The modular solar system is focused on supporting productive uses within households and small businesses. In households, such uses may include expanding lighting or powering electronic and electrical devices that contribute to a better quality of life. This may, for example, provide more time for cooking in the evening, open up longer periods of time for studying, or allow people to spend time with their families and neighbours while watching the TV or listening to the stereo. For small businesses, these systems make it possible to invest in refrigeration and cooling appliances that improve the longevity of perishable products. Similarly, investment in electrical processing appliances can increase productivity and revenue potential.

While expanding the capacity of existing systems will make them more useful, it is envisaged that in the future, such systems will also support interconnection with neighbouring solar systems, facilitating electricity sharing. Such an approach would allow the off-grid electricity ecosystem to implement peer-to-peer electricity trading, potentially increasing demand organically within underserved communities. For example, potential electricity users could purchase electricity from neighbours who already had such systems, but who did not consume the full amount of electricity produced, particularly during the day. This surplus could be sold in real time or stored by the system owner using a product like Solego, and subsequently sold to a neighbour as the demand arose. This shared-ownership model and the opportunity to generate more income by providing electricity as a service represents the next evolutionary step for Solarworx's innovative product offering.

Companies such as ME SOLshare, Unbound Solar, and Solartechno have introduced modular products that focus on an improved consumer experience. However, one of the differentiating features of the Solego range is its unique audio-instruction function, available in local languages. This feature goes a step further with regard to simplifying the consumer experience, and reduces the need for local distributors to provide detailed customer training and other customer-care services.

Solarworx places a strong focus on design and manufacturing quality. The sale of the solar systems and the associated Solego products uses a business-to-business (B2B) model instead of a business-to-consumer (B2C) approach.

Illustration of business model innovation
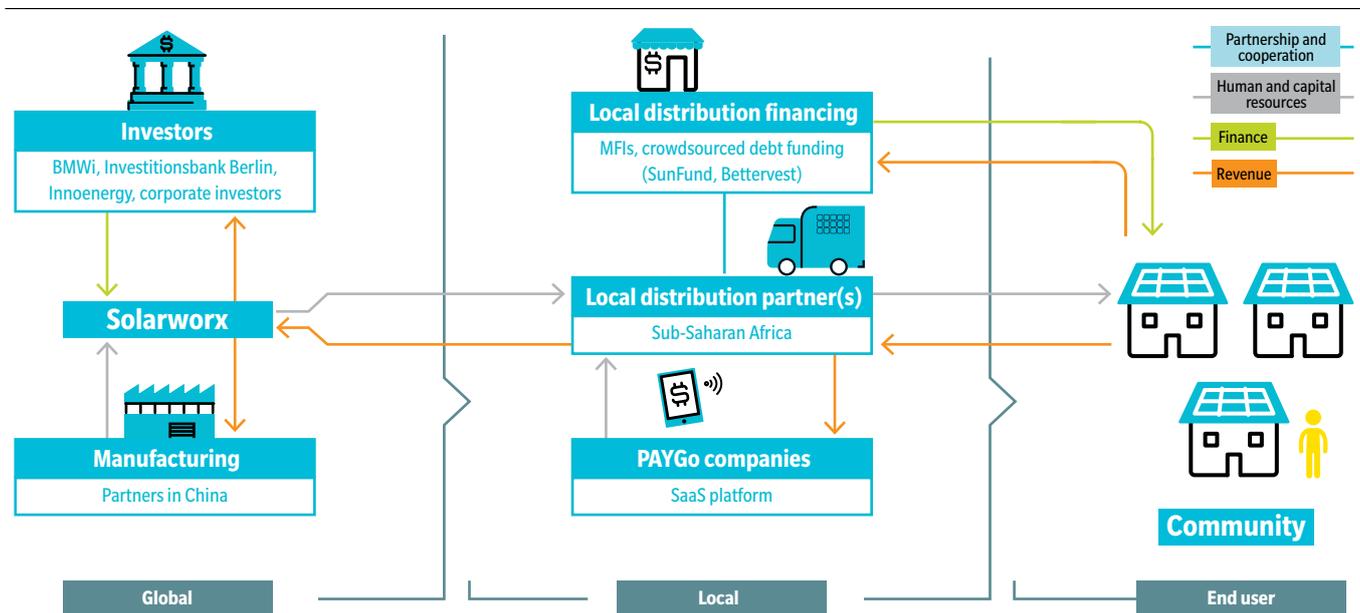
CASE STUDY

SOLARWORX, A BOTTOM-UP OFF-GRID SOLAR ELECTRIFICATION STARTUP

Design and manufacture of scalable and modular PAYGo-enabled solar solutions to provide electricity access to off-grid communities worldwide

First prototype installation by Solarworx in Cameroon, April 2018 (Source: Solarworx)

Solarworx at a glance

Berlin-based startup Solarworx has been working since 2018 to provide a large population with solar-based power solutions. The company offers energy access that can expand along with customers' demand. Solarworx's modular solar system design can keep pace with customers' increasing incomes and energy needs. In addition to stackable modules, a DC microgrid extension module has been developed that allows existing devices to connect with each other, forming a microgrid (enabled with PAYGo functionality and remote-monitoring features). The Solego system is included in bundled products, and comes with capacities of 80Wh or 160Wh. Products are marketed in such a way that they can be easily associated with the main appliances they can power; thus, the product range includes water-pumping kits, refrigeration kits, barbershop kits, lighting kits, and home kits. These kits power devices including LED lights, radios, ventilators, phone-charging points, laptops, televisions, hair cutters, solar fridges, water pumps, and angle grinders.

Solarworx creates partnerships to offer a wide array of end-user financing (with microfinance institutions) and payment options (with mobile money providers). Its B2B approach, involving partnerships with local distributors, enables broad deployment even though Solarworx is based in Germany. This

Key figures
- Key geographies: Germany (design), China (manufacturing), Cameroon, Senegal, Zambia, Kenya, Tanzania, Rwanda and Uganda (distribution)
- Team: Eight permanent employees
- Year founded: 2018

Business model innovation
- Product: Solego: modular off-grid solar systems for homes and businesses
- BMI: Circular design – modularity, stackable
- SDGs addressed:

Contact details
- Website: https://www.solarworx.io/
- Felix Boldt, founder and CEO

also shields Solarworx from incurring liability due to remotely controlled direct sales.

While distributors selling solar home systems are the primary clients, indirect beneficiaries of Solarworx products include households and small businesses. Target beneficiaries range from peri-urban areas that have minimal or unreliable grid access (referred to as "under the grid") to the most remote locations in Sub-Saharan Africa.

An initial pair of pilot projects in Senegal and Cameroon in 2018 featured the installation of 250 systems, followed by five Solego product bundles. Distribution is today scaling up rapidly across Sub-Saharan Africa, with Solego products available in Ivory Coast, Nigeria, Togo, Zambia, Malawi, and Uganda since 2020.

"As an aspiring manufacturer of solar off-grid solutions, Solarworx seeks to revolutionise energy access. The modularity and interconnectivity of our products enable off-grid users to experience an innovative and new way of electrification – not only achieving SDG 7 by 2030, but also letting millions of people climb the energy ladder is at the heart of our mission."

Felix Boldt, Co-Founder and CEO

Innovation at Solarworx

Solarworx's innovation stems from the unique value proposition provided to the end user – that is, an energy infrastructure that grows with the consumer's energy needs and demands. It avoids duplicative capital expenditure on the power system each time the user wants to increase power-generation capacity and appliance use. The relationship between Solarworx as a product and service provider and the households, consumers, and MSMEs it serves is envisioned for the long term by using a circular utility model. This implies that the business model's success requires Solarworx and its distribution partners to provide end users with long-lasting products and services. This will, over time, reduce resource extraction and maximise product utility.

The use of an Internet of Things (IoT) infrastructure is a critical innovation with regard to system data management and analytics, enabling remote operations with partners across the globe. For example, aspects of the product design can be encrypted and communicated safely to manufacturing partners in China. The distributors, who

Installation of Solarworx system through local distributors (Cameroon, 2019)

act as Solarworx's direct clients, can subsequently use this technology-enabled distribution architecture remotely, receiving support in marketing and sales, installation procedures, and post-sales servicing through remote diagnosis.

As a material innovation, the product's casings are made from non-polluting bio-plastics. This highlights the priority given to sustainability throughout the design process.

Amongst other features, the product design includes a consumer-conscious interface with audio instructions provided in local languages. On the financing front, PAYGo features and mobile money options enhance affordability for the target community.

Technological innovation

Solarworx's base module features capacities as low as 50W, but can be scaled up to almost 500W. The use case appeals to households, farmers, builders (heavy-duty work), and other small businesses. For families, the modular system serves devices including TVs, security lights, fans, refrigerators, laptops, LED bulbs, USB ports, and portable stereo radios. To serve businesses and the farming community, the system can be connected to power tools, water pumps, shop-lights, DC refrigerators, or USB charging portals, or can even be used to sell electricity to neighbours. The products guides the end users in local languages such as English, French, Swahili, and Wolof.

Solego products undergo an internal quality-assurance testing process, and are marked with a unique identification code before dispatch. Each system is heavily encrypted in a manner connected to its unique identification code. A monitoring feature included in the systems allows for remote maintenance services. The use of IoT technology allows design, production, and remote monitoring to be tracked more accurately. This allows processes to have clear ownership, implementation protocols, and data-protection requirements, and in turn makes it easier to collaborate with businesses along the entire supply chain without compromising on Solarworx's unique design, high manufacturing standards, and data security.

© Solarworx

Installation of Solarworx system through local distributors (Cameroon, 2019)

The product uses an environmentally sustainable design. The product housings consist of wood-based plastics, and the innovative batteries (LiFePO4) are not made of rare resources. With regard to the issue of recycling batteries, Solarworx is currently in conversation with European recyclers, and is evaluating a sustainable process to close the materials loop, and thus further reduce its intake of new raw materials for each product.

Distribution strategy

The organisation provides an intensive onboarding service to each new distributor, helping to enhance its operational processes in order to improve end-customer acquisition. The product can be sold outright to end customers, or can be financed through a loan that makes use of a microfinance payment plan. Solarworx and its distributors use the expertise of collaborating microfinance banks to ensure customer creditworthiness.

The systems can be activated by the customers using mobile phone credit instalments. However, even in the absence of PAYGo features, payments can be made using vouchers/scratch cards that can be purchased directly from kiosks. Solarworx devices are integrated with software-as-a-service (SaaS) platforms used by off-grid distributors that allow the company to integrate the technology seamlessly into existing distributor processes. The SaaS platforms enable distributors to monitor sales, track payments and invoices, oversee system operations, and establish a technology-based consumer interface all through a software application.

Solarworx's innovation has received several awards and grants. In 2018, the Investitionsbank Berlin (IBB) approved a grant for Solarworx's sustainable business model. They are also a beneficiary of KfW DEG's grant scheme (DEG Ventures, 2020-21). The company also won the Digital Solar and Storage award sponsored by SolarPowerEurope, the BPW energy startup business plan competition, and the Empower a Billion Lives (EBL) competition in Baltimore (2019). It was also recognised at the MakeItMatter awards (2019), and was nominated as one of the top 100 cleantech start-ups by the Germany Energy Agency (Dena) and the World Energy Council (WEC).

Success factors for business model innovation

- Consumer-centric design and user-friendly interface
- Scalable modular component system that addresses affordability challenges
- Decentralised operational model that includes partnering with local distributors to reach consumers, thus mitigating regional market risks
- Strong focus on IoT infrastructure, enabling a dependable supply chain

Spotlight on partnerships

At the time of the prototype installation in Cameroon, the company's co-founders realised that for their technology to be successful, synergies and partnerships had to be established in place of centralised and often complicated, lengthy supply chains.

The B2B sales strategy focuses on local distribution partners, PAYGo companies, and financing institutions with a focus on Sub-Saharan Africa. The solar home systems, with PAYGo and remote-monitoring features, are designed in Germany. After the products are manufactured in China, they are sold to the distribution partners in Africa. Solarworx helps train the distribution partners, and provides strategic marketing and sales support.

The company works with leading software and technology providers, including Solaris Offgrid, Angaza, PaygOps, PAYGEE, and Lumeter, to facilitate last-mile functions such as customer management and after-sales services.

The company relies on regional partnerships, such as its partnership with Solkamtech (Cameroon) under the USAID / Power Africa grant, to provide bundled services such as solar home systems and LPG cooking solutions.

Spotlight on beneficiaries

The success story of 42-year-old farmer Ngamu Nyouma from the village of Sekande in Cameroon illustrates the product's real impact on users. Nyouma's income from livestock earnings was decreasing to levels that made basic living difficult. However, his situation improved dramatically when he invested in the Solego haircutting system, setting up shop with an initial outlay of only USD 142, and using the pay-as-you-go service. Even after loan-servicing expenses, he now saves nearly USD 1.74 out of the USD 3 he earns each day from haircuts and phone-charging services. In the evenings, Nyouma carries the system home, allowing his family to engage in more household activities after dark. He also provides his neighbours with electricity free of charge, leading to stronger community cohesion. Inspired, he wants to pay off his credit early, and invest in a new shop to expand his business. Nyouma's transition illustrates the benefits possible using community-conscious technology solutions.

Impact

Community: Product design decisions centre on the community's needs, allowing customers to increase system capacity as required. The Solego range of products, which allow connections between solar panels and with additional consumer appliances, are built as portable and expandable products. The flexible financing options lower the entry barrier for the end user, making the systems more affordable for low-income consumers. Working through local distributor networks opens opportunities for community-led business models.

Organisational: The company has eight full-time staff members, with a network of more than 10 distribution partners across Sub-Saharan Africa. Solarworx provides its distributors with capacity-building support, and helps bundle products with marketing strategies suitable for specific target consumer segments.

Environmental: As an immediate next goal, Solarworx plans to expand its activities to 12 countries. As a result, it will have a positive impact on off-grid households resulting in the abatement of more than 61,000 tonnes of CO_2 emissions due to the use of better-quality materials, the replacement of polluting fuels, and improved logistics. Ecologically sound materials are used to produce the systems, and the batteries used do not include rare elements. There are plans to improve material recyclability, and the company is currently in discussions with relevant stakeholders on the issue of battery recycling.

Replication and scalability

While Solarworx is looking to replicate its business model in new markets, it first needs to overcome some challenges. These include harmonising product quality standards with international and national regulations, and achieving interoperability across systems and national B2B distributors. The company has developed independent testing protocols separate from those of the International Electrotechnical Commission (IEC) or Lighting Global. However, many countries are also creating their own standards. This regulatory aspect may pose a challenge when seeking to enter new markets. To avoid this, Solarworx is in conversation with market competitors to help achieve further standardisation, which would enable interoperability across systems. The organisation perceives that this would reduce the chance of conflict with regulators, and could even be a best practice for regulatory bodies to consider when formulating standards.

The B2B approach means that Solarworx engages with distribution partners in regions across the target countries. The company sees its combined technological design and distribution approach as a replication strategy that gives it a significant competitive advantage in the Sub-Saharan region.

There is considerable potential with regard to scaling the business model as it provides a solution to the problem that many parts of solar home systems (like the batteries) need to be replaced just after the system has been paid of after three to four years. This keeps users from buying larger systems as they cannot afford them. Solarworx's products enable the user to grow their system with their growing demand for electricity. Through concerted recycling and disposal efforts, Solego systems have the potential to recover material and save costs. To this end, Solarworx is aiming to incorporate best practices for end-of-life management by seeking partnerships with recyclers. Such a strategy would help maintain the product line's core value proposition, while improving the business model's ability to scale up in system size and across consumer segments.

Several countries are subjecting off-grid solar businesses to increasing regulation, since they are provided with government incentives such as capital subsidies, licensing allowances, and other tax benefits. Solarworx's outreach strategy is a mitigating factor here. The company's local partners share both the local risk and the associated revenue. The product deployment partnerships are not limited to any major distributor, therefore creating healthy market competition. These aspects reflect a business structure that promises robust business model scalability.

INTERCONNECTED SOLAR HOME SYSTEMS MAXIMISE UTILITY

© ME SOLshare Ltd.

Microfinance loan officer training session on usage of the monitoring Android-based SOLapp (Bangladesh, 2018)

Key challenges

Since 2010, Bangladesh's progress in reducing the electricity-access deficit, at an annual rate of over three percentage points,[6] has placed it among the world leaders in this regard. These steps forward have resulted due both to decentralised and centralised electrification infrastructures.[7] [8] On-grid electrification has reached about 93% of the population, according to official statistics.[9] However, Bangladesh has implemented one of the most successful off-grid access programmes in the world. Managed by the Infrastructure Development Company Limited (IDCOL), a government agency, in partnership with non-governmental organisations responsible for financial inclusion, the SHS programme has reached over 4.3 million households and businesses in remote rural areas of Bangladesh. It is expected that Bangladesh will achieve universal access to electricity well ahead of the Sustainable Energy for All (SDG 7) target of 2030.

CASE STUDY COMPANY
ME SOLshare Ltd.

PRODUCTIVE APPLIANCE
Village cinemas (large TV), barbers (hair trimmers), computer shops (printer, photocopy and internet), pharmacies (fridge for medication and nebuliser for children with asthma), sewing room (motor), electric rickshaw charging

SIMILAR BUSINESS MODEL INNOVATIONS
Okra Solar, Solarworx

However, the aggressive national grid expansion has not taken the existing stock of 4.3 million SHSes into account, creating three issues. First, at the household level, many end users have been left with dual power infrastructures – one based on the new AC grid, and the other based on the DC SHS. This has resulted in redundant wiring, and has required investment in new compatible appliances. Second, the national grid is unreliable, with frequent power outages, voltage fluctuations, and brown- and blackouts, forcing end users to rely on a secondary power option – usually either a pre-existing SHS, or a backup diesel generator. Third, all SHS systems were acquired through IDCOL's microfinancing program with consumer financing provided through the financial-inclusion partner organisations; however, as households were connected to the grid, these end users stopped utilising the solar systems, and hence also stopped repaying the microloan instalments. This

6   IEA, IRENA, UNSD, WB, WHO. Tracking SDG 7: The Energy Progress Report 2019, 2019, https://www.irena.org/publications/2019/May/Tracking-SDG7-The-Energy-Progress-Report-2019.

7   Pachauri, S. et al. On measuring energy poverty in Indian households, World Development, 2004, https://www.sciencedirect.com/science/article/pii/S0305750X04001500?casa_token=HpZ7zu-t3HgAAAAA:uMPVxdtjHF5Tp4ZYesHE_isFu0KBf07p-wlMtPm5xhL43KQtZIH0C2ZQN_zNdAxefu7p3-ZstBY.

8   Groh, S. The role of energy in development processes --The energy poverty penalty: Case study of Arequipa (Peru), Energy for Sustainable Development, 2014, https://www.sciencedirect.com/science/article/pii/S0973082613001087?casa_token=MKFgWywyH_QAAAAA:l_S7JBxpmcQJG3sKZ_U40pcKo-AJDVVqTM7rcHK_sEKPB9JL5HpbuA3Tkk3OXY1oAgjt1eH_EKg.

9   BSS Dhaka. Power coverage reaches 93pc people in Bangladesh, The Daily Star, 2019, https://www.thedailystar.net/backpage/access-to-electricity-in-bangladesh-coverage-reaches-93-percent-1748935.

Installation of the world's first peer-to-peer grid in a rural area (Bangladesh, 2015)

© ME SOLshare Ltd.

in turn led to numerous loan defaults within the partner organisations' portfolios, while also necessitating the disposal of a considerable quantity of batteries and photovoltaic (PV) panels.

Bangladesh's goal is to provide 100% of the population with access to electric power by 2021. However, more than 10 million people will not have access to grid-based electricity due to their geographical location in the deltas of the country, where the national grid's network cannot be extended. These remote communities also frequently have solar home systems installed, with an average capacity of 40Wp and a dump load of about 30% for each system due to system design constraints. This leads to an average daily excess capacity of 600,000 kWh. Further empirical data shows that people suffering from energy poverty in Bangladesh more generally spend approximately USD 3.50 per kWh for lighting, and USD 10.50 per kWh for mobile phone charging.

About the innovation

Peer-to-peer grids enable bottom-up, decentralised electrification, facilitating both the consumption and production of electricity via electricity trading. P2P electricity trading is a business model based on an interconnected platform that serves as an online and physical marketplace in which consumers and producers trade electricity directly, without the need for an intermediary. P2P electricity trading can be compared to the activities of Uber or Airbnb, as it provides a platform that allows distributed local energy generators to sell the electricity they produce at the desired price to consumers willing to pay that price. The P2P trading model can be established among neighbours within a local community, as well as on a larger scale, among various communities. It emerged as a solution to the growing use

of decentralised energy sources, which creates redundant consumer-level infrastructure (multiple power-generation sources) and involves end-of-life management issues for system components (batteries, solar panels, cabling).

There are several notable P2P initiatives around the world. In Malaysia, the Sustainable Energy Development Authority is piloting a P2P grid through which "prosumers" who both generate and consume energy can trade electricity with pure consumers or sell their excess solar photovoltaic electricity to the local utility provider, Tenaga Nasional Berhad (TNB). Activity on these exchanges is tracked using blockchain technology. The Brooklyn Microgrid pilot is an energy marketplace which allows prosumers to sell the excess solar energy they generate to New York City residents who prefer to use renewable energy. In Cambodia, Okra Solar works with the national utility to expand energy access within remote areas. With the help of an IoT technical architecture, Okra Solar builds IoT smart grids that are owned by the national utility. Each home interconnected within these mesh grids has both PV panels and batteries installed. If a family fails to pay for electricity, it can be disconnected without affecting its peers, the other households integrated into the mesh grid.

In Bangladesh, SOLshare was in 2015 the world's first company to set up a solar P2P trading grid, thus bringing solar energy to remote rural communities that are either off or weakly connected to the grid. Using a circular economy approach, SOLshare seeks to leverage the existing SHS infrastructure and increase its utility in the following ways: 1) reducing end users' electricity-usage redundancies by eliminating AC/DC compatibility issues for appliances; 2) assuring an uninterrupted energy supply when the end user needs and can afford it; and 3) increasing the utilisation of existing assets – the SHSes – with each SHS component

playing a role in the newly formed P2P grid. Under this model, the PV panel becomes the electricity generator for any interconnected household, while the the battery serves as a reservoir storing electricity that can be sold to other households.

SOLshare has taken advantage of the market opportunity within Bangladesh by allowing people both with and without SHSes to trade surplus electricity. SOLshare targets Bangladeshi households and small businesses in densely populated off-grid villages. These communities need a flexible, stable, and sufficient supply of electricity, at an affordable price point, for lighting, phone charging, entertainment, and business-generating activities. SOLshare's direct customers are the microfinance institutions or NGOs that provide loans and distribute the solar systems.[10] These partners need an innovative means of improving their current portfolios, including ways to incentivise end users to consume electricity, repay microloans, and acquire new appliances. This allows these organisations to offer products better suited to the market – for example, productive appliances and loans for businesses – while also making a healthy profit. Thus, the market opportunity rests in interconnecting existing decentralised solar-energy generation and storage assets, thus linking producers, consumers, prosumers, and large companies in smart grids that enable P2P energy transactions.

SOLshare provides low-cost solar-energy trading, PAYGo and cash-in-as-you-go (CAYG) solutions to low-income citizens,[11] transforming the way they use and pay for clean energy. Users become solar entrepreneurs, earning money in real time by trading surplus solar electricity generated by their SHSes with their peers. Peers are other SHS users who need more electricity than their system provides, or non-users who cannot afford the price of a complete system. SOLshare has been called the Uber of the off-grid world, as it does not own its fleet of SHSes, but instead aggregates existing underutilised assets and provides a metering, distribution, and payment platform for the efficient allocation of clean electricity in off-grid areas. The SOLshare P2P solar electricity-trading platform leverages a growing market of more than 4.3 million SHSes (most of them with batteries) through close B2B partnerships with large Bangladeshi SHS providers that serve both as microfinance providers and product distributors. These providers have experience both with financing and distributing SHSes, as well as with providing technical training and after-sales services to rural households and SMEs. The SOLshare platform consists of two primary components. This is a hardware solution called the SOLbox, the world's first DC bi-directional smart meter and solar-charge controller, which functions as an individual node within the electricity trading network. The second aspect is a software solution, a digital backend that facilitates secure and reliable peer-to-peer (P2P) electricity transactions; this also features integrated mobile money payment services, as well as data-analytics and grid-management functions.

Illustration of business model innovation
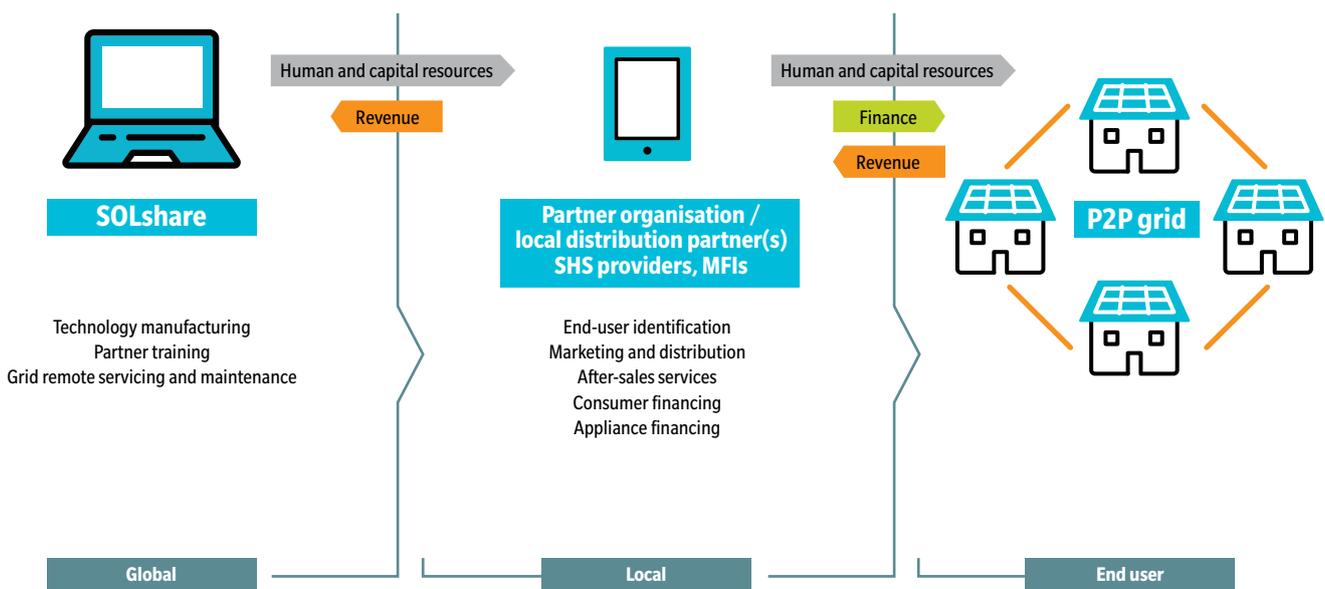
10 These partner organisations handle the entire supply chain, including the functions of end-user identification, appraisal, SHS installation, after-sales service, and loan collection.
11 Cash-in-as-you-go is the opposite of pay-as-you-go, with revenue generated per each kWh sold.

CASE STUDY

SOLSHARE, A START-UP BRINGING THE ENERGY TRANSITION TO THE GLOBAL SOUTH

Design and manufacture of IoT-driven trading platforms for rural households

©ME SOLshare Ltd.

SOLshare team-building event (Bangladesh, 2019)

SOLshare at a glance

SOLshare was founded in Bangladesh in 2015 to provide rural end consumers with a reliable supply of electricity at a rate affordable for people with very low incomes. It was inspired by a team of PhD students' findings that the millions of solar systems in Bangladesh produce a 30% surplus of energy totalling USD 1 billion in unused energy value every year.

This unused energy is available during the day, when SHSes reach their maximum capacity. However, everybody needs more power to run appliances during the evening and the morning, but however, this surplus energy was unavailable at this time, due to the systems' design constraints.

To address this problem, SOLshare developed SOLbazaar, an IoT-driven trading platform that enables people to trade the excess solar energy generated by their solar home systems. SOLbazaar is a dynamic energy marketplace that allows SHS users to sell their excess energy to other SHS users or non-users who lack their own home systems. Under this model, one party earns money, while the other gains access to affordable electricity. The energy sellers can also choose to keep the excess energy themselves, and utilise it to run extra appliances such as a TV, fridge, or computer.

Key figures
- Key geographies: Bangladesh, India
- Team: 70 permanent employees
- Year founded: 2015

Business model innovation
- Product: SOLbox: bi-directional meter for interconnecting SHSes; SOLbazaar: the energy marketplace
- BMI: Circular design – utility maximisation
- SDGs addressed:

| 1 NO POVERTY | 3 GOOD HEALTH AND WELL-BEING | 5 GENDER EQUALITY | 7 AFFORDABLE AND CLEAN ENERGY | 8 DECENT WORK AND ECONOMIC GROWTH | 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE | 10 REDUCED INEQUALITIES | 11 SUSTAINABLE CITIES AND COMMUNITIES | 13 CLIMATE ACTION |

Contact details
- Website: www.me-solshare.com
- Sebastian Groh, CEO

SOLshare's end users fall into three categories: consumers, producers, and prosumers. Pure consumers are usually low-income families (average family size is 4.5 people) who cannot afford to buy an SHS themselves. To access energy, they have previously used kerosene lamps or had their lamps and mobile phones charged outside their homes at a high cost. With the SOLshare solution, they can save up to 50% and benefit from the convenience of charging

Demonstration of SOLgrids-powered internet use (Bangladesh, 2019)

"Bangladesh is home to the world's first ICT-enabled peer-to-peer electricity-trading network for rural households with and without solar home systems."

Jeffrey Sachs, director of Earth Institute

their appliances at home. If they have previously used kerosene lamps, there are also health benefits. Prosumers are households or small businesses with SHSes that need more power and flexibility. Microbusinesses include village cinemas (which need power for their large TVs), barbers (hair trimmers), computer shops (printers, photocopiers, and computers with internet access), pharmacies (refrigerators for medications and nebulisers for children with asthma), sewing rooms (motors), and general shops (fans and lights to attract customers). Last, producers are SOLshare's smart solar entrepreneurs who install systems for the sole use of selling the electricity produced to the grid for a profit.

SOLshare has won many awards, including the Ashden Award 2020, the MIT SOLVE 2020 "Good Jobs and Inclusive Entrepreneurship" award and the DAVOS ENERGY WEEK 2021 "Energy Efficiency" award.

By the end of 2020, SOLshare was operating more than 40 P2P grids in Bangladesh and India.

Innovation at SOLshare

SOLshare P2P grids are installed in areas that do not have access to the national grid. Villagers agree to set up a P2P network that consists of existing and new SHSes, along with storage devices owned by individuals. Like Airbnb, SOLshare creates a trading platform based on circular-economy principles. The community platform enables people to form a distributed clean-energy grid. Thus, people build the solar grid themselves, and can eventually connect it to the national grid. A SOLshare grid operates in a manner similar to a swarm of bees, in that no central intelligence governs the network, and a loss of power in one node is compensated for by the

contributions of others. Instead of individual solar home systems working in isolation, SOLshare's platform links them together to create a solar-power-production swarm, thereby allowing the use or sale of previously surplus and unutilised power produced by these systems.

SOLshare expects that solar panels will be the leading clean-energy technology in rural Bangladesh. Electric batteries powered by these panels will be used for appliances, agricultural machinery, and even vehicles. Electric vehicles such as rickshaws and small transports are widely used in rural areas. Nevertheless, no charging concept is currently in place. By creating a pool of solar units and enabling the interconnection of appliances consuming a lot of electricity, P2P grids are the ideal setting for rural solar power stations.

In a SOLshare grid, every node is connected through a SOLbox. The SOLbox is the world's first and only machine-to-machine (M2M) integrated direct-current (DC) bi-directional smart power meter; as such, it forms one node in a peer-to-peer DC solar grid. The SOLbox also optimises individual SHS battery charge states, and facilitates remote grid monitoring, optimisation, and control.

SOLbazaar, an energy marketplace for rural households

Technological innovation

The SOLbazaar P2P grid consists of three primary elements: the SOLbox, the SOLapp, and the SOLweb.

SOLbox is a bi-directional DC electricity meter that enables P2P electricity trading, smart grid management, remote monitoring, mobile money payments, and data analytics. The SOLbox enables the creation of a DC smart grid, integrating with existing hardware such as an SHS or battery, and then connecting this device with other SOLboxes in nearby homes or businesses. A SOLbox can either be connected to an existing SHS or be installed in a household that lacks any SHS of its own. In the former case, the functionality of the SHS is upgraded from being purely consumer-led electricity generation and storage system to a new function as part of a prosumer trading system, allowing it to become a source of income. In the latter case, where the household lacks its own solar system, it provides the ability to buy electricity with minimal up-front costs (that is, the consumer is not required to invest in a new SHS).

Business in rural Bangladesh using electricity for entertainment and news (Bangladesh, 2019)

The SOLapp manages customer portfolios, storing user information and payment details. It tracks users' activities and energy consumption. The information from these first two components is then passed on to the third component, the SOLweb, where the information is analysed and irregularities identified.

The SOLbox, SOLapp, and SOLweb together form the SOLbazaar, which enables one house to connect smoothly to another, ultimately supporting networks constituting hundreds of individual households, all of which is possible due to the open nature of SOLshare's trading platform. As the SOLshare network grows, it can also connect with the national grid, operating in island mode when the grid is unavailable, and drawing power from the grid when it is available.

The P2P grids are dynamic in the sense that new households can be added to the grid. The P2P grids can also be interconnected among themselves, thus growing in a bottom-up manner towards the national grid. Finally, the P2P grids can be interconnected to the national grid at a single point (referred to as the point of common coupling). Thus able to reach multiple end users through a single connection point, the national utility can reduce costs and risks associated with the new infrastructure (network extension, metres for each household). P2P grids also serve as a backup power source as built-in intelligence can balance loads and deliver excess power to strained national grids.

Distribution strategy

SOLshare's direct clients are the microfinance institutions and NGOs that sell solar home systems to rural consumers on a microloan basis, while also providing the necessary complementary services such as installation, consumer training, and maintenance. There are 56 such entities in Bangladesh, serving more than 4 million customers. These distributors have achieved economies of scale, while developing a good understanding of the market and solid

reputations. Moreover, these entities have worked with IDCOL to develop industry standards that ensure high product and service quality. SOLshare's clients are the largest such organisations, including Grameen Shakti (1.8 million solar systems distributed), UBOMUS, BGEF, REDI, and GHEL. SOLshare's sales and business-development team initiates, designs, and consolidates shared-value B2B partnerships with the distribution entities, allowing it to access a large customer base, secure mass production, and optimise the supply chain. Hence, SOLshare leverages existing distribution channels rather than selling products or services directly to end users. The financing and distribution entities take care of marketing, sales, and after-sales services, as well as technical training. This allows SOLshare to avoid distribution costs in difficult-to-reach geographically dispersed zones. However, SOLshare does provide training to the distribution entities and their technical service staffs, both with regard to installing and maintaining the hardware and operating the management platforms. Additionally, SOLshare has a customer relationship management system that helps solve any issues that may arise from the use of the technology platforms.

Success factors for business model innovation

- B2B partnership with local companies that provide direct service to end users in more than two million solar home systems

- Low technology cost, as components are manufactured close to end users

- Decentralised operational model that includes partnering with local distributors to reach consumers, mitigating regional market risks

- Strong focus on IoT infrastructure that enables real-time servicing

Impact

Community: By providing a market-based solution to participants in P2P grids, SOLshare helps create financial incentives to use energy resources more efficiently. Wasted energy means either energy that could have generated revenue for producers, or energy that has been paid for but is unused (or misused) by consumers. Within the P2P grids, participants are empowered to make rational decisions when using energy. As an additional benefit, the existence of a trading network incentivises private investment in renewable-energy generation, encouraging local entrepreneurs to invest in solar home systems to help satisfy growing demand.

Citizen: The ability to buy and sell electricity puts control directly into the hands of rural households. They are no longer only beneficiaries of rural electrification projects or simple consumers of energy. Instead, they are actors in the microenergy transition within their community. This empowerment has a direct impact on women, who are the primary SOLbox users during the afternoon trading hours when excess power is available. It also encourages children to learn the concept of commercial exchange. This gives the household's SHS an inherent value beyond that of merely energy access.

Environmental: Without having to acquire an SHS of their own, households can replace polluting energy sources such as kerosene lamps, firewood, candles, disposable batteries, and car batteries. Greenhouse gas emissions are reduced, as well as environmental impacts associated with obtaining and the disposal of these technologies. By the end of 2020, SOLshare had impacted more than 2,570 lives, preventing use of 1,756 litres of diesel, and abating the emissions of 4,970 kg of CO_2 on an annual basis.

Prosumer in a SOLgrid: Dr. Bimol Das powers his own pharmacy and sells his surplus electricity to his neighbours (Mollabazaar, Bangladesh, 2019)

Spotlight on beneficiaries

Dr. Bimol Das runs a small pharmacy in Mollabazaar, Rangabali. In addition to prescribing medicines to patients, he also charges mobile phones for many local residents. Dr. Bimol Das has two solar panels, respectively with capacities of 130 Wp and 85 Wp, and a 130 Ah battery to store the energy generated.

Before the SOLgrid was installed at Mollabazar, Dr. Bimol Das only used his 130 Wp panel, as this produced sufficient energy for his shop even after giving a little power to the small electronics repair stall that shared his premises.

When Dr. Bimol Das first heard about the proposition, he asked numerous questions in order to understand the technology and how he would benefit from it. Ultimately, he was pleased to learn that he could connect his 85 Wp panel to the system and sell the surplus energy, allowing him to become a solar-energy entrepreneur.

Spotlight on partnerships

SOLshare assists its distributor organisations in conducting regional marketing campaigns aimed at securing contracts with end-user clusters interested in joining a smart grid. Once the end user has signed a contract, the distributor invests in the SOLbox, as well as grid cabling and associated ICT hardware such as Wi-Fi routers and backup photovoltaic installations.

SOLshare trains distributor field staff on how to install and operate the components, maintain the P2P grid, and integrate the SOLbox into their catalogue of solar products. It also provides other related training and after-sales services.

SOLshare also offers distributors an ongoing subscription for basic and premium data services, including mobile payment collection, grid management and optimisation, data analytics, and remote technical support for maintenance activities. The distributors recover this investment over 12 to 24 months, depending on the end-user monthly connection fees negotiated. They also receive a 50% share of the trading fee on energy sold.

A tariff of USD 0.20 per kWh provides income for prosumers or producers with their own solar home systems. It also provides access to electricity for those without such systems at a cost 25% lower than would be available using a 20Wp SHS.

The average prosumer household that sells 50% of its generated energy earns approximately USD 10 per month. A producer breaks even within two years, with a simple return on investment of 173% after three years.

Replication and scalability

The SOLshare electricity-trading network can function with any combination or type of solar home system or standalone SHS battery in any part of the world. The hardware enabling the sharing of electricity and remote monitoring of equipment is entirely replicable, and needs only to be paired with a suitable local GSM network. The backend database is centralised and can support international markets. Nevertheless, local database management is possible.

Preferably, a mobile banking provider should be active in the region. If not, payment can be collected in cash by a local agent, who can use the SOLapp to update customer accounts upon the collection of monthly fees.

The distribution model is unique to Bangladesh. However, it can easily be adapted to suit more conventional commercial solar home system markets, such as those in Kenya or Tanzania. Partnering with a suitable SHS distributor or microfinancing institution would lead to a range of mutual benefits similar to those achieved with the microfinance institutions and NGOs that serve as distributors in Bangladesh. Markets where SHSes are not yet present can also be served by partnering with a suitable local actor with contacts in rural communities, alongside an appropriate local microfinancing institution.

The SOLshare grid concept can be applied in any under-electrified area in the Global South with a minimum of 10 households or SMEs located close to each other (with no maximum limit), making the concept applicable and scalable for millions of families worldwide.

ENABLING A MULTISOURCE INTEGRATED POWER SYSTEM

© ZOLA Electric

Stackability of ZOLA Infinity for powering multiple appliances (Nigeria, 2020)

Key challenges

The electrification gap is widely recognised as one of the primary barriers to development in Sub-Saharan African countries. On-grid electricity customers in Sub-Sahara Africa experience electricity supply that is unreliable compared to that of other regions worldwide. According to the World Bank's Doing Business report (2020), more than 78.7% of the firms interviewed in SSA experience electrical outages. The level of reliability experienced by households also varies strongly, with more than 50% of grid-connected households in SSA reporting an electricity supply no more than 50% of the time.

In Nigeria – ZOLA Electric's first target market for its Infinity integrated power system – almost half the population lacks access to electricity. The rest of the Nigerian population is underserved by the electricity grid. As a result, diesel generators are the default source of power, with an estimated 100 million people currently relying on diesel generators each day (GTM, 2019). According to Nigeria's Rural Electrification Agency (REA, 2017), the use of these generators collectively costs Nigeria's households and businesses nearly USD 14 billion every year, while the Energy to Access Institute (Dalberg, 2019) estimates that fuel subsidies for small gasoline-powered generators cost the government USD 1.6-2.2 billion each year. Besides the economic costs, diesel generators bring significant health risks including lung disorders caused by emissions, as well as environmental risks including air and noise pollution. Diesel generators produce about 29 million metric tonnes of

CO_2 emissions each year in Nigeria, a total comparable to the annual emissions from 6.3 million passenger vehicles.

The massive dependence on diesel fuel in Nigeria reflects a clear demand for energy across end-user segments (urban, peri-urban, rural, on-grid and weak-on-grid, households, and MSMEs), not just in off-grid communities. Nigeria's REA estimates the size of the market for minigrids and the solar home systems used to complement grid access at around USD 9.2 billion per year. ZOLA's Infinity system targets this consumer segment in the Nigerian market.

About the innovation

The Infinity integrated power system, launched by ZOLA Electric in 2020, is a lithium-ion battery-based hybrid power system. It is designed for emerging markets, and is intended to solve the problems of power outages in the grid and dependence on polluting fuel sources.

Urban and peri-urban consumers who belong to the upper tier of electricity access are today seeking solutions that can be easily integrated with their existing power infrastructures, such as national grid connections and petrol- or diesel-based generators. While backup systems complementing existing power sources do exist in the form of uninterruptible power supply (UPS) systems and inverters, Infinity goes a step further. First, its interconnection system accepts additional power sources, thus facilitating use of typically off-grid solar and battery solutions for higher-tier end users. Second, the architecture of the Infinity integration system automates selection of the most optimum power source in real time, without user intervention.

Comparable products in the market include UPS systems that accept inputs from two or more systems simultaneously, as well as integrated power supply (IPS) products. The main difference is that while UPS and IPS systems are typically used as backup power sources, ZOLA's Infinity is viewed as a primary electricity source, providing round-the-clock AC power to its users. It employs smart storage technology to store grid- or solar-generated electricity, autonomously delivering power from the most efficient source, resulting in a cost-effective solution. It is a sustainable and reliable alternative to diesel generators, and addresses the unreliability of grid-supplied power. Moreover, the Infinity system offers financing options such as PAYGo and mobile money features to make solar panels an affordable option, thus reducing the cost barrier for new users.

Infinity competes with diesel generator market players, including manufacturers, fuel distributors, and generator service providers. This diesel market plays a large role in Nigeria's electricity sector. If Infinity is successful in establishing its presence, the grid transmission and distribution network providers would also need to respond to this transition. Specifically, they would be pushed to provide better power management, power quality, and cost-effectiveness in order to remain relevant for the end user.

The core innovation is an intelligent hybrid power system that measures, continuously tracks, and optimises the performance of connected power sources. System data collected in real time can be used to make improvements in the design of connected power sources, since it also tracks their characteristics. An integrated system of this nature can therefore be used to improve the quality of power supply more generally, enabling comparability between sources, including the grid, in terms of price and reliability.

Illustration of business model innovation
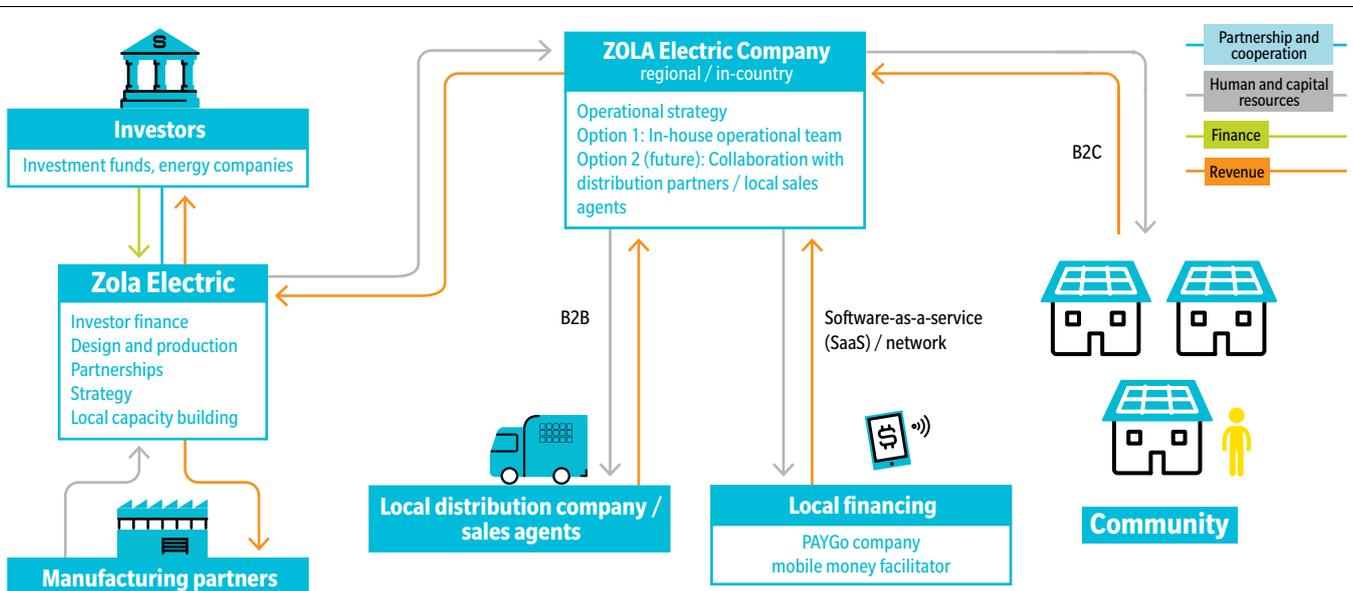
CASE STUDY

ZOLA ELECTRIC

Building distributed energy solutions for clean, affordable, and reliable power for homes and businesses

© ZOLA Electric

Image: ZOLA Infinity integrated power system (Source: ZOLA Electric)

ZOLA Electric at a glance

ZOLA Electric (formerly Off Grid Electric) was founded in 2012, with an initial mission of replacing candles and kerosene with a clean fuel alternative. After setting up operations in Tanzania, the organisation expanded into Rwanda, Ghana, and the Ivory Coast.

ZOLA Electric saw that its target consumers had a demand for more integration possibilities with regard to their existing power sources. This was a key driver behind development of the Infinity product, which launched in 2019. At that point, the company transitioned from leasing and selling home solar kits to individual households to offering solar products coupled with energy storage and other energy-efficient devices, thus providing a more comprehensive energy solution.

The aim was to enable underserved electricity consumers to offset utility bills and steer them away from polluting and expensive petrol/diesel generators. The easily scalable Infinity product creates minimal disruption within the existing power system. A single unit is built to be compatible with solar panels having an initial capacity of 325W, and it can easily be scaled to support a minigrid as large as 120 kWp (kilowatt peak), or even more.

Key figures
- Key geographies: Netherlands (ZOLA HQ), United States (ZOLA Labs), Nigeria, Ghana, Tanzania, Ivory Coast, Rwanda
- Staff: Over 1,500
- Installed systems: 213,000 active energy systems
- Beneficiaries: 1.1 million (all products)
- Year founded: in 2012 as Off Grid Electric

Business model innovation
- Product: A lithium-ion battery-based hybrid power system that intelligently integrates various electricity sources
- BMI: Circular design – multifunctionality
- SDGs addressed:

Contact details
- Website: https://zolaelectric.com/product-category/zola-infinity/
- Bill Lenihan, CEO

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Customer support for ZOLA Infinity (Nigeria, 2020)

Our mission is to democratise renewable energy globally.

Bill Lenihan, CEO, ZOLA Electric

Innovation at ZOLA Electric

ZOLA Electric began by introducing solar home systems (SHS), targeting communities with weak grid connections or which were completely off-grid. Its market rivals in the early days (2012) included companies such as M-Kopa and BBOXX. With the release of its Infinity power system, ZOLA Electric expanded its focus to urban and peri-urban areas, thus including users across the entire spectrum of electricity-access tiers. Infinity marks a step forward towards the future displacement of diesel- and gasoline-based systems, a change urgently needed in cities such as Lagos, where residents and businesses have limited access to reliable grid power, and are thus dependent on generators despite increasing demand and ample ability to pay for electricity.

The innovation distinguishing ZOLA Infinity from existing IPS or UPS products is its intelligent primary source of power supply and management, using IoT technology, which functions without displacing existing power sources for the client. The design innovations include the following features (described in detail below): 1) integrated power, 2) smart power, 3) upgraded power, and 4) power for life.

Integrated power: Current flows from solar panels, batteries, and the grid are integrated and optimised so as to deliver electric power at the lowest possible cost, and with minimum interruption. The system incorporates a parallel power unit, which is a microinverter technology standard used globally to integrate several panels into a system. The 20-millisecond changeover between on- and off-grid modes prevents light flickering associated with unstable power. Infinity's multifunctionality enables it to switch seamlessly and automatically between different sources of power, a feature that remains unique in the sector. This reduces redundancy and minimises electricity costs even for consumers who may have reliable supplies, but still face disproportionately high costs.

Smart power: The smart power system is an intelligent embedded system with the following features:

- Global System for Mobile Communications (GSM) functionality, enabling the power system to be continuously updated.

- The performance of connected components is automatically optimised on the basis of real-time monitoring, enabling adjustment of overall system operating parameters.

The benefits associated with this smart Li-ion battery-based storage system include:

- Cost-optimised management that automatically minimises fuel and grid costs
- Smartphone monitoring that enables tracking of the system's automated performance
- Voltage protection to ensure safe power supply
- Customisable storage that provides power access during grid outages
- Customisable power supply tailored to the needs of connected appliances
- Limitless expansion, so that power supplies can be upgraded to reflect growing needs
- Long-life design backed by a five-year warranty and service agreement
- PAYGo features that allow customers to finance their systems
- Lithium batteries that ensure a long product lifetime with few parts replacements.

ZOLA is helping customers power their homes and businesses, democratising the provision of energy with clean, affordable, and reliable distributed solar and smart storage solutions. ZOLA products provide power to more than 1.1 million people across more than 200,000 homes and businesses across Ghana, Ivory Coast, Nigeria, Rwanda and Tanzania.

"Our vision is to deliver affordable, powerful renewable electricity everywhere and for everyone."

Xavier Helgesen, co-founder, ZOLA Electric

- If electricity is unavailable from the grid, Infinity intelligently chooses between the various other connected power sources. For instance, when sufficient sunlight is available, it prioritises electricity generated by solar panels over the operation of diesel generators. This applies both to powering loads and to battery charging in cases of surplus production during sunlight hours. With ongoing performance monitoring, the system can preempt functions that would otherwise charge the battery from the grid based on current battery parameters.

- Both ZOLA and the consumer can track system performance through a smartphone application. Infinity's grid connection operates without the use of a transfer switch, and does not turn off in case of grid failure.

- Infinity is responsive to local frequency and voltage measurements from the primary battery (which also controls power flow from other sources).

Upgradeable power: Infinity's modular construction makes it possible to expand the system quickly and connect more appliances whenever the end user desires. Additional solar panels can be added at any time without rewiring or redesigning the system, therefore lowering the burden of resource extraction due to new components. It can grow without limits to support even three-phase and industrial applications. While a basic Infinity system unit can connect to a 325 W panel and hold 2.3 kWh of energy, ZOLA's 120 kWp (kilowatt peak) minigrid in Rwanda (2020) illustrates the degree to which the system is scalable. ZOLA plans to expand Infinity's capacity further over the next two years, up to 240 kWp.

Power for life: The organisation offers a standard five-year end-to-end warranty, with the option to extend. A multi-inverter architecture ensures that failures are infrequent. Longer life is achieved through smart thermal-performance management of the lithium-ion battery pack, using IoT technology. Exhausted battery packs can be swapped out without replacing the rest of the system.

While the company was once vertically integrated, ZOLA Electric is now gradually unbundling certain aspects of distribution. This shift in the company's operational strategy has taken place in parallel with expansion into new markets, and has enabled higher operational efficiency. With the company now set to move away from direct sales where

possible, the aim is to conduct capacity-building sessions and skills-transfer programmes with local businesses. Therefore, both business-to-customer (B2C) and business-to-business (B2B) strategies remain relevant.

ZOLA Electric has been recognised for its strides in the sector. It has been awarded the UNFCCC Momentum for Change Award (2016), the Ashden Award (2014), and the Zayed Future Energy Prize (2016), and was named a Global Cleantech 100 company (2020).

Success factors for business model innovation

- Minimum disruption for the consumer's existing electric power infrastructure.

- A high-performing product with a consumer-friendly interface, which enables the transition to clean energy use for end users belonging to upper electricity-access tiers.

- Low up-front costs when expanding an existing system due to Infinity's modular construction.

- A strong focus on design quality and performance, even as the company shifts its operational focus away from direct sales to outsourced distribution.

Spotlight on partnerships

In 2019, ZOLA Electric was among the highest-funded companies in the energy-access space, having raised investment from Tesla, SolarCity, Vulcan Capital, DBL Ventures, the Omidyar Network and Helio Partners, along with energy companies EDF, Total, and GE Ventures.

Impact

Community and local businesses: The basic Infinity system, priced at around USD 1,000, is affordable for an end user with a monthly income of USD 400 and above. Investing in the Infinity system instead of more generator backup capacity gives purchasers the ability to connect clean power sources such as solar home systems and storage mechanisms such as battery banks to the energy mix, while optimising their overall electricity costs. This consequently

Spotlight on beneficiaries

ZOLA Infinity was first launched in Lagos, with a focus on urban and peri-urban populations with weak connections to the power grid. Given the unreliability of grid power, Lagos' electricity consumers are used to arranging for backup power sources. However, the copious amounts of emissions produced by diesel generators are a health risk to the local population, and exacerbate the impact of climate change. Nigeria's urban population is familiar with the sound of generators, which is omnipresent when the grid is short on supply. The demand for a cleaner, quieter, and more reliable source of power exists across households and businesses, irrespective of income level.

© ZOLA Electric

Installation and after-sales services for ZOLA Infinity systems (Nigeria, 2020)

reduces generator operating times, resulting in improved air quality. The power-management gains and ability to switch automatically between power sources increases the number of productive hours available each day to conduct household or business activities.

Organisation: With nearly 1,500 employees, ZOLA has been branching out from providing basic power necessities in rural regions to addressing myriad challenges up and down the energy ladder. The organisation was an early market entrant that began by helping build off-grid markets in its target countries. The introduction of the Infinity product was strategic, since new supply chains and supporting businesses have emerged in both existing and future target markets. The product paves the way for current and future products and services – especially those with IoT features – to be integrated into the system. In order to enable a focus on design and IoT integration, the organisation has been moving towards a more decentralised distribution structure, and plans to unbundle operations in other regions as well.

Replication and scalability

The scalability of ZOLA Electric's Infinity stems from its modular design, consisting of a building-block structure that makes installation and expansion easy. The well-established financing mechanisms in Nigeria and the fast-growing market for such mechanisms in other SSA countries provide a promising foundation for the product.

The established diesel market in Nigeria has always been a hurdle to the integration of renewables in the electricity mix. Infinity's nature as a transition product that operates parallel to the diesel market creates an environment for a natural progression towards clean fuels.

ZOLA Electric plans to continue innovating, and will launch its distributed grid functionality in 2021. Data connectivity, software improvements, automation, and more IoT products make the overall system more cost-effective due to sophisticated analytics tools. It is only a matter of time, ZOLA Electric predicts, before net metering across such systems becomes possible. Electricity trading within a distributed energy-production network will then become a source of income, further enhancing the replicability prospects for a product like Infinity.

Interview list

Organisation	Interviewee(s)
AMPERES	Tarek Ketelsen
ME SOLshare Ltd.	Dr. Sebastian Groh
SolarWorX	Felix Boldt
Switch Batteries	Mike O'Hanlon
ZOLA Electric	Doye Ogionwo
Cameron Smith

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