



Decentralised Renewable Energy Innovations to Boost Agri-Sector Productivity & Address Global Food System Challenges



Zero hunger can be achieved by providing energy beneficiaries with the **means to produce, transform and consume food in a clean and sustainable way**, thereby enhancing both their food security and nutrition.

IMPRINTS

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ABOUT UNIDO INVESTMENT & TECHNOLOGY PROMOTION OFFICE GERMANY

As part of the United Nations system, The UNIDO Investment and Technology Promotion Office Germany (UNIDO ITPO Germany) mobilises investments and technologies for sustainable industrial

development. Situated at the UN Campus Bonn, ITPO Germany supports investors and companies by facilitating technology transfer from Germany to developing countries and economies in transition.

ABOUT ALLIANCE FOR RURAL ELECTRIFICATION

Established in 2006, ARE is the only global business association that represents the whole decentralised renewable energy sector for integrating rural electrification in developing and emerging countries.

With more than 170 Members, ARE aims to promote a sustainable decentralised renewable energy industry for the 21st century, activating markets for affordable energy services, and creating local jobs and inclusive green economies. ARE enables improved energy access through business development support for its Membership along the whole value chain of off-grid technologies.

UNIDO ITPO GERMANY - ARE COOPERATION

UNIDO ITPO Germany - ARE cooperation was established in the wake of the MoU signed between UNIDO and ARE in January 2019. Autumn 2020 marked the commencement of this cooperation with a common objective to foster cross-sectoral coordination, technology exchange and business matchmaking. The ITPO-ARE cooperation aims to showcase technologies, expertise and experience of German/European companies from the decentralised renewable energy (DRE) sector in emerging markets. Along with that, the cooperation is also striving to facilitate interaction between key DRE stakeholders by providing a strong platform for mobilising investments towards global energy access efforts and achievement of SDG-7 and other SDGs by 2030.

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LIST OF ABBREVIATIONS

ABO Active Battery Optimiser	CSR Corporate Social Responsibility	KEPHIS Kenya Plant Health Inspectorate Service	PCP Public-Community Partnership
ACDB Association for the Development of Bambadinca	DC Direct Current	kg Kilogramme	PENHA Pastoral & Environmental Network in the Horn of Africa
Ah Ampere hour	DRE Decentralised Renewable Energy	Ksh Kenyan Shillings	PV Photovoltaic
ARE Alliance for Rural Electrification	EDP Energias de Portugal	kVA Kilovolt-Ampere	ROI Return on Investment
B2C Business to Customer	EEP Energy & Environment Partnership Trust Fund	kW Kilowatt	SCE Solar Cooling Engineering
BB Banco do Brasil	EPC Engineering Procurement & Construction	kWh Kilowatt-hour	SCEB Bambadinca Energy Service Community
BESS Battery Energy Storage System	EU European Union	kWp Kilowatt peak	SDG Sustainable Development Goal
BMZ Federal Ministry of Economic Cooperation and Development (Germany)	EUR Euro	l Litre	SIDA Swedish International Development Cooperation Agency
CapEx Capital Expenditure	GHG Greenhouse Gas	m Metre	SKDRDP Shri Kshetra Dharmasthala Rural Development Project
CBF Co-operative Bank Foundation	GIZ German Corporation for International Cooperation	M Million	SME Small & Medium-sized Enterprise
CCM Chama Cha Mapinduzi	GSM Global System for Mobile Communication	MFI Microfinance Institution	SWP Solar Water Pump
cm Centimetre	ha Hectare	MW Megawatt-hour	UNIDO United Nations Industrial Development Organization
CO₂ Carbon dioxide	hp Horsepower	NGO Non-Governmental Organisation	USB Universal Serial Bus
COSV Coordinamento delle Organizzazioni per il Servizio Volontario	HV High Voltage	O&E Operation & Execution	V Volt
CSO Civil Society Organisation	IoT Internet of Things	O&M Operation & Maintenance	W Watt
	ITPO Investment & Technology Promotion Office	OECD Organisation for Economic Co-operation & Development	
		OpEx Operational Expenditure	
		PAYG Pay as You Go	

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Introduction



1. INTRODUCTION

Agriculture is a source of livelihood for 86% of people living in rural areas globally. Besides farming, livelihoods can encompass various activities in other key agricultural sub-sectors, including livestock and fishing and aquaculture.¹ There are many elements to modern agricultural value chains such as collection, production, processing, storage, transport, distribution, and trade. They all contribute to what is broadly defined as a food system.² The global food system is responsible for feeding people all over the world.



Figure 1: Benefits from agriculture.

Countries irrespective of their scale of development rely on the agricultural sector in one way or another. The role of agriculture can be considered as one of the most important in any economy. The benefits of agriculture are listed in the figure below.³

The agricultural sector is one of the major sources of income in many countries and it also contributes to the national economy

and international trade. In addition, it not only provides food, fodder and raw materials (wax, wood, etc.), but also attracts foreign investment in the sector of the respective countries and at a broader level, contributing to the global food system.⁴

The global food system is fundamental to the achievement of many of the 2030 Sustainable Development Goals — in particular, SDGs-1, 2, 3, 5, 6, 7, 8, 9, 10, 12, 13, and 15. Yet, with less than 10 years to go, food systems are still failing to ensure adequate food supply and sufficient nutrition levels in many places, while contributing to environmental degradation and greenhouse gas emissions.⁵

It is essential to bring the significant challenges the global food system is facing to everyone's attention. The Organisation for Economic Co-operation and Development (OECD) recently highlighted three major challenges faced by the global food system:⁶

- **Feeding a growing population:** Development in agriculture can contribute to ending extreme poverty, boost shared prosperity and feed a projected 9.7 billion people by 2050.⁷ However, not only will there be many more mouths to feed globally, but the purchasing power in emerging economies is increasing rapidly which will eventually boost the demand for more varieties of food such as meat, fish etc.⁸
- **Providing a livelihood for farmers:** Food production is the most common livelihood in rural areas, especially in emerging markets. Most poverty-stricken regions are particularly reliant on farming for their income generation. There are approximately 570 million farms worldwide today, with millions of people working in food-related jobs.⁹

1 FAO, <http://www.fao.org/rural-employment/agricultural-sub-sectors/en/>, (online)

2 VEF Virtual Series, *Sustainable Energy and Food Systems*, pg 6, 2020

3 Farming Portal, *The Importance of Agriculture*, 2019 (online)

4 FAO, *Trends and Impacts of Foreign Investment in Developing Country Agriculture*, pg 3, 2013

5 See footnote 2

6 OECD, *Three key challenges facing agriculture and how to start solving them*, 2019 (online)

7 World Bank, *Agriculture and Food*, 2020 (online)

8 FAO, *What is the future of food and farming*, (online)

9 FAO, *Family Farming Knowledge Platform*, (online)

Climate change (varying rain patterns, flooding, soil erosion etc.) and other external factors (political, social, traditional agri-practices, etc.), as well as the COVID-19 pandemic, have adversely affect agriculture and deprive the poor of their livelihoods.

- **Environmental protection:** With nearly 40% of the global land surface being used for agriculture, the sector also has a strong environmental impact, including a sizeable contribution to global greenhouse gas (GHG) emissions amounting to 11%. Irrigation accounts for 70% of global water use and increasing land use for agricultural expansion can lead to loss of biodiversity and more emissions.



Figure 2: Major challenges to global food system.

There is a strong need for increased adoption of sustainable agricultural practices to bring the food from farm to fork while addressing the above three challenges. This is where decentralised renewable energy (DRE) technologies can and must play a key role. Moreover, as innovation in DRE-powered agricultural equipment and appliances steam ahead, their technical and commercial viability will improve further.¹⁰ In that regard, ARE members have been pioneering DRE projects embedding Productive Use of Renewable Energy (PURE) in their sustainable business models. PURE has also been a central element in ARE's policy and advocacy strategies since 2015.¹¹

UNIDO ITPO Germany, similarly, is committed to stimulate 'agri-production and food-processing with sustainable energy' by promoting outward investment and technology transfer. In line with that, UNIDO ITPO Germany also advocates for PURE and assists the industry, particularly small and medium-sized enterprises (SMEs), with DRE innovation in the agricultural sector.¹²

Examples of DRE innovations include water pumping for irrigation with renewable energy, drying produce with solar heating, agro-processing (milling, grinding, pressing etc.), cold storage (milk, produce, processed food items, etc.), cooking & heating, fish farming with renewable energy technologies like solar-powered boats, lighting, communications, and transport.

Many entities across the globe are already adopting innovative and clean technologies to power agriculture and ensure the achievements of the benefits listed above. Therefore, the objective of this publication is to highlight key innovations and best practices from around the world, especially from emerging markets, that sustainably increase productivity in the agricultural sector using DRE technologies and thus help solve global challenges in food systems.



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¹⁰ Power for All, *Powering Agriculture eBooklet*, 2020 (online)

¹¹ ARE, *The Productive Use of Renewable Energy in Africa*, 2015

¹² UNIDO, *Energy access for productive uses*, (online)

2

Unlocking DRE Innovations to Stimulate Agricultural Growth



2. UNLOCKING DRE INNOVATIONS TO STIMULATE AGRICULTURAL GROWTH

The 15 success stories featured in this publication demonstrate the huge potential of decentralised renewable energy technology solutions to boost agri-sector productivity and accelerate decarbonisation efforts. Agriculture and other agro-based activities, such as harvesting, processing, transport, etc., are at the heart of the rural economy and yet the full potential of the sector cannot be realised due to the lack of access to energy, notably electricity.

Given the urgency of achieving the SDGs by 2030, DRE technologies can provide immediate solutions. With the right mix of technology, financing, and capacity building, DRE can not only provide access to household electrification but also power

productive use appliances such as solar water pumps, milling machine, refrigeration system and many more. The upcoming sections outline the major barriers identified in the projects as well as provide an overview of different DRE technologies introduced to overcome the barriers.

2.1 MAJOR BARRIERS

The case studies featured in this publication are addressing some of the key barriers the agricultural sector is facing in different regions around the world. Key obstacles to increased productivity, and hence increased income, in the agricultural sector include the following.



Lack of access to essential services, including clean energy, water, etc



Lack of access to high-quality seeds & modern agricultural practices



Lack of access to agricultural & agro-processing equipment & machinery & to energy efficient appliances



Lack of access to finance



Lack of access to markets



Lack of awareness & information about DRE solutions



Lack of education/skilled labour



Lack of consideration of gender dimensions

2.2 DRE TECHNOLOGIES LEADING THE WAY

The technologies showcased in this publication range from simple solar equipment to hybrid and smart solar systems used for different applications, such as water pump-

ing, irrigation, cooling, milling, desalination, aquaculture, etc. Biomass driven steam engine technology is also included, used for producing electrical and thermal energy. An overview of the technologies and their applications is outlined below:

Organisation	Country	DRE Technology	Applications
Boreal Light	Kenya	Solar PV-enabled water pumping with remote monitoring	Drinking water, irrigation, fish farming, sanitation, DC appliances and cell phone charging
Co-operative Bank Foundation	Kenya	Solar PV and storage	Greenhouse farming, irrigation and lighting
GFM	Spain	Hybrid (solar PV, storage, IT-enabled)	Primarily for clean water access; additionally, agri-processing, cold storage, water pumping, etc.
Gham Power	Nepal	Solar water pump	Solar irrigation
OffgridSun	Zimbabwe	Hybrid (solar PV, IT-enabled)	Access to water and irrigation
Phaesun	Kenya	Solar milk cooling system	Milk chilling and storage
Practical Action	Zimbabwe	Solar PV	Irrigation
Ryse Energy	Ghana	Hybrid (solar PV, wind, storage)	Irrigation, electricity for lighting and heating
Seawater Greenhouse	Somaliland	Solar PV and storage	Desalination, irrigation and salt production
SELCO Foundation	India	Solar PV and storage	Flour milling
Simusolar	Tanzania	Solar PV	Irrigation and clean water supply
SunCulture	Kenya	Smart solar PV and storage	Irrigation
TESVOLT	Brazil	Hybrid (solar PV, storage, IT-enabled)	Irrigation
UNIDO/TESE	Guinea-Bissau	Solar PV mini-grid	Access to energy and water, irrigation for higher productivity, cooling and processing
Village Industrial Power	Kenya	Biomass driven steam engine	Crop/produce drying

2.3 FINANCING STRUCTURES

Delivering energy solutions to the rural and urban poor is met by the major hurdle of limited access to finance at the local and national levels and insufficient targeted finance flows at the international level. Unfortunately, the allocation of investments towards DRE solutions remains low as compared to grid-connected solutions.¹³ While there is increased attention

and interest to enable greater investment in energy access for poorer communities across regions, the specific options and mechanisms to be used in varying contexts are still being tested and yet to be clearly defined.¹⁴

The projects in the publication showcase various types of innovative financing structures with regards to the DRE project that are spanned across different regions of the

¹³ SEforALL, *Energizing Finance: Understanding the Landscape*, 2020 (online)

¹⁴ HIVOS, *Financing Decentralized Renewable Energy for the Last Mile*, pg 4, 2019

world and thereby provide an impetus to the work on accessing affordable credit for DRE uptake. The table below showcases an overview of the financing structures used by the projects in this publication.

Organisation	Financing structure
Boreal Light	Grant + equity
Co-operative Bank Foundation	Grant + equity
GFM	Grant + equity
Gham Power	Grant + equity + debt
OffgridSun	Grant + equity
Phaesun	Grant
Practical Action	Grant
Ryse Energy	Grant
Seawater Greenhouse	Grant + equity
SELCO Foundation	Grant + equity + debt
Simusolar	Equity + debt
SunCulture	Grant + equity + debt
TESVOLT	Grant
UNIDO/TESE	Grant + debt
Village Industrial Power	Grant + equity

2.4 PROJECT OUTCOMES

Experiences from the featured case studies show the potential of DRE systems to enhance agricultural productivity and address global food system challenges.

The case studies demonstrate the transformational potential of DRE solutions for the agricultural sector as well as related activities, like chilling, storage, drying, desalination, agro-processing, etc., in addition to providing access to electricity for local farmers, rural households and community facilities, like schools. Furthermore, the projects created additional income-generation opportunities for the local communities and ensured environmental sustainability by avoiding/reducing greenhouse gas emissions. Below is a summary of the challenges and outcomes of the projects.

Organisation	Challenges	Outcomes
Boreal Light	Lack of electricity access, low groundwater levels, poor water quality, poor agricultural productivity, remoteness of the village and resistance to change by locals.	<ul style="list-style-type: none"> • Drinking water for 3,000 inhabitants • About 236 tonnes of CO₂ emissions avoided annually • Onsite availability of fresh fish • Adoption of vertical farming methods • 13 new jobs created
Co-operative Bank Foundation	Youth unemployment, traditional agricultural practices and poor nutrition.	<ul style="list-style-type: none"> • Seven solar-powered agribusiness enterprises were set up in seven public schools • About 1,400 tonnes of CO₂ emissions avoided annually • Improvement in the health of the students thanks to better access to farm crops • Cost savings on purchasing vegetables • School students skilled in modern agribusiness driven by DRE

GFM (Pilot project)	Lack of access to electricity and water.	<ul style="list-style-type: none"> • During the test phase, the system supplied up to 250 l of drinking water for two days • Water supply can be maximised to adapt in wet and humid conditions • Provisions to provide electricity for irrigation and cooling • Potential to avoid 16,887.24 kg of CO₂ emissions annually • Six new jobs created during the design, construction and testing phase
Gham Power	Affordability, lack of reliable and sustainable source of irrigation, and traditional agricultural practices.	<ul style="list-style-type: none"> • Deployed around 200 solar irrigation systems in the past three years, with almost 100 systems installed through commercial financing • Overall increase in agricultural productivity by around 11% • About 420 tonnes of CO₂ emissions avoided annually • Up to 10 jobs created
OffgridSun	Droughts, food insecurity, drinking water access and reliable irrigation facilities.	<ul style="list-style-type: none"> • 350 people benefited from solar pumping systems • Productivity of growing cereals and vegetables increased by 15% on average over the three-year project period • 135 new jobs created
Phaesun	Lack of access to cooling systems for milk storage, minimal hygienic conditions, and wastage of milk.	<ul style="list-style-type: none"> • 10 farms and cooperatives have been equipped with solar milk cooling systems with a capacity of 60 l / day each • Reduction in milk losses by approximately 25% • At least 50 people could increase their income • Use of a natural refrigerant with low global warming potential
Practical Action	Low average rainfall and dependency on rain-fed agriculture, crop failures due to climate change, food insecurity, and usage of expensive and polluting diesel-powered irrigation schemes.	<ul style="list-style-type: none"> • Agricultural production doubled to about 143 ha, with significant yield increases • 422 households involved have gone from subsistence farming to be able to sell excess produce, thus improving their livelihoods • Project has been replicated reaching an additional 900 farming households

Ryse Energy	Lack of access to electricity and infrastructure, logistical challenges due to remoteness of village, dependency on expensive, and polluting diesel-powered electricity.	<ul style="list-style-type: none"> • Enabled water pumping and irrigation systems • Local community of around 500 people gained access to electricity for basic needs, such as lighting and heating • About 85 metric tonnes of CO₂ emissions avoided annually • An estimated 200 lives were positively impacted by the installation, creating over 20 jobs within the community
Seawater Greenhouse	Agriculture is constrained by high temperatures and lack of water resulting in low yields.	<ul style="list-style-type: none"> • First desalination system in the Horn of Africa powered 100% by renewable energy • Production of salt • Successful crop production of tomatoes, cucumber, lettuce and melon • Four new jobs created and potential for more after establishment of local ownership • The project is carbon neutral in operation
SELCO Foundation	Lack of access to rice milling equipment resulting in long-distance travel and inconvenience, and lack of stable electricity supply.	<ul style="list-style-type: none"> • The solar-powered flour mill acts as an important perennial source of income for Ms. Rosy Dabale (beneficiary) • The solution allowed for the community, and particularly women and widows to access this basic service locally saving them time and transportation costs • Provided food security during COVID-19 induced lockdowns • Two new jobs created • Raised awareness about DRE technology in the community
Simusolar	Poor agricultural practices, high operational costs, pest, diseases, dependency on rain-fed farming limiting productivity, lack of skilled labour, and poor access to electricity.	<ul style="list-style-type: none"> • Tomato production increased from 1 to 2 tonnes, cucumber production from 800 to 1,800 kg, green vegetable production from 4 to 8 bags, onion production from 500 to 1,000 kg, papaya production from 700 to 1,300 units and sweet peppers were added • Water supply increased from 10,000 to 16,000 l/day • Up to seven new jobs created • About 487 kg of CO₂ emissions avoided annually

SunCulture	Dependency on rain-fed agriculture, acute food insecurity, dependency on expensive and polluting petrol pumps, affordability, and lack of awareness of DRE technology.	<ul style="list-style-type: none"> • High confidence of SunCulture's farmer for better yields and 87% reported an increase in agriculture production • 80% of the farmers experienced an increase in money earned and an average revenue increase of 44% per season • 95% of the farmers reported improvements in their quality of life • About 1,228 kg of CO₂ emissions avoided annually • An average of 1.5 local jobs are created per solar irrigation system
TESVOLT	Dependency on expensive and polluting diesel gensets for irrigation and logistical challenges due to remoteness of the farm.	<ul style="list-style-type: none"> • Access to solar irrigation enabled the farm to increase production from one harvest per year to three crops per year (beans, corn and soybeans) • About 1,076 tonnes of CO₂ emissions avoided annually • 50 new jobs created
UNIDO/TESE	Lack of access to electricity, dependency on expensive and polluting diesel gensets, and affordability.	<ul style="list-style-type: none"> • Bambadinca is one of the few villages in Guinea-Bissau with a functioning energy and water supply service • Provided access to electricity services for around 6,500 rural inhabitants, 630 households, 84 businesses and 16 public institutions • The share of families with access to electricity increased from 5% to over 85%, while reducing the share of income spent on energy from 24% to 5-10% • Better impacts if electrification and agro-development approaches are combined (e.g. business development support and provision of micro-credits) • People involved in agriculture and food processing (e.g. cashew, cassava, fruits) have particularly benefited from cost reductions and productivity gains (e.g. through cooling, irrigation), as well as provided micro-credits • About 409 tonnes of CO₂ emissions avoided annually
Village Industrial Power	Post-harvest losses	<ul style="list-style-type: none"> • Provided access to solar-powered drying units; • The dryers are capable of processing up to 1 tonne of perishable fresh food per day • About 254.69 tonnes of CO₂ emissions avoided annually • 38 new jobs created

3

Key Recommendations





KEY RECOMMENDATIONS

Based on best practices from the 15 case studies included in this publication and general observations, ARE and UNIDO ITPO Germany developed the following recommendations for public and private stakeholders working in the field to boost DRE uptake to power agricultural productivity.

INCLUSIVENESS & COOPERATIVE WORK APPROACH:

An essential factor for the successful realisation of a DRE project to enhance agricultural productivity is the active involvement of all key stakeholders and alignment of interests. As seen in the projects of Gham Power, OffgridSun, Ryse Energy and UNIDO, project developers, local authorities and ministries, MFIs, and the beneficiaries/end-users, have all worked together to ensure successful implementation, operation and maintenance (O&M) of DRE projects. For instance, in UNIDO's project in Guinea-Bissau, the utility management is sustained by a Public-Community Partnership (PCP) comprising a local village association, traditional leaders and ministries to manage and operate the mini-grid project.

The COVID-19 pandemic has clearly slowed down global efforts towards achieving the SDGs. Under these conditions, the world is left with only a handful of years to accelerate its efforts and achieve the goals. Thus, it is strongly recommended to adopt a co-operative approach for DRE project development and implementation by involving government entities, local communities, and other key stakeholders throughout all phases to ensure the successful imple-

mentation and scaling up of DRE projects powering agriculture.

Another lesson can also be taken from OffgridSun's project in Zimbabwe where the success of that project is attributed to the right selection of the project areas and the strong involvement of community stakeholders and beneficiaries, especially when the community develops a strong sense of ownership of the project activities and installations.

RAISING AWARENESS & THE ADOPTION OF MODERN AGRICULTURAL PRACTICES TO CATALYSE DRE TECHNOLOGY DEMAND IN AGRICULTURE:

It is high time to think beyond the supply side of DRE projects and focus on energy planning to create and aggregate demand for DRE technologies to power agriculture and related activities. ARE and UNIDO ITPO Germany encourage governments and international funding partners to explore options to create and stimulate demand for integration of DRE in agriculture:

- To gradually transition from traditional agricultural practices and introduce modern methods powered by DRE;
- To improve productivity while decarbonising the agricultural sector.

This can be done by raising awareness among the local communities about the benefits of adopting state-of-the-art farming practices, by demonstrating the advantages of DRE technologies to improve productivity, by providing access to know-how

and finance and by introducing capacity building measures to maintain and troubleshoot the DRE systems. This results in demand creation for the adoption of DRE technologies in agriculture and with high demand, there will be more scope for DRE project implementations to power agriculture.

ADDRESS GENDER-SPECIFIC ISSUES:

Embedding gender mainstreaming in DRE projects enables both a larger impact of projects and increases their sustainability, while contributing to the SDGs. Examples can be seen in the projects of OffgridSun and SELCO Foundation where gender dimensions were identified i.e. distance women need to travel to collect clean water in Lupane and Makoni districts, Zimbabwe (OffgridSun) or to mill their small quantities of rice in Kesarolli, India (SELCO Foundation). Consequently, the instalment of DRE systems has both substantially improved the quality of life and livelihoods of women, while simultaneously contributed to the success of DRE projects and their long-term sustainability because the general ability to pay for electricity was enhanced.

It is highly essential to note that women entrepreneurs can be strong agents of change if they have a conducive environment. Women-owned small and medium-sized enterprises (SMEs) are estimated to represent 30 to 37% of the total number of SMEs in emerging markets. Thus, DRE solutions can power the development of rural businesses and improve both women's incomes and decision-making power in local communities.¹⁵

DATA COLLECTION, ASSESSMENT & SHARING FOR EFFICIENT PROJECT OPTIMISATION:

A general and important practice that has proven beneficial throughout a DRE project cycle is the collection and processing of data. Data collection can be divided into two stages: pre- and post-commissioning of the project. Pre-commissioning project data entails identification of project

sites, demography, consumption profile (if existing, if not, developed statistically),

WOMEN ENTREPRENEURS CAN BE STRONG AGENTS OF CHANGE IF THEY HAVE A CONDUCIVE ENVIRONMENT.

choice of DRE technology, social aspects (e.g. gender dimensions) etc. Post-commissioning project data mainly focuses on the impact of the project such as social, economic, and environmental outcomes. The collection and processing of these data level the playing field for further innovation in the implementation of DRE projects and post-commissioning optimisation of existing DRE projects, including those powering the agricultural sector.

The successful technical, financial, and social models featured in this publication provide useful information/data from the implemented projects. These data can cater to the scientific community, researchers and academia as dependable source material and thus can help with their applied research. Therefore, it is highly recommended to install proper data collection mechanisms.

INNOVATIVE FINANCING & FINANCIAL INSTRUMENTS FOR IMPLEMENTATION & REPLICATION OF DRE TECHNOLOGIES IN AGRICULTURE

Access to finance has long been a key barrier to the deployment of DRE technologies in agriculture at scale. Different financing mechanisms were adopted by all the projects where a mix of grants, equity, and, in some instances, debt can be observed. For example, UNIDO's project in Guinea-Bissau struck a balance between certain clients' inability to pay and the long-term finan-

¹⁵ ARE, *Women Entrepreneurs as Key Drivers in the Decentralised Renewable Energy Sector - Best Practices and Innovative Business Models*, 2020

cial viability of the project by introducing a pre-paid, cost-reflective tariff model with cross-subsidising elements favouring the poor. Moreover, it demonstrated that better impacts can be achieved if electrification and agro-development approaches are combined (e.g. business development support, micro-credits). Another example is Boreal Light's project in Kenya which used revenues from the sale of carbon credits generated by the initial project to finance future projects. Gham Power's project in Nepal is financing with a combination of grants and debt along with a small equity contribution by the end-user.

Therefore, it is recommended to consider innovative financing structures while designing a project for a rural population where the 'ability to pay' can be a challenge. Such successful models can be replicated in subsequent projects ensuring their financial sustainability and the affordability of the services. In addition, establishing management and financial capacities of the future operators of a respective project should also be considered.

ESTABLISH EFFECTIVE POLICIES & REGULATIONS:

One of the major barriers to a successful DRE project deployment at scale is the lack of policies and regulations which are necessary to enable and facilitate the successful deployment of DRE technologies to power agricultural sector. As identified in UNIDO's project in Guinea-Bissau, due to the weak regulatory framework and the lack of risk mitigation instruments (e.g. guarantees), investment risks for the private sector remained high.

Therefore, policymakers are recommended to liaise with counterparts, business associations and international partners, to explore and establish regulations and frameworks in place to further support agricultural sectors with DRE solutions.¹⁶ On top of that, it is vital to ensure that the policies are designed keeping the gender inclusiveness as well as social, technical, and environmental sustainability in mind.

HOLISTIC APPROACH WHEN IMPLEMENTING DRE TECHNOLOGIES:

Powering agriculture does not finish with after the commissioning of DRE projects, rather commissioning should mark the beginning of a long-time partnership with rural communities. On that note, it is recommended that developers should keep an eye to develop projects holistically and to serve multiple economic, social and development needs. In the case of Boreal Light's project in Kenya, the DRE project provided multiple services, including access to drinking water, irrigation, fish farming, sanitation, powering DC appliances, cell phone charging etc. Similarly, another pilot project implemented by Generaciones Fotovoltaicas de La Mancha in Spain served both to increase access to electricity and clean water, while the electricity generated by the system can additionally be used for agro-processing, cold storage, water pumping, etc. The argument holds true for most of the case studies presented in the publication and thus,

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16 RECP, *Mini-Grid Policy Toolkit: Policy and Business Frameworks for Successful Mini-Grid Rollouts*, pg 102, 2014

recommended for project developers to consider and replicate.



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EFFICIENT APPLIANCES: ENSURING BOTH QUALITY & AFFORDABILITY:

Quality of equipment and appliances is central to provide a durable performance with the highest efficiency and a smooth user experience. Therefore, quality is a vital factor to be taken into consideration during design, manufacturing, and procurement. On the other hand, affordability can also be a challenge due to low-income levels and limited ability to pay in rural areas. A careful balance must be struck in the pricing and design of such appliances. Governments and international funding partners can also lend a hand via different measures¹⁷ to ensure the balance is maintained between quality and affordability. For example, governments can, via regulations, as well as targeted programmes support markets for affordable and high-quality appliances.

One solution that has been applied by Phaesun is to use local materials instead of imported alternatives, thus increasing local added value, as well as making systems pay-as-you-go compatible, creating attractive business models even in regions with low purchasing power.

CUSTOMER-CENTRIC & FLEXIBLE SYSTEM DESIGN & OPERATIONS:

Another important point to consider while realising a DRE project to power agriculture is to do prior assessments of potential

local challenges and then opt for a customer-centric design, as outlined for example in the project in Tanzania by Simusolar. In this project, an innovative approach was undertaken to include a customer-centred system design, which is critical for affordability. This approach also helped identify the challenges from a gender perspective and suitable solutions can be designed to address them. Therefore, customer-centric designs are always recommended as they are fit for purpose to address the local challenge.

With time, the local challenge also evolves e.g. growth in demand and hence the designers are also advised to consider employing flexibility and modularity in their system design. In the case of GFM's project in Spain, the WatEnergy is presented as an autonomous, portable, flexible and easy-to-install hybrid solution for electricity and drinking water generation. The Phaesun project in Kenya showcases the development of their modular SelfChill® concept to meet the demand for medium-scale milk cooling systems.

CAPACITY BUILDING IN COOPERATION WITH LOCAL STAKEHOLDERS & BENEFICIARIES FOR THE O&M OF SYSTEMS:

Successful installation and O&M of systems are key factors for the sustainability of agricultural projects powered by DRE. In many success stories, sustainability has been assured when local communities are involved in O&M activities of the DRE systems. Therefore, all the case study contributors in this publication have unanimously vouched for proper training and technical know-how transfer to optimally operate and maintain the DRE systems.

In SELCO Foundation's project, for example, technical training on the use and maintenance of the rice milling machine and solar components as well as bookkeeping and accounting was delivered to the end-users, which ensured the long-term sustainability of the project. Another good way forward, shown by Practical Action's project, is to form community-level irrigation management structures which include

¹⁷ Efficiency for Access, *Promoting High-Performing Appliances: Advisory Services for Governments*, pg 1, 2019

O&M committees. Furthermore, the Ministry of Agriculture provided technical backstopping and mentoring. When it came to raising capital for O&M, a maintenance fund was created with profits from sales which was then used for O&M. A lesson from the UNIDO project can be drawn as it has trained over 700 key stakeholders and implemented an awareness-raising campaign on energy saving. The latter was combined with a flexible tariff, which was higher during the night, reflecting the increasing generation costs of the PV mini-grid system due to the use of batteries or diesel generation.

Above all, capacity building at the local level is not only beneficial for the project but also creates income generation opportunities in rural communities. Youth unemployment

is one of the burning topics in the world.¹⁸ The Co-operative Bank Foundation in its project has identified youth unemployment as one grave issue in Kenya and decided to address the problem directly at a school level. Thanks to this project, young students are obtaining modern agricultural skills integrating DRE which in future will enable them to earn their living.

By 2030, the entire DRE value chain, including sales, installation, service, appliances, and operations and maintenance is projected to create 4.5 million jobs globally.¹⁹ Therefore, it is strongly recommended for all major stakeholders to work together to integrate capacity building and hence efficiency, reliability, and safety of DRE systems as a cornerstone of rural electrification projects and programmes.

¹⁸ The Global Economy, [Youth unemployment - Country rankings](#), 2020 (online)

¹⁹ Power for All, [Powering Jobs Census 2019: The Energy Access Workforce](#), pg 3, 2019

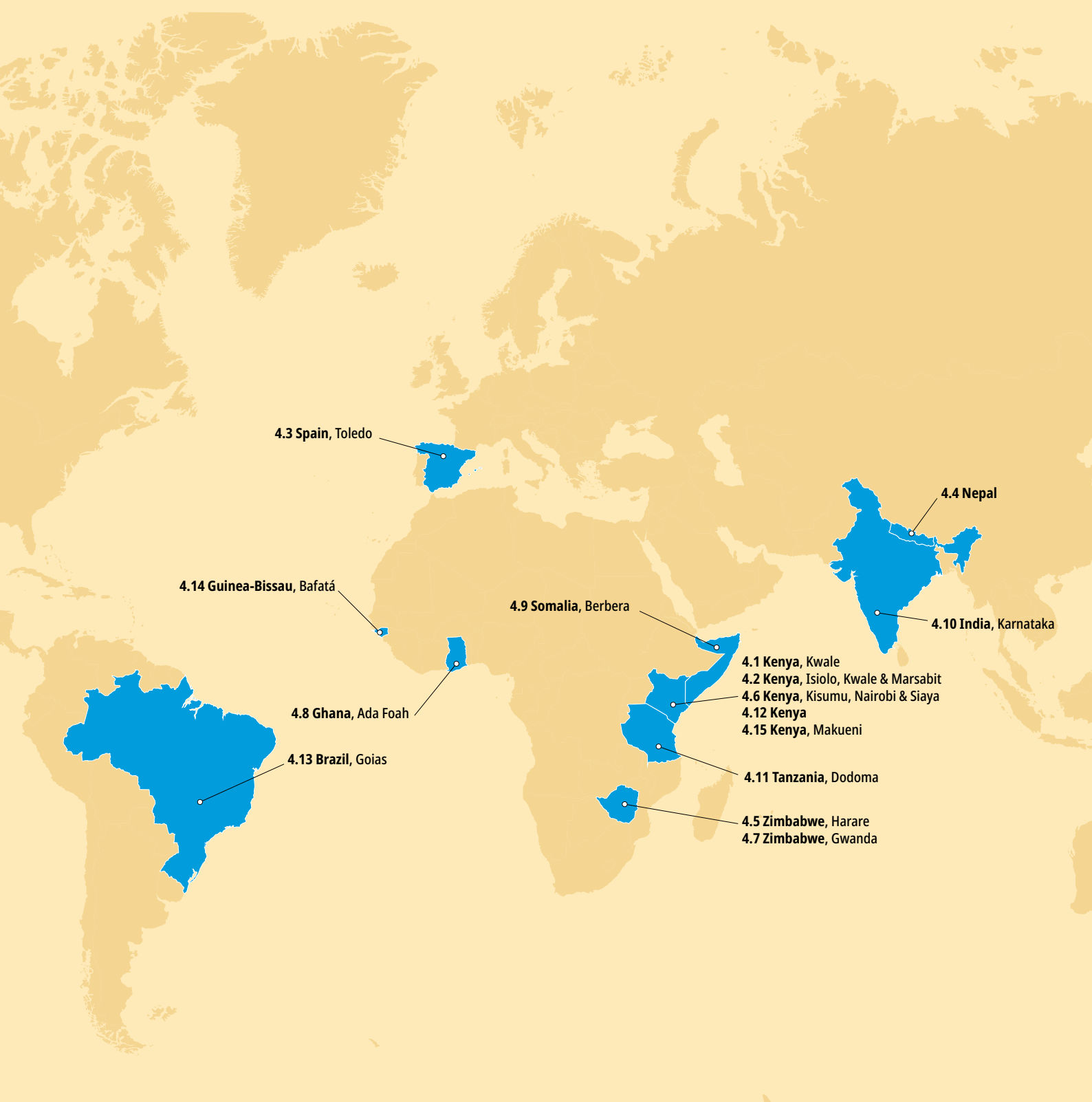
Challenge	Recommendation	Stakeholders
Social sustainability	<p>Inclusiveness and collective work approach with clear task division, accountability and ownership</p> <p>Build awareness on various tariff models and their impacts on different income groups and select a tailored option reflecting the needs (avoid blueprints)</p> <p>Address gender-specific issues, by providing equal opportunity for women and men to lead, participate in and benefit from the projects</p> <p>Raise awareness on energy saving potentials</p> <p>Raise early awareness on potential income-generating opportunities</p>	<p>Governments; private sector DRE operators, Civil Society organisations (CSOs); international funding partners; and local community representatives.</p>
Technical sustainability	<p>Data collection, assessment and sharing for efficient project optimisation</p> <p>Establish effective policies and regulations</p> <p>Holistic approach when implementing DRE technologies</p> <p>Customer-centric system design and operations – as per regulations and standards</p> <p>Capacity building to local stakeholders and beneficiaries for self-sufficient O&M and tariff structure</p>	<p>DRE project developers, operators and O&M technicians; government and policymakers; and local communities.</p>
Financial & institutional sustainability	<p>Build awareness on the advantages and disadvantages of various operation and execution (O&E) models and select the most suitable solution (avoid blueprints)</p> <p>Innovative financing and financial instruments for implementation and replication of DRE technologies in agriculture</p> <p>Efficient appliances ensuring both quality and affordability</p> <p>Build management and financial capacities of the future operator</p>	<p>Government; international funding partner; CSOs; and private sector.</p>
Environmental sustainability	<p>Raising awareness and the adoption of modern agricultural practices to catalyse demand for DRE technologies to boost agricultural productivity</p>	<p>Government; international funding partner; CSOs; private sector; and local communities.</p>

4

Case Studies



DRE INNOVATIONS TO BOOST AGRI-SECTOR PRODUCTIVITY & ADDRESS GLOBAL FOOD SYSTEM CHALLENGES: 15 CASE STUDIES



4.3 Spain, Toledo

4.14 Guinea-Bissau, Bafatá

4.8 Ghana, Ada Foah

4.13 Brazil, Goiás

4.9 Somalia, Berbera

4.1 Kenya, Kwale

4.2 Kenya, Isiolo, Kwale & Marsabit

4.6 Kenya, Kisumu, Nairobi & Siaya

4.12 Kenya

4.15 Kenya, Makueni

4.11 Tanzania, Dodoma

4.5 Zimbabwe, Harare

4.7 Zimbabwe, Gwanda

4.4 Nepal

4.10 India, Karnataka

4.1 BOREAL LIGHT

» Summary

- **Organisation:** Boreal Light GmbH
- **Project name:** Burani WaterKiosk
- **Project location:** Burani Village, Kwale County, Kenya
- **Project period:** March - August 2019
- **Project costs:** EUR 100,000

- » **Stakeholders:** Boreal Light GmbH (manufacturer of solar water desalination system); WaterKiosk Ltd. (installation and operation); Atmosfair gGmbH (financing and owner of its carbon credits); Bilal Sustainable Development Program (project auditor and community facilitator); and local communities (beneficiaries)

CONTEXT & MAJOR BARRIERS

Burani village lacks access to the electricity grid and is affected by falling groundwater levels and deteriorating water quality, resulting in an extreme drop in farming as well as negative health impacts, including a low protein diet for villagers.²⁰ By providing clean water to villagers, they are now able to produce cash crops and affordable fresh fish at the centre of the village and enjoy the highest quality of drinking water at affordable costs without having to walk long distances to fetch water. While the remoteness of the village meant substantial logistical challenges, the main obstacle was changing the mindset among the locals for adopting the technology and benefiting from it on a commercial and sustainable basis.



©Boreal Light

DRE SOLUTION

34 panels of 310 W each generate 11 kW solar energy to power submersible, feed booster, and aeration pumps as well as for lighting and mobile charging. 32 panels deliver 700 V DC to the high voltage line and

two other panels supply a low voltage 24 V DC line.

The Winture Planet Cube solar desalination system developed by Boreal Light GmbH is pumping 2,500 l of brackish water from a 140 m deep saline borehole and treating raw water to produce 2,000 l of hygiene drinking water per hour, for irrigation (680 plants), a fish farm (3 x 12 m³) and sanitation water (5,000 l / day). It includes a 24/7 remote monitoring system connected to the technical support office in Berlin.



©Boreal Light

Solar aeration pumps give enough oxygen to fishponds, and the excess of electricity from the solar array leaves enough power to charge cell phones and other DC appliances in the village.

BUSINESS MODEL & PROJECT FINANCING

Of the total costs of EUR 100,000, EUR 50,000 were received as a grant from Atmosfair gGmbH, EUR 20,000 from Boreal

²⁰ Own assessment and local public survey.

Light GmbH and EUR 30,000 equivalent service cost from the Bilal Sustainable Development Program. WaterKiosk Ltd owns and operates the machine. Burani WaterKiosk has a “holistic approach B2C” business model in which the generated revenue is made through selling water at EUR 0.7 per 20 l refilled bottle, vegetables and fresh fish. The collected revenue covers the entire running expenses, including operators’ salaries, spare parts and maintenance.



©Boreal Light

OUTCOMES

The project has provided drinking water for 3,000 inhabitants of Burani and its surrounding villages, eliminating the role of water trucking and water boiling. The use of solar energy versus diesel saves a minimum of 236 tonnes of CO₂ per year in this project. Besides, fresh fish is now available right at the heart of the village and there is no need to drive four hours to buy fish. The vertical farm connected to the system is offering new farming methods and business opportunities to the villagers. The three segments of the project, all in all, have created three permanent jobs and 10 value-added jobs.



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LESSONS LEARNT

The project is now being replicated in 46 more sites in Kenya. The new projects have been financed indirectly through revenues from CO₂ credits generated by the project. Such an innovative finance method, as well as the holistic approach, offer new opportunities to least developed communities. Investing in local capacities, involving the local community, proper auditing, daily management and monitoring were the key to success.

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4.2 CO-OPERATIVE BANK FOUNDATION

» Summary:

- **Organisation:** Co-operative Bank Foundation
- **Project name:** Adoption of Agribusiness & Use of Renewable Energy Technologies for Agriculture by Youth in Kenya
- **Project location:** Isiolo, Kwale & Marsabit Counties, Kenya
- **Project period:** March 2019 - July 2020
- **Project costs:** EUR 91,485

- ### » Stakeholders:
- Co-operative Bank Foundation (CBF) (project development and implementation); Energias de Portugal (EDP) (financing); Other stakeholders involve Ministry of Agriculture, Ministry of Education, and respective County Governments; and secondary schools in arid and semi-arid areas of Isiolo, Marsabit and Kwale Counties (beneficiaries).

CONTEXT & MAJOR BARRIERS

Unemployment among the youth in Kenya has been increasing at an alarming rate. With 500,000 to 800,000 young Kenyans entering the job market each year, its economy has not been able to provide the necessary amount of employment opportunities – formal and informal alike.²¹

Agriculture remains an important economic activity with great potential of alleviating poverty in Kenya. The project focused on encouraging youth in secondary schools to engage in climate-smart agriculture. Solar energy technology was selected since the targeted areas enjoy high solar radiation all year round.



©Co-operative Bank Foundation

DRE SOLUTION

The project set up greenhouse farming in schools powered by solar irrigation systems to ensure there was no interruption

of food production all year round. 12 greenhouses with a solar irrigation pump system were installed in seven schools.

The solar pumping system has three main parts: the 80 W PV panels which convert sunlight into electrical energy to drive the DC motor with a current of 5 A DC; a specially designed unit coupled to a flywheel, which drives a pump; and a reciprocating, positive displacement, high-efficiency piston pump. Some of the schools have installed additional solar panels for lighting connected to the solar irrigation system.

BUSINESS MODEL & PROJECT FINANCING

The total project costs of EUR 91,485 were co-financed by Energias de Portugal (EDP) and Co-operative Bank Foundation. Each school owns a DRE system and has developed a business plan for the project. CBF expects that through the sale of surplus produce the schools will generate income to ensure the sustainability of the project.

OUTCOMES

Seven solar-powered agribusiness enterprises were set up in seven public schools. It is estimated that a diesel pump is responsible for approximately 200 kg of CO₂ emissions per year.²²

Hence, with this project, 1,400 kg of CO₂ emissions per year will be avoided. The nutrition of the students will also be en-

21 British Council, *Youth Employment in Kenya*, pg 4, 2017

22 REEEP, *The Business Case for Solar Irrigation in Kenya*, pg 5, (online)

hanced by the farm produce. For example, an output of 360 kg of spinach per term improved the diet of the students and resulted in savings on the high cost of purchasing vegetables.

LESSONS LEARNT

Creating awareness among the youth of the benefits and use of DRE solutions while in school will promote future uptake and adoption leading to better outcomes for conservation of the environment through



©Co-operative Bank Foundation

the use of clean energy. Agribusiness with use of DRE offers numerous opportunities for livelihoods and job creation for youth in Africa today due to the reduced costs of energy which increases the rate of profitability.

Access to DRE encourages the use of technologies that will eventually transform agriculture in Kenya. The project served as a demonstration project to the community sharing knowledge on the use of sustainable energy. Co-operative Bank Foundation plans to roll out the project to other public secondary schools in other Counties in Kenya.

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4.3 GENERACIONES FOTOVOLTAICAS DE LA MANCHA

» Summary:

- **Organisation:** Generaciones Fotovoltaicas de La Mancha (GFM)
- **Project name:** WatEnergy
- **Project location:** Villacañas, Toledo, Spain (test phase), prototype to be installed in Jordan
- **Project period:** January 2020 - Ongoing
- **Project costs:** EUR 100,000

- ### » Stakeholders:
- GFM (project implementation); Government of Castilla-La Mancha in Spain (financing). Several non-governmental organisations (NGOs) joined in the testing phase for adapting the solution to critical groups.

CONTEXT & MAJOR BARRIERS

Access to electricity and drinking water is essential for well-being, health and social and economic development. Unfortunately, lack of the same is a huge challenge in many parts of the world, greatly affecting people's living conditions and possibilities of thriving. In some cases, diesel generators are used to power inefficient well pumps where the water quality is poor which results in diseases and infections.

WatEnergy is presented as an autonomous, portable and easy-to-install hybrid solution for electricity and drinking water generation. The system was originally designed for diesel generator as back up option, but it can work together with other renewable energy sources such as wind.

The testing phase issues were rectified to adjust to the temperature and moisture levels to maximise water generation and avoid system underperformance. The final product is specially tailored for countries experiencing droughts.

DRE SOLUTION

WatEnergy can be defined as a decentralised, hybrid and portable PV energy generator which is equipped with the essential technology for providing drinking water autonomously. The solar energy generation is primarily used to power an integral atmospheric condenser which generates up to 500 l of drinking water/day. The excess power could either be stored or used in productive activities such as milling, cold storage or water pumping.

The solution is composed of 30 kW solar PV panels, an AC-DC coupling system and 62 kWh lithium batteries. In addition to that, WatEnergy features a smart management platform that allows GFM to remotely control the operation, including room temperature, humidity, radiation, and system status.

BUSINESS MODEL & PROJECT FINANCING

The cost of the project is EUR 100,000, 80% of which was funded by the regional government of the Castilla-La Mancha (grant). The rest was financed by GFM (equity). Consequently, it is currently owned by GFM.

The scaling strategy is based on a mixed financing structure, comprising of public funding as well as private contributions through revenues from electricity and water consumption.



©Generaciones Fotovoltaicas de La Mancha

OUTCOMES

During the testing phase, WatEnergy was able to supply up to 250 l of drinking water for two days. As relative humidity rises, the level of production increases. Consequently, it is expected to maximise water production in countries where the climate is wet and hot.

On average, WatEnergy can produce 43,800 Wh yearly, so it means up to 16,887.24 kg of CO₂ annually. About six temporary jobs were created during the design, construction and testing phase.



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LESSONS LEARNT

As WatEnergy is incorporated in a portable shipping container, it could be shipped anywhere. Having considered this, the system can operate in any place where solar radiation and moisture is present. During the testing phase, the water generation worked as planned, taking into consideration that in Spain the humidity levels are very low. The solution will then be donated to an NGO operating in the Middle East, where humidity conditions allow the water and power production to be increased and, as a result, accelerate the amortisation.

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4.4 GHAM POWER

» Summary

- **Organisation:** Gham Power
- **Project name:** Yield Improvement in a Box
- **Project location:** Western Nepal
- **Project period:** September 2019 - October 2022
- **Project costs:** EUR 33,500

- » **Stakeholders:** Gham Power (project development and implementation); micro-finance institutions (MFIs) (financing); and local farmers and their communities (beneficiaries).

CONTEXT & MAJOR BARRIERS

Nepal is a developing nation, with 25% of its population living under the poverty line.²³ With a high economic standing, Nepal's agriculture sector provides livelihoods to about 60% of the population.²⁴ The sector is pivotal in increasing income, alleviating poverty, and uplifting the living conditions of Nepali people. To a larger degree, the country's poverty is a direct function of its unproductive agricultural sector.²⁵

Currently, farmers do not have a reliable and sustainable source of irrigation. Additionally, they follow traditional agricultural practices resulting in low agricultural productivity and low returns. Gham Power's solution to the current problem faced by Nepali farmers is an integrated service – "Yield Improvement in a Box." Through this, Gham Power provides smallholder farmers with reliable irrigation, affordable financing and personalised agri-advisory, helping them adopt modern farming methods and eventually improve farm efficiency.

DRE SOLUTION

Gham Power's approach to solving the problem at hand is through providing solar water pumps (SWPs) as a reliable source of irrigation financed by partner MFIs, coupled with value-added services through personalised agri-advisory. The Gham Power solution – "Yield Improvement in a Box" – includes free agri-advisory services, training on modern agriculture techniques and

data-driven solutions for efficient monitoring of the farm.



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BUSINESS MODEL & PROJECT FINANCING

Gham Power has developed partnerships with almost half a dozen MFIs and grassroots cooperatives with a cumulative member base of over 100,000 farmers. Gham Power provides training and support for social mobilisation and outreach activities for these partner organisations while they primarily focus on demand aggregation and financing. The micro-finance partners can finance 50-100% of the system cost (up to 50% financing from Gham Power) while the farmers can pay up to 5% as equity. The systems are typically financed over three years' term through monthly payments. The ownership of the system transfers from Gham Power to the respective farmer as soon as they complete their payments.

²³ ADB, *Poverty Data: Nepal*, 2019 (online)

²⁴ Dahal et al, *New State Structure and Agriculture Governance: A Case of Service Delivery to Local Farmers in the Eastern Gangetic Plains of Nepal*, pg 1, 2020

²⁵ USAID, *Nepal: Agriculture and Food Security*, 2020 (online)

OUTCOMES

Gham Power has deployed around 200 solar irrigation systems in the past three years, with almost 100 systems installed through commercial financing. Preliminary impact assessment on these farmers indicates a potential for up to 80% increase in farm income within the project term, i.e. three years. Through replacement of diesel-powered pumps and farm advisory on efficient practices, the farm expenses have been reduced by up to 10% in the first year itself, while land acreage also increased by up to 8% on average thus leading to an overall increase in productivity/yield by around 11%. Considering all the beneficiaries, including farming households and other stakeholders involved in the value chain, a single project helps to create or supplement five to 10 jobs. Additionally, each project curbs an average of 2.1 tonnes CO₂ per year, which means for around 200 systems that Gham Power has deployed so far, the systems directly curb 420 tonnes of CO₂ per year.



©Gham Power

LESSONS LEARNT

The 'Yield Improvement in a Box' project has reinforced Gham Power's approach on delivering holistic solutions to the farmers that go beyond the installation of solar devices like water pumps. Delivering low cost, yet tailored agri-advisory to the farmers can have a significant positive impact for the farmers following age-old traditional practices.



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Gham Power also realised that it is important to work closely with key stakeholders, regulatory bodies and policymakers to align the incentives and create an enabling environment for scaling up. Gham Power is continuously working with several partners from government, development agencies as well as the private sector to expand its solution in Nepal and to replicate the integrated approach in other countries in South and South-East Asia.

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4.5 OFFGRIDSUN

» Summary:

- **Organisation:** OffgridSun
- **Project name:** Strengthening the Resilience of Rural Communities Affected by Drought Due to El Niño
- **Project location:** Lupane & Makoni districts, Harare, Zimbabwe
- **Project period:** September 2017 - May 2020
- **Project costs:** EUR 890,000

» **Stakeholders:** Coordinamento delle Organizzazioni per il Servizio Volontario (COSV) (project developent); OffgridSun (DRE supplier). Agenzia Italiana per la Cooperazione allo Sviluppo (AICS), ActionAid Zimbabwe, Linkages for Economic Advancement of the Disadvantaged (LEAD) (financing); Other stakeholders involved are Gikko, Ministries, local authorities and farmers associations; and rural communities (beneficiaries).

CONTEXT & MAJOR BARRIERS

EL Niño is a cyclical pattern causing droughts in southern Africa, among others in Zimbabwe. This creates challenges in terms of food security, access to drinkable water, and resistance to natural, economic and social shocks.²⁶

This project aims at strengthening the resilience of rural communities affected by El Niño in Lupane and Makoni districts.

In 2018, a severe drought hit the country, one of the most difficult to manage in the last years. Fortunately, a sufficient agricultural harvest was produced for the supply of all the families involved in the project.

The choice of renewable energy technology was solar, due to the climatic and environmental conditions of the country. Zimbabwe is an arid and very sunny country, characterised by drought, ideal for prefer-

ring solar energy to the wind, hydroelectric or geothermal energy.

DRE SOLUTION

The OffgridSun solar pumping systems benefit the small farmers in rural communities struggling with water access, which threatens their food security. By building wells and equipping them with solar pumping facilities together with appropriate training, it directly mitigates the risks of droughts in this arid area and provides access to water. It is especially true for women who will spend less time collecting water, unlocking more time to dedicate to other productive activities. The equipment allows a better water supply for schools, nutritional gardens and watering of cattle.

Each solar pumping system is powered by 11 PV modules of 260 W. They include a supporting structure, a 1.1 kW submerged hydraulic pump and a driver equipped with a Bluetooth monitoring system allowing for remote control and engine management of the pump. In total, nine such systems were installed.

BUSINESS MODEL & PROJECT FINANCING

The total project cost was approximately EUR 890,000, of which EUR 846,000 were received in the form of a grant from AICS.



©OffgridSun

²⁶ COSV, *Support to rural communities to mitigate the effects of El Niño and promote resilience to adverse climatic conditions*, 2017 (online)

COSV, ActionAid Zimbabwe and LEAD together provided approximately EUR 44,000 in equity.

The solar pumping systems are owned by nine local management committees. Sustainability of the project including the maintenance of the systems is guaranteed by the benefits resulting from the sale of the additional agricultural products that were produced thanks to the newly built infrastructure.



©OffgridSun

OUTCOMES

350 people benefited from the implementation of the OffgridSun solar pumping systems, overall improving their access to water. About 135 people had new income generation opportunities concerning water management in two districts.

Due to the installation of the systems, the productivity of growing cereals and vegetables increased by 15% on average over the 3-year project period.

LESSONS LEARNT

The success of this project is based primarily on the correct selection of the project areas and the strong involvement of beneficiaries, especially when they develop a strong sense of ownership of the project activities and installations. The project also included proactive involvement of local and district authorities and ministries at the central level. This collaboration, the efficient coordination between the different partners, as well as regular communication to update all farmers on the status of the project were decisive factors for the sustainability of the project.



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OffgridSun
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4.6 PHAESUN

» Summary:

- **Organisation:** Phaesun GmbH in cooperation with University Hohenheim & Solar Cooling Engineering UG founded the “SelfChill Team”
- **Project name:** Improving Milk Value Chains through Solar Cooling
- **Project location:** Kisumu, Nairobi, and Siaya, Kenya
- **Project period:** January 2016 - December 2018
- **Project costs:** EUR 200,000

» **Stakeholders:** SelfChill Team and Strathmore University Kenya (project development and implementation); Powering Agriculture (financing); and local dairy cooperatives (beneficiaries).

CONTEXT & MAJOR BARRIERS

Smallholder dairy farms are the major providers of marketed milk in Kenya. Due to the low individual production levels, farmers are usually associated with cooperatives. Dairy cooperatives are responsible for collecting the raw milk from the members to supply bigger volumes to dairy plants or the market. These cooperatives are often constrained by minimal hygienic standards and the lack of cooling systems leading to high microbial contamination of the milk. As a result, 20-30% of the milk is estimated to be lost.²⁷

potential to make the dairy value chain more efficient by using clean energy.

This technical concept was optimised by the University’s spin-off company, Solar Cooling Engineering (SCE) and Phaesun. The new innovative SelfChill strategy offers a modular solution that can be adapted to different farm sizes and milk collection systems. In the new concept, the produced cold is stored in an ice reservoir, the so-called water chiller, which can be either used to cool milk cans or to cool entire milk tanks.

DRE SOLUTION

A baseline study to interview farmers and to train them in the use of the technology took place. University Hohenheim and University Strathmore conducted technical training to transfer knowledge about solar cooling technologies to local technicians, solar installers and other stakeholders.

Phaesun together with the University of Hohenheim has conceptualised a solar milk cooling system based on the use of conventional milk-cans and adapted DC refrigerators. The milk cooling system called Milky Way consists of the Steca DC Freezer PF 166, four solar modules of 150Wp, two 82 Ah batteries, milk cans, ice cups, electronics and installation material. This technology assures the preservation of milk quality from the farm to the main collection centre or market and shows great



©Phaesun

BUSINESS MODEL & PROJECT FINANCING

The project was funded through *Powering Agriculture* by GIZ and BMZ. To prove economic sustainability, the objective was to demonstrate that dairy farmers appreciate the cooling of milk and can pay a monthly rate for the service. The implemented pay-

²⁷ IDEAS, *Improving milk value chains through solar milk cooling*, 2018

ment model proved to be successful and confirmed the great potential of this innovative approach. At the end of the project, the ownership of the systems was transferred to the farmers.



©Phaesun

OUTCOMES

Under the project, about 10 farms and co-operatives have been equipped with solar milk cooling systems with a capacity of 60 l / day each, thus reducing milk losses by approximately 25%. That means that

a minimum of 50 people could increase their income.

As the cooling systems completely rely on solar energy, no CO₂ emissions are produced while using the systems. Another important factor to guarantee a sustainable system is the use of a natural refrigerant with low global warming potential.

LESSONS LEARNT

In the course of the project, it became apparent that there is also a great demand for medium-scale milk cooling systems. As a result, SCE in cooperation with Phaesun developed the modular *SelfChill*® concept. Local materials can be used, thus increasing local added value and the systems are pay-as-you-go compatible, creating attractive business models even in regions with low purchasing power. In the latest project “PV-Cool Kenya”, which started in July 2020, a cold room for agricultural products (20m³), a milk chiller (560 l) and an ice machine (50 kg/day) will be installed in Kenya demonstrating the potential of the *SelfChill*® concept.



©Phaesun

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PRACTICAL ACTION

» Summary:

- **Organisation:** Practical Action
- **Project name:** Enhanced Agricultural Productivity & Resilience to Climate Change through Solar-powered Irrigation
- **Project location:** Gwanda district, Zimbabwe
- **Project period:** October 2017 - January 2021
- **Project costs:** EUR 1,900,000

- ### » Stakeholders:
- Practical Action (project implementation lead); Ukuthula Trust (local NGO partner); Government stakeholders such as Ministry of Lands, Agriculture, Water, Climate and Rural Resettlement, the Ministry of Women Affairs, Community, Small and Medium Enterprises and the Gwanda Rural District Council (project design, implementation, and review); Other stakeholders involve local leadership were also engaged and consulted at various stages; and local farmers (beneficiaries).

CONTEXT & MAJOR BARRIERS

Gwanda district has a low average rainfall of less than 450 mm per annum,²⁸ yet rain-fed agriculture dominates. This coupled with climate change means that crop failures have become increasingly frequent and food security is being compromised. As the area is off-grid and remote, access to energy for irrigation has been a challenge. While diesel-powered irrigation schemes had been established previously, they have become dysfunctional due to high costs and difficulties accessing fuel.

DRE SOLUTION

The project installed 31 stand-alone solar systems (1.36-3.6kW each) to pump water from boreholes and two solar systems (4.08 kW and 37.62 kW peak) pumping water from dams. The water is pumped to irrigation schemes ranging from 4 to 25 hectares in size and smaller gardens ranging from 0.5 to 2.5 hectares in size. The solar pumping units have no batteries, however, water storage tanks are installed as a backup. For the larger schemes, a diesel engine was installed as a backup.

All beneficiaries were trained in operation and maintenance (O&M) and community level irrigation management structures were formed which include O&M committees. The training was done in collaboration with local staff from the Agriculture

Ministry who will remain in direct contact with the community to provide technical backstopping and mentoring.

The DRE solution was coupled with agronomic skill-building and participatory market systems development to empower farmers to better understand and engage in markets.



©Practical Action

BUSINESS MODEL & PROJECT FINANCING

The total project cost was EUR 1,900,000, grant-funded by the Swedish International Development Cooperation Agency (SIDA). The DRE system is community-owned with a monitoring and oversight role by the rural district council. Internal saving and lending groups have been established with their profits channelled into a maintenance fund.

²⁸ FAO, *Zimbabwe's natural regions and farming systems*, 2006 (online)

OUTCOMES

The area under agricultural production has almost doubled to about 143 hectares, with significant yield increases. The 422 households involved have gone from subsistence farming to be able to sell excess produce, thus improving their livelihoods.



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LESSONS LEARNT

The introduction of solar energy has been no silver bullet. It has been important to ensure that water and energy are utilised efficiently through water management practices and proper O&M of the equipment. This requires refresher training and easy access to after-sales support.

To address financing challenges for small-holder farmers, equipment suppliers and financial institutions have to work together to come up with tailored financing/payment packages.

The project has so far been replicated in the form of two projects expanding into other wards of Gwanda district reaching an additional 900 farming households.

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Practical ACTION

4.7 RYSE ENERGY

» Summary:

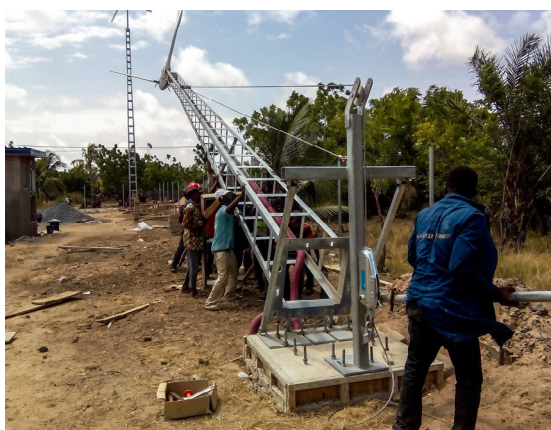
- **Organisation:** Ryse Energy
- **Project name:** Resilient Renewable Mini-grid in Ghana
- **Project location:** Ada Foah, Ghana
- **Project period:** February - May 2016
- **Project costs:** EUR 180,000

- ### » Stakeholders:
- Ryse Energy and Trama TechnoAmbiental (project development implementation) and the United Nations (financing); and local community (beneficiaries).

CONTEXT & MAJOR BARRIERS

Whilst Ghana has one of the highest energy access rates in Sub-Saharan Africa,²⁹ access to energy in the remote agricultural and rural areas of the country is extremely challenging. High diesel costs and lack of infrastructure to reach last-mile communities was the primary reason for the project.

A challenge faced was the change in system design. Initially, it was planned to deliver a DRE system to enhance agricultural output through an increase in reliable energy. As the project progressed, it became apparent that the entire village in Ada Foah was in a state of extreme energy poverty with no access to electricity. Therefore, the scope of the project was then changed to develop a hybrid solar-wind mini-grid DRE system to provide energy for agricultural activity as well as for other basic energy needs of the village. The system also required hydraulic tilt-up towers for manual installation without the need for a crane.



©Ryse Energy

DRE SOLUTION

A hybrid wind-solar mini-grid system was selected as the optimum solution. A farm was selected as the project site for the installation of the system based on the availability of a large open area as well as access to unobstructed wind. The system incorporates the following components:

- 2 x Ryse Energy E-5 wind turbines, 220V, 5 kW
- 1 x 40 kW PV solar array
- 6 x inverters Studer XTH 8000-48
- 250 x REC PV modules
- 2 x banks of 48V batteries OPZV 3,500 Ah-C10

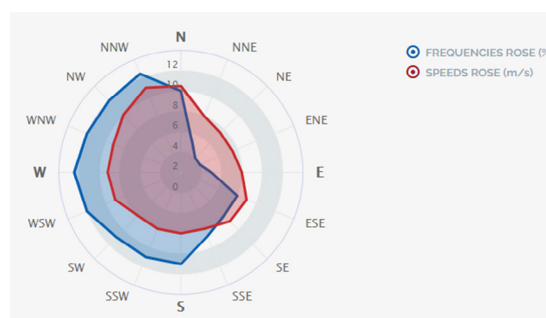


Figure 1: wind speed rose at site.

The DRE system is used as the area's primary energy source, providing over 316 kWh/day to the community and peak power of ~ 50 W. The different energy technologies complement one another to keep the generation flow constant day and night. Community training regarding op-

²⁹ World Bank, [Access to electricity \(% of population\) - Sub-Saharan Africa](#), 2018 (online)

eration and maintenance was undertaken to ensure the reliability and resilience of the system.

BUSINESS MODEL & PROJECT FINANCING

The total project cost was approximately EUR 180,000 which was funded with a grant from the United Nations. Trama TechnoAmbiental owns the DRE system. In terms of ongoing operation and maintenance, training was conducted by Ryse Energy's team to the local communities to ensure resilience and reliability of the system. Operational costs are very low with the local community maintaining the



©Ryse Energy

system.

OUTCOMES

The DRE system enabled agriculture to blossom as water pumping and irrigation systems can now be operated. In addition to that, the local community of around 500 people gained access to electricity for

basic needs, such as lighting and heating. The resulting energy access would've resulted in a reduction of 85 metric tonnes of CO₂ per year if fossil fuels were utilised which is the amount of emissions avoided. An estimated 200 lives were positively impacted by the installation, creating over 20 jobs within the community.

LESSONS LEARNT

The potential for replication and scale-up of this system is extremely high, the combination of wind, solar and energy storage creates a resilient and reliable system which generates consistent renewable energy for agricultural needs and wider community services. Ryse Energy believes the collaboration with the local community, system design, energy output was a great success. The highlight is the change of the project design from a purely agricultural installation to a village mini-grid.

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4.8 SEAWATER GREENHOUSE

» Summary:

- **Organisation:** Seawater Greenhouse Ltd
- **Project name:** Sustainable Intensification of Agriculture in the Horn of Africa
- **Project location:** Berbera, Somalia
- **Project period:** January 2017 - Ongoing
- **Project costs:** EUR 220,000

- » **Stakeholders:** Seawater Greenhouse Ltd (project implementation); UK Agritech Catalyst (financing); Ministry of Environment and Rural Affairs (provided land lease); Other stakeholder involve Pastoral and Environmental Network in the Horn of Africa (PENHA);³⁰ and local farmers and community (beneficiaries).

CONTEXT & MAJOR BARRIERS

Agriculture in Somalia / Somaliland is severely constrained by high temperatures and lack of water.

Less than 1% of the land is cultivated and yields are low.³¹ The Seawater Greenhouse process, optimised for the location, exploits the prevailing wind to evaporate seawater. Cooling the air and raising the humidity enables high-value crops to grow where formerly this was not possible. Desalination and evaporative cooling are driven by high- and low-pressure pumps, powered by solar PV. Local expertise in horticulture and soil science, in general, is lacking in the region.



©Seawater Greenhouse

DRE SOLUTION

10 kW solar PV array together with battery backup and 220 V inverter to drive 1.6kW seawater reverse osmosis desalination

unit and freshwater pumps for drip irrigation. Using the wind directly to drive the evaporative cooling (no fans). Evaporative cooling is essentially an adiabatic process, with negligible heat flow, as air is passed through a wetted media or water spray.³²

Basic training and illustrated operational manuals were provided to the local team. More advanced training is required and the project is actively seeking grant opportunities to meet this requirement. The total project period was three years from design to implementation. Operation is currently ongoing.

BUSINESS MODEL & PROJECT FINANCING

Total project costs are EUR 220,000. Hardware and construction costs for a 1-hectare pilot farm are approximately EUR 90,000 each. The project was partly funded by a UK Agritech Catalyst government grant and from company resources. It is currently co-owned by Seawater Greenhouse Ltd and PENHA.

The project team is in the process of converting the project into a locally owned co-operative business.

Currently, the project is not financially sustainable, owing to high-security costs and low skillsets. The project team plans to overcome this with local ownership and training.

³⁰ PENHA, [About PENHA](#), (online)

³¹ FAO, [Agriculture: Building Resilience](#), (online)

³² Science Direct, [Evaporative Cooling](#), (online)



©Seawater Greenhouse

OUTCOMES

The project is the first desalination system in the Horn of Africa powered 100% by renewable energy. Desalination is achieved with zero discharge. Salt is produced from the concentrated brine after evaporative cooling. Courtesy to this first Seawater Greenhouse in Africa, successful crops include tomatoes, cucumber, lettuce, melon. Trees are planted around the site.

Four temporary jobs were created during this project and more income generation opportunities will be unlocked once local ownership is established. The project is zero carbon in operation. The potential for CO₂ sequestration at scale is significant.

LESSONS LEARNT

The project demonstrates that it is technically feasible for the region to be self-sufficient in food, given scale-up, skill and know-how. The team is currently seeking how best to achieve that, starting with training, testing and demonstration centre.

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4.9 SELCO FOUNDATION

» Summary:

- **Organisation:** SELCO Foundation
- **Project name:** Solar-powered Flour Mill for Individual Entrepreneurs
- **Project location:** Agsalkatta Village, Karnataka, India
- **Project period:** December 2018 - March 2019
- **Project costs:** EUR 4,100

- ### » Stakeholders:
- SELCO Foundation (project implementation); Shri Kshetra Dharmasthala Rural Development Project (SKDRDP) (financing); SELCO Solar Pvt Ltd. (solar integration partner); and Ms. Rosy Dabale (beneficiary).

CONTEXT & MAJOR BARRIERS

Agsalkatta is inhabited by 375 people of Siddi community of East African descent. The villagers are smallholder farmers who needed to travel to Kesarolli some 2 km away for milling of their small quantities of rice. The village itself suffers from lack of stable power supply. The introduction of an efficient solar-powered flour mill allows local farmers to mill their produce locally for self-consumption as well as for selling at markets for income generation. It cuts down travel costs significantly leading to community savings. Frequent travel to the remote village and the need for awareness-raising among the villagers were the main challenges.

DRE SOLUTION

The flour mill operates on 2 hp single phase system, 3 hours solar backup hybrid system, a combination of both grid and solar power, with a capacity to process 15-16 kg of grains per hour. The solar system has 10 panels, 250 W x 8 batteries of 150 Ah and a 5 kVA inverter. The local solar system integrator, SELCO Solar Pvt Ltd., ensures immediate servicing as and when required. SELCO Foundation provided technical training on the use and maintenance of the machine and solar components. Training on bookkeeping and accounting was delivered to the end users.

BUSINESS MODEL & PROJECT FINANCING

Rosy lacked financial resources to fund her flour milling solution worth EUR 4,100. With minimum savings, lack of social capi-

tal and barely any additional family income, Rosy required support to finance her unit through a combination of capital subsidy, loan and her contribution from her savings. The total project cost was covered by SELCO Foundation through an MFI loan (90%) and a personal contribution (10%) by the female entrepreneur, end user and new owner of the facility, Ms. Rosy Dabale. The energy enterprise SELCO Solar Light Pvt Ltd. provides free servicing twice for the first year. Thereafter, an annual maintenance fee of EUR 2.79 paid by the end user allows them to avail servicing twice in a year.



©SELCO Foundation

OUTCOMES

The flour mill acts as an important perennial source of income Ms. Rosy Dabale. She was linked to a financial institution to

be able to access a loan for adopting this long-term asset and was provided training and capacity building. This solution allowed for the community, and especially women and widows to access this basic service locally saving them time (one day per trip) and transportation costs (EUR 0.30 to 0.60 per trip). Due to this solution bringing access locally, even during COVID induced lockdowns which inhibited movement, the community had food security. Solarisation has reduced Ms. Dabale's monthly electricity bill by EUR 5 and increased her income by EUR 23. The project raised awareness about technology in the community and created two new jobs.

LESSONS LEARNT

Over 20 solar-powered flour milling units have been deployed across the states of Karnataka, Odisha and Jharkhand in India. Ownership of these solutions lies with individuals, self-help groups and farmer producer organisations. Agriculture value chain solutions are continuing to be implemented with partners in India. The learnings (technical, financial, social models) will be shared with national and global partners who could implement these solutions in their respective geographies.



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4.10 SIMUSOLAR

» Summary:

- **Organisation:** SIMUSOLAR Ltd.
- **Project name:** Kaliyo Farm Horticulture Farming: SWP installation
- **Project location:** Ihumwa, Dodoma, Tanzania
- **Project period:** June 2019 - Ongoing
- **Project costs:** EUR 3,000

- » **Stakeholders:** Simusolar Ltd (project implementation and financing); and Ms. Winfrida Kaliyo (Kaliyo farm owner and beneficiary).

CONTEXT & MAJOR BARRIERS

Challenges faced in the farming community include high operational costs, pests, diseases, and minimally skilled labour. Smallholder agriculture supports the livelihoods of more than half of the labour force, however, productivity is severely limited.³³

Economic opportunities are often limited to subsistence farming relying on rain-fed agriculture and the effects of climate change are becoming a growing challenge making harvests unreliable.³⁴ Heavy dependence on rain-fed farming practices leaves Africans vulnerable in terms of food security.³⁵ Only 28% of rural households in Dodoma, Tanzania are connected to electricity.³⁶ Photovoltaic panels provide the electricity needed to run pumps economically with no batteries required, providing scalability to fit the energy requirement of any solar water pump (SWP) system.

The innovative approaches used by Simusolar include customer-centred system design and underwriting at the farm using a smart-phone app, and financing of the equipment, which is critical for affordability. Farmers typically do not have access to credit, therefore they cannot purchase equipment to improve the sustainability or profitability of their operations.³⁷ Another major challenge to technology adoption is a general lack of awareness about the availability and benefits of SWP.³⁸

DRE SOLUTION

After installation of the SWP, productivity increased. The money previously used on diesel is now invested in farming tools, fertilizers, herbicides and pesticides, hiring skilled labour and high-quality seeds. The SWP is rated at 3hp and can be used for up to 160 m head with 3 kW of PV. The pump installed is Simusolar's Kina Pump with six solar panels (1.7 kW), set at 120 m of depth.

Technicians from Simusolar train farmers on proper pump operation. Simusolar provides a 2-year warranty, and technicians provide service as needed. Design, underwriting and installation processes are streamlined. Time from initial customer request to project completion was under two months.



©Simusolar

33 FACTOR[e] Ventures, *The Opportunity at the Nexus of Energy and Agriculture*, pg 10, 2020 (online)

34 ARE, *Practical Action - Transforming African Rural Livelihoods through Solar Irrigation*, 2020 (online)

35 Kudzai Chimhangwa, *How green innovation can transform African agriculture*, 2020 (online)

36 REA, *Energy Access and Use Situation Survey II In Tanzania Mainland*, 2020 (online)

37 Next Billion, *Solving the Credit Impasse: How Big Data and AI are Generating Funding Opportunities for Smallholder Farmers in Africa*, 2020 (online)

38 60 Decibels, *Why Off-Grid Energy Matters*, 2020 (online)



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BUSINESS MODEL & PROJECT FINANCING

The cost of the SWP system, including installation, was EUR 3,000. It was financed through a down-payment of EUR 750 and monthly instalments of EUR 125 over 18 months. Financing is directly provided by Simusolar, supported by debt providers. The owner of the SWP system is Winfrida Kaliyo once her monthly payments are completed. Long-term sustainability is ensured by Simusolar's commitment to providing (paid) service even after the warranty period expires.

OUTCOMES

The main outcomes of this project include increased agricultural production and income for this smallholder farmer. Tomato production increased from 1 to 2 tonnes, cucumber production from 800 to 1,800 kg, green vegetable production from 4 to 8 bags, onion production from 500 to 1,000 kg, papaya production from 700 to 1,300 units and sweet peppers were added. Water supply increased from 10,000 to 16,000 l/day. Additional employment included two skilled permanent jobs and five seasonal jobs. Running costs for the fuel pump went from EUR 70/month to zero, and annual CO₂ emissions were reduced by 487 kg.³⁹ The introduction of SWPs contributes significantly to the SDGs-1, 2, 3, 7, 8, 9 and 13.



©Simusolar

LESSONS LEARNT

Farmer satisfaction was high, although it was indicated that support for selling produce would be valuable. Customer referrals are crucial to expanded awareness and acceptance of SWP. Farmers currently using fuel-powered pumps gain significant, immediate benefits by switching to solar pumps.

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³⁹ Agroberichten Buitenland, *Increasing the use of solar powered pumps for Irrigation in Tanzania*, 2020 (online)

4.11 SUNCULTURE

» Summary:

- **Organisation:** SunCulture
- **Project name:** Solar-powered Irrigation Systems for Smallholder Farmers Bundled with Pay-As-You-Grow Financing
- **Project location:** Kenya
- **Project period:** January 2019 - Ongoing
- **Project costs:** EUR 5,000,000 - 15,000,000 (Ongoing)

- ### » Stakeholders:
- SunCulture (project development and implementation); Local governments (distribution partners); and SunCulture's customers and rural smallholder farmers (beneficiaries).

CONTEXT & MAJOR BARRIERS

96% of Africa's smallholder farmers rely on rain-fed agriculture, and consequently, Africa's agricultural productivity is at about 50% of the average growth seen in other developing countries.⁴⁰ In Kenya, around 1.8 million people in rural and arid/semi-arid land areas faced high levels of acute food insecurity during August to September 2020.⁴¹

SunCulture's RainMaker2 with ClimateSmart Battery utilises solar technology as an affordable, sustainable, and effective alternative to rain-fed irrigation or petrol pumps. SunCulture's battery system ensures electricity supply in homes during the night and for irrigation on cloudy days.

Major obstacles include affordability and awareness of the technology. SunCulture has implemented a Pay-As-You-Grow financing solution allowing farmers to pay small monthly fees and the company has addressed lack of awareness through marketing campaigns, regional sales and support centres, and industry advocacy.

DRE SOLUTION

SunCulture launched the RainMaker2 with ClimateSmart Battery in January 2019, bundled with financing, delivery, installation, training and after-sales service to create a complete package for smallholder farmers in sub-Saharan Africa that increases crop productivity through irrigation.

Specifications:

- GSM PAY-G & IoT Enabled
- 444 Wh Lithium battery + 310 W Solar Panel
- Heads and flow up to 60m and 3,000 l/h
- 4 x 600 Lumens LED Bulbs + 2 x USB ports
- 4 x sprinklers + fittings
- Optimised for < 2 acres irrigation



©SunCulture

BUSINESS MODEL & PROJECT FINANCING

The cost of the RainMaker2 and ClimateSmart Battery system is EUR 1,080 which is paid over 30 months and includes operating costs. After the solar pump is paid off, the customer owns the system. SunCulture's project is funded 60%

⁴⁰ Oxford Business Group, *Agriculture in 2019*, 2019 (online)

⁴¹ Reliefweb, *Integrated Food Security Phase Classification*, 2020 (online)



©SunCulture

through equity, 15% through debt and 25% through grants.

OUTCOMES

60 Decibels recently surveyed SunCulture customers. The following impacts were reported:

About 85% of SunCulture's farmer customers are confident about their farming activities over the next month, compared to just 37% of Kenyan farmers overall. 87% reported an increase in agriculture production. This resulted in 80% of the farmers having an increase in money earned and an average revenue increase of 44% per season.

95% of the farmers reported improvements in their quality of life. SunCulture's impact on money earned deepens over time. While 32% of respondents who have owned SunCulture systems for less than a year reported their income had *very much improved*, that rose to 68% of respondents who have owned SunCulture systems for more than a year.



©SunCulture

In addition to that, 1,228 kgs of CO₂ emissions are avoided annually by replacing a petrol irrigation pump. Kenya alone has an opportunity to avoid over 1 million tonnes of CO₂ annually by replacing petrol pumps with solar irrigation products. SunCulture estimates that an average of 1.5 local jobs are created per solar irrigation system.

LESSONS LEARNT

SunCulture is focused on scaling across Kenya and through existing distribution partners in Uganda, Ethiopia and Togo. There is a huge potential across Africa. SunCulture is looking for new markets and partnerships to replicate their proven model. Demand-side financial incentives to reduce costs for farmers will drive this change faster and reach more financially constrained farmers. SunCulture, therefore, recommends governments and international funding partners to support the scaling of solar-powered irrigation systems for smallholder farmers.

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4.12 TESVOLT

» Summary:

- **Organisation:** TESVOLT GmbH
- **Project name:** Mandengo SMART Hybrid Irrigation Project
- **Project location:** Mandengo Farm, Quirinópolis, State of Goiás, Brazil
- **Project period:** May 2020 - Ongoing
- **Project costs:** EUR 1,577,244.45

- ### » Stakeholders:
- TESVOLT GmbH (project implementation); BRYDS Soluções em Energia (EPC Partner); IDEATEK (Service Partner); Banco do Brasil S.A. (financing); and Mandengo Farm (owner of the asset and beneficiary).

CONTEXT & MAJOR BARRIERS

It is estimated that there are between 1,000 and 1,200 rural properties that use a diesel generator to irrigate in Brazil. The goal was to show the rural producers of Mandengo Farm the potential of solar energy and its applicability.⁴²

The Mandengo Farm's biggest challenge was that it was fully dependent on generators, creating high cost in electricity, diesel, and transportation preventing the land to bloom to its fullest. TESVOLT provided the solution to enhance the productivity in an environmentally friendly way, bringing the cost down from EUR 0.16/kWh to EUR 0.04/kWh.

The Farm is located in a remote area where internet access and wireless connectivity is limited. During project implementation, the day-to-day transportation to the project location was challenging due to rough terrain.



©TESVOLT

DRE SOLUTION

Technology implemented:

- TESVOLT System - TS HV with ABO inside (active battery optimiser)
- TS HV - High Voltage Generation
- Power: nominal power output of battery storage 150 kVA
- Battery capacity: 307.2 kWh in first construction phase; capacity expandable
- PV Installation -700 kVA / 800 kWp solar/ SMA Sunny High Power

Both BRYDS Soluções em Energia (EPC Partner) and IDEATEK (Service Partner) were trained and certified by TESVOLT Academy to commission the system successfully. The Battery Energy Storage System (BESS) was installed in a climatized room to prolong life expectancy.

A storage solution was required as a back-up for the installed hybrid system. Therefore, a high-performance storage system with a high depth of discharge, many guaranteed cycles with easy installation and high operational reliability implementation of the SMART Hybrid Microgrid Optimisation. This is ensured by a one-time inspection per year and low internal energy consumption of the system electronics.

OUTCOMES

With the implementation of this SMART Hybrid Microgrid project, the farm benefited from an immediate diesel use re-

⁴² Globo Rural, Photovoltaic energy takes mega irrigation project to interior of Goiás, 2020 (online)

duction of approx. 70 l/hr to 25 l/hr. This marks a more than 64% reduction in diesel use and CO₂ emissions.

The hybrid photovoltaic system for irrigation also enabled the farm to increase production from one harvest per year to three crops per year (beans, corn and soybeans). The implementation of the Mandengo project created approximately 50 new jobs and has effectively decreased CO₂ emissions by approximately 1,076 tonnes per year.



©TESVOLT

LESSONS LEARNT

The customer intends to double or triple battery energy storage capacity soon, after ascertaining that the SMART Hybrid Microgrid was a complete success. Optimisations continue to improve such as the firmware of the hybrid controller which is currently being improved and updated by SMA to better serve the existing consumption profile and maximise the power usage of BESS.

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TESVOLT
THE ENERGY STORAGE EXPERTS

4.13 UNIDO/TESE

» Summary:

- **Organisation:** TESE – Associação para o Desenvolvimento
- **Project name:** *Bambadinca Sta Claro*: Renewable Energy Community Programme for Productive Uses
- **Location:** Bafatá, Bambadinca village, Guinea-Bissau
- **Project period:** January 2011 - January 2015
- **Project costs:** ~ EUR 2,200,000

- » **Stakeholders:** TESE (project development and implementation); UNIDO (co-funder and technical assistance provider); and the Community Association for the Development of Bambadinca (ACDB)⁴³ (beneficiary and responsible for local community participation).

CONTEXT & PROBLEMS ADDRESSED

Electricity access in Guinea-Bissau remains below 10%. Rural communities depend on traditional energy sources or privately owned expensive diesel generators. 6,500 people in Bambadinca village rely mainly on income generated by agricultural and commercial activities. In 2011, around 70% of the population lived in extreme poverty and 95% had no electricity access. Households spent almost 24% of monthly income on traditional energy solutions.⁴⁴ The high costs for low-quality energy services hampered basic economic activities.

THE DRE SOLUTION

A solar PV-hybrid technology solution was chosen based on the favourable solar conditions (i.e. yearly average ~5,5 kWh/m²/day). The mini-grid comprises three groups of PV power plants with a total installed capacity of 312 kWp, 135 kW bidirectional inverters, 1,101 kWh battery banks, and two back-up diesel generators (100 kW each). More than 700 key stakeholders, ranging from technical personnel to clients, received training on mini-grid issues.



©UNIDO/TESE

BUSINESS & OPERATIONAL MODEL

The project cost of approximately EUR 2,200,000 was grant funded by the EU, UNIDO⁴⁵ and Portugal. Alongside these grants, micro-credits were provided to finance initial connection costs or to support income-generating activities. To strike a balance between certain clients' inability to pay and the long-term financial sustainability of the project, a pre-paid, cost-reflective tariff model was introduced, with cross-subsidising elements favouring the poor. The utility management is sustained by a Public-Community Partnership (PCP), comprising ACDB, traditional leaders and the Ministry of Industry and Energy. ACDB is managing the newly created Bambadinca Energy Service Community (SCEB),⁴⁶ which is operating the mini-grid.

⁴³ ECREEE, *Associação de Comunitária para o Desenvolvimento de Bambadinca*, (online)

⁴⁴ UNIDO, *Project Document*, 2014 (online)

⁴⁵ Through a GEF funded project titled: "Promoting Renewable Energy Investment in the Electricity Sector of Guinea-Bissau"

⁴⁶ ECREEE, *Serviço Comunitário de Energia Bambadinca*, (online)



©UNIDO/TESE

OUTCOMES

Today, Bambadinca is one of the few villages in Guinea-Bissau with a functioning energy and water supply service. The project has provided access to electricity services for around 6,500 rural inhabitants, 630 households, 84 businesses and 16 public institutions. The families have increased their access to electricity from 5% to over 85% while reducing their energy expenditure from 24% to 5-10%. People involved in agriculture and food processing (e.g. cashew, cassava, fruits) have particularly benefited from productivity gains (e.g. through cooling, irrigation). The project will reduce greenhouse gas emissions by at least 409 tonnes of CO₂ eq/ year and 8,180 tonnes CO₂ eq over its 20 years life-time.



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LESSONS LEARNT

After five operational years, the following can be drawn:

Solar PV mini-grids are a feasible and competitive option for Guinea-Bissau's rural electrification. There are strong benefits in combining electrification with income-generating development approaches and local community participation throughout the project cycle is key. The community management model has allowed consensual decision making and inclusive solutions. Limited financial management capacity has led to payment problems for the replacement of spare parts.

The pilot project has demonstrated the business case for private sector participation and foreign direct investment (FDI) in mini-grids. However, due to the weak regulatory framework and the lack of risk mitigation instruments (e.g. guarantees), investment risks for the private sector remain high. Due to fossil fuel subsidies, rural mini-grids have to compete with the social electricity tariffs in the capital.

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4.14 VILLAGE INDUSTRIAL POWER

» Summary:

- **Organisation:** Village Industrial Power, Inc.
- **Project name:** Renewable Off-grid Productive Power for Rural Development & Agricultural Processing
- **Project location:** Makueni County, Kenya
- **Project period:** March 2019 - April 2021 (Ongoing)
- **Project costs:** EUR 485,698

» **Stakeholders:** Village Industrial Power (project development), Makueni County Government (overseeing agreements), apex co-operative for county farmers (project implementation), EEP Africa and Shell Foundation (financing); and local farmer entrepreneurs (beneficiaries).

CONTEXT & MAJOR BARRIERS

According to the Kenya Plant Health Inspectorate Service (KEPHIS), Makueni is the leading mango producing county in Kenya, but farmers suffer from post-harvest losses of up to 40%.⁴⁷ County Governments started to address the issue through state-run enterprises such as Makueni County's Kalamba Fruit Processing Facility. However, the plant absorbs less than 2% of production, pays low prices for fresh mango (EUR 0.11 per kg) and does not operate profitably. In the private sector, farmers attempt solar drying but suffer losses and lack access to markets. There are a handful of enterprises that are engaged in centralised mechanical drying for domestic consumption.



©Village Industrial Power

Village Industrial Power's choice of renewable energy technology was a biomass driven steam engine which can generate

electrical and thermal energy. The size of the technology solution is ideal for small-holder farms, it is not reliant upon ever-changing weather patterns and it allows for consistent quality and continuity in the supply chain.



©Village Industrial Power

DRE SOLUTION

The VIP 10-40 is an off-grid electrical and thermal energy solution which can burn diverse biomass fuels, including wood, nutshells, maize cobs, and biomass pellets in a high-efficiency, low-emission combustion chamber.

VIP's SpeediDryer uses powerful air movement and low drying temperature to rapidly dry high moisture perishable foods. 150 kgs of fresh fruit slices having moisture contents of 80-94% can be dried to 10-15% moisture content in 5-6 hours, regardless of ambient humidity. Two Speed-

47 Korir, M. K. et al, *Assessment of Postharvest Challenges of Mango Fruits in Upper Athi River Basin*, pg 668, 2013

iDryers can be powered with a VIP 10-40, processing up to one tonne of perishable fresh food per day.

Additionally, the operational framework used by VIP has been designed to address regulatory requirements and access high-value markets for decentralised production.

BUSINESS MODEL & PROJECT FINANCING

The total project cost was EUR 485,698. The financing sources included a 64% grant from the Energy and Environment Partnership Trust Fund (EEP Africa), 26% Shell Foundation and 10% equity. The DRE systems were installed on a lease-to-purchase basis whereby VIP owns the equipment during the lease term of up to five years. Farmers deliver dried fruits to an aggregation site, where they are paid. The dried crops are then exported and sold in the US. VIP earns a margin on equipment and a margin on dried crop sales.



©Village Industrial Power

OUTCOMES

An estimated 38 jobs will be directly created through this project. In terms of CO₂ emissions reduced or avoided, we estimate 254.69 tonnes per year.

The VIP 10-40 provides up to 10 kW instantaneous, three phase electricity and 60 kg per hour of low-pressure steam. This is used to power both cabinet style fruit/vegetable dryers and bin dryers, addressing post-harvest losses.

LESSONS LEARNT

Village Industrial Power has an agreement with Muranga County Government to finance a pilot installation at the sub-county level, with sub-county apex co-operative Ithanga as an implementer. Village Industrial Power also has an agreement with Makueni County Government, co-operatives and other smallholder farmers to expand installations next season if the production and route-to-market are successfully proven in the upcoming season.

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