ENGIE ENERGY ACCESS

TOWARDS UNIVERSAL ACCESS TO ENERGY:

Enabling A Multi-Technology Approach In A Mini-Grid Environment

ENGIE

TABLE OF CONTENTS

ABBREVIATIONS

AfDB	Africa Development Bank Group	**PUE**	Productive Use of Energy
AMDA	Africa Minigrid Developers Associations	**PV**	Photovoltaic Energy
EEA	ENGIE Energy Access	**SBS**	Solar Business System
ESMAP	Sector Management Assistance Program	**SDG**	Sustainable Development Goal
IEA	International Energy Agency	**SHS**	Solar Home System
NGO	Non-Governmental Organisation	**SSA**	Sub-Saharan Africa
OPEX	Operating Expenditure	**TA**	Technical Assistance

AUTHORS OF THE REPORT

Gillian-Alexandre Huart
Chief Executive Officer

Patrick Westman
Global Head of Strategy & Policy

Diane Domkam
Public Affairs Manager

ACKNOWLEDGEMENTS

This white paper was prepared with the support and contribution of subject matter experts from across the industry and from internal team members. The authors sincerely thank the following interviewees for their generosity and critical insights.

INDUSTRY THOUGHT PARTNERS

Daniel Schroth
Director for Renewable Energy & Energy Efficiency

Ignacio Perez-Arriaga
Director

David Lecoque
CEO
Jens Jaeger
Director of Policy

Sandra Liz Hon
CEO

James Doree
Managing Director

Patrick Tonui
Director of Policy

Lullu Krugel
Partner, Sustainability

Grégoire Jacquot
Senior Specialist
Alvin Jose
Programme Manager

Chandrasekar Govindarajalu
Practice Manager, ESMAP

John Ouko
COO
Grace Perkins
Chief Growth Officer

KEY INTERNAL CONTRIBUTORS

David de Villiers
Head of Business Development

Randa Mrabat
Head of Mini-grid Product & Commercial

Onyinye Anene-Nzelu
Head of Mini-grids Nigeria

Mathieu Brun
Head of Grant Funding

Leslie Otto
Global Branding Manager

Mukabanji Mutanuka
Head of BD, Southern Africa

Mate Kafungwa
Strategic Project Manager

Victor Ouko
Strategy Manager

Katja Damman
Head of Corporate Relations

Harriet Okwi
Strategy Consultant

1. EXECUTIVE SUMMARY

Powering Sub-Saharan Africa: A Multi-Technology Approach to Bridge the Energy Divide

As of today, 600 million people in Sub-Saharan Africa lack access to electricity, with a concerning growing trend projected to 2030. The energy divide is exacerbated by rapid population growth, low household incomes, and a need for innovative solutions tailored to the region's unique challenges. A multifaceted approach is imperative to address the diverse energy needs of the region. There are three main electrification strategies, each playing a crucial role in addressing varied energy needs in areas with differing infrastructure development and resource availability:

1. **Grid Extension:** Expanding the existing national electricity grid, particularly in urban or peri-urban regions closer to existing infrastructure with higher energy demands;

2. **Mini-grids:** Small-scale, localised power networks that operate independently or in conjunction with the main grid, making them ideal for remote areas; and,

3. **Standalone Systems:** Solar home systems and solar business systems are tailored for households or small enterprises and vital in areas with low population density or where traditional grid connections are unfeasible.

Achieving SDG7 requires more than just deploying these renewable energy technologies – it requires an impact-driven approach that rigorously delineates the intended impacts, goals, and unique needs of the communities served. By emphasising these objectives, developers have the flexibility to propose innovative and bespoke solutions that align with the unique needs of each community, whilst leveraging the synergies of various technologies. This comprehensive approach enhances affordability, cost efficiency, competition, and local empowerment.

Mini-grids have a crucial role to play in accelerating access to clean and affordable energy, as well as boosting local economies. ESMAP's 2022 publication, "Mini-Grids for Half a Billion People," highlights the importance of mini-grids in stimulating economic activities, job creation, and sustainable development. However, with the current pace of mini-grid development, the goal of reaching universal energy access by 2030 will not be met. Indeed, a recent ESMAP report indicates that of the 160,000 mini-grids needed to electrify 380 million people in Sub-Saharan Africa by 2030, only 3,100 had been installed by 2021. These alarming numbers prove the need to implement innovative business models, tailor a more robust regulatory framework, and advocate for more inclusive stakeholder involvement.

Although mini-grids hold significant promise and have strong industry interest, numerous challenges hinder their commercial viability. We believe the following challenges can be addressed over the shorter term:

- **Separate tendering designs** that often favour distinct technologies, overlooking populations that neither have the energy needs nor the financial means for the chosen solution, thereby hampering the economic viability of mini-grid projects.

- **Funder preference** for specific technologies limits the technology scope and hinders the development of integrated solutions, as funders often favour a single specific technology.

- **Integrated business model viability assessment gaps** result in uncertainties and higher risks for investors. Current assessments lack thorough financial planning and overlook a crucial aspect: assessing the financial viability of the chosen technology in its intended location.

- **At times, lack of inclusiveness in project design**, with projects predominantly led by the public sector and funders, often overlooking the crucial involvement of the private sector and diverse stakeholders.

To address these challenges, ENGIE Energy Access has identified a way forward with clear solutions to enable the multi-technology approach in a mini-grid environment. The illustration below provides the steps and requirements that will facilitate the approach.

Our recommendations for enabling the multi-technology approach [1]

Planning

- Including a **business model viability assessment** in site selection, that includes **diverse technology** types
- Including a **risk assessment and allocation** framework

Tendering Process Design

- Exploring **desired impacts, objectives**, and **requirements** before selecting technologies
- Including **multiple technology types** in **tenders** to provide energy based on people energy needs and financial capabilities

Funding

- Including a **consortium of funders** that maintains their focus on preferred technologies, while **supporting integrated projects**

Engagement

Inclusive engagement with all players in the ecosystem with the aim to build programs that are **better aligned** with **market** and **end-user** needs

New Business Models

All technologies to be offered to customers as an **“energy-as-a-service” model**, to enable consumers to access reliable and sustainable energy without the burden of owning and maintaining complex energy systems, and to be able to seamlessly transition between technologies as user demand changes

We strongly believe that the multi-technology approach within the mini-grid environment offers a distinct opportunity that necessitates the active engagement of a broad range of industry stakeholders and the development of a well-tailored business model across different technologies. The way forward we present above would require concerted and inclusive work among industry players to move toward implementation.

[1] EEA analysis.

With only six years remaining to achieve the United Nations' Sustainable Development Goals for energy, providing universal energy access in Sub-Saharan Africa at the rate required to achieve these goals is becoming increasingly difficult. The sector needs an impact-driven, integrated approach using multiple technologies, centred on the energy needs of communities. As solar mini-grids are a key identified solution, our industry must actively work to improve their effectiveness and commercial viability. Furthermore, success hinges on collaboration among stakeholders, and the immediate next steps involve engaging the industry to consider the practicalities of implementing a multi-technology approach to accelerate mini-grid development.

As we continue our journey toward universal energy access, it is crucial to address the multifaceted challenges that lie ahead. ENGIE Energy Access will publish subsequent reports that will delve into these issues, offering insights and solutions to navigate the intricate energy access landscape in Sub-Saharan Africa.

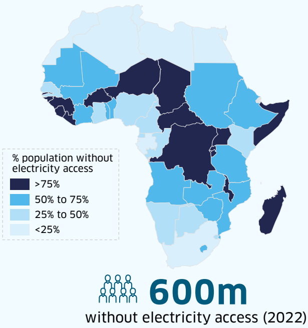
2. THE PROBLEM: SDG7 WILL REMAIN ELUSIVE IN 2030 IN A BUSINESS-AS-USUAL APPROACH

2.1 SDG7 IS OFF-TRACK

At present, 600 million people in Sub-Saharan Africa (SSA) lack access to electricity. By 2030, this number is projected to drop only mildly to 524 million. This marginal gain in energy access is partly because any progress made is eroded by the region's demographic trends. Rapid population growth outpaces energy infrastructure development. Moreover, the recent COVID-19 pandemic strained household incomes and the ability to afford market solutions.

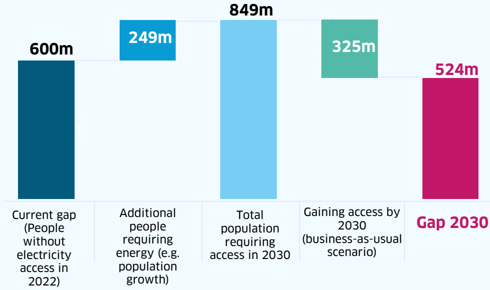
Figure 1. An overview of the energy access market in Africa [2]

Sub-Saharan Africa concentrates the lowest rate of electrification on the planet



At current rates of electrification, we estimate an electrification gap of over 520m people by 2030

Projected Electrification Gap to 2030



2.2 EXISTING ENERGY ACCESS SOLUTIONS PURSUED VIA A SINGLE-TECHNOLOGY APPROACH

To date, electrification has involved three technologies: grid extension, mini-grids, and standalone systems, mostly pursued via a single-technology approach. We elaborate on these technologies below:

1. **Grid Extension:** This approach involves the expansion of the existing national electricity grid to new areas, mainly urban or peri-urban regions that are relatively closer to the existing grid infrastructure and have higher energy demand. Grids typically draw their power from large, centralised power plants (e.g. coal, natural gas, hydro, solar and wind) and increasingly from distributed generation such as solar photovoltaic or biogas units connected at a low voltage[3]. Grid energy is low cost primarily due to economies of scale and frequently because of heavy subsidies.

[2]Sources : EEA Analysis, IEA access rates 2022 and 2030: UN Population Division (2022): World Population Prospects
[3]IEA (2020) Defining Energy Access: 2020 Methodology

2. **Mini-grids:** Mini-grids are small-scale, localised power networks operating independently or in conjunction with the main grid. They are particularly suitable for remote areas where grid extension is not feasible due to high costs or geographical constraints. Mini-grids can utilise various power sources, including renewables like solar, wind, or hydro. Due to the long-term nature of mini-grid projects, developers go beyond providing electricity to include comprehensive solutions and strategic partnerships that stimulate demand and unlock the productive potential of the communities served.

3. **Standalone Systems – Solar Home Systems (SHS):** SHS are individual energy solutions designed for households or small enterprises. They are ideal in areas with low population density or where grid connection and mini-grids are not viable. Standalone systems are typically powered by renewable sources like solar panels and are equipped with battery storage. They are highly adaptable, easy and fast to deploy, and require relatively low upfront investment.

4. **Standalone Systems – Solar Business Systems (SBS):** These are fully integrated systems with photovoltaic panels, battery storage, and invertors to provide electricity access for lighting, cooling, and powering appliances. The system's configuration is flexible to allow for system sizing according to customer needs. They can be used as an entire electrification solution in the case of off-grid setups, or as a back-up for customers connected to any unreliable main grids.

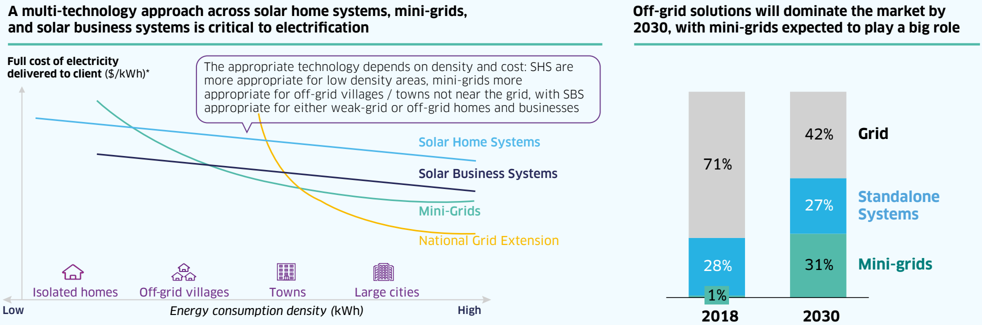
Thus far, the dominant approach has been to deploy these solutions separately, with most of the private sector pursuing a single-technology approach. **Yet each solution plays a critical role in addressing different energy needs and situations, particularly in regions with varying energy demand levels, infrastructure development and resource availability.** Advancing energy access solutions effectively necessitates a blend of investments in main grid expansion, mini-grids, standalone systems (SHS and SBS), and initiatives promoting productive uses of energy while concurrently reinforcing human capital.

2.3 THE OPPORTUNITY IN PURSUING A MULTI-TECHNOLOGY APPROACH

To reduce the access to energy gap and drive towards SDG7, a wide range of stakeholders have identified integrated approaches to energy policy planning to leverage various technologies. Industry leaders have supported policymakers in setting inclusive planning approaches and policy measures that support using a combination of grid, mini-grid, and off-grid technologies.

As represented in *Figure 2* below, **the multi-technology approach would provide energy to a community based on energy consumption density and cost.** Low-density areas with lower levels of economic development are often best served with SHS, while mini-grids are appropriate for communities with higher willingness and abilities to pay. Mini-grid development, however, needs to be accelerated in the coming years to serve more households. Moreover, to provide access to electricity to a wider range of customers, EEA has added the SBS to its range of technologies, as illustrated in *Figure 3* of the rural community of the future.

Figure 2. Segmentation of solutions for energy access [4]



[4]EEA analysis; IEA (2022), Population with and without Electricity Access by Technology in Sub-Saharan Africa; IEA (2020), Defining Energy Access: 2020 Methodology.

Figure 3. ENGIE Energy Access' vision for the electrified rural community of the future [5]

In SSA's context, implementing a multi-technology approach is critical for the following reasons:

- **Enhanced affordability,** with the ability to deploy appropriately sized energy solutions, the multi-technology approach ensures improved affordability by eliminating the need to invest in oversized systems that consumers may not require or cannot afford.

- **Cost efficiency**, by avoiding the deployment of unnecessarily large-scale solutions, the multi-technology approach is more cost-effective, reduces consumer expenses and promotes financial sustainability.

- **Stimulating competition,** by embracing a multi-technology approach embedded in competitive hybrid tenders that cater to diverse consumer needs. This encourages innovation and healthy competition among energy providers, leading to more tailored and efficient solutions.

- **Empowerment and choice,** by offering a variety of energy technologies, the multi-technology approach empowers local communities, allowing them to make informed decisions and exercise control over their energy consumption, tailoring solutions to their specific needs.

Positively, it has generally been accepted that a multi-technology approach is critical to energy access. Most African countries now have national energy plans that include various technology types through a least-cost-to-electrify approach. However, implementing them and bringing the approach to life has been challenging, especially within the mini-grid environment.

[5] EEA illustration.

Innovative models tailored to the region's unique challenges will be needed to implement this approach. More specifically, off-grid communities that vary in size, location and energy demand will require their needs and financial ability to be thoroughly identified and the right technology chosen to ensure long-term project success. Thus, a multi-technology approach centred around impact-driven objectives and addressing the challenges and needs of decentralised communities will be crucial.

Realistically, we will not reach universal energy access by 2030 with the current business models. Consequently, we are proposing to drive forward the implementation of the multi-technology approach with a set of actionable solutions over the short term. **However, it is important to stress that the viability of these solutions will depend on other challenges being identified and addressed over the long term.** For example, structural reforms of the regulatory framework will ensure the efficient implementation of the multi-technology approach and strengthen the business environment.

3. THE CASE OF MINI-GRIDS: CHALLENGES WITH THE CURRENT APPROACH

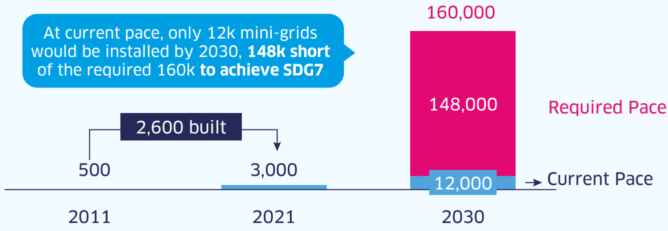
Within the off-grid landscape, mini-grids emerge as a strong solution to augment electricity consumption, foster local economies, and yield long-term benefits for developers, communities, and national utilities. As highlighted in ESMAP's 2022 publication "Mini-grids for Half a Billion People"[6] and Renewvia Energy's report "Social and Economic Impact Analysis of Solar Mini-Grids in Rural Africa"[7], integrating income-generating appliances with mini-grids holds pivotal significance for various reasons, including:

- Enhancing financial viability for developers by reducing the levelized cost of energy and increasing profit margins;
- Transforming the energy landscape and driving socio-economic improvements in areas such as gender equality, productivity, health, safety and economic development;
- Fostering community development by stimulating job creation and economic activities; and
- Facilitating national utilities' access to consumers who demand high-quality electricity and possess the capability to pay upon interconnection with the primary grid.

According to ESMAP's report, **160,000 mini-grids are needed to electrify 380 million people in SSA by 2030.[8] In *Figure 4,* as of 2021, we stand at 3,100, with only 2,600 built in the previous ten years.** It is also crucial to highlight that many installed first generation mini-grids are proving unreliable, facing numerous issues, and failing to serve the communities adequately.

[6]ESMAP (2022), Mini-Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers.
[7]Renewvia Energy (2024), Social and Economic Impact Analysis of Solar Mini-Grids in Rural Africa: A Cohort Study from Kenya and Nigeria.
[8]ESMAP (see #6).

Figure 4. Number of installed mini-grids from 2010 to 2021 & projection for 2030 [9]



At the current rate and with the current approach, deploying all the mini-grids that are needed by 2030 will be practically impossible. As argued throughout this paper, the multi-technology approach could improve the viability of mini-grid projects and facilitate energy access tailored to the needs and affordability of consumers. Nevertheless, challenges related to regulatory frameworks, tariff setting methods and productive use of energy financing included in project planning need to be addressed.

This paper advocates adopting a multi-technology approach to address these pressing issues, particularly within the mini-grid sphere. The emphasis on the mini-grid environment stems from the need to identify and deploy commercially viable models to ensure mini-grids can make a key contribution to achieving SDG7.

Despite the potential of mini-grids and the industry's appetite to develop them at a larger scale, they face significant hurdles in becoming commercially viable. The economic feasibility of connecting households with only basic energy needs to a mini-grid concerns both funders and developers. Indeed, mini-grid business models, as they are currently designed, present substantive challenges that need to be addressed to accelerate deployment in a multi-technology approach.

The first **four challenges** can be addressed over the **shorter term**, as they can be addressed by a limited number of stakeholders:

1. **Separate tendering designs:** Different energy technologies are nearly always procured through distinct processes with limited latitude given to developers to propose solutions based on population needs and affordability.

2. **Funder preference:** Despite SSA being the primary destination for investment in off-grid renewables with USD 2.2 billion attracted in 2010-2021 out of the total 3.1 billion worldwide[10] , we have noticed that quite often, funders express preference for particular technology types with a predefined envelop to be disbursed over several years. Indeed, IRENA provides a breakdown of funding by technology types: SHS at USD 1.7 billion, micro/mini-grids at USD 648 million and other off-grid at USD 610 million[11]. These numbers show how SHS attracts significantly more funding than other technologies.

[9] ESMAP (see #6).
[10] IRENA (2023), Global landscape of renewable energy finance. P17.
[11] Ibid. P 88.

3. **Integrated business model viability assessment:** Technical and economic analyses consider the least cost electrification model between on and off-grid technologies. However, limited research is conducted to assess in-depth the viability of the chosen technology in the assigned location.

4. **Inclusiveness in project design:** Project design is usually led by the public sector and funding organisations, with at times limited involvement from the private sector.

The **following four** challenges are critical to the implementation of the multi-technology approach and are addressable over the longer term with further holistic involvement and engagement of key stakeholders:

5. **Inconsistent focus and government investment:** Centralised energy production and distribution are generally better resourced, with governments often not having a comparable focus on mini-grids or standalone systems (which are primarily supported through tax exemptions and time-bound grants).

6. **Means and needs for last-mile customers:** The current approaches tend to exclude customers who cannot afford the mini-grid tariffs and/or have reduced energy needs. The current tariff setting methodologies do not consider homes and businesses that would be best served by standalone systems within the same service area as the mini-grid system. Additionally, with an appropriate regulatory and subsidy framework, the existing tariff structures could be revised, for example by permitting cross-subsidies between commercial and residential customers, as utilities do. This change would allow mini-grid users to transition from paying cost-reflective tariffs to being charged the same rates as those connected to the main grid.

7. **Discrepancy between cost-reflective tariffs and 'social tariffs':** Government subsidy budgets often only cover main grid-connected citizens, whereas off-grid populations with lower abilities to pay are left with higher energy tariffs. Even more problematic is that some governments are advocating for the subsidised national tariff to be applied across all access to energy solutions, threatening the financial viability of private sector investments.

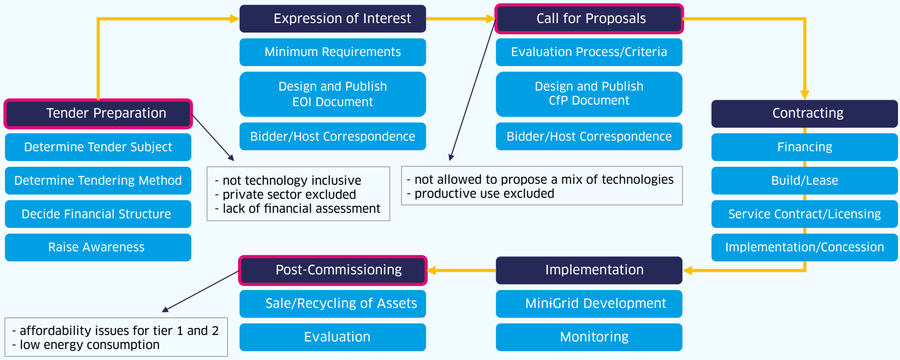
8. **Regulatory framework:** The current regulatory framework is not always adapted to the multi-technology approach. Despite collaboration between governments and international organisations to design appropriate regulations, challenges still need to be addressed. More work must be done to allow developers to propose technologies based on site needs in a well-regulated environment.

To find actionable solutions in the shorter term to enable the implementation of the multi-technology approach in a mini-grid environment, we have decided to **focus this white paper on addressing the first four challenges**. However, **solving the other key challenges is equally important** to successfully implement the multi-technology approach. **After providing insights on each challenge, we will present a way forward.**

3.1 SEPARATE TENDERING DESIGNS

Figure 5 presents an overview of the current mini-grid tender process, including detailed steps from tender preparation to post-commissioning. As highlighted in the illustration, tenders designed by public stakeholders and funding organisations often push for the electrification of all villages based on the number of connections developers can deliver with a single technology, effectively excluding income-generating appliances to increase electricity consumption and boost the economy.

Figure 5. Current mini-grid tender process and critical challenges [12]



Indeed, mini-grids as they are built today struggle to be viable, as they provide energy to tier 1 and 2 customers who have limited financial resources to cover the high cost of connection, and only have basic to medium energy needs.

Within calls for proposals, for example, the price of a smart meter required for a mini-grid connection is approximately USD 30. In contrast, for a family using 1 kWh/month at USD 0.20, the income of the developer of USD 2.4 per year amounts to a 150-month (or 12.5 years) payback period, without considering additional expenses like logistics, cables, poles and in-house connections. This represents half the duration for the longest concession periods, indicating that mini-grids are not economically viable for some families, particularly those with low energy consumption.

In such cases, SHS, with its lower upfront and operational costs, emerge as a more suitable option. However, tender processes often only support procuring one technology, which is not always the most appropriate. Operators often find it challenging to achieve a positive return on investment, particularly from customers whose primary electricity use is minimal. This low usage does not generate sufficient revenue to cover the operational and maintenance costs of the mini-grids.

[12] GIZ (2019), GIZ experience on Mini-grid Tenders: Uganda, Madagascar and Nigeria and EEA analysis.

Furthermore, at the time of contracting, financing is often limited to the mini-grid itself and does not account for the levers that can stimulate demand. The productive use of energy, by small businesses or in the agricultural sector, significantly increases electricity demand. Accurate demand forecasting, which considers productive use, can lead to more efficient energy planning and distribution. This higher demand not only justifies the investment in mini-grid infrastructure but also promotes economic development in the communities served.

Demand stimulation should focus on income-generating equipment such as freezers, fridges, grain mills, grinders and agriculture processing and storage equipment. A CrossBoundary Innovation Lab appliance financing study showed that average consumption per user is 48% higher on sites where appliance financing is offered[13]. The cost of the appliance, financing cost, and cost of logistics to deliver the appliance to the customer should be considered as part of the total finance price of the appliance.

3.2 FUNDER PREFERENCE

A new report from the IEA produced in partnership with the African Development Bank Group, "Financing Clean Energy in Africa", found that providing universal electricity access to all Africans requires USD 22 billion annually from now to 2030[14]. There is a pressing need for investment in small-scale projects, predominantly in rural areas, aimed at consumers with minimal financial capacity. There is a disparity between the available capital types and the requirements of Africa's nascent clean energy sector, especially evident in the scarcity of early-stage and equity financing.

The preference among funders in the international community for specific types of energy technologies often limits the scope of funding to particular categories such as centralised systems, mini-grids, or standalone units, typically excluding integrated approaches.

However, a potential solution to this challenge lies not in urging funders to diversify their individual portfolios but in encouraging the formation of consortia of funding organisations destined for the multi-technology approach.

3.3 INTEGRATED BUSINESS MODEL VIABILITY ASSESSMENT

An integrated financial approach focused on evaluating a project's financial feasibility constitutes one of several methods devised to assess risks and potential margins. Within this process, developers evaluate elements such as demand levels, avenues for economic growth, geospatial analysis, the accuracy of chosen technologies, and the project's profitability and sustainability.

[13]CrossBoundary (2023), Appliance Financing 1.0, 2.0 and 3.0: Sub-Saharan Africa
[14]IEA (2023), Financing Clean Energy in Africa

The curent methodology to determine national electrification plans focuses on technical and economic assessment, which includes identifying the least-cost electrification model between on-grid and off-grid technologies. However, this approach relies heavily on geospatial mapping and often overlooks a crucial aspect: conducting thorough research to assess the financial viability of the chosen technology in its intended location. This gap in the analytical process can result in higher financial risks for investors, as it fails to consider the project's unique geographical, socio-economic, and infrastructural factors. Moreover, it is important to mention that due diligence is 100% borne by developers, leading to increased business development efforts and project costs.

Some of the financial viability issues that have been noticed during the tendering process are:

- Targeted number of connections via mini-grids or SHS higher than the size of the local population in the targeted communities;
- Extensive number of hours to move from one site to the next within one earmarked cluster, which would have a high impact on future OPEX;
- Selected sites that were already electrified or earmarked for connection via grid extension in the coming year; and,
- Selected sites that were in dangerous zones.

3.4 INCLUSIVENESS IN PROJECT DESIGN

Typical practice in energy sector project design heavily leans towards public sector entities and funding organisations, often limiting the active involvement of the private sector.

Yet, there is an emerging consensus of the critical significance of inclusivity in project design. Indeed, private sector investment is critical to meeting electrification goals, and brings innovative and market-driven approaches that contribute to project success. Moreover, continued collaboration among stakeholders and inclusiveness in decision-making processes is essential in ensuring that integrated energy projects lead to inclusive development.

It is widely agreed that involving various stakeholders is vital for a more efficient and successful approach to energy projects, notably the private sector and end-users in the communities. This collective engagement brings diverse expertise and fosters a more comprehensive alignment of initiatives with community needs and sustainability objectives.

When funding cannot be used to directly invest in off-grid companies, involving the private sector during project design is also important during the design of any technical assistance (TA) services that accompany grant facilities or tenders. TA services should be designed in a way that makes it flexible enough so that private sector companies and funders can jointly decide on the type of TA needed, as well as the partner that will deliver the TA.

4. THE WAY FORWARD: ENABLING THE MULTI-TECHNOLOGY APPROACH IN A MINI-GRID ENVIRONMENT

ENGIE Energy Access has identified potential solutions to the key challenges, including improved financial planning, optimised tendering process, funding models, and more inclusive stakeholder engagement. These aim to facilitate the implementation of a multi-technology approach in a mini-grid environment. *Figure 6* below summarises our initial set of recommendations.

Figure 6. Our recommendations to enable the multi-technology approach [15]

Planning	Tendering Process Design	Funding
Including a **business model viability assessment** in site selection, that includes **diverse technology** types	Exploring **desired impacts, objectives**, and **requirements** before selecting technologies	Including a **consortium of funders** that maintains their focus on preferred technologies, while **supporting integrated projects**
Including a **risk assessment and allocation** framework	Including **multiple technology types** in **tenders** to provide energy based on people energy needs and financial capabilities	

Engagement

Inclusive engagement with all players in the ecosystem with the aim to build programs that are **better aligned** with **market** and **end-user** needs

New Business Models

All technologies to be offered to customers as an **"energy-as-a-service" model**, to enable consumers to access reliable and sustainable energy without the burden of owning and maintaining complex energy systems, and to be able to seamlessly transition between technologies as user demand changes

Below, we examine each of these potential solutions in further detail.

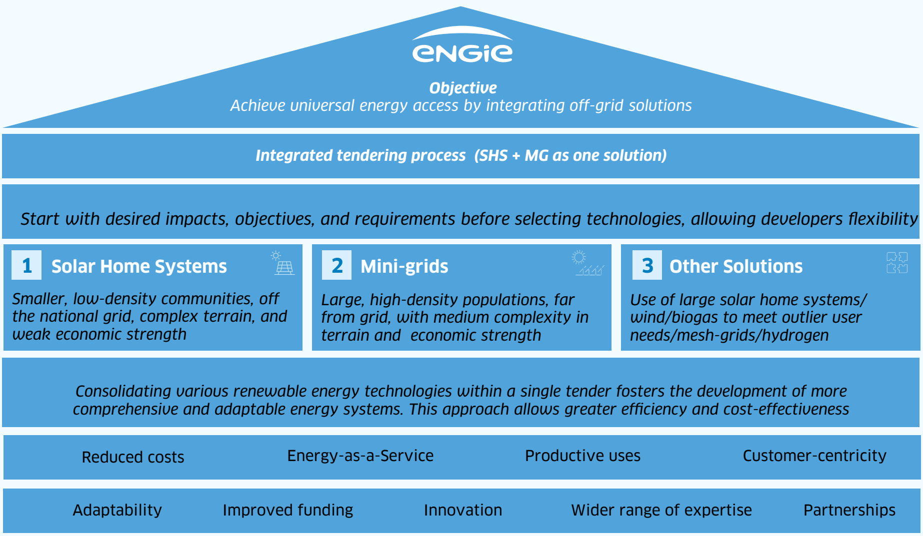
[15] EEA analysis.

4.1 NEW TENDER MODELS FOR INTEGRATED SOLUTIONS

In the integrated tendering process, adopting an impact-driven approach is pivotal. This begins with clearly defining the communities' desired impact, objectives, and specific requirements. By doing so, developers have the flexibility to propose innovative, bespoke solutions that align with the unique needs of each community and the resources available while leveraging the synergies of various technologies to meet objectives effectively. Indeed, a technology-centric focus risks limiting the scope of solutions, potentially leading to an over-expansion of a few solutions (i.e., SHS) and overlooking the diverse range of solutions available. Our proposed approach effectively ensures a more holistic and inclusive path to achieving universal electrification targets.

Thus, procuring different technologies through the same process to have the best solution for the consumer needs is essential in the integrated tender model. To this end, a potential model for an integrated multi-technology tender is portrayed in *Figure 7* below.

Figure 7. Proposed integrated tendering approach [16]



At the tender preparation stage, all relevant stakeholders will determine a range of objectives to be reached and identify the appropriate technologies based on the community's needs, purchasing power, and available natural resources. For instance, in areas where the mix of solutions is designed around SHS and mini-grids, providing solar kits as a service while the mini-grid is being built accelerates electricity deployment without requiring heavy upfront capital investments from customers. Additionally, procuring integrated technology allows the ultimate service provider to operate a larger service area and serve more customers, beyond the dense population centre best suited for mini-grids.

[16] EEA analysis.

Furthermore, enabling the electrification of small businesses and essential social infrastructures, like healthcare facilities, schools, and agricultural equipment, becomes feasible through larger SBS, as indicated in solution 3 of *Figure 7* above. This comprehensive and adaptable tendering process will benefit the community, the private and public sectors, local development, and accelerate access to energy.

The model aligns with the varied needs of communities and optimises resource utilisation, cost, and efficiency, bringing key benefits:

- **Cost-effectiveness of technology for households:** With the integrated approach, customers would be provided energy with the technology that best suits their energy needs and income.

- **Productive use subsidy:** Introducing productive use subsidies within mini-grid tendering programs presents a compelling strategy to bolster energy projects' economic viability and long-term sustainability. By incentivising the incorporation of productive use initiatives, such as supporting local businesses, agricultural activities, or small-scale industries, these subsidies can stimulate increased energy consumption and demand within the community. This not only enhances the financial viability of the mini-grid by creating a more consistent and substantial revenue stream but also fosters local economic development, driving job creation and entrepreneurship.

- **Customer-centricity:** is essential in a multi-technology approach to energy solutions, ensuring a seamless and consistent experience for the consumer. This approach guarantees uniform quality across different technologies, ensuring that lighting levels, product lifetime, and pricing are consistent and aligned with customer needs. Educating local populations about the benefits of being connected to various technologies while receiving the same high product quality standards is essential. Demonstrating the feasibility of transitioning between technologies without compromising service quality is crucial. This strategy not only builds trust and confidence among users but also reinforces the commitment to providing reliable, affordable, and sustainable energy solutions tailored to the unique needs of each community.

4.2 COLLECTIVE POOLING OF FUNDS

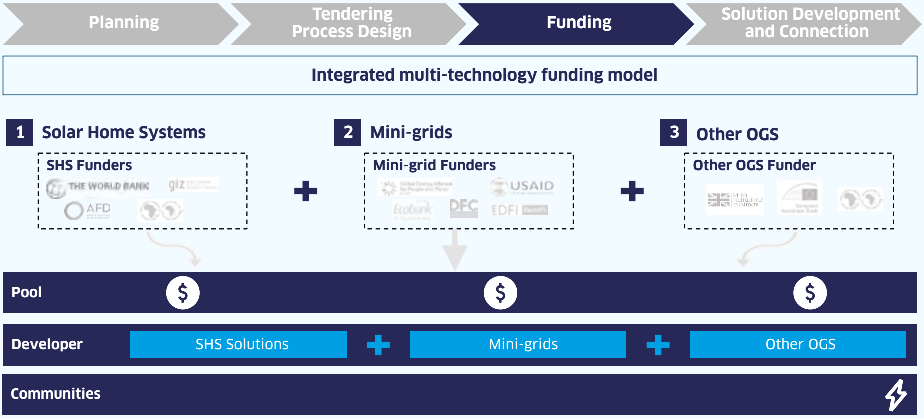
In an ideal world, funders would support all technology types. However, given that funders have specific investment mandates that do not cover all technologies, we need solutions that recognise this reality.

An option is to pool funders into an integrated process, but each can maintain their focus on their preferred area of expertise while collectively supporting integrated energy projects. This consortium approach allows for the amalgamation of different technologies within the same community, effectively leveraging the strengths of each system.

For instance, one funder could finance the mini-grid component, while another supports deploying standalone solar systems. As illustrated in *Figure 8*, this funding model fosters cooperation among funders and developers on the same project.

This collaborative funding model could lead to more comprehensive and adaptive energy solutions better suited to meet the diverse needs of communities, especially in areas with complex energy requirements. It also fosters cooperation among funders, aligning individual goals with the broader objective of sustainable and equitable energy access. Such consortia can facilitate the pooling of resources, risk-sharing, and the creation of more impactful, large-scale projects, ultimately driving the agenda of universal energy access with more efficient and innovative approaches.

Figure 8. Collective pooling of funds [17]



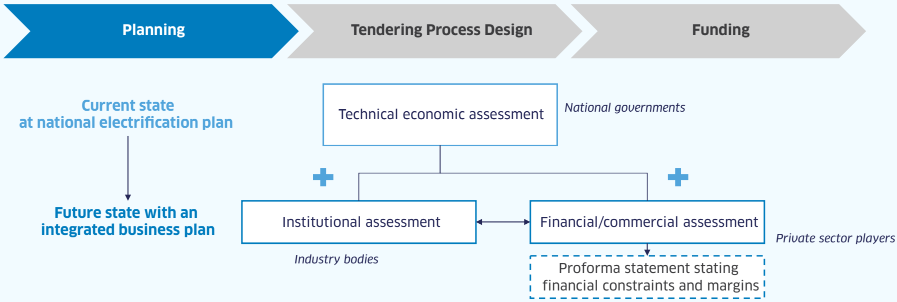
4.3 INTEGRATED BUSINESS MODEL VIABILITY ASSESSMENT

To support the multi-technology approach, technical assessments should be complemented by institutional and financial assessments, including a structured risk allocation plan. Specifically, at the tender stage, companies should be required to provide thoroughly assessed financial and commercial plans that highlight the investment constraints and margins. This could be provided in the form of a proforma statement. This approach mitigates risks associated with uncertain market conditions or inadequate infrastructure and optimises resource allocation, ensuring that investments are channelled more strategically toward initiatives that align with local needs.

As captured in *Figure 9*, the current technical assessment commissioned by the government is important for a geospatial overview of the country's need for electricity. Moreover, we must go a step further to ensure institutional and financial assessments during the tender preparation. The financial assessment, for instance, will allow developers to better investigate the project constraints and margins that can be expected for a particular site. This will contribute to strengthening the economic viability of integrated projects.

[17] Ibid.

Figure 9. Integrated business model viability assessment approach [18]



Structuring risk assessment and allocation framework

One crucial element in integrated multi-technology project planning involves distributing risks among all stakeholders. However, this risk allocation process can only occur once all project risks have been identified and thoroughly analysed. **In such complex projects, risks need to be clearly classifiable, measurable, and contractually allocated to the party with the best capability to manage them.** After the identification and analysis phase, the framework can be utilised to assess the most suitable allocation arrangements for each identified risk. This might include technical, financial, regulatory, and environmental risks.

Indeed, the risks associated with off-grid projects differ from one another, and the unique attributes of each project make it inherently challenging to propose a standardised risk structure that applies universally. The risk categories listed in Figure 10 are a set of generally applicable priorities based on project experience. Nevertheless, conducting more comprehensive risk identification tailored to specific projects is essential, considering additional factors to develop a project-specific risk analysis. Moreover, a well-structured risk assessment and allocation framework can boost investor confidence by providing clarity and predictability and enabling informed decisions on whether it is necessary to retain a transfer of risks. It can also facilitate smoother project execution by minimising disputes and delays related to unforeseen risks.

[18] Ibid.

Figure 10. Risk allocation and mitigation instruments [19]

Categories	Examples	Mitigation Instruments	Owner
Political & Regulatory	• Land Acquisition • Tax Incentives • Encroachment Framework • Tariffication Model • Local Currency Guarantees • Political Risks	• Political risk insurance, by establishing a clear, predictable and legitimate institutional framework	**Government**
Macro-economic & Business	• Exchange and Interest Rate • Currency Guarantees • Insurance • Fund Disbursement • Demand	• Capital market and credit guarantees (e.g. MIGA risk guarantees, World Bank and AfDB partial credit guarantees) • Co-financing instruments and asset management • Hedging instruments (private fund manager, e.g. responsibility Investments) • Provision of local currency indexed loans	**IFIs DFIs**
Technical	• Construction • Operation • Commercial	• Contractual arrangement • Operation and maintenance agreements	**Private sector**

[19] GIZ (2019), GIZ experience on Mini-grid Tenders: Uganda, Madagascar and Nigeria and EEA analysis.

4.4 INCLUSIVENESS IN PROJECT DESIGN

Electrification is often expensive, and rural electrification is even more complex as it interfaces with bottom-of-pyramid customers, who have minimal disposable income and are exposed to various socio-economic vulnerabilities.

To achieve specific energy access goals, rural electrification needs an ecosystem-based approach that engages diverse stakeholders, prominently involving private sector entities. This holistic approach aims to better tailor projects to the distinct requirements of the communities they intend to serve, fostering alignment with government economic development strategies. By collaborating with various stakeholders, initiatives can be customised to support and elevate specific sectors crucial to economic growth, such as enhancing the efficiency of agricultural practices, bolstering advancements in fishing capabilities, or optimising operations in industries like oil palm cultivation. This collaboration also ensures that energy interventions serve as catalysts for targeted economic development, amplifying the impact of electrification on local economies and contributing to broader regional or national growth objectives.

In addition, this inclusive approach minimises risks by leveraging varied expertise and perspectives and enhances the potential for long-term success. The project design should then be used to structure innovative and flexible financing mechanisms that address viability gaps in the current funding windows and peculiarities of off-grid projects. Projects can become more responsive, adaptable, and sustainable by ensuring that initial designs incorporate inputs from all sectors, including those directly impacted by these initiatives. Stakeholders to be involved in this inclusive approach include the public and private sectors, funding organisations, and NGOs, among others.

4.5 NEW BUSINESS MODEL FOR THE INTEGRATED APPROACH

In pursuing universal energy access, developers must adopt innovative business models to maximise the effectiveness of a multi-technology approach. Key to this strategy is making the consumer experience seamless and practical from an integrated perspective. This will most likely require introducing an “energy-as-a-service” model for standalone systems at mini-grid sites.

Traditionally, SHS follows a “lease-to-own” model, whilst mini-grids follow “energy-as-a-service”. Under the “energy-as-a-service” model, consumers can access reliable and sustainable energy without owning and maintaining complex energy systems. Instead, they pay for the energy they use, like a utility bill. For customers to move freely across multiple technologies, as their energy needs change, they must be on the same model. **Therefore, it is critical for the multi-technology approach that SHS offerings close to mini-grid sites are transitioned to an “energy-as-a-service” model.** This fundamentally changes the way energy will be provided to underserved communities.

To bring this vision to fruition, the private sector will play a pivotal role. This transition will require innovation in product design, distribution channels, and payment mechanisms, aligning with rural and remote populations' unique needs and financial capacities. Furthermore, the establishment of a proper regulatory framework is essential. Governments and regulatory bodies must create an enabling environment that supports the growth of energy-as-a-service models, fostering competition and ensuring consumer protection. This framework should address issues such as quality standards, pricing transparency, and dispute resolution mechanisms to build trust and confidence in the market.

5. CONCLUSION

With only six years remaining to achieve the energy-related SDGs, the prospect of realising universal energy access in Sub-Saharan Africa within the constraints of current approaches and business models becomes challenging. The problem is exacerbated by the region's rapidly expanding population, security tensions, macroeconomic instability, complexities arising from the scarcity of critical components and geopolitical uncertainty.

In light of these challenges, **our white paper underscores the urgency of embracing an impact-driven integrated approach powered by multiple technologies.** This approach places the needs of the millions without access to energy at its core, and recognises the importance of choosing the most suitable technologies. While solar mini-grids have been a frontrunner, we must also explore alternative solutions like hydropower, wind and biogas to tailor our energy solutions to diverse resource contexts.

Crucially, our success in achieving ambitious objectives hinges on close collaboration and coordination among stakeholders. This white paper has outlined the principles that will guide implementing a multi-technology approach in a mini-grid environment. However, we recognise that to make this vision a reality we need the industry to mobilise and further refine the model, so we can collectively drive forward a solution together.

As we continue our journey toward universal energy access, it is crucial to address the multifaceted challenges that lie ahead. Subsequent white papers will delve into these issues, offering insights and solutions to navigate sub-Saharan Africa's intricate energy access landscape.

6. REFERENCES

CrossBoundary (2023), Appliance Financing 1.0, 2.0 and 3.0: Sub-Saharan Africa

ESMAP (2022), Mini-Grids for Half a Billion People | Market Outlook and Handbook for Decision Makers

GIZ (2019), GIZ experience on Mini-grid Tenders: Uganda, Madagascar and Nigeria

Global Commission to End Energy Poverty (2020), Integrated Distribution Framework: Guiding principles for universal electricity access

GOGLA (2022), Off-Grid Solar Market Trends Report 2022

IEA (2020), Defining energy access: 2020 methodology

IEA (2023), Financing Clean Energy in Africa

IEA (2022), Population with and without electricity access by technology in sub-Saharan Africa

IRENA (2023), Global landscape of renewable energy finance

Renewvia Energy Corporation (2024), Social and Economic Impact Analysis of Solar Mini-Grids in Rural Africa: A Cohort Study from Kenya and Nigeria

ABOUT THE AUTHORS

GILLIAN-ALEXANDRE HUART

Chief Executive Officer

With over 20 years in the energy sector and an in-depth knowledge of the entire physical and financial energy value chain, Gillian is leading the only company in the sector offering SHS and mini-grids solutions, with a focus on the productive use of energy.

PATRICK WESTMAN

Global Head of Strategy & Policy

Patrick brings over a decade of experience across strategy and transformation. He has held various global and country leadership roles with EEA in strategy, sales and customer finance. Previously, he was a strategy consultant, delivering projects across the technology, health, agriculture, financial services and public sectors.

DIANE DOMKAM

Public Affairs Manager

Diane has over half a decade of experience in the energy sector, working on policy and institutional affairs both on on-grid and off-grid energy. She has extensive knowledge about the African energy context, challenges and opportunities.

ABOUT US

ENGIE Energy Access is the leading Pay-As-You-Go (PAYGO) and mini-grids solutions provider in Africa. The company develops innovative, off-grid solar solutions for homes, public services and businesses, enabling customers and distribution partners access to clean, affordable energy. The PAYGo solar home systems are financed through affordable installments and the mini-grids foster economic development by enabling electrical productive use and triggering business opportunities for entrepreneurs in rural communities. With over 1,800 employees, operations in nine countries across Africa (Benin, Cote d'Ivoire, Kenya, Mozambique, Nigeria, Rwanda, Tanzania, Uganda and Zambia), more than 2 million customers and 12 million more lives impacted so far, ENGIE Energy Access aims to remain the leading clean energy company, serving millions of customers across Africa by 2025.

We have a measurable economic, social and environmental impact

12M+	**52%**	**95%**	**~6k**	**45 MW**
People Impacted	women managers	employees in Africa	sales agents	of solar capacity installed

OUR GUIDING PRINCIPLES

OUR MISSION

Deliver life-changing, affordable, reliable, and sustainable energy solutions with exceptional customer experience.

OUR AMBITION

Be a leading decentralized energy company that impacts 20 million lives by 2025.

OUR PURPOSE

Improve quality of life and economic potential of grid-deficient communities.

ONE TEAM

We support each other and celebrate diversity.

BOLD

We dare to innovate and make it happen.

CUSTOMER CENTRIC

We pursue an Exceptional Customer Experience

PERFORMANCE DRIVEN

We are empowered to set ambitious targets and deliver results.

INTEGRITY

We act with transparency and honesty.


ENGIE ENERGY ACCESS
Follow Us
ENGIE