# Understanding the **Clean Energy Transition** with **Community-Driven Decentralised Renewable Energy** projects in Germany and Sub-Saharan Africa

Alliance for Rural Electrification

*Shining a Light for Progress*

# IMPRINTS

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## ABOUT GREEN PEOPLE'S ENERGY (GBE)

The Initiative Green People's Energy for Africa was launched by Dr. Gerd Müller, the then German Federal Minister for Economic Cooperation and Development, in June 2017. This initiative aims to enable, expand and secure the supply of sustainable energy in rural Africa. It is part of Germany's Marshall Plan with Africa and relies on the broad participation of small and medium-sized enterprises, municipalities, cooperatives, public associations and citizens.

## ABOUT THE ALLIANCE FOR RURAL ELECTRIFICATION (ARE)

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

With more than 185 Members, ARE is the global association for the DRE industry, catalysing private sector-driven markets for sustainable electricity services, creating jobs and powering equitable green economies.

## GBE – ARE COOPERATION

The partners entered into a cooperation with a view to support GBE's mission to improve the conditions for DRE supply in selected sub-Saharan African countries with the participation of citizens, cooperatives and companies. The promotion of renewable energy projects across countries remains a top priority and is implemented by strengthening partnerships and exchange between actors in Europe and Africa. Focus will be on knowledge sharing and exchange between Germany and the nine GBE-countries (Benin, Ivory Coast, Ethiopia, Ghana, Mozambique, Namibia, Senegal, Uganda and Zambia).

# LIST OF ABBREVIATIONS

**A360** Azimut 360 SCCL

**AC** Alternating Current

**AIP** Association Ivoirienne pour le Progrès

**ANARE** Autorité Nationale de Régulation du secteur de l'Electricité

**ARE** Alliance for Rural Electrification

**BMBF** German Federal Ministry of Education and Research

**BOT** Build-Operate-Transfer

**CAPEX** Capital Expenditure

**CENORED** Central North Regional Electricity Distributor

**CHP** Combined Heat and Power

**CIE** Compagnie Ivoirienne d'Electricité

**CI-Energies** Société des Energies de Côte d'Ivoire

**$CO_2$** Carbon Dioxide

**DC** Direct Current

**DESFERS** Economic and Social Development of Women through Renewable Energies in the Sahel

**DF** Akwaba Délégation Fondation Akwaba

**DGE** Diréction Génerale de l'Énergie

**DoD** Depth of Discharge

**DRE** Decentralised Renewable Energy

**DRFN** Desert Research Foundation of Namibia

**e4D** Energy for Development Programme

**ECCD** Energy and Climate Change Division

**EPSRC** Engineering and Physical Science Research Council

**ESA** Energy Service Agents

**FCFA** CFA franc

**GBE** Green People's Energy

**GDSI** GDS International

**GEF-UNIDO** Global Environment Facility - United Nations Industrial Development Organisation

**GHG** Green House Gas

**GIZ ECO** German International Cooperation Energy Coordination Office

**HNU** Hochschule Neu-Ulm (Neu-Ulm University of Applied Sciences)

**HSS** Hanns-Seidel-Stiftung Namibia

**IGA** Income Generating Activities

**LMP** Lithium Metal Polymer

**MEFPA** Ministry of Employment, Vocational Training and Handicrafts

**MFIs** Microfinance Institutions

**MFP** Multi-Functional Platforms

**MG** Mini-Grid

**MHP** Micro-Hydropower Plant

**MME** . Ministry of Mines and Energy (Namibia)

**MWE** Mozambique Women for Energy

**MZN** Mozambican metical

**NEI** Namibia Energy Institute

**NEP** National Electrification Programme (Ethiopia)

**NGO** Non-Governmental Organisation

**O&M** Operation and Maintenance

**OCSSCO** Oromia Credit and Saving Share Company

**OPEC** Organisation of the Petroleum Exporting Countries

**OPzS** Ortsfest (stationary), PanZerplatte (tubular plate), S = Flüssig (flooded)

**OTRC** Otjozondjupa Regional Council

**PFAN** Private Financing Advisory Network

**PROCEED** Pathway to Renewable Off-Grid Community Energy for Development

**PURE** Productive Use of Renewable Energy

**PV** Photovoltaic

**RE** Renewable Energy

**REA** Uganda Rural Electrification Agency, Uganda

**REDMP** Rural Electricity Distribution Master Plan of Namibia

**REIAoN** Renewable Energy Industry Association of Namibia

**RHCs** Rural Health Centres

**RO** Reverse Osmosis

**RUFEP** Rural Finance Expansion Programme

**SACREEE** SADC Centre for Renewable Energy and Energy Efficiency

**SCENE** Sustainable Community Energy Network

**SDGs** Sustainable Development Goals

**SERG** Sustainable Energy Research Group

**SHS** Solar Home Systems

**SLS** Solar Lighting Systems

**SMEs** Small-Medium Enterprises

**SOPIE** Société d'Opération Ivoirienne d'Electricité

**TeoG** Technik ohne Grenzen

**TEP** Tsumkwe Energy Project

**THI** Technische Hochschule Ingolstadt (Ingolstadt University of Applied Sciences)

**Zambia** MOH Zambian Ministry of Health

## UNITS OF MEASUREMENT

**Ah** Ampere hour

**Hz** Hertz

**l/h** litres/hour

**km** kilometre

**kV** kilovolt

**kVA** kilovolt-ampere

**kW** kilowatt

**kWh** kilowatt-hour

**kWp** kilowatt-peak

**LV** Low Voltage

**m** metre

**MWh** Mega Watt hour

**V** Voltage

**V/Ah** Volt/ampere-hour

**Wp** Watt-peak

# Foreword

# FOREWORD

Two decades ago, the Renewable Energy Act was passed in the German Parliament, giving birth to Germany's energy transition. Parliamentarians from various parties worked together to build its foundations: a feed-in tariff system for renewable energy; a grid feed-in guarantee for electricity from decentralised renewable energies (DRE) and a fixed feed-in price for 20 years.

This change led to the rapid rise of prosumers - people who produce their own electricity - in addition to consuming it. Citizen-owned wind farms and solar systems as well as energy cooperatives were founded, producing electricity for their community, thus adding income, and creating regional value. Now, there are almost 2 million households in Germany that participate in the energy transition in this way. Electricity production has been put in the hands of the people. Many farmers now earn more from their electricity production than from their food production. In the meantime, 350,000 jobs have been created in the business and craft sectors thanks to renewable energy.

In Germany itself, more than 50% of electricity was produced from renewable energy – thereby climate friendly – in 2020. A great achievement!

Due to demand, the costs for renewable energies has decreased. And in the meantime, photovoltaics and wind power are the most cost-effective electricity producers all over the world. Its push to develop renewable energies is probably the greatest gift that Germany has been able to give the world. The whole world can now benefit from it.

To unlock such opportunities, community-driven DRE projects have the necessary potential. In order to trace improvements made, as well as to identify the benefits of such community-centered projects in Africa, the Green People's Energy programme by GIZ, and the Alliance for Rural Electrification embarked on a joint journey to locate local projects from Africa where local communities have been involved in different stages of the project, thereby contributing to their community's own economic advancement. This publication acts as a proof of concept - that if the community-driven DRE projects are scaled up, the SDG-7 (access to affordable and clean energy) and other related SDGs can be achieved faster.

It is with great pleasure that we have the opportunity to invite readers to take stock of the projects identified in Germany and in selected African countries and learn from the significant experiences presented by the community-driven DRE projects that are featured in this publication.

**Bärbel Höhn**

BMZ Special Representative
for Energy in Africa

**Josef Göppel**

BMZ Special Representative
for Energy in Africa

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# Executive Summary

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# EXECUTIVE SUMMARY

With the goals of the Paris Agreement seemingly challenging to achieve by 2030, new approaches to the clean energy transition are required. To achieve wide scale decarbonisation, there is a strong need to look beyond economic and technical aspects and consider the social dimension of renewable electrification.

It is in other words essential that decarbonisation also stems from local initiatives undertaken or supported by communities. **Community-driven energy projects, particularly in the decentralised renewable energy (DRE) sector thus have a critical role to play in driving the global transition to cleaner energy systems**.

The **objective of this publication is to shed light on 12 community-driven or supported projects from Germany and selected countries from Africa** notably Ivory Coast, Benin, Mozambique, Ethiopia, Ghana, Namibia, Senegal, Uganda, and Zambia.

Experiences based on the case studies from selected African countries in this publication show that communities, especially when provided with the right financial and technical support, can effectively participate in the development and management of small-scale energy infrastructure to deliver essential energy services in partnership with the private sector, local and national governments, as well as international partners and other institutions.

Similarly, the case studies in this publication from German community-run renewable energy projects show that the factors that drive citizens to contribute are their individual values, participatory motives, favourable policies and commitment towards the environment and the development of the surrounding locality (regional value creation).

**The major barriers and the key recommendations based on the findings from the case studies are segmented across three pillars namely social, financial, and technical barriers**. The recommendations are targeted towards stakeholders from the public sector, private sector, civil societies and communities.

The authors conclude that there is a huge potential to be explored when it comes to community-driven DRE projects and with the right mix of ingredients such as strong political goodwill, investment, innovation, and participatory approach from the local communities, these community-driven DRE projects can be successfully scaled up. Such projects can massively contribute to the goals of universal energy access and the clean energy transition.

**David Lecoque**
CEO
Alliance for Rural Electrification

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# Introduction

# INTRODUCTION

Climate change impacts have accelerated and amplified over the last decades. Extreme weather, natural disasters, economic collapses, food and water insecurity, are all symptoms of this crisis. Similarly, 759 million[1] people currently lack access to electricity, while another 2.8 billion[2] still suffer from unreliable electricity services. With the goals of the Paris Agreement seemingly challenging to achieve by 2030, new approaches to the clean energy transition are required.

Strong political goodwill, development of apt framework conditions, setting priorities when it comes to global investments are of the essence. Cooperating/collaborating with governments, private sector, civil society organisations, citizens and communities is equally vital.

This publication explores the potential of community-driven decentralised renewable energy (DRE) projects to address the climate crisis, provide access to electricity and contribute to socio-economic development in communities. In this publication, 'community-driven DRE projects' refer to energy projects where citizens from the area of the project are actively involved in different stages of the project(s) contributing to its/their design, operation, maintenance, and management with an aim to provide clean and reliable energy access to the local community and trigger economic prosperity in the area.

A wide range of different community-centred energy projects are already being implemented globally, driven by renewable energy support schemes[3] and increased awareness of collective actions.[4] Lessons learnt from Germany and Africa show that these are based on bottom-up approaches designed to meet local needs while contributing to energy access and security, while reducing greenhouse gas emissions, empowering communities to adapt to climate change as well as bridging local action to national priorities.

By co-creating projects with communities or "crowdsourcing", ideas and innovations are extended beyond the boundaries of private sector and government, herewith reducing project risks as the solutions are sourced from the target beneficiaries. More importantly, community-driven energy projects also operate on the principles of transparency, participation, accountability, and enhanced local capacity and skills development[5] - all with a shared responsibility approach to overcome the risks and develop a sense of togetherness. For example, as seen in majority of the featured case studies, community representatives often manage the power generation systems locally, which in turn creates local skilled green jobs.

In cases where DRE technologies are deployed, the positive multiplier effects are especially evident. As DRE projects are often driven directly with and by communities, they are adapted to local electricity needs, such as productive and community uses of energy (e.g. micro-enterprises, shops, schools, health care clinics, etc.) which are indispensable to socio-economic development.[6] Community DRE projects thus not only provide the means for decarbonisation of the energy sector and hence counter the climate crisis, but in this way also help to intertwine local and global economies by catalysing rural socio-economic development.

Additionally, as highlighted in the University of Southampton case study, the revenues generated from community-projects driven by DRE are often re-invested in the community, contributing to local socio-economic development, while narrowing the gap between rich and poor, urban

1 ESMAP, Tracking SDG 7 Report, 2021, (online)
2 The Rockefeller Foundation, Press Release, 2021, (online)
3 Frontiers in Energy Research, Social innovation in community energy in Europe: A Review of the evidence, 2019, (online)
4 European Commission, Energy communities: an overview of energy and social innovation, 2020 (online)
5 World Bank, Community-driven Development, 2020, (online)
6 IRENA, et al., Energy Sector Transformation: Decentralized Renewable Energy for Universal Energy Access, 2018, (online).

and rural areas, and contributes to evening out of gender imbalances.[7] This publication highlights the nuances both in the context of Germany and selected African countries with factual examples in the case studies featured.

In Germany, the national long-term strategy for the development of a low-carbon energy system based on renewable energy is driven by the Energiewende (Energy Transition). The objective is to gradually phase out conventional energy sources, promote the heavy adoption of renewable energy resources and become carbon neutral by 2050.[8] In light of that, the case studies from Germany highlight how citizens have taken the initiative to make a positive impact by opting for clean energy sources.

Similarly, the presence of ubiquitous renewable energy resources, development in innovative technologies, digitalisation, falling costs for renewable energy technologies and the presence of a dynamic young population offer key opportunities for Sub-Saharan Africa to achieve the clean energy transition through community-driven DRE projects. The projects from Africa featured in this publication are developed in partnership with private sector, public sector or both. As more communities start to be aware of the benefits of community DRE projects, so does their potential to generate income and local development prospects. As a result, more community-driven initiatives will start seeing the light of day.

7 ARE, Women Entrepreneurs as Key Drivers in the Decentralised Renewable Energy Sector: Best Practices and Innovative Business Models, 2020 (online)
8 Clean Energy Wire, Germany's greenhouse gas emissions and energy transition targets, 2020 (online)

## KEY BENEFITS

Based on the analysis of the case studies from both Africa and Germany, ARE has identified six main benefits in adopting community-driven DRE projects. These benefits can also be framed as opportunities for community-driven DRE projects as they are building foundation for overcoming the challenges which will be identified in the subsequent sections.

## BENEFITS FROM COMMUNITY-DRIVEN DRE SOLUTIONS

| | |
|---|---|
| **Energy security** | Renewable technologies can provide power in the remote locations where the national grid hasn't reached. Without DRE, communities either have no or irregular access to energy. Therefore, encouraging community participation will put power generation and maintenance in the hands of local communities which helps circumvent project related challenges, creating energy security for off-grid areas and providing reliable power supply in grid-connected areas and contributing to voltage stability - thereby boosting the resilience of energy supply in rural and remote communities. |
| **Productive uses of renewable energy (PURE)** | Community-driven renewable energy projects contribute to the economic development in communities by catering to local electricity demand, thereby stimulating demand and increasing productivity of income-generating activities such as agriculture, healthcare, education, etc. |
| **Energy efficiency & saving on energy bills** | Community participation instills a sense of responsibility in the citizens which helps in introducing and adhering to energy efficiency measures. With such measures, not only can the energy demand-supply balance be maintained, but it is also favourable for the environment. Additionally, efficient uses of energy will help check on the energy bills for the citizens avoiding making big dents in their pockets. |
| **Project ownership & consciousness** | Local community project participation and ownership helps overcome public opposition facing renewable energy development, thus advancing its uptake, as well as contributing to lower risks of project failure. It also empowers local communities to tailor electricity production to their specific needs. |
| **Local investments** | Communities present an important potential source of investment, and revenue from community-led renewables projects is often reinvested in the local economy, thus creating virtuous development cycles. Successful community-driven projects potentially also attract policy and resource investments by governments and other supporters. |
| **Local green & skilled job creation** | Community-driven renewable energy projects significantly contribute to knowledge transfer, local skill development and creation of skilled green jobs in communities, such as renewable energy field technicians and operators. Training and capacity building initiatives help facilitate job creation. |

## MAJOR BARRIERS

The case studies featured in this publication highlight some of the notable barriers faced in community-driven DRE projects, both in German and African contexts. These include social, financial and technical barriers. Restrictions triggered by the COVID-19 pandemic were a common feature permeating the case studies.

**Social** barriers refer to general and societal hurdles and bottlenecks hindering the successful implementation of community-driven DRE projects, whereas **financial and business**-related barriers are linked challenges related to funding, project organisation and management. Lastly, **technical** barriers are issues that needs to be addressed occurring from lack of skills and assessment.

## BARRIERS FACED IN DEVELOPING COMMUNITY-DRIVEN DRE SOLUTIONS

### Social Barriers

- Limited energy awareness and ownership
- Gender inequality and cultural restraints
- Dynamic energy needs and related community priorities
- Lack of trust and resistance to change
- Policy challenges and lack of clear national electrification regulations

### Financial and Business Barriers

- Limited access to funding
- Limited sustainable business models

### Technical Barriers

- Lack of data collection and assesment
- Lack of technical and managerial skills to manage the energy system
- Complex project planning due to remote areas
- Lack of monitoring solutions and proper tariff and load projections

Restrictions due to measures introduced to tackle COVID-19 pandemic

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# Key lessons learnt and recommendations

# KEY LESSONS LEARNT AND RECOMMENDATIONS

Based on best practices from the case studies in this publication, as well as available publications and research on community-driven DRE projects, ARE developed the following recommendations for private sector, public sector, civil society and local community stakeholders that strive to achieve the Sustainable Development Goal (SDG) - 7 (Ensure access to affordable, reliable, sustainable and modern energy for all) and SDG - 13 (Take urgent action to combat climate change and its impacts) and the socio-economic benefits associated with the goals. The recommendations are provided in line with the three segments of barriers identified in the previous chapter.


## RECOMMENDATIONS TO ADDRESS SOCIAL BARRIERS

> ***Citizen participation, together with the commitment of the people who drive the projects forward, is the key to the success of our projects.***
> Günter Mögele, Deputy Mayor, Wildpoldsried, Germany

**1. Raising awareness about integration and good practices of renewable energy**: A common success factor across the case studies is that they left no stones unturned in advocating for renewable energy options in local communities. Knowledge sessions, educational campaigns, awareness camps, behavioural change communications, competitions, the inclusion of renewable energy and sustainability subjects in the school curriculum, are all good ways for the local/national administrations to raise awareness within communities on the benefits and need for renewable energy solutions.

This learning establishes a snowball effect where more and more people are inspired by the success stories and take part in the process of change. On that note, ARE recommends that information and awareness raising campaigns become an integral part of community driven DRE projects.

**2. Active citizen participation and community engagement**: All the case studies from both Germany and Africa showcase a strong will and collective desire of the citizens to bring about necessary changes to ensure local power supply and value creation. This means tailored use of locally available renewable energy resources to generate clean electricity for local livelihoods and income generation opportunities. Hence, communities should come forward and take initiative together with key public, private and civil society stakeholders to manage and run the local power systems. This will also spread project related risks among all stakeholders, which in turn ensures collective action to address and overcome the issues.

**3. Consideration of gender and cultural dimensions**: The presence of high levels of gender inequality socially, economically and culturally creates a major barrier for women to participate in economic activities of a community. The majority of the case studies featured in this publication notably BürgerEnergie Solingen, Azimut 360, GDS International, Carlos Morgado Foundation, Grino Water Solutions, and Plan International emphasised this issue and ensured the inclusion of women in different stages of their projects respectively. This increases the likelihood of active and equal participation in development efforts of the local communities. ARE therefore recommends that a gender lens is applied to all community-driven DRE projects, consisting of a structured process with tools and measures to identify gender gaps and ensure the equal participation of women. More detailed recommendations can be found in the recent publication from ARE on gender and energy.[9] The authors would recommend to project developers and

9 See footnote 8

other involved stakeholders that in order to gain trust, the energy transition shall gradually be introduced through honest and clear communication between project developers and local communities.

**4. DRE project governance, conflict resolution and decision-making**: Strong governance of community-driven renewable energy projects is another success factor. Based on lessons learnt from the case studies in this publication, the establishment of a savings group/association/cooperative is recommended for local community organisations to efficiently coordinate the administrative work, O&M, accounting, and other tasks. Public sector or private sector utilities may also collaborate with communities to help set up such local governing bodies. Utmost importance must be given to local governance, particularly the allocation of roles and responsibilities. The administrators of community organisations are hence recommended to establish an internal system to clearly define the roles of their departments and personnel to operate and maintain the DRE power system with the help from local community members. A strong governance structure with the continuous involvement of the local representatives in the project will in turn also boost the sense of ownership, address the local priorities and also coordinate on future energy demand-supply balance.

**5. Conducve policy and regulatory frameworks for community participation**: Among other policy initiatives around the German Energiewende, the Electricity Feed Act of 1991 and Renewable Energy Sources Act of 2000, as highlighted in the Energy village Wildpoldsried case study are two leading examples of policies that made way for the massive renewable energy integration in the German energy system and boosted citizen participation significantly which can be framed as a pivotal social change.

On top of that, it is recommended that policymakers in Sub-Saharan Africa implement even deeper power sector reforms and policies, particularly streamlining the bureaucratic steps, to accelerate the implementation of clean DRE projects and to encourage additional citizen and community participation in the clean energy transition.

## RECOMMENDATIONS TO ADDRESS FINANCIAL AND BUSINESS BARRIERS

***The success results from this project directly motivated the project investor to finance two more projects in Africa which demonstrated the investor confidence in our solution.***

Alireza Derkshayan, Grino Water Solutions

**1. Innovative financing, financial instruments and technical assistance initiatives**: Lack of funding was highlighted as one of the major problems across the case studies. Financing has two sides to it. One is the financing of projects on the supply side (e.g. capital expenditure to initiate the project) and another is financing to enable affordability for end-users and hence boost demand for electricity and for productive uses services (e.g. consumer finance). It is thus recommended that funding partners and governments keep both sides of the coin in mind when designing electrification programmes to de-risk the implementation of DRE projects.

A thorough socio-economic analysis is recommended to understand the local conditions of the project site(s) and various innovative financing methods could be explored in the local context to boost investor confidence and ensure an adequate flow of funding. For example, lobbying and building awareness of local banks and other micro-finance institutions so that they can provide credit to energy customers as opposed to seeing them as high-risk clients due to lack of credit history. Additionally, technical assistance initiatives like the GET.invest Finance Catalyst[10] and Private Financing Advisory Network (PFAN)[11] play a crucial role in connecting project developers and companies with financiers including through cooperation with sector organisations such as ARE.

10 GET.invest, GET.invest Finance Catalyst, 2021 (online)
11 PFAN, About PFAN, 2021 (online)

On the supply side, the University of Southampton case study outlined the creation of a joint funding model between a developer and government that was applied for mini-grid projects.

On the demand side, the Plan International case study highlighted the creation of a guarantee fund that covers 50% of the capital costs for the smaller productive usage PV systems for the locals, thus boosting the ability of local communities to pay for productive appliances using renewable electricity. On that note, it is recommended that further research and piloting of innovative consumer financing for productive use appliances is conducted.

**2. Introduction of innovative business models**: The German case studies in this publication provide rich examples of citizens' participation for local value creation enabling the clean energy transition as well as increased income-generation opportunities, based on favourable nationwide policies and novel business models. Likewise, the African case studies in the publication are the successful projects on the ground that provide best-in-class examples that can inspire other communities, making the clean energy transition a reality.

One such example is the innovative Key Maker Model in the HNU case study. Another instance can be noted in the GIZ EnDev and HNU case studies respectively where productive and anchor loads are integrated to maintain the levels of demand. The identification and implementation of solutions that will ensure best business case in each local context is recommended.

## RECOMMENDATIONS TO ADDRESS TECHNICAL BARRIERS

**1. Regular data collection, monitoring, assessment and sharing:** Across several case studies, lack of data is mentioned as a key barrier. Creating provisions for data collection, assessment and sharing is thus recommended for DRE companies, utilities and communities because it helps with technical and financial sustainability, and feeds into the research and development of knowledge products, which allows project developers to adapt, innovate, and develop solutions catering to the needs of the communities.

> ***The sustainability of the project is essential, and it favours a holistic approach that goes beyond the provision of a solution for access to electricity and focuses on the overall economic development of the communities.***
> *Alexis Rehbinder, GDS International*

Regular monitoring of the DRE projects and the services they provide also ensure the proper upkeep of the systems and assists the local electricity operators to identify and troubleshoot when issues appear. Regular monitoring will also help the project owners to plan for the future addition of generation capacity as the demand grows.

**2. Embedding long-term sustainability through capacity building for local communities**: Imparting technical, entrepreneurial and managerial training was a key success factor and a top priority across the case studies in this publication to ensure technical sustainability of DRE projects. Technical capacity building for local communities improves long-term sustainability of DRE projects, enhances technical knowhow and skills development within communities, creates skilled jobs and bolsters the sense of ownership from citizens.

In addition, regular engagement with the community via entrepreneurial training initiatives builds trust and knowhow among the local communities to manage and maintain the power systems. Lastly, managerial training through general info sessions, administrative trainings to run the projects, financial training (for example on tariff setting, revenue collection and accounting) are also important for the long-term sustainability of projects.

Capacity building for local communities is thus an essential recommendation for private sector, government stakeholders, international partners, utilities, and community/civil society organisations undertaking DRE projects.

**3. Ensuring full community involvement in project planning and operations**: Whether community-driven DRE projects are implemented together with utilities, private sector partners or public utilities, it is recommended to fully involve the community in all phases of the project, especially in project planning and operation to enable better understanding of community(ies)-wide development needs. This helps to prioritise real community needs, increases the likelihood of success and ensures local ownership.

**4. Grid compatibility of DRE solutions**: Project developers are recommended to take the existing national energy policies and future national grid expansion plans into consideration while designing DRE solutions in remote areas so that at the time of grid extension, the DRE system may be integrated. Policymakers, on the other hand, are also recommended to provide clearly defined guidelines based on geospatial planning when it comes to electrification schemes of the country (grid expansion vs off-grid electrification), as well as establish technical and financial provisions for connection of mini-grids with the grid when it arrives. One good example is highlighted in the GIZ EnDev case study where the national utility established a mini-grid directive on grid expansion.

| | Major Barriers | | Key Recommendations |
|---|---|---|---|
| Social | Limited energy awareness and ownership | → | Raising awareness about integration and good practices of renewable energy<br>Active citizen participation/ community engagement |
| Social | Gender inequality and cultural restraints | → | Consideration of gender and cultural dimensions |
| Social | Dynamic energy needs and related community priorities | → | DRE project governance, conflict resolution and decision making |
| Social | Policy challenges and lack of clear national electrification regulations | → | Conducive policy and regulatory frameworks |
| Financial & Business | Limited access to funding | → | Innovative financing, financial instruments, and technical assistance initiatives |
| Financial & Business | Limited sustainable business models | → | Introduction of innovative business models |
| Technical | Lack of data collection and assesment | → | Regular data collection, assessment and sharing |
| Technical | Lack of technical and managerial skills to manage the energy system | → | Embedding long-term sustainability through capacity building for local communities |
| Technical | Complex project planning due to remote areas | → | Ensuring full community involvement in project planning and operations |
| Technical | Lack of monitoring solutions and proper tariff and load projections | → | Grid compatibility of DRE solutions |

The restrictions due to the measures introduced to tackle COVID-19 pandemic remained a barrier across all three segments outlined in the table above. For concrete recommendations in that regard for DRE sector, see ARE COVID-19 Call to Action.

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# Case Studies

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# FROM GERMANY

## 4.1 BÜRGERENERGIE SOLINGEN

"IT'S IMPORTANT TO COME TOGETHER AS A COMMUNITY AND BRAINSTORM WITH EACH OTHER"

» **Summary**
- **Organisation**: BürgerEnergie Solingen eG (registered cooperative)
- **Project location**: Solingen, Germany
- **Project period**: 2014 - ongoing

The former headmistress of a comprehensive school, Mrs. Ingeborg Friege, founded the cooperative BürgerEnergie Solingen eG (BESG eG) in 2014 together with 33 other citizens from Solingen and was its spokesperson until recently. Everyone in BESG works on a voluntary basis and together they make an important contribution to a climate-friendly, locally produced energy supply for the people in their hometown of Solingen. Ingeborg Friege has always been involved, for example as a development aid worker in Tanzania and in Cameroon. Here she tells us what drives her and how the BürgerEnergie Solingen cooperative works.

Already after graduating from high school, I decided with my husband to go into development cooperation after graduation. We both studied mathematics and physics to become teachers and then decided to go to Tanzania. We were idealists and wanted to do something good for the world, to make up a little bit with our means for what the Germans had done to the people in their former colonial territories.

We were convinced to go to Tanzania by the then President Julius Nyrere with his ideas for better school education. After our studies and the traineeship, we taught for three years at a church boarding school on the western slope of Kilimanjaro. We learned a lot, for example Swahili or how to live well with little water and a simple standard of living. When we later had our first child, we went to Cameroon for another three years with the German development cooperation. We taught there and trained teachers.

We then settled in Solingen and spent our lives here. During my last 14 professional years until 2011, I was the head of a comprehensive school. Since then I have been a pensioner.

A father of a student who was involved in local politics then asked me if I would like to co-found a citizens' energy cooperative. The local politicians had decided to retrieve the municipal utilities and never again leave them in the hands of a large investor. The successful pressure by the citizens helped remove the big investor. Thereafter, the adventure of planning the foundation of a citizens' energy cooperative started in my own living room with people from very different backgrounds which motivated me tremendously.

Together with other Solingen citizens, we then drew up a charter and preamble and set ourselves the goal of actively shaping the energy transition in Solingen. In 2014, we were then able to officially found our cooperative BürgerEnergie Solingen eG, BESG and began looking for allies. Soon, the cooperative association and local politicians were also on board.

Next, we thought about what we could do in Solingen to make the energy supply as regional and climate-neutral as possible. We came across many things that already existed, for example, the solar register or the studies from the Wuppertal Institute. It soon became clear that we had no large farms, we have little wind and no water in the Bergisches Land to generate energy. Our greatest potential was electricity generation on solar roofs.

So, we decided that our cooperative should invest in regenerative energy production through photovoltaic systems on Solingen roofs. We have set ourselves the goal of regional value creation in order to allow local businesses to profit, and we have taken up the cause of informing the city's population, for example with information tables where we talk to the citizens of Solingen about clean energy.

We were able to build our first photovoltaic system on the roof of a company in the city of Solingen in 2015. We held a big inauguration ceremony, also to become visible. We invited television and the press and made our information available to anyone who wanted to hear it.

In this way, we succeeded in convincing numerous other people from Solingen to become members of our association. Some have subscribed to shares to support us financially, others work with us themselves today and contribute to the development of BESG eG with their ideas and their skills. Today we have more than 300 members and about half a million EUR in assets. With this, we have been able to realise a dozen major projects. 40% of our members are women, and our decision-making bodies are made up of equal numbers of women and men as far as possible for example, we have two women and two men on the board.

Politically, we are broadly positioned. Among other things, we take great care to ensure that political disputes do not lead to unproductive discussions in our cooperative. Another principle is that our cooperative works purely on a voluntary basis. No one is paid for her or his work.

To date, we have built a total of 11 major PV systems on Solingen's roofs. With the amount of electricity, we produce, we can supply around 172 two-person households with electricity. Our solar plants are located on municipal facilities such as schools and on municipal or private companies.

In addition, we have also initiated other projects. Together with the Solingen municipal utility, we launched BESG citizen electricity for private and commercial customers in our region. BESG citizen electricity is free of nuclear and coal-fired electricity and comes 100% from renewable energies.

It meets the highest green electricity standards and the price includes the "solar penny". This is 0.005 EUR / kWh. This is used to finance special measures to support the energy transition in Solingen. For some years now, primary schools have been receiving the funds from us to purchase teaching materials on the subject of "Generating and using sustainable energies". We also build solar plants and lease them to companies for their own use and we are working with our transport companies on ideas and projects on how to operate our buses locally in a climate-friendly way. Anyone can come forward and join us. Everybody brings in his competences. One of us is a graphic designer and helps us with the design of our publicity material, others organise our regular get-together. Of course, we don't always agree. That's why it's important to come together as a community and brainstorm with each other to find the best solution for everyone. For me personally, the most important thing is to get the people of Solingen interested in the work of our BESG and to tell them: This is where you can get involved and participate as that is the advantage of a cooperative - everyone can participate.

I am the only one of the active ones who is retired now. All the others are still working. It gives me a lot of pleasure to help shape something as meaningful as a citizen energy cooperative. It's simply fun to see how a group can work together to implement very concrete projects that exceed the possibilities of an individual.

Together, citizens can turn ideas into concrete projects that an individual cannot manage. Such visible successes then in turn, encourage other people to get involved. A snowball effect can arise if the joint project is perceived as forward-looking.

The conditions in developing countries are very different and, as a European, I would do well to use recommendations sparingly. After all, many of the existential problems and hardships that arise there are at least partly caused by us industrialised countries.

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## 4.2 ELEKTRIZITÄTSWERKE SCHÖNAU

THE PIONEERS - WHEN GERMAN ELECTRICITY BECAME GREENER

» **Summary:**
- **Organisation:** Elektrizitätswerke Schönau (EWS)
- **Project location:** Schönau, Germany
- **Project period**: 1991 – ongoing

### CONTEXT

Ursula and Michael Sladek founded Elektrizitätswerke Schönau as an energy cooperative of the people in their neighbourhood and have thus written German energy history. Yet the couple, who have raised five children together, started life in a completely different way professionally: Ursula Sladek is a primary school teacher, Michael Sladek is a general practitioner.

Chernobyl, the first major accident of a nuclear reactor in 1986[12], made them think and act: Together with other members of a citizens' initiative, they founded the Schönau Electricity Works (EWS) in the wake of the nuclear disaster. They wanted to offer an alternative to nuclear energy, which was still very widespread in Germany at the time.

The two people of conviction had to clear many obstacles out of the way, but their life together for nuclear-free electricity production has paid off. Today, Elektrizitätswerke Schönau produces and sells only regeneratively generated electricity and heat and has become one of the pioneers of citizen energy projects in Germany and perhaps even in Europe.

Through lectures, discussions and publications, Ursula and Michael Sladek have inspired numerous other people in Germany to launch their own citizens' projects for emission-free energy. Their company is also very successful financially today. The EWS makes a turnover of more than 200 million EUR per year and the profit that

the cooperative makes stays in the region around Schönau.

The Sladek couple managed and steered the EWS for a good 30 years. A few years ago, they passed the company on to the next generation. However, both are still committed to clean energy and also engage themselves in Africa, for example in Cameroon, where they work in a village to improve living conditions.

### INTERVIEW

**You are one of the pioneers of the energy transition in Germany. What motivated you back then?**

**Ursula Sladek:** Chernobyl was the decisive event. Until the reactor there exploded in 1986, people could not imagine that such a nuclear accident could happen at all. That got us thinking about how to generate clean and, above all, nuclear-free energy without polluting the environment. Thereafter, it happened very quickly that we founded a citizens' initiative together with others to produce our own cleanly generated electricity to take over the Schoenau

12 World Nuclear Association, Chernobyl Accident 1986, 2021 (online)

power grid and to sell only nuclear- and coal-free electricity to all its customers.

**Michael Sladek:** I could have known all this before the nuclear accident in Chernobyl because I studied medicine. The fact that you can no longer breathe the air or drink the water after the accident had a very strong impact on both of us. At that time, I was very catholic and was convinced of creation. After Chernobyl however, I gave up my church commitment and went into local politics, because the chances of changing something were much greater there.

**After such a world event, why did you think you could change something locally? Don't you have to go into the German parliament?**

**Michael Sladek:** You have to have the courage and believe that you can really change something together with others. I always advocate strong participation and involvement of local citizens. We then decided on a cooperative with an entrepreneurial approach. That worked very well. It's not always about big politics, but with the commitment and the financial contributions from people, you can already change a lot.

**What do you need then?**

**Michael Sladek:** You need good comrades-in-arms. There are always many people around you who want to get involved. Many citizens can make a very high level of commitment if they want to bring about real changes that are beyond the commercial motives. This is the case all over the world. It is not for nothing that civic engagement is also part of the UN's Sustainable Development Goals. Many citizens have their own values. They are not interested in money, but in what can be achieved with money. Money is not for hoarding, it is about using money to create good things for yourself and the people around you.

**How do you handle money in your cooperative?**

**Ursula Sladek:** In the beginning, we did everything on a voluntary basis, it took a while until we could pay ourselves. Today it is different. It is important for us that as many people as possible from the region also participate financially in our cooperative so that the money we generate does not benefit any corporations but the people here in Wiesenthal. Of course, the members receive a return on the money they have paid into the cooperative. That is 3%. The management is paid reasonably but does not receive any additional remuneration or bonuses. That leaves a lot of money, of course to be used for initiating new projects.

**Michael Sladek:** We put on the greed brake. We quickly achieved financial success and could have paid out 20%returns in some years. With the greed brake, we have a considerable amount left over, which we can use to invest in other cooperatives, for example. I see us as a nudge by talking to the churches about good energy solutions.

**Ursula Sladek:** Sometimes, even as a cooperative, you need financial staying power and have to build up reserves. The energy transition also has a lot to do with heat. It doesn't pay off after three years, it takes much longer. You have to put money aside for that.

**Michael Sladek:** Another basic idea of Elektrizitätswerke Schönau is local value creation. We place our orders here in the region. So, when people here give money to the cooperative, it also benefits the people who work here because they get orders from the EWS.

**Ursula Sladek:** That is important and also very nice to see that the people who live here also work in the cooperative directly or on behalf of the cooperative. We did everything on a voluntary basis for many years. Today, 200 people work for the EWS, all of whom live here.

**That is a super success. Why did it work so well?**

**Ursula Sladek:** The history of Schönau is an encouraging story against powerlessness. In the beginning, we stood alone with only a few people against the nuclear lobby, and over the decades we have achieved something together with many people. Today I call this the Schönau feeling: I am not powerless, I can achieve something myself together with other people. That has been the driving force.

**Michael Sladek:** We were all lateral entrants and had to teach ourselves everything. With our new knowledge, we then did electricity seminars and told other people how it worked for us. There are hundreds of people from all over Germany. A lot has come out of this, a network of people that has emerged and that has also shaped us. A participatory idea has emerged that has swept many along with it and of course, the climate issue is an added catalyst. People no longer want to stand by and watch. Everyone is part of the change, and everyone must participate if we want to protect the climate.

**How do you overcome hurdles that at first seem insurmountable?**

**Ursula Sladek:** We overcame hurdles because we divided everything into small steps and then went step by step. First, we announced electricity-saving competitions, then we founded companies and financed our first small systems. That worked, and in the process, we made the great discovery that it doesn't fail for lack of money, that's what we learned. So, we continued to work step by step. Then came the idea of buying the grid in our municipality, which was a very long road that also included setbacks and years of discussions. But there were always stages that we managed to get through. And every stage that you manage to get through must be appreciated and celebrated. Celebrating together is very important, and we have done that very consistently.

**What are the overall lessons learnt from the projects with community involvement? Could you highlight factors of success and mistakes to avoid based on your experiences?**

In the middle, very centrally, is trust. We have earned the trust of our citizens by starting with ourselves, for example, when it comes to saving electricity. We spent months testing on ourselves, on our own families, how to use energy sparingly and efficiently. When we saw what great potential savings were possible, only then did we organise the electricity-saving competitions for the whole town.

Of course, the community of like-minded people, which was very important especially in the phase of intensive political work during the citizens' referendums. You support each other when things are difficult and build each other up to overcome bad experiences.

The way we communicate is also a success factor. Back then during the citizens' referendums just as today with the customers of the EWS. It's important that we listen to each other, also put up with the positions of the other side and try to find solutions together.

No pointing fingers - very important.

**How other developing countries/emerging economies can be inspired from these lessons and implement such practices in their countries? Any recommendations?**

We think that in one way or another our success factors are transferable to some extent. However, in order to be more specific, we think that you need to have a lot of information about the countries and societies in question. Therefore, we do not have any recommendations, but everybody can take out of our story what fits for him, for his society, his country.

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## 4.3 ENERGY VILLAGE WILDPOLDSRIED

### MAKING IT SIMPLE: "WE BELIEVE THAT EVERY HOUSE SHOULD BE A POWER PLANT"

» **Summary:**
- **Organisation:** Energy Village Wildpoldsried
- **Project location**: Wildpoldsried, Germany
- **Project period:** 1999 – ongoing

Wildpoldsried gave itself a new mission statement a good 20 years ago: Wildpoldsried Innovativ Richtungsweisend - a village goes its own way. Today, the Bavarian municipality produces eight times more energy than it consumes - making it a European leader. Everything is generated exclusively from renewable sources. The people of Wildpoldsried were not primarily concerned about the climate - they wanted to use and strengthen their local resources.


If you are looking for a model in Germany of what the energy generation of the future could look like, you can drive past Berlin, Hamburg, Frankfurt, Munich and all the other big cities with a peace of mind. In the very south of the country, just before heading up into the Alps near Lake Constance, you should make a stop and bring a little time with you because what the Allgäu village community of Wildpoldsried has achieved here in the last 20 years is diverse and impressive.

*"We can prove that a supply from exclusively ecological energy sources works locally,"* said Arno Zengerle and Günter Mögele in unison. Both were the mayors of the city. They started a new term of office a good 20 years ago with the then municipal council team, the new body decided across party lines to develop a new mission statement.

It is called *WIR - ein Dorf geht seinen Weg (WE - a village goes its own way)* and is based on the three pillars of energy, wood and water. According to the people of Wildpoldsried at the time, energy should be saved and generated regeneratively in the future, wood should be used as extensively as possible as an ecological building material, and the community's water should be protected above and below ground and the wastewater should be cleaned ecologically.

At first glance, these may seem like very ecological goals, but the Wildpoldsrieders were primarily concerned with looking at the resources and living space of their own community. *"We were not concerned with climate protection. We had a different background,"* said Arno Zengerle, who led the community as full-time mayor for more than 20 years. *"We were concerned with regionality, our own resources and the protection of our local environment."*

Today, experts call linking the three pillars of energy, wood and water as sector coupling. It is considered the key to really being able to manage the ecological transformation. In the municipality of Wildpoldsried, it was above all many projects that emerged and grew out of the three-pillar mission statement over the years such as solar thermal energy for hot water, geothermal energy, woodchip, pellet and biogas heating, as well as the village's own district heating network with nine combined heat and power (CHP) plants for heating, photovoltaics, wind turbines and reactivated small hydroelectric power plants for electricity generation.

From all these projects, the small municipality, which is home to less than 3,000 people, generates eight times more energy than it can consume itself. Wildpoldsried has thus made it into the top tier of European municipalities that produce energy in an environmentally and climate-friendly way. In 2018, the municipality received the European Energy Award in Gold for the second time and this time even achieved the highest score among 1,500 European municipalities.

*"We are not great strategists and project planners, we like to try things out,"* said Günther Mögele, the city's current honorary second mayor. Simply doing things: This trial and error has resulted in some best practice examples that the people of Wildpoldsried are interested in because they own these projects which are ecologically clean and economically attractive.

Universities and global corporations are now also interested in the small Bavarian village, including Siemens, the Fraunhofer Institute and Universities from Aachen and Kempten. They researched here what is considered one of the most important keys for the exclusive use of renewable energies. Particularly, how do you get the solar and wind plants, which depend on the weather and climate and are therefore not always reliable, to combine with each other so reliably that electricity always flows?

The people of Wildpoldsried have found answers to this, for example, the Sonnen company, which is based in the village and develops electricity storage systems for private households and small businesses. With the Sonnen community, it maintains its own power grid into which not only the people of Wildpoldsried but also Sonnen customers from other towns feed their self-generated surplus solar power and get some from there when they do not have enough power themselves. The electric cars of the Wildpoldsried are also powered by solar power - Günter Mögele has two at home himself.

Wildpoldsried's working approach is also very clear in the solution to one of the most difficult problems in energy production i.e., heating. A farmer in the village produces biogas from agricultural waste products such as green cuttings, liquid manure and maize silage which are delivered by numerous farms from a radius of 60 km. The biogas produced is then supplied via gas pipelines to nine combined heat and power plants in the village.

Gas combustion produces electricity and heat which are used to supply all public buildings, a senior citizens' residential complex, a kindergarten and a hotel, as well as numerous households, in a climate-neutral way and much more cheaply than with fossil energy sources. This goes down well with many families. *"They save money, no oil purchase and maintenance costs for their own heating,"* said Arno Zengerle. *"This is not only a very good option for the people of Wildpoldsried but also for the climate because we need five times more energy for heating than for electricity."* The Wildpoldsried heating model saves the emissions of 350,000 litres of heating oil.

A decisive impetus for Wildpoldsried was the collective desire in the village to find their own solutions with the mission statement. A second was the Electricity Feed Act of 1991, which made it possible for the first time in the world to feed ecologically generated electricity into the grid, and the Renewable Energy Sources Act of 2000, which caused the compensation rates for electricity from photovoltaic systems to skyrocket.

This also spurred the people of Wildpoldsried to invest in solar systems on their own roofs, also by achieving more favourable prices in purchasing cooperatives. Moreover, there are publicly operated solar systems on numerous roofs owned by the municipality, for example on schools, car parks and the town hall.

What all these projects have in common is that the citizens were able to actively participate in them - in designing them, but also in financing them. *"Citizen participation, together with the commitment of the people who drive the projects forward, is the key to the success of our projects,"* said Günther Mögele. *"Moreover, many people do their own projects in their own homes. We believe that every house should be a power plant."*

Many of the projects yield decent returns. The energy village of Wildpoldsried not only produces its own electricity but also many citizens earn money from and with their own electricity. *"Many residents ask us when we will start the next project because they would like to invest money again,"* said Arno Zengerle. *"Because we organise our projects as a citizens' energy cooperative or a limited partnership, we also don't need an expensive administration that we have to pay."*

Socially, ecologically and economically - when it comes to sustainability, the people of Wildpoldsried are not easily outdone.

With respect to the recommendations for emerging economies, we can imagine that before any action is started in Africa, one has to consider who will lose out as a result. If it is not possible to get these people on board, then there is a chance that even such positive approaches will be opposed. For example, someone who trades in gasoline used for power generators will not agree that the same electricity is now being generated with PV. There are certainly many other examples.

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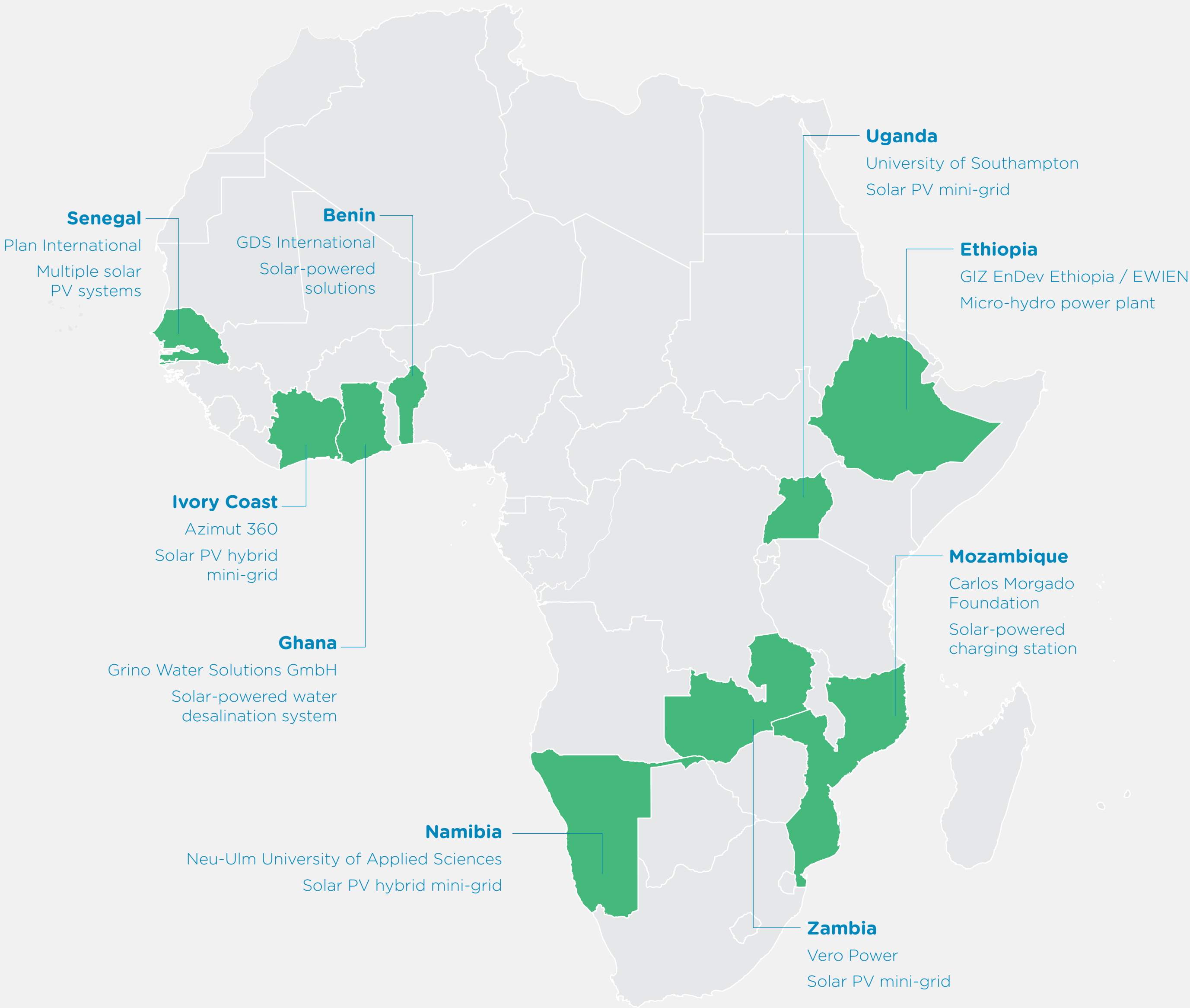
# FROM AFRICA



Senegal
Plan International
Multiple solar PV systems
Benin
GDS International
Solar-powered solutions
Uganda
University of Southampton
Solar PV mini-grid
Ethiopia
GIZ EnDev Ethiopia / EWIEN
Micro-hydro power plant
Ivory Coast
Azimut 360
Solar PV hybrid mini-grid
Mozambique
Carlos Morgado Foundation
Solar-powered charging station
Ghana
Grino Water Solutions GmbH
Solar-powered water desalination system
Namibia
Neu-Ulm University of Applied Sciences
Solar PV hybrid mini-grid
Zambia
Vero Power
Solar PV mini-grid

## 4.4 AZIMUT 360

» **Summary**
- **Organisation**: Azimut 360 SCCL
- **Project name**: Electrification of 7 rural communities with self-managed PV solar hybrid micro-grids in the Zanzan Region (Ivory Coast): Gbreko Kanian
- **Project location:** Boudou, Gansé, Kakpin, Kapé, Solokaye, Kromambira and Zamou; Zanzan district; Bounkani region, Ivory Coast.
- **Project period:** February 2012 – August 2017
- **Total project budget:** 2,700,915 EUR
- **Total generation capacity:** 218.4 kWp
- **Total GHG emissions avoided:** 217.1 tonnes/year

### STAKEHOLDERS

Délégation Fondation Akwaba (DF Akwaba), NGO based in Bouaké, Ivory Coast (consortium leader and local coordinator), Azimut 360 SCCL (A360), non-profit engineering cooperative based in Spain (technical design, management, and training), CI-Energies, former Société d'Opération Ivoirienne d'Électricité (SOPIE) (Institutional partner) and Association Ivoirienne pour le Progrès (AIP), NGO based in Bouaké, Ivory Coast (local population mobilisation and sensitisation), European Union and United Nations Industrial Development Organization (financier stakeholders)

### CONTEXT & MAJOR BARRIERS

In 2008, the rural poverty rate in the country was 62.5% compared to 29.5% in urban areas, and the electricity penetration rate was 31%, where the proportion of households using electricity as the primary source of lighting was 14% in rural areas compared to 77% in urban areas.[13] The extremely low access rate of modern energy services in rural areas had a significant influence on the quality of life of households, especially on women, including lack of basic social services (health, education, & other services) for the citizens which diminished their development opportunities.

The project identification was led by the Délégation Fondation Akwaba and Azimut 360 as part of the call for proposals of the EU Energy Facility II in 2009, and in cooperation with CI-Energies (former Société d'Opération Ivoirienne d'Électricité - SOPIE) as a local institutional partner. Since the Zanzan district had the lowest electrification rate in the country in 2009, the seven villages selected for the project would have not been electrified within the next 10 years.

A socio-economic study was carried out to identify the existing energy sources available, the local structures for social organisation, community users to be electrified, potential productive uses of energy as well as the capacity and the willingness for the population to pay for the electricity. Before the project, the locals relied on small diesel gensets, battery-powered flashlights, and some individual Solar Home Systems (SHS) for their energy demand. No public lightning or other community users had access to electricity.

The availability of abundant solar energy and the long distance from the main grid led to the choice of solar-photovoltaic hybrid mini-grid solution to power up the seven villages. The mini-grids technical

13 DSRP, Côte d'Ivoire, Stratégie de Réduction de la Pauvreté Rapport d'Étape au titre de l'année, 2009 (online)

design complied with national standards for rural electrification (Low Voltage (LV) grid connections, household's electrical installation, LV distribution grid and public lightning) to ensure that the mini-grids could be integrated into the national grid when it reached the seven villages.

**Major obstacles encountered were:**

**Change of beneficiaries:** Two out of seven communities dropped out during the implementation phase due to distrust towards the project (past experiences of being scammed). Two new villages were identified to replace them.

**Institutional blockade:** The project adhered to the then electricity law of non-privatisation of electricity services and created seven local associations in the frame of the project to manage electricity generation, and their members (households and businesses) would pay a monthly contribution in exchange. Local associations would also ensure electricity supply for community uses such as the health centre, the school, or the public lighting. The new Government[14] in 2010 approved a new Electricity Law[15] and despite a favourable report from the National Authority for Regulation of the Electricity Sector (ANARE) endorsing the project before and after the approval of the new Law, the compliance with the electricity law regarding commercialisation was questioned. The issue was solved after significant efforts including EU diplomatic intervention.

**Lack of funds:** During the identification phase Nassian town hall ensured a contribution of 382,840 EUR to the project. However, during the implementation, this co-financing could not be ensured, and complementary funds had to be sourced.

**New needs identified:** Water pumping (strong demand led by villages women), storage and purification elements were later included in the project for which Probitas Foundation provided additional funds.

## COMMUNITY DRE SOLUTION

These seven villages were selected during the project identification phase and were approached through their representatives (chiefs of village, women's associations, youth associations) and expressed their willingness to participate in the project. During this phase, the discussions and inputs received from some existing local governance bodies (Nassian prefect and sub-prefect) were also very helpful.

- Community participation was ensured throughout the project phases to ensure project ownership and guarantee project sustainability in the mid and long term:
- Workshops and training about Solar Energy and Energy Efficiency. Separate training for women ensured their participation.
- Creation of seven Mini-Grid Users Association and management of the mini-grids. At least one woman was included on the board and specific training was conducted for some positions (like treasurer). A Federation (Gbreko Kanian Federation) as a supra-structure for the seven associations was created to increase synergies and share services (management, maintenance service, purchases) between the seven villages and thus, contributing to the mini-grids performance in the mid and long term.
- Selection of one supervisor per association, to ensure basic maintenance tasks and recruitment of locals during the implementation phase.
- A Technicians Association for mini-grids installation and maintenance was created and trained during the project, integrating people from the seven villages. 11 people (10 men, one woman) collaborated on the mini-grids installation tasks, including households' electrical installation.

14 Wikipedia, Ivorian Presidential Election, 2010 (online)
15 Journal Officiel, Loi Code de l'électricité, 2014 (online)

### Technical specifications for the 7 PV solar hybrid micro-grid in Ivory Coast

| **General Data** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Location** | Zamou | Solokaye | Kapé | Kakpin | Gansé | Boudou | Kromambira | **TOTAL** |
| **Population** | 801 | 395 | 404 | 516 | 669 | 507 | 666 | **3,958** |
| **Monthly consumption** (kWh/month) | 3,376 | 1,552 | 1,967 | 2,753 | 3,924 | 1,702 | 1,681 | **17 MWh/ month** |
| **Mini-grids** | | | | | | | | |
| **Solar PV Field** | | | | | | | | |
| **Nominal PV power** (kWp) | 39 | 20.3 | 29.6 | 39 | 31.2 | 29.6 | 29.6 | **218.4 kWp** |
| **Technology** | Poly-crystalline | | | | | | | |
| **OPzS Batteries, 48 V** | | | | | | | | |
| **Capacity (C100)** (Ah) | 7,500 | 3,600 | 3,600 | 7,500 | 7,500 | 3,600 | 3,600 | **36,900 Ah** |
| **Capacity** (kWh) | 360 | 172.8 | 172.8 | 360 | 360 | 172.8 | 172.8 | **1,771.2 kWh** |
| **Autonomy** (Days) | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | **2.5 days** |
| **LV Distribution Network** | | | | | | | | |
| **Household connections** | 129 | 68 | 79 | 145 | 121 | 78 | 78 | **698** |
| **Services connection** | 8 | 5 | 4 | 7 | 6 | 6 | 5 | **41** |
| **Public lighting points** | 60 | 47 | 44 | 67 | 41 | 42 | 44 | **345** |

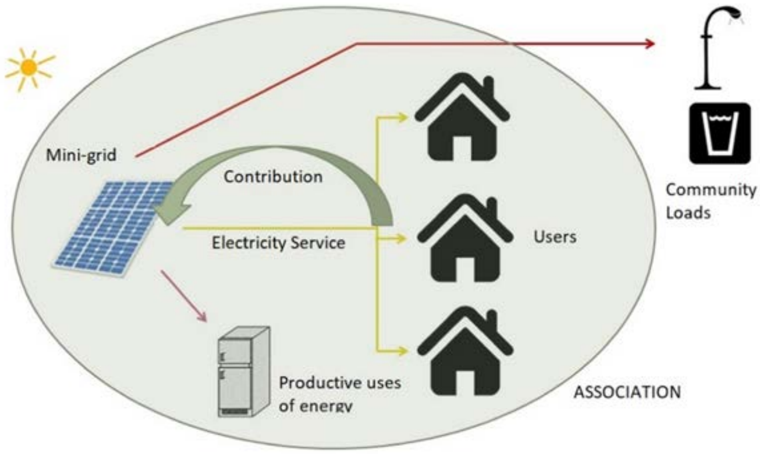
## BUSINESS MODEL & PROJECT FINANCING

Several proposals were submitted to several donors from 2009 to 2017 in order to build the mini-grids, as well as other side interventions to boost development in the seven communities:

Each mini-grid belongs to the village (including people connected and not connected to the mini-grid) and the local associations manage the mini-grid systems including the productive uses of energy encouraged in the frame of the project (community fridges, freezers and mills). The Gbreko Kanian Federation manages the financial and technical tasks and the mini-grids are self-managed by the users.

### Overview of the project's budget

| European Union Energy Facility II | GEF-UNIDO | UNDP | Côte d'Ivoire Énergies | Délégation Fondation Akwaba | Azimut 360 | Local Population | Total |
|---|---|---|---|---|---|---|---|
| 1,920,000 EUR | 382,840 EUR | 50,000 EUR | 129,000 EUR (in kind contribution) | 97,075 EUR (in kind contribution) | 72,000 EUR (in kind contribution) | 50,000 EUR | **2,700,915 EUR** |




*Mini-grid project structure*

There is strictly no electricity commercialisation and the energy produced by the mini-grids are exclusively used to power the loads of the local households, community uses (school, health centre, street lighting) and productive use activities (fridges, freezers, mills). Association members make a monthly fee according to their expected energy consumption.

Followed by the socio-economic study, five different consumer levels (daily energy bundle) were set. Members contribute to the mini-grid operation and management proportionally to their expected electricity consumption. Monthly fees were calculated to ensure financial balance and they include individual electricity service (50%), amortisation of batteries (40%) and community services consumptions (10%). The business model was endorsed by ANARÉ and SOPIE (CI-Énergies).

## OUTCOMES

The community is now almost 100% electrified. Electricity for community uses (health, educational, water pumping and religious buildings) is ensured and productive activities such as community fridges, freezers, mills, water pumping, storage, purification and distribution systems were established. Overall consumer satisfaction is very high, especially for the small villages not suffering from energy shortages.

At least 34 local jobs were created directly in the frame of the project: 11 installers, 2 federations (manager and technical director), 7 mini-grid supervisors and 14 productive uses managers. In addition, at least 100 local jobs were created indirectly following the project.

The national grid arrived in one of the villages (Kakpin) by the end of 2020. Despite the mini-grids being designed to be compatible with the Ivory Coast standards, a contract establishment between the CIE and the Gbreko Kanian Federation (GKF) turned out to be challenging and hence, the project implementation team decided to dismantle the Kakpin solar mini-grid and use the equipment to reinforce the rest of the mini-grids in other communities, especially Gansé, where the power demand increased for the fish preservation.

## LESSONS LEARNT

Solar hybrid mini-grids are an interesting DRE solution to pre-electrify rural isolated villages in the Ivory Coast as well as in regions and countries in West Africa. The project in terms of technology and design has a huge potential for replication, as well

as from the management point of view (self-managed systems). Despite some limitations, it has shown to be robust and cost-efficient, and the mini-grids continue to operate five years later.

Funding remained a massive challenge. (Grant based) investments are required for mini-grid construction. Additionally, political, economic and social stability are needed to ensure the mini-grid performance in the mid and long term. Finally, it is essential to make sure that a project is not only compatible with the local electricity laws but also consistent with the political vision of the rural electrification authorities in the country before its implementation starts.

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## 4.5 CARLOS MORGADO FOUNDATION

» **Summary**

- **Organisation:** Carlos Morgado Foundation
- **Project name:** Solar Giraffe
- **Project location:** Mangunze, Gaza, Mozambique
- **Project period:** October 2015 – December 2020
- **Total project budget:** 7,000 EUR
- **Total generation capacity:** 2.7 kWp
- **Total GHG emissions avoided:** 640 tonnes/year

### STAKEHOLDERS

Carlos Morgado Foundation (design and implementation), Nykani Mavoko Association (local community liaison) and Mozambique Women of Energy (MWE) (community engagement and training on energy transition)

### CONTEXT & MAJOR BARRIERS

The Carlos Morgado Foundation has been working with the Mangunze rural community for more than 10 years. After each project's conclusion, the team continued to work with community members to identify the next initiative to address pressing needs in the community. After developing several projects together, the community identified a lack of access to energy as a major deterrent to its sustainable development. In 2018, the World Bank found that only 7.9% of rural Mozambique had access to electricity.[16] After engaging with community members on their specific energy needs, the Foundation determined that a cell phone charging station attached to a shared community space would have a significant positive impact on their lives.

A few years and several iterations later, the design of a covered structure to support solar panels and create a community space, in a shape of a giraffe, was finalised. Solar energy was the clear choice for this solution, given that Mangunze, Gaza, does not have access to the national grid electricity supply. Access to funding and challenges brought along by COVID-19 were the most significant hurdles the project faced.

### COMMUNITY DRE SOLUTION

The Foundation approached the community to share the concept of the proposed community space. The first version presented was simply a roof with solar panels on it. Immediately, the community members advised that the panels should be raised higher to mitigate any attempts of vandalism. This is when the "Solar Giraffe" was born. Two of the previous four poles of the roof got longer, and the Giraffe's long neck took shape. The solar system (batteries, inverter, charge controller and remote control) was installed in a technical closet on the ground. The front of the closet accommodates 10 cell phone charging outlets and a radio, while the back houses the switchboard that protects the equipment by not allowing higher loads to be charged and the solar system.

In terms of implementation, the Solar Giraffe had two phases: first, the installation of the structure, and second, the installation of the solar system and closet. In both phases, youth from the community offered invaluable support including labour, community engagement on the use of the equipment and advocacy on energy transition. With the assistance of MWE – Mozambique Women of Energy, two women were trained to maintain the space, assist users and evaluate the use of the Solar Giraffe. This was done by conducting interviews with users and recording how the community members use the space.

16 The World Bank, Access to electricity, rural (% of rural population)- Mozambique, 2021 (online)

**Technical specifications for the Solar Giraffe project in Mangunze, Mozambique**

| Solar Plant | Battery Details | | | | | | | Charge Controller | Inverter |
|---|---|---|---|---|---|---|---|---|---|
| kWp | No. | Capacity / Battery | Type | System Voltage | DoD | Battery Bank | Usable Power | | |
| 2.7 | 4 | 12 V / 110 Ah | Victron / AGM | 24V | 60% | 5.3 kWh | 3.2 kWh | 100 V / 20 A | 24 V / 250 VA |

| Battery Type | DoD | Estimated Lifetime | Cost | Maintenance |
|---|---|---|---|---|
| Lead-acid (VRLA AGM) | 60% | 7-10 years | 2.23 EUR / Ah | Low |

## BUSINESS MODEL & PROJECT FINANCING

The total funds provided to build the first Solar Giraffe was 7,000 EUR. The Foundation applied and was awarded the grant from the Head of Mission of the Embassy of Ireland in Mozambique. The system is owned by the Carlos Morgado Foundation. At the moment, in the pilot phase of implementation, testing is still being completed, the system is still changing, for example, a battery monitor was installed afterwards because the original system did not report the power used; an Android tablet is planned to be added to the technical closet to offer more access to information; the space has transformed from original solution by the community including seating area and landscaping; and, finally, extra night lights are planned to be installed in the near future for extra protection of the system and surrounding areas.

The use of Solar Giraffe is free. Early conversations with the community indicated willingness to pay a small fee to use the Solar Giraffe; a Pay-As-You-Go is being studied. Local research shows that an average cost to charge a phone for someone with a solar home system (SHS) is around 10 Mozambican meticais (MZN) or 0.11 EUR per charge and the operation costs, covered for six months by the original funds, are around 2,000 MZN (22.59 EUR) per month. Hence, a smaller fee is foreseen to be charged to cover the cost and maintain a cost advantage for using the system.

## OUTCOMES

The Solar Giraffe charges at least 20 phones per day with more usage on the weekends and cloudy/rainy days. In addition, two jobs were created; Clara and Sónia (two women) are the managers on-site. They maintain the space, control the charging and advocate about benefits of energy transition and renewable energy to their fellow community members. Consumer satisfaction is high.

The grid-connection is not expected to be available in near future. There is a clear understanding in the community that eventually the national grid will reach Mangunze, but the community believes that even then, the Solar Giraffe will continue to be utilised.

## LESSONS LEARNT

The Foundation is excited about an opportunity to work on a new prototype of the Solar Giraffe that pumps and stores water. Decentralised solutions like the Solar Giraffe are essential in rural areas. The use of cell phones is crucial to communities like Mangunze to improve economic, social and cultural conditions. The Solar Giraffe is recommended because it meets the community's needs, at lower cost, while promoting community engagement. Other recommendations fall in two main points: speak with a community before making any proposal and use a participatory approach, on the implementation and operation, of the proposed solution.

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## 4.6 GDS INTERNATIONAL

» **Summary**

- **Organisation:** GDS International
- **Project name:** Innovative rural electrification microgrid in Benin
- **Project location:** Benin
- **Project period:** 2022 - 2042
- **Total project budget:** < 10 million EUR
- **Total generation capacity:** 1,7 MWp / 3 MWh
- **Total GHG emissions avoided:** 1,345 tonnes/year

### STAKEHOLDERS

GDS International (GDSI) (project development and EPC partner) and ARESS (local partner in charge of the marketing, operation and maintenance of the electricity services)

### CONTEXT & MAJOR BARRIERS

The Consortium's main mission is to promote wellbeing in rural areas while increasing access to electricity thanks to an innovative decentralised energy production approach supporting (i) rural economic growth, (ii) rural electricity access, and ultimately (iii) the financial and economic viability of mini-grid investments.

DRE (Decentralised Renewable Energy) is the best alternative in remote areas underserved by the national grid expansion plan. In dense and dynamic villages with a wide range of commercial and productive users, DRE mini-grids are the best solution for energy access. Hence, solar-powered DRE mini-grid solutions will be implemented in this project.

12 villages are selected in the regions of Alibori, Atacora, Collines and Borgou. Currently, the electricity supply is limited to solar bulbs, few solar panels and in rare cases, shared diesel generators which don't account for the basic needs of the population. Indeed, only 17% of the population has access to electricity in the rural areas of Benin, according to the World Bank[17]. GDS International DRE mini-grid project will address the electricity needs of domestic households, public infrastructure, commercial, and productive users.

Rurality should not be a sign of mediocrity in the choice of solutions and products. Low-cost technologies should not be opted to offer services at cheaper prices because they typically compromise the performance and durability of the system installed. Extreme environmental conditions encountered at isolated sites place a strain on equipment operation. To cope with those constraints, GDS International chooses to rely on industry leaders whose products meet internationally recognised quality requirements.

### COMMUNITY DRE SOLUTION

Key factors to the project's success are the commitment and support from the local population. Consultative missions to raise awareness and provide information ensured the full involvement of the service customers. From the very first studies, the village chiefs, representatives of the final beneficiaries, were informed and consulted. They participated in the selection of the land on which the power plant will be built and will be involved in the layout of the network to secure the land and avoid possible conflicts with the villagers.

In the operational phase, the local operations manager will be responsible for ensuring that men, women, and marginalised people are included in the project. Throughout the project, women will facilitate village consultations in which representatives of all social classes will be solicited. Training and coaching by the project teams will strengthen the capacity of women and representatives of marginalised groups to play a key role in these

17 World Bank, Access to electricity, rural (% of rural population) – Benin, 2019 (online)

bodies. Suggestion/complaint boxes will also be available to allow a continuous link between the beneficiaries and the project's operation and maintenance managers.

The direct involvement of villagers will be considered in operational processes or for maintenance interventions as needed:

- 2 villagers per site will be trained and paid to maintain the production plant and carry out connection work and minor repairs. They will also be responsible for reporting any problems to the local technical teams.
- 1 villager will be paid to guard the plant at night.
- A dozen villagers will be trained and paid to clean the solar panels.
- 3 villagers per site will work as translators to facilitate contact with the beneficiaries who do not always speak French. Women will be given priority for these jobs.

The choice to use local labour empowers and ensures a better understanding of the expectations of the village community and thus an adequate response to any complaints about the project can be delivered.

## BUSINESS MODEL & PROJECT FINANCING

The total cost of the project is estimated to be <10 million EUR. The project is part of the OCEF (Off-Grid Clean Energy Facility) program and benefits from result-based grant funding corresponding to around 50% of the initial investment. The project is still under financial closure. A project company has been created which will own the DRE system for the length of the concession agreement (20 years). The local partner will ensure the operation and maintenance (O&M) on the field. The revenues will be able to cover these costs over the long term.

## OUTCOMES

The system has been designed to meet the 10-year energy needs of nearly 3,800 households, 1 600 productive activities and 70 community infrastructures. The production capacity will be increased, as needed, to keep pace with consumption until year 20 and serve more than 6,000 households, 2,400 productive activities and 100 community infrastructures.

The project's goal goes beyond energy access by promoting local economic development, notably through productive electrical services. GDS International provides a sustainable technological solution designed to meet the challenges of isolated sites. In addition, the installation of solar kits is envisaged as an alternative to meet the demands outside the connection perimeter.

More than 100 people will be employed during the construction phase and as many during the operation phase, more than half of whom will be women. Quality of service and customer satisfaction are at the heart of the project's approach. Surveys will be conducted throughout the life of the project to assess customer feedback and, as necessary, enhance practices.

## LESSONS LEARNT

GDS International provides a clean, efficient, and replicable energy solution compared to the energy sources currently used by households (solar bulbs, diesel generators, solar kits). The energy access service, the productive services and the accompaniment of partners aim at developing local entrepreneurship. The inclusion of the most marginalised locals is considered to be a key success factor.

Too many subsidised projects are abandoned after a few years of operation due to a lack of adequate resources. The sustainability of the project is essential, and it favours a holistic approach that goes beyond the provision of a solution for access to electricity and focuses on the overall economic development of the communities.

**Technical Sustainability**

- State-of-the-art, quality products from established suppliers
- A renewable and robust technical solution, considering local constraints, is unconditionally guaranteed and therefore without any bad surprises in the medium term

**Economic Sustainability**

- A modular solution to avoid oversizing the initial installation
- Predictable operational costs: limited use of diesel generator and negotiated contracts with service providers to avoid tariff distortion
- Secure revenues: through mobile prepayment, extensive field studies on the demand to limit uncertainties on revenues, user support measures, and services to value energy consumption during the day

**Social Sustainability**

- Ownership of the project by local communities, a key success factor made possible by regular awareness-raising, information and consultation missions
- Knowledge of the territory and users: a network of agents close to the population and a flexible managerial approach to adapt quickly to customer expectations
- Quality of service and after-sales follow-up

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## 4.7 GIZ ENDEV ETHIOPIA / EWIEN

» **Summary**

- **Organisation:** GIZ Energising Development Ethiopia, Ethiopian Women in Energy (EWiEN)
- **Project name:** Access to Modern Energy Services - Piloting cooperative MHP mini-grids
- **Project location:** Sidama zone in Sidama region and Jimma zone in Oromia region, Ethiopia
- **Project period:** September 2010 – March 2016
- **Total project budget:** 2,500,000 EUR
- **Total generation capacity:** 7-58 kWp
- **Total GHG emissions avoided:** 103.9 tonnes/year

### STAKEHOLDERS

GIZ Energising Development (technical assistance, financing, training and overseeing the implementation of the project), government institutions, mainly water and energy bureaus and cooperative bureaus from regional to district office levels (assisted in providing trainings, setting up the energy cooperatives, as well as supervision and follow up of activities after commission), universities, local communities (beneficiaries and responsible for operation and preventive maintenance of the mini-grids) and private organisation (community cooperative establishment, development of design and tender documents, manufacturing mechanical and structural parts, construction and commission of the project)

### CONTEXT & MAJOR BARRIERS

The project contained five community-owned pilot micro-hydropower (MHP) mini-grids built in Ethiopia's two regional states: Sidama region (previously part of Southern Nations, Nationalities, and People's region, SNNPR) and Oromia region. The MHP project was initiated by the German Development Cooperation through the multi-donor Energising Development (EnDev) Programme. Initially called, 'Access to Modern Energy Services Ethiopia' (AMES-E), the project was designed to showcase the potential of cooperative managed, owned and operated mini-grids to electrify rural areas.

The sites were selected for implementation due to the isolated nature of the rural communities and located far from the national grid. Therefore, implementing a DRE solution as opposed to extending the grid was found to be technically and economically feasible. As the project sites were near river basins, as well as available productive applications (flour mills), MHP was the preferred generation technology for the project. In addition, MHPs were found to present low negative environmental and socio-economic impacts. Before the implementation of the MHPs, residents relied on kerosene, candles, or firewood for lighting and other energy needs.[18]

### COMMUNITY DRE SOLUTION

The MHP mini-grids are low voltage grids with installed generation capacity ranging from 7 to 58 kW. The table below details the sizes of MHPs along with the number and type of connections at each site.[19]

Technical specifications for the Access to Modern Energy Services - Piloting cooperative MHP mini-grids in Ethiopia

18 Katharina Wiese, Energy 4 all? Investigating gendered energy justice implications of community-based micro-hydropower cooperatives in Ethiopia, Master thesis, 2018, p. 9-35, (online)

19 Terms of reference for Assessing the requirements for optimizing / re-operationalizing five micro-hydropower mini-grids and study productive use of electricity potential, March 2020

| Site name | Region | Installed capacity (kW) | Business model | Number of connections | | |
|---|---|---|---|---|---|---|
| | | | | Households | Social institutions | Productive users |
| Erete | Sidama | 33 | Cooperative | 204 | 12 | 29 |
| Gobecho I | Sidama | 7 | Cooperative | 38 | 4 | 16 |
| Gobecho II | Sidama | 34 | Cooperative | 137 | 14 | 2 |
| Hagere-Sodicha | Sidama | 58 | Cooperative | 231 | 16 | 59 |
| Leku Migira | Oromia | 13 | Cooperative | 183 | 8 | 16 |

The low and medium voltage national distribution grid is owned, managed and operated by the Ethiopian Electric Utility (EEU). The utility decides where to extend the distribution grid following its own electrification strategy as well as in line with the National Electrification Plan, NEP 2.0. Therefore, there is a chance that the MHP mini-grids would be encroached by the national grid if it comes in their vicinity. In such scenario, the mini-grid directive stipulates compensation for the mini-grid owners. The mini-grid directive, approved by the Ethiopian Energy Authority (EEA) in December 2020, provides detailed rules on licensing, tariff determination, tariff approval procedures, and grid encroachment.[20]

## BUSINESS MODEL & PROJECT FINANCING

The local communities, at each site, formed a cooperative that owns and manages the mini-grids once the projects were completed. The cooperatives are responsible for setting and collecting tariffs, operation, and maintenance of the power plants. Anyone living at the sites can become a cooperative member by paying a registration fee and buying a share for a small amount of money. A flat tariff structure is in place. As there is no electricity meter, a tariff is determined based on the number of bulbs and socket outlets.[21]

The total project budget is estimated to be 2,500,000 EUR. Although most of the capital and project costs were grant funded by the GIZ EnDev program, the local communities contributed with some percentage of the labour cost in-kind as well as the costs of indoor installations during the project construction phase. The cooperatives were linked with the local office of the Omo Microfinance institution in the case of Sidama region, and Oromia Credit and Saving Share Company (OCSSCO) in Oromia for start-up finance for different income generation activities like milling, etc. Furthermore, capacities were developed in the Selam Vocational centre and workshop in Hawassa, the workshop that manufactured the turbine for Ererte site, to provide technical service for the MHPs in Sidama and as well the Jima Agricultural Research Centre, that manufactured the turbine for the Leku Migira site, to provide technical services to the cooperatives and connections established.

## OUTCOMES

In general, the different communities had high levels of satisfaction after the project. Electricity provision is perceived as having a positive impact on their day-to-day lives. As can be seen from the table above, 793 households, 54 social institutions and 122 productive users (in some cases, anchor loads) were provided access to electricity through the five MHP based mini-grids. The households mainly benefited from lighting and were able to reduce expenses and indoor pollution related to the usage of kerosene and candles. However, as the communities continued to use biomass for cooking, time spent by women collecting

20 Mini-Grid Directive No. 268/2020, 2020 (online)
21 See footnote 19

firewood and preparing fuel materials has not changed.[22]

Schools, health posts and religious centres are among the social institutions electrified by the mini-grids. New productive use loads that came after electrification include barber shops, cell phone charging services, small businesses, and coffee and tea shops. Furthermore, existing businesses were able to attract more businesses and provide more services to their customers through new appliances such as TV, among others.[23] In addition to the hundreds of indirect jobs created through increased economic activities and productive use loads, 10 permanent jobs were created directly. At each site, one guard and one operator were employed. The cooperative management members carry out their responsibilities on a voluntary basis.

## LESSONS LEARNT

The main challenges in implementing this project were developing a sense of ownership, technical skill gap of different levels and high turnover of trained technicians, lack of metering system and the low electricity tariff of the main grid customers. The local communities were consulted at different stages of the project to ensure project buy-in and develop a sense of ownership as they will be owning and operating the project after commissioning. However, limited involvement of the community in the decision-making process and lack of clear definition of roles and responsibilities among stakeholders have substantially affected the long-term (financial) sustainability of the projects.

Lack of sense of ownership of the projects by the community as well as irregular collection of tariffs coupled with low willingness to pay has resulted in problems with the management of the cooperatives. In addition, the MHPs experienced a reduced connection rate at the initial stage of the project's implementation resulting from financial constraints by community members to pay the connection fee. To address this issue, GIZ is focusing on implementing capacity building measures for the cooperatives across the different levels and exploring ways to bring in private sector service providers to manage the project.

During the implementation phase, insufficient financial capability, and limited knowledge to operate and maintain the plants impacted the functionality of the projects and resulted in a suspension of operation of few MHPs.

GIZ has issued terms of reference for hiring a consultant to study the technical and organisational status of the MHPs and make recommendations for technical and operational measures to optimise / re-launch the project.[20]

The experience so far with these cooperative MHP mini-grids shows that the establishment of a robust and professional management for the mini-grids and as well the cooperative itself, the promotion of productive use of the electricity to enhance financial sustainability and socio-economic impact and assure access to a reliable repair and maintenance service provision are decisive for sustainability of the whole venture.

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22 See footnote 19
23 See footnote 19

## 4.8 GRINO WATER SOLUTIONS GMBH

» **Summary:**
- **Organisation:** Grino Water Solutions GmbH
- **Project name:** Water for Everyone
- **Project location:** Cape Coast, Ghana
- **Project period:** October 2019 – October 2020
- **Total project budget:** 60,000 EUR
- **Total generation capacity:** 8 kWp Solar PV system providing 2,500 litre of drinking water per day
- **Total GHG emissions avoided:** Estimated 90 tonnes/system lifetime

### STAKEHOLDERS

Grino Water Solutions (manufacturer, installation, project development and implementation); Innovation und Zukunft Stiftung (financing) Technik ohne Grenzen (TeoG) e.V. (community facilitator); students and the community (beneficiaries)

### CONTEXT & MAJOR BARRIERS

Access to electricity and drinking water is a fundamental right for health, social and economic development. Although Cape Coast is among the 10 big cities in Ghana and has more than 140,000 inhabitants, people lack access to electricity and water.[24] The situation is even worse in schools - on one hand, low-quality water is not always available and on the other hand, the price of the water is not affordable.[25] Therefore, every year many students leave schools to earn some money and fetch water for their families. It is the same condition for women in the communities where they spend a long time every day to fetch water for their families, locking all their time instead of having any social activities.[26] Seawater and sun energy as the most abundant resources are all Grino's technology needs to meet any restrictions and produce sustainable and high-quality water.

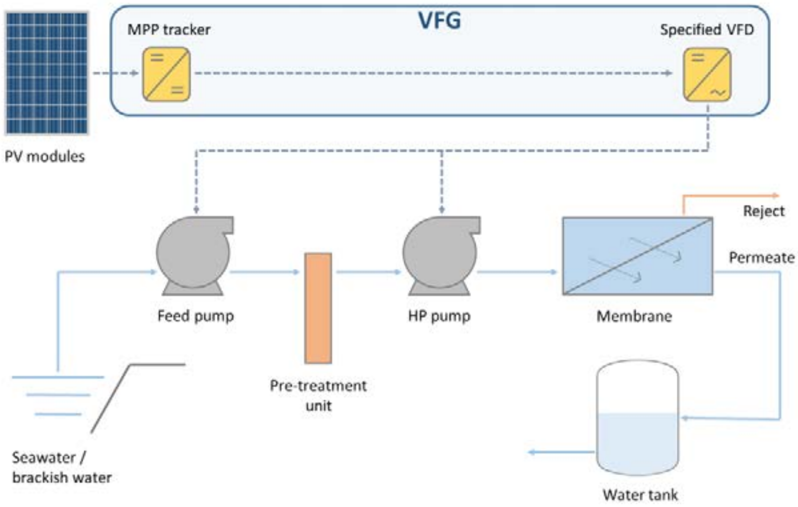
Lack of detailed data on the current status of existing infrastructure, restriction of pandemic and variable regulations for shipping, traveling and contracting, as well as developing successful and trustful partnerships with local companies and providing security for the system, were the most challenging issues for this project.

### COMMUNITY DRE SOLUTION

In this project, the energy generated by 24 PV panels (8 kWp) is distributed among borehole pump, feed pump, high-pressure pump, and the water distribution system. Grino's new technology (patent pending) allows the system to work dynamically and operate with little available solar energy without using any battery. Therefore, Grino's system works at least one hour more than any other solar based desalination systems in the market and produces more water. Feedwater is pumped from a coastal borehole (120 m) to a seawater reverse

24 World Population Overview, Ghana Population, 2021 (online)
25 K. Bigson, E.K. Essuman, C.W Lotse, Food Hygiene Practices at the Ghana School Feeding Programme in Wa and Cape Coast Cities , 2020 (online)
26 Akvorsr, Cape Coast Water Supply Project 2014 (online)

osmosis (RO) system, which produces 300 l/h drinking water. In addition, there is always some energy available for mobile charging and lighting. Removing the battery and fully automatic operation makes the system simple and easy-to-use for customers. Furthermore, remote monitoring from Germany, after-sales services by the local companies, and training locals for maintenance ensure the sustainability of the project.




*Technical block diagram*

The project was done under the full commitment of the community. The installation place was selected by the local team of TeoG in Ghana. Besides, this local team helped Grino to find local partners. Grino always cooperates with local companies for the installation to support the local businesses as well as to transfer the know-how. In this project, borehole construction, piping, solar panel installation, RO room construction, and after-sales services are handled by a partnership with local companies.

In addition, to cover the maintenance costs, part of the produced water will be bought by the local community. The water tariff is fixed together with the community and the sale of the water will be managed by women to maximise their contribution to the project. Grino's system operates automatically and easily, allowing the operator without any specific skills to run the system and manage water sales and distribution. Additionally, Grino seeks to eliminate all water-related discrimination and inequalities through a fully women-led business model locally.

Simple maintenances can be done by the operator, while Grino's local after-sales service partners support the operator by suppling spare parts and providing technical advice.

## BUSINESS MODEL & PROJECT FINANCING

The community project was financed by Innovation und Zukunft Stiftung to build an innovative stand-alone system to provide drinking water. This non-profit project provides clean water free of charge for students and 30% of the produced water will be sold to the community to compensate for the maintenance costs and ensure the sustainability of the project. This model provides a long-term social and environmental impact.


The project business model is based on Build-Operate-Transfer (BOT), i.e., during the first three years, Grino owns and operates the system. The goal of this period is to teach the locals step by step on a long-term basis and to avoid O&M problems after transferring the system to the school at the end of the period.

## OUTCOMES

The project has provided drinking water for about 1,000 inhabitants including 600 students (Philip Quaque school and Jacob Wilson-Say) and 400 locals of Cape Coast. Applying Grino's technology instead of using diesel generators saves up to 90 tonnes of $CO_2$ during the lifetime of the system, respectively. Apart from three temporary local jobs during construction, installation, and preparation of the project, Grino created two permanent jobs as security and salesperson for this project.

Utilising the system with abundant resources and removing the expensive battery makes the product not only reliable but also affordable. The community can rely on this and get the benefits for their daily uses without any problems. Simple operation, minimum maintenance, and high quality are all reasons which bring a high level of satisfaction to the community.

Grino's priority is to provide water in remote areas, where people have no access to water and energy. As the second priority, Grino is also interested to provide water in grid-connected areas.

## LESSONS LEARNT

By removing the batteries from solar desalination plants, the system lasts for up to 15 years with the lowest maintenance costs. Grino developed a new technology (patent-pending) and achieved a proof-of-concept of the innovation through this project. The water produced was tested by an authorised lab in Germany, which approved the water quality. This innovation can provide water for the people and communities in remote areas at an affordable price.

The success results from this project directly motivated the project investor to finance two more projects in Africa which demonstrated investor confidence in our solution. Proof of the innovative technology and holistic solution, creating awareness among the community of the benefits and use of DRE solutions, engaging the empowered local community to the project, and improving standard living conditions specifically during the COVID-19 pandemic, are some of the great experiences that were achieved during this pilot project.

Based on the experiences from this project, it is highly recommendable to fully involve the community in the DRE projects. It not only leads to saving project costs and time, but by prioritising the real community needs, the project has a higher success rate. In this specific project, the main part of the generated power is used for the desalination system and the rest will be used for lighting and charging mobiles.

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## 4.9 HNU & NEI

» **Summary**

- **Organisation:** Neu-Ulm University of Applied Sciences (HNU), Namibia Energy Institute (NEI) and Partners
- **Project name:** Tsumkwe Energy Project (TEP), Pathway to Renewable Off-Grid Community Energy for Development (PROCEED)
- **Project location:** Tsumkwe, Namibia
- **Project period:** March 2008 – Ongoing
- **Total project budget:** 2.99 million EUR (TEP), 1.25 million EUR (PROCEED)
- **Total generation capacity:** 304 kWp PV power, 600  diesel power, 3,025 kWh battery capacity (as of February 2021)
- **Total GHG emissions avoided:** Estimated 100,000 tonnes/year (considering the current PV share)

### STAKEHOLDERS

Tsumkwe Energy Project (TEP), 2008-2012

Desert Research Foundation of Namibia (DRFN) (project execution)

Follow up project - Pathway to Renewable Off-Grid Community Energy for Development (PROCEED) 2019 - Ongoing

Technische Hochschule Ingolstadt, Neu-Ulm University of Applied Sciences and University Bayreuth (conception and project execution), IBC Solar AG, NEI, Alensy Energy Solutions, Renewable Energy Industry Association of Namibia, SADC Centre for Renewable Energy and Energy Efficiency (SACREEE) and Hanns-Seidel-Stiftung Namibia (academic and consortium partners)

### CONTEXT & MAJOR BARRIERS

Tsumkwe is located in the north-eastern part of Namibia. The distance to the next settlement, Grootfontein, that provides access to basic services is 304 km away. Due to the remote character and based on Namibia's Rural Electricity Distribution Master Plan, Tsumkwe is classified as an off-grid area. Based on the resulting high connecting costs, Tsumkwe will not be connected to the grid in the near future.[27,28]

The electrical infrastructure in Tsumkwe has its origin in Namibia's pre-independence period, where Tsumkwe served as a military base for the South African Army. After Namibia's independence in 1990, the government took over the basic infrastructure. However, the power supply was unreliable and due to increasing costs of diesel, electricity supply started to be restricted, which had an adverse influence on livelihood. The system generally was poorly maintained and its usage along with diesel spills polluted the environment. The tariff was not affordable for residents until that time, although the government heavily subsidised it, which led to an enormous annual deficit for the Otjozondjupa Regional Council (OTRC). In 2005, it was assessed whether a hybrid mini-grid energy supply system using solar energy and diesel would be a feasible long-term electrification approach for Tsumkwe.

The usage of solar power is not at all surprising, as Namibia exhibits the second-highest level of solar irradiation in the world.[29] The community was involved in the planning phase and was engaged in the execution. Local employment for construction was especially important to create a sense of ownership for the infrastructure. In addition, educational campaigns have been organised, focusing particularly on informing the community about the project

27 United Nations Development Programme, **Off-grid Energisation master plan for namibia**, 2013 (online)
28 Zongwe DP, Ileka H, Reuther K, Rural Electrification with Hybrid Mini-Grids: Finding an Efficient and Durable Ownership Model, 2017
29 United Nations, UN Namibia goes solar halving power consumption, 2017 (online)

itself, maintenance of the stoves or solar water heater, and energy efficiency. This was accompanied by several informative flyers that educated residents on how to save money through energy-efficient measures, among other things.[30,31]

## COMMUNITY DRE SOLUTION

The European Commission, NamPower and the OTRC, funded the resulting project. The installed hybrid mini-grid is comprised of solar PV panels with 202 kWp complemented by a 650 diesel generator. The battery backup had a capacity of 766 kWh. The Namibian government's share thereby primarily benefited from the introduction of energy efficiency appliances, for example, electric water heaters were replaced by solar water heaters, electric stoves were replaced with gas burners, and households were equipped with energy-efficient light bulbs. 50 residents, who were not connected to the mini-grid, received electric lanterns, which could be recharged at the solar charging kiosk. Although the experts' advice was to run the hybrid mini-grid system autonomously through an independent operator, ownership of the system was transferred to the OTRC. Operation and maintenance of the mini-grids was under the responsibility of the Department of Works residing in Tsumkwe.

A visit to the mini-grid in 2016 uncovered that the system was not properly utilised. Due to a general lack of control, the energy efficiency measures were not respected among the community and eventually, energy theft occurred. Thus, the Ministry of Mines and Energy (MME) decided in 2017 to transfer the ownership of the system to the Central North Regional Electricity Distributor (CENORED), being responsible for the respective licensing area. Throughout the following years, CENORED was able to expand the PV system to 304 kWp, which led to a better split of total electricity generation. In addition, the electricity supply became more reliable providing 24/7 electricity, which is an obvious benefit for the community.

## BUSINESS MODEL & PROJECT FINANCING

The European Commission (75%), NamPower (14%) and the OTRC (11%) funded the TEP with 2.99 million EUR. The research and consultancy PROCEED is financed by the German Federal Ministry of Education and Research (BMBF) with approximately 1.25 million EUR.

After the transfer of ownership to CENORED, the total electricity production costs have been reduced to just below 2 NAD/kWh (~0.11 EUR). Considering the two different tariffs for private households and institutional/commercial customers, the average tariff now lies at around 2.6 NAD/kWh (~ 0. 15 EUR). However, due to the lack of a clear business model, an economically viable operation covering full costs has not been possible in recent years. The running tariffs allow only to cover operational costs, mainly diesel. CAPEX costs were not considered leading to delays in replacing spare parts necessary. In order to improve the current situation, the project is looking in particular at the key maker model approach, which is currently being worked on. According to this model, the operator integrates an anchor customer that processes raw materials sourced from the local community with electricity from the mini-grid and eventually sells the final products to customers in urban areas.

## OUTCOMES

Interviews with community members have been conducted to better understand the situation, particularly with regards to the reliability of the system and the affordability of the tariffs. In general, community members were satisfied with the availabili-

30 EU Energy Initiative Partnership Dialogue Facility, Mini-Grid Policy Toolkit-Case Study, (online)
31 Desert Research Foundation of Namibia, Tsumkwe Energy Project, (online)

ty of uninterrupted electricity, even though they did not perceive the unit prices to be reasonable.[32] This outcome will support the possible development of a new tariff model to be combined with measures that further improve energy efficiency among the population to reduce peak load in the long term.

## LESSONS LEARNT

Since the mini-grid was installed in 2011, the system lacked regular maintenance, which resulted in several malfunctions. Although repairs and an expansion are needed, this cannot be internally financed due to the tariff-setting covering only operational costs. Despite the endeavours of involving the community during the planning and construction phase, understanding of electricity and its eventual (commercial) use remains limited. Therefore, the follow-up project PROCEED was initiated in 2019 to investigate the current challenges and to assist CENORED with improving the situation.

The project specifically aims to support the establishment of productive use cases within the community to alleviate poverty and increase income, with the goal of having a better cost-recovery tariff system. In addition to a technical and economic workstream, the project is particularly complemented by a socio-economic work package focused on holistically integrating the community perspective. Another neglected key aspect is to train not only the population but also technical staff to be able to maintain the system properly in the long run.

Overall, community-driven projects must go beyond resident consultation and information and include an educational pathway for community members to both train local technical staff and develop productive use cases from the outset. These projects must also be monitored over time to achieve sustainable project success.

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32 Hoeck I, Steurer E, Dolunay Ö, Ileka H, Challenges for off-grid electrification in rural areas. Assessment of the situation in Namibia using the examples of Gam and Tsumkwe, 2021 (online)

## 4.10 PLAN INTERNATIONAL

» **Summary:**

- **Organisation:** Fundación Plan International España
- **Project name:** Economic and Social Development of Women through Renewable Energies in the Sahel (DESFERS)
- **Project location:** Senegal, Mali, Niger. This case study is focused only on Senegal.
- **Project period:** June 2018 – August 2023 (ongoing)
- **Total project budget:** 9.57 million EUR, approx. 3 million EUR for Senegal
- **Total generation capacity:** 554 kWp (foreseen), 160 kWp in Senegal only
- **Total GHG emissions avoided:** 4.5 tonnes/year, only for Senegal

### STAKEHOLDERS

Fundacion Plan International España, (project coordination, development and implementation), ACRA (project development and implementation), Agence Nationale pour les Energies Renouvelables (ANER) and the Agence Sénégalaise d'Electrification rurale (ASER) (project development and implementation). GIZ Energising Development (EnDev) programme and Schneider Electric Foundation (Training of Trainers and laboratories rehabilitations), University Carlos III of Madrid (Didactic materials) and Alliance for Clean Cookstoves. Other stakeholders include women saving/economic groups and existing income generating activities run by women (beneficiaries), local electricity operators, local financial institutions, Ministry of Employment, Vocational Training and Handicrafts (MEFPA).

### CONTEXT & MAJOR BARRIERS

The idea was developed due to the regular contacts that Plan International field personnel have with most of the 200 local communities targeted in Kaolack and Casamance region, as well as during the project proposal identification field missions. The efforts made it possible to identify the high level of potential economic activities within the project communities, the need for capacity building and access to basic economic development-related services (internet connection, affordable financial services, decent quality RE product/services, etc).

Needs assessment in the communities demonstrated high levels of gender inequality, socially, economically and culturally, which created a major barrier to women's participation in economic activities.[33] Introducing DRE to the communities with their support and engagement, and empowering women to be the key leaders and agents of related income-generating activities (IGAs) had major potential to transform traditional gender roles and empower women and girls. DRE solutions will be used in this project because of their potential to increase existing IGAs' productivity and effectiveness contributing to the economic sustainability in the communities.

The chosen technical solutions range from small pico-PV systems to PV Solar Micro-Grids (SMG). Solar Lighting System (SLS), Solar Home System (SHS), productive use systems (e.g., pumping systems, milling systems, cooling systems, etc) and Multi-Functional solar Platform (MFP) will be implemented.

Undoubtedly, the COVID-19 emergency had a significant impact on the project, particularly on the field activities. Likewise, the lack of a clear plan for the national grid extension for electrification hindered the project's activities and more than 50% of the originally selected sites were replaced in order to avoid an overlap between the two technical solutions (Independent rural electrification and national grid extension). Nowadays, the risk for future overlapping

33 Plan International assessment

among the two solutions remains, despite the emerging efforts of the legal framework which seeks to de-risk investments as well as the development of the operator's business. For this reason, technically the DRE solutions are designed to be national grid-compatible when it arrives and hence ensures sustainability.

## COMMUNITY DRE SOLUTION

The community members and mainly the saving groups are the key actors of this project. As introduced, the idea comes from the regular interaction between Plan International Staff and the women's groups. Their enthusiasm in optimising the community's existing economic activities or creating new ones motivated them to begin the proposal preparation.

Those group members set up clear planning for the activity's implementation in relation to their economic/social needs (e.g., agriculture calendar etc). Finally, the members will be part of the mechanism and not only beneficiaries. In fact, the ESA (Energy Service Agents) members of the saving groups, will be the promoters of DRE solutions and will have the role to facilitate access to credit at affordable conditions for the women entrepreneurs. They will create a link between the IGA owners and the private sector actors providing those services (e.g., financial institutions, pay-as-you-go providers etc). Additionally, the ESAs will be trained to be part of the basic O&M services needed by the operators to reduce costs and increase efficiency and effectiveness when preventive and corrective maintenance must be applied.

**Technical specifications for the DESFERS mini-grid in Senegal**

| **Infrastructure Type** | **MFP 1** | **MFP 2** | **SMG 1** | **SMG 2** | **SMG 3** | **SMG 4** |
|---|---|---|---|---|---|---|
| **Energy Needs Estimation** (kWh/year) | 22 | 32 | 43 | 53 | 60 | 80 |
| **Estimation of Power Demand** (kW) | 7.5 | 7.7 | 7.5 | 9 | 14 | 15 |
| **Minimum PV Peak Power** (kWp) | 5 | 7.5 | 10 | 12.5 | 15 | 15 |
| **PV Generator Structure** | Pergola/ roof-top | Pergola/ roof-top | Ground-mounted/ Pergola | Ground-mounted/ Pergola | Ground-mounted/ Pergola | Ground-mounted/ Pergola |
| **3-phase Nominal Power (continue at 25°C)** (kVA) | 11 | 11 | 11 | 13 | 20 | 20 |
| **3-phase Backup (generator)** (kVA) | 6 | 7 | 9 | 10 | 14 | 14 |
| **Storage** | 14 kWh, C10, 3,500 cycles minimum | 18 kWh, C10, 3,500 cycles minimum | 22 kWh, C10, 35,000 cycles minimum | 30 kWh, C10, 3 500 cycles minimum | 30 kWh, C10, 3 500 cycles minimum | 52 kWh, C10, 3 500 cycles minimum |
| **Monitoring** | Yes | Yes | Yes | Yes | Yes | Yes |
| **LV Network** | No | No | Yes | Yes | Yes | Yes |

The long-term sustainability of the project is based on the direct involvement of the members of the saving groups (ESA) who will ensure a trusted connection among the final beneficiaries (the women entrepreneurs) and the different stakeholders and services providers. Thanks to the received training, the ESAs will act as support for the women entrepreneurs, especially during the start-up period. On top of that, women entrepreneurs as well as the local operators will need to cover part of the initial investment related to their respective activities. 20% will be asked to the operators for obtaining the concessions of their solar PV infrastructure and 5% to the women entrepreneurs for accessing the credit mechanism. Sharing the risk is a proven way to ensure a real commitment of the final beneficiaries which turns into higher durability of the entire action.

## BUSINESS MODEL & PROJECT FINANCING

Approximately 3 million EUR is being funded for the project work being carried out in Senegal. 80% of the total budget is a grant by EUROPEAID and the remaining 20% will be covered by the project consortium through grants (10% Organisation of the Petroleum Exporting Countries (OPEC) Fund for International Development already secured).

The local Rural Electrification Agencies for the micro-grids will own the assets and will receive 15-year concessions from the State. The bigger DRE systems (the Solar Micro Grids) will be operated by the local/international operators through public concessions. The operator will have to contribute the 20% of the CAPEX and will be supported by local communities for the O&M.

The project has set up a consistent number of IGA based on existing/new women economic activities which will enable the financial sustainability of the DRE based services. In order to purchase the productive machine or the DRE systems, the women will have access to an affordable credit service. The project has facilitated the creation of this financial mechanism through the implementation of a guarantee fund that will cover the 50% of the credits mobilised by the financial institutions for the smaller productive usage PV systems.

**DESFERS project outcomes observed in Senegal**

| | |
|---|---|
| **Specific Objectives:** To facilitate the 1,500 small and medium-sized enterprises of women (from 200 Saving groups) access to entrepreneurship in the sustainable energy sector in Senegal, by developing a favourable context, by facilitating access to credit and solar energy; and by strengthening the capacities of women and operators of integrated energy services. | |
| No. of female (Small Medium Enterprises (SMEs) that have access to renewable energy and have engaged in income-generating activities using or marketing renewable energy (compared to women who already have access to and/or are engaged in IGAs using or marketing renewable energy before 2018) | 1,500 companies – August 2023 |
| No. of kW of additional renewable energy capacity installed with project grants - exclusively for IGAs of (groups of) women using or marketing renewable energy | 160 kW - August 2022 |
| Capital value in the portfolio of Micro Finance Institutions (MFIs) for loans to SMEs for services and IGAs using or marketing renewable energy | 1.5 million EUR - August 2022 |

At the moment the project has finished the training sessions for all the beneficiaries and has already started the preparation of the process related to access to the credit (business plan preparation, evaluation, submission). On top of that, the launching of the tender process for procurement, installation and operation has been already released.

## LESSONS LEARNT

The goal of Plan international is to use this or a similar model to ensure decent social and economic development for women and youth in the more than 50 developing countries where it is currently working. The network and platform for exchange on this experience easily reach the target of 160,000 women in Senegal.

The economic empowerment projects should focus more on the activities and solutions related to the reduction of the social/cultural barriers which impede women to properly access economic development possibilities and merging those activities with their family/life responsibilities. Also, the follow-up of the IGA is crucial. Thanks to digital tools, this project is setting the base for a close follow up done directly by the community with the support of Plan International.

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## 4.11 UNIVERSITY OF SOUTHAMPTON

University of Southampton

» **Summary**
- **Organisation:** University of Southampton
- **Project name:** Energy for Development (e4D) Programme
- **Project location:** Kyamugarura and Kanyegaramire, Uganda
- **Project period:** February 2015 – Ongoing
- **Total project budget:** 290,000 EUR
- **Total generation capacity:** 27 kWp
- **Total GHG emissions avoided:** 10 tonnes/year

### STAKEHOLDERS

University of Southampton (ECCD/SERG) (fundraising, design, and implementation), Rural Electrification Agency (REA), Uganda (co-funding, provided grid network for transmission and current owner & maintainer), local cooperatives (management, day to day operations and revenue collection) and communities in Kyamugarura and Kanyegaramire (beneficiaries)

### CONTEXT & MAJOR BARRIERS

Kyamugarura and Kanyegaramire villages are about 20 km from the nearest town with electricity (Kyenjojo). Prior to this project intervention, as per the survey, the villagers were dependent on kerosene lamps for lighting and diesel generators for other electrical power needs. These marginalised communities only had very limited seasonal income related to farming and thus represented only the primary tier of electrification.[34] There are no plans for the national grid to be extended to the region in foreseeable future. With availability of abundant sunshine, a PV based solution was chosen.

The Energy and Climate Change Division (ECCD) and the Sustainable Energy Research Group (SERG) at the University of Southampton, UK in 2008 initiated the Energy for Development Programme[35] (e4D). The Ugandan mini-grids are part of the six-community managed solar PV powered with battery storage mini-grids installation in East Africa under the programme.[36] In 2015, two Ugandan mini-grids were installed in Kyamugarura and Kanyegaramire (13.5 kWp each) in Kyenjojo district.

*Kyamugarura mini-grid during construction shipping container mounted superstructure*

*Kyamugarura mini-grid plant room during construction*

These mini-grids supply electricity 24 hours a day to businesses, health centres, schools, places of worship and households. Around 1,500 local people have benefited from the two projects in Uganda. Both the projects are cooperatives, governed by Ugandan regulations and managed by elected members of the local communities. The 13.5 kWp mini-grids have a designed

34 Energy for Development (e4D) Programme survey
35 Energy for Development, (online)
36 University of Southampton, Energy Access, (online)

*Four PV string combiner boxes in Kanyegaramire mini-grid during construction*

*Top view of the Kanyegaramire mini-grid*

capacity of 28 kWh/d, and it is estimated that around 10 tonnes of GHG emissions are avoided yearly through each of these projects.

All e4D designed and implemented mini-grids were instigated as learning entities in order to provide the required design, operational and economic evidence to governments, policymakers, funders and mini-grid developers, to make better-informed decisions regarding the design, implementation and economic approaches for mini-grid deployment at scale.

## COMMUNITY DRE SOLUTION

At the initial phase, surveys and consultations with the local communities were made with local communities. Based on the information collected, PV-battery systems were designed (table below) to deliver 28 kWh/d electricity in each village and although initial demand was low (~6.5 kWh/d), demand grew rapidly over the next years, exceeding the design capacity.[37] Both projects are similar in size, capacity and architecture.

**Technical specifications for the Kyamugarura and Kanyegaramire mini-grids, Kyenjojo, Uganda**

| | |
|---|---|
| **PV** | Total 13.5 kWp, 4 PV arrays (250 Wp/panel) |
| **Battery** | 38.4 kWh lead-acid gel battery bank (set at 50% DoD) |
| **Charge controller** | 4 x 60 A Outback FLEXmax |
| **Inverter** | 2 x 5 Single phase (48 VDC/230 VAC) Victron Quattro |
| **Distribution** | 4 km long 230 V 50 Hz single-phase AC line<br><br>Divided into essential and non-essential circuits |
| **Revenue collection** | Pre-pay meter with card top-up facility |
| **Monitoring** | Data logger DT 85 (remote monitoring and data acquisition) |
| **Project costs** | The PV-battery power plant cost was around ~ 5,000 EUR/kWp (4,300 EUR/kWp) Network cost was cover by the Ugandan REA |

The ECCD/SERG team in the UK, regularly monitors the projects and selected consumers through the online monitoring system and supports the local cooperatives and REA to troubleshoot as and when necessary. In addition, the team works closely with REA and regularly visits both sites and supports capacity building through training and demonstrations.

## BUSINESS MODEL & PROJECT FINANCING

As mentioned earlier, the e4D programme and project deployments stemmed from a grant[38] awarded by the Engineering and Physical Science Research Council (EPSRC).[39] Implementations were undertaken in partnership with REA in Uganda with shared project costs. The power plant was funded from the grant, while the electrical distribution network was funded by

37 Bahaj and James, Electrical mini-grids for development: Lessons from the field, 2019 (online)
38 EPSRC, Replication of Rural Decentralised off-grid Electricity Generation through Technology and Business Innovation, 2009 (online)
39 Engineering and Physical Science Research Council, (online)

the government agency responsible for rural electrification. The cost of the fully installed and commissioned power plant (PV system, balance of system, protection, and batteries) was around 4,120 EUR /kWp. Once deployed, the mini-grids were handed over to REA Uganda, and operated by the elected local cooperatives. The electricity tariff was set to be slightly higher than the national grid. The Cooperatives collect the revenue through the sales of electricity and invest in the project and the community businesses.

## OUTCOMES

Over 144 businesses, two health centres and two schools have been connected to the two mini-grids, providing access to energy for lighting, refrigeration, electronic devices and battery charging from 2015 until the present. Through ongoing surveys, there is clear progress in health, education and commercial services etc within these villages. Six full-time and two temporary employment opportunities were created as part of this project.

## LESSONS LEARNT

To our knowledge, the projects initiated under the e4D programme were the first in East Africa where a joint funding model between a developer and government was applied for mini-grid projects. This joint funding approach is now becoming de-facto in many projects, which is important to support reduced tariffs for the poor rural regions in Africa.

Demand grew very rapidly after commissioning, driven partly by a low regulated grid-parity tariff and by a desire for high-intensity inefficient security lighting. This required an intervention to replace the lighting with low energy units to prevent the system from being overloaded. Demand slowed but continued to rise and eventually, the design capacity was exceeded, and the batteries began to fail, resulting in blackouts. Upgrades are currently planned with REA, incorporating diesel backup and lithium-ion batteries for increased resilience.

Survey work has been carried out in several neighbouring villages in collaboration with REA to assess the potential to establish a cluster of mini-grids in the area.

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## 4.12 VERO POWER

» **Summary:**
- **Organisation:** Vero Grid Ltd (Registered in England and trading as Vero Power)
- **Project name:** Ngabwe Secondary School – Vero Solar Pole
- **Project location:** Ngabwe, Central province, Zambia
- **Project period**: April 2019 – October 2021 (Extended 3 months due to COVID-19)
- **Total project budget:** 32,000 EUR
- **Total generation capacity:** 4.25 kWp – 8.8 kWh
- **Total GHG emissions avoided:** 2 tonnes/year

### STAKEHOLDERS

Vero Grid Ltd (development, design & delivery of rural off-grid electrification projects), Techlink (Pty) Ltd (local technical delivery partner), Smart Village Ltd (local project partner to promote innovative renewable energy solutions and value-adding technology interventions for rural communities and off-grid enterprises in Zambia)

### CONTEXT & MAJOR BARRIERS

Zambia has 2,800 MW of installed electricity generation capacity, of which 85% is hydro based. National access to electricity averages at 31% with 67% of the urban and 4% of the rural population having access to power. The Government of Zambia (GoZ) set a goal for universal electricity access for all Zambians by 2030.[40]

Multiple unsuccessful attempts for sourcing grant funding to construct a solar mini-grid led to the decision by the partners (Vero Power and Smart Village) working very closely with the community to self-fund the electrification of Ngabwe Secondary school, seven teacher houses, boys and girls dormitories respectively. The area is 140 km from the nearest grid point and difficult to get to especially in the rainy season The school and other buildings remain in the dark after sunset without any active power supply with the exception of some solar home systems in the teachers' quarters.

After surveying the school and engaging with the school community, the 'Vero Solar Pole' idea was born to electrify smaller clusters in a more flexible way to drive down the cost per connection. Vero Power collaborated with Power Blox (also an ARE Member) to realise the project. The Solar Pole system was chosen as the technology due to the availability of sunlight, distance from the grid and easy operation of plug & play solutions. The major barrier however was the complexity in planning and implementation of electrification projects in such remote locations.

### COMMUNITY DRE SOLUTION

Four Solar Pole top arrays each 1.06 kWp with 2 kWh (PowerBlox LiFePO4) were chosen due to reliability and remoteness of the site for a plug and play solution. The metering solution from SparkMeter (also an ARE Member) was installed to monitor/control/limit the load to each point. Solar Street lights were also installed at various points around the school and dormitories for increased visibility, security and safety.

40 USAID, Zambia Energy Sector Overview, 2021 (online)

Smart Village has been working with the local community since 2017. Savings groups have been established with the support from RUFEP (Rural Finance Expansion Programme) which has been very successful, building a strong relationship with the community. A pre-feasibility report was undertaken by the University of Zambia on the area, Vero Power visited the site with Smart Village for community engagement multiple times before implementation and had the blessing of the late Chief Ngabwe.

**Technical specifications for the Ngabwe Secondary School – Vero Solar Pole**

| Battery & MPPT Detail Note: Power Blox PBX-200 Li/LE Units (Integrated) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Quantity** | **Total Project** | **Integrated Battery and capacity** | **System Voltage** | **Battery** | **DOD** | **Expected Lifetime** | **Output rating** |
| 8 | 8.8 kWh | 2 x LiFePO4 50 AH 12 V | 24 V | 1200 Wh | 90% | >10 years | AC 47 Hz |
| **Solar Plant Details** | | | | | | | |
| **Quantity** | **kWp per Pole** | **System Total** | 10 x SparkMeter SM16R and AC Distribution Network | | | | |
| 4 | 1.06 kWp | 4.25 kWp | 10 x Allbro Ready Boards with LED Lighting<br>6 x 15 W Solar Street Lights | | | | |


*Network diagram*

The head teacher and other teachers were trained in the general operation of the systems and have successfully over the two years at multiple points diagnosed and sorted out issues with the system over the phone from the site with the team in the UK and Lusaka.

## BUSINESS MODEL & PROJECT FINANCING

As an initial project, the cost to deliver was 32,000 EUR which was 80% self-funded by Vero Power and 20% by Smart Village. Both Vero Power and Smart Village own the DRE system.

Without subsidies or further grant funding, expanding the electrification to homes and other classrooms is a big challenge. Vero Power and Smart Village are working on PURE models for Vero Impact Hubs (entrepreneurs operated solar-powered kiosks) to help generate local income and boost the local economy. However, there is still not enough financial support for the energy access sector which is sought for this project to achieve the UN's SDGs locally.

## OUTCOMES

At least 50 people (teachers and pupils) have lighting and power in their homes and dormitories after sunset. The standard of living has improved with more possibilities for studying and entertainment. Approximately 40 pupils have access to night classes and extra-curricular activities. Hundreds of community members have access to area lighting via solar street lighting around the school and water pump.

No direct jobs were created so far, however, free power is provided to the school in return for O&M duties to date. A solar streetlight was donated to a local shop, the shopkeeper helped install systems, and this has boosted his evening trade. Income generation prospects were favourable after the sunset due to the area lighting by solar streetlights.

The consumer satisfaction rate is high with the electrification of their establishments and the surrounding areas. At the time of the development of this project, no future plans for merging the DRE solution with the national grid were in place.

## LESSONS LEARNT

There is a huge demand for the power solution provided by Vero Power e.g., Vero Power Hubs from the local communities, however, financial support remains the biggest challenge. The model is highly replicable and quick to install, maintenance is a minimum and it is a cost-effective solution for dispersed communities which fits nicely between mini-grids and solar home systems.

Based on our experiences, more attention should be given to PURE activities focusing on public and commercial institutions like schools, health clinics and small-scale businesses.

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