DANISH REFUGEE COUNCIL

Climate Compatible Growth

BUILDING A CASE FOR **INVESTING IN ENERGY-ENABLED GROWTH IN REFUGEE HOSTING DISTRICTS**

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UKaid from the British people

Foreword

Access to energy is often regarded as a core need among displacement-affected communities but is rarely prioritised as part of humanitarian assistance, leaving most refugee hosting districts without suitable access to energy for cooking, lighting and productive use for small business activities. While many initiatives have been developed to support better access to clean energy solutions in displacement settings over the last few years, most approaches have been at the individual household level and therefore struggle with scale or lack the capacity for particularly small businesses to harness additional opportunities that energy access can provide. Our collective aim should be to provide sustainable access to energy that is both affordable and meets the energy needs of communities to support growth.

This study with Oxford University's Climate Compatible Growth team has been the first step for the Danish Refugee Council to explore this challenge, looking to understand potential pathways for larger scale clean energy initiatives in the form of mini-grids and how we could potentially finance investments into expanding energy access into refugee hosting districts. It is clear that we need to think bigger to tackle energy access challenges and so by looking at developing a business case for investing in mini-grids, we hope that we can reach the scale required for impact in a commercially viable way to ensure approaches can be scaled.

Approaching this from the angle of energy-enabled growth provided by the Oxford University team has been very useful in helping us frame not only the value that larger investments could provide but helped us understand how we can develop financially sustainable approaches. This is the first step of many before we can succeed in implementing clean energy investment projects to support target groups but has been a good entry point to understanding the challenges and opportunities. With thanks to the Oxford team for their work and insights and looking forward to taking this forward.

Alistair Cowan
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Kalobeyei Settlement Minigrid, Turkana County, Kenya (July 22, 2022).

PHOTO: DOUGLAS COX, RENEWVIA ENERGY AFRICA

Executive Summary

This study explores the potential for mini-grid development to enable energy-driven growth in East African refugee hosting districts (RHDs), identifying key factors for successful investment. Commissioned by the Danish Refugee Council (DRC) and conducted in collaboration with Oxford University's Climate Compatible Growth team, the research aimed to identify essential conditions, required data, and mechanisms to attract investment for mini-grid electrification in RHDs. The study utilised interviews with mini-grid developers and surveys of businesses in the Dadaab refugee settlements in Kenya to gather insights.

The research identified several critical factors necessary for viable mini-grid investment in RHDs. These include evidence of existing and sufficient demand for energy, potential for demand growth, off-take guarantees from key users, confirmed cooperation from regulators and political bodies, availability of patient capital (long-term low cost investments), and appropriate operation and ownership models matching the community's capacity and needs. These factors form the foundation for successful mini-grid projects in refugee settings.

Comprehensive data collection is crucial for constructing a robust business case for mini-grid investment in RHDs. The study highlighted the need for detailed information on RHD demographics and trends, community leadership structures, existing businesses and energy usage, potential key users, regulations on mini-grid provision, political sentiment on refugee electrification, and funder expectations on payback periods and interest rates. These data points will help investors and developers assess the viability and potential risks of mini-grid projects.

Investor decisions in RHD mini-grid projects are influenced by specific financial and operational factors. These include the ability to provide patient capital with low interest rates, evidence of blended financing approaches, and flexibility on standard funding conditions in RHD contexts. Understanding these influences is key to attracting and securing investment for mini-grid projects in refugee settings.

The study proposes several mechanisms to attract investment and facilitate mini-grid development in RHDs. **These include making licensing processes more efficient, leveraging skilled refugees for technical roles, improving monitoring and evaluation to demonstrate impact, and generating evidence by conducting more case studies of financially viable RHD mini-grids.** These strategies aim to address the unique challenges of RHD contexts while capitalising on their opportunities.

While RHDs present challenges, they also offer significant opportunities for mini-grid development. Challenges include complex bureaucracy and limited financing options for renewable energy mini-grid electrification pathways. However, RHDs also offer opportunities such as concentrated demand and potential cost savings compared to diesel generators. The report provides a data collection tool and recommendations for organisations like DRC to identify promising RHDs for mini-grid investment and facilitate engagement between stakeholders.

This report highlights the potential for mini-grids to enable sustainable energy access and economic growth in refugee settings, while emphasising the need for innovative financing and operational approaches tailored to the unique RHD contexts. This research provides valuable insights for organisations, investors, and policymakers working towards energy-enabled growth in refugee hosting districts.

Contents

1 INTRODUCTION

Access to energy in refugee hosting districts (RHDs) is an ongoing challenge, hampering growth potential that energy access can provide. The aim of this research project is to examine the potential benefits and opportunities associated with investing in energy-enabled growth in RHDs in East Africa to drive investment in electrification in RHDs. This study has been commissioned by the Danish Refugee Council (DRC), which works with displacement-affected communities across the displacement cycle in 10 countries across East Africa and 40 countries globally, committed to ensure a dignified life for all displaced.

The provision of adequate energy services within RHDs is essential for meeting the basic needs of refugees, supporting their well-being, and offering economic opportunities[1]. However, energy access in RHDs often remains limited, leading to challenges for both the refugee populations and the host communities. As such, this study investigates whether these challenges could be solved via mini-grid electrification through an analysis of whether there is a viable business case for energy solutions in RHDs with a focus on mini-grids.

For this study, we delve into RHDs in Kenya, a country that has long been a significant host for refugees, with a current population exceeding 676,332 from Somalia, South Sudan, the Democratic Republic of Congo, and Ethiopia[2]. Kenya's Refugees Act 2021 provides a legal framework for designating specific areas where refugees must reside, considering conditions affecting their protection and safety[3]. It also recognises the right of refugees to work under certain conditions; however, uncertainties

Somalian refugees fetch water at the new Ifo-extension in Dadaab Refugee Camp on August 14, 2011

PHOTO: ISTOCKPHOTO

What is a refugee hosting district (RHD)?

This report uses the term Refugee Hosting Districts (RHDs) to refer to geographic areas that accommodate large refugee populations and are characterised by unique socio-economic dynamics and challenges. They can include refugee camps, as well as other refugee hosting contexts.

Dadaab Refugee Complex Context

As of January 2023, the Dadaab complex shelters 233,828 refugees. Yet, it receives comparatively less funding compared to other refugee camps in Kenya, likely due to its proximity to the unstable Somali border and the activities of terror groups in the area. These geopolitical and financial challenges, alongside its underdeveloped energy infrastructure, mean that the data represent a conservative view on feasibility – if energy services are needed in Dadaab, they are likely to experience even more uptake in other RHDs. The Dadaab complex includes three refugee camps: namely Dagahaley, Ifo, and Hagadera.

Refugee shelters in the Dadaab camp, northern Kenya

PHOTO: PETE LEWIS/DEPARTMENT FOR INTERNATIONAL DEVELOPMENT, 16 JULY 2011

regarding this Act's implementation highlight the critical need to afford refugees access to economic opportunities within their camps. This includes enabling refugees to access, produce, and export value-added products beyond the camps, facilitated by services such as electricity access – a key focus of this report.

Our research investigates the economic feasibility of mini-grids in RHDs. It aims to answer the following questions:

- What are the **essential conditions** for a viable business case to invest in mini-grids in RHDs?
- What **data** are required to construct such a business case?
- What other factors may **influence** an investor's decision to engage in an RHD?
- Which **mechanisms and structures** can attract investors to engage in RHD energy projects?

To answer these questions, we leverage (a) interviews with mini-grid developers across Africa and (b) survey data collected from business owners in the Dadaab refugee complex. The interview data are used to identify business models and financial pathways for mini-grid development in RHDs, and interestingly highlight two case study examples of extant RHD mini-grids which provide lessons for DRC. The data from Dadaab allow us to understand business stability and energy demands in the RHD context.

The overarching goal of this study is to explore the case for investing in energy-enabled growth within RHDs in East Africa. We begin with a comprehensive literature review, exploring the concept of energy-enabled growth, business models, projects and financing structures, and the associated opportunities and challenges. This is followed by a method section detailing the process of data collection and analysis. This leads to the development of a data collection tool which collects data on the key conditions determining mini-grid viability in RHDs. We conclude with actionable recommendations for DRC with the aim of fostering sustainable and inclusive development in RHDs.

2 LITERATURE REVIEW: BUSINESS MODEL DESIGN AND DATA NEEDS

An in-depth literature review was conducted to explore the conditions, data, and mechanisms required to create a viable business case for mini-grid development in RHDs. This review focused on business models and documented cases related to mini-grid electrification and/or energy access in RHDs. It aimed to identify business models which have been successful as well as those which have failed, to draw broad lessons learned from the collected individual case studies. It also sought evidence of business models which enable economic growth through energy services, and how these relate to the RHD context. It delves into the financial mechanisms supporting off-grid projects and the strategies for setting tariffs in mini-grids. The literature review covered both academic and grey literature as well as existing policy and legal frameworks. The literature is synthesised in the subsections below.

2.1. Energy-enabled growth in RHDs

For the majority of those living in humanitarian settings, access to an energy source is critical for their survival, enabling access to better health services, livelihoods, and safety[4]. However, supporting sustainable energy access in such settings remains difficult. Traditional approaches from humanitarian agencies have struggled to provide sustainable energy access and have often relied on fossil fuels, as have some refugee-led grassroots efforts[5]. Delivering renewable energy solutions that meet the needs of refugees is challenging, but inclusive design – engaging refugee communities, humanitarian agencies, and the private sector – shows promise for substantial improvements[6].

Indeed, solar products ranging from pico-scale to household-level solar home systems (SHSs) have recently gained traction for lighting and powering small businesses like phone charging in RHDs[7]. This drive has been led by entrepreneurs such as BBox and other private sector initiatives, demonstrating that market-based approaches can extend energy access in RHDs and surrounding areas[8]. This success has spurred interest for solar mini-grid companies to provide higher-capacity electricity for administrative buildings, clinics, businesses, and household cooking[9]. While this diverse demand points to the potential financial viability of sustainable energy businesses, developing successful business models in humanitarian settings remains complex. This is especially due to the limited and mostly inconsistent income streams of refugees, but also fears regarding the temporary nature of such settings[10].

2.2. Existing business models

To facilitate energy-enabled growth in RHDs, it is necessary to identify viable business models for the required energy services. Generally, business models for off-grid energy are often conflated with delivery models (e.g., SHSs, mini-grids) and revenue models (e.g., pay-as-you-go, fee-for-service). Clearly distinguishing these concepts facilitates the planning and development of commercially viable business models tailored to energy access in RHDs.

A business model consists of three main elements: the purpose for its existence (**value proposition**), the way it generates profit from that purpose (**value capture**), and the various participants, like government, regulators, and companies in the value chain, who play crucial roles in delivering value (**value networks**)[11]. For example, an off-grid energy company provides

> “To facilitate energy-enabled growth in refugee hosting districts, it is necessary to identify viable business models for the required energy services.”

electricity that enables productive activities (value proposition); it does this by coordinating through partnerships across actors – government and community organisations (value network) – while also generating profits (value capture). The financial viability of off-grid energy systems in RHDs relies on business models that facilitate these complex value exchanges between all relevant stakeholders.

Various business models have been proposed to enhance energy solutions in RHDs. Cerrada (2017) suggests photovoltaic (PV) mini-grid build-own-operate models[12], Hove (2021)[13] and Boodhna (2019)[8] underscore the importance of data-driven, sustainable energy solutions, with Hove particularly pointing to the potential of hybrid mini-grids. Similarly, Maalim (2021)[14] and Corbyn (2018)[15] advocate for innovative approaches like shared energy parks and private-sector engagement to improve energy access in refugee camps, aiming to provide affordable, sustainable, and inclusive energy services to displaced communities.

Although models in the RHDs are still developing, learnings from rural electrification can provide a starting point. Off-grid business models can be broadly differentiated into two approaches, namely (1) retail and (2) service.

1. **Retail models** sell standalone products, with system sizes ranging from 10W to 50W, either upfront or through instalments, with the goal of individual ownership. Products like solar lamps and SHSs aim to make energy for basic needs accessible to consumers. The systems are simple plug-and-play setups and sometimes include electrical appliances for domestic and limited productive uses. Through flexible pay-as-you-go payments over a finite period (normally 2–3 years), often relying on mobile money-enabled transactions, consumers can own energy systems for their households. Energy companies collaborate with telecom companies and community influencers to drive awareness and uptake of energy products. By enabling household lighting and safety, retail models have played a major role in expanding energy access in camps[16].
2. **Service models**, on the other hand, take a broader economic development approach by bundling household lighting and energy for productive uses like agriculture and cold storage to increase profits[17]. The system sizes are normally above 30kW and have the potential to create income opportunities by powering, for example, businesses and healthcare facilities while also meeting other household needs such as cooking. This larger-scale approach, however, requires substantial cross-sector coordination between local leaders, NGOs, and other invested stakeholders across the camp. It also requires innovative financing mechanisms and de-risking of investments[11].

2.3. Off-grid project financing

Most rural electrification initiatives in low- and middle-income countries (LMICs) have been implemented by the private sector, with full or partial donor funding. For example, in recent years, millions of systems ranging from mini-grids to SHSs have been installed across numerous government- and donor-led rural electrification programs at a significant cost. These initiatives aim to increase access to electricity in rural areas of LMICs, where grid extension is often challenging and expensive[18]. In the recent past, the industry has seen

an emergence of small businesses and social enterprises like Azuri and Barefoot Power, which operated on a trial-and-error basis to determine effective business models before eventually achieving profitability[19]. These entrepreneurial approaches, though still dependent on grants, show promise for emerging energy access initiatives in displacement settings but require low-cost capital given the nature of such locations.

When it comes to scaling up development with larger electricity generation equipment like mini-grids, rural electrification uses different financing mechanisms ranging from grants and subsidies to equity and loans[20]. The selection depends on factors such as whether the mini-grid is a pilot, its size, and the project's stage of development. Early-stage, higher-risk projects are more likely to rely on grants, subsidies, and equity financing, while more advanced projects perceived to have lower risk can obtain debt financing in addition to grants and subsidies[21].

In all cases, grants and subsidies typically cover at least 30% of investment expenses for mini-grids[22]. These are commonly used for pilot projects, early development costs, capital investments, and technical support. Funding sources include international development agencies, local government, trusts, foundations, and individual angel investors.

There are some innovative financing mechanisms that address specific challenges in the off-grid energy sector: blended and portfolio financing. These act as strategic approaches to help make off-grid energy projects more attractive and feasible for a wide range of investors.

Blended finance

Off-grid energy companies operating in rural communities often utilise blended finance strategies to overcome the financial challenges associated with establishing and scaling their operations. Blended finance combines public, private, and philanthropic capital to mitigate risks and enhance the viability of projects that might otherwise struggle to attract investment[23]. In the context of rural electrification, this approach typically involves a mix of concessional loans, grants, equity investments, and guarantees from development finance institutions, impact investors, and commercial lenders[24]. For instance, companies may secure grant funding for initial market assessments and pilot projects, followed by concessional debt to finance equipment purchases and installation. As the business model proves successful, they can then attract commercial equity to scale operations[25]. This layered approach to financing helps address the high upfront costs and perceived risks associated with off-grid energy projects in rural areas, ultimately enabling companies to provide clean, reliable electricity to underserved communities.

Portfolio financing

Portfolio financing for mini-grids involves bundling multiple projects together to attract larger investments and reduce overall risk. This approach is particularly relevant for mini-grid developers operating across various locations or countries. By aggregating multiple projects, developers can achieve economies of scale, reduce transaction costs, and potentially access more favourable financing terms[26].

For mini-grids specifically, portfolio financing helps address some of the key challenges in attracting investment, such as:

- **Risk mitigation:** By diversifying across multiple sites, the overall risk of the investment is reduced, as poor performance in one location can be offset by better performance in others.
- **Scale:** Bundling projects allows developers to reach the scale necessary to attract larger investors who might not be interested in single, small-scale projects.

- **Standardisation:** Portfolio approaches can help standardise project development and financing processes, making it easier for investors to assess and compare opportunities[27].

However, implementing portfolio financing for mini-grids also comes with challenges, including the complexity of structuring such deals and the need for a pipeline of viable projects. Additionally, local regulatory environments and market conditions can vary significantly across different sites, adding another layer of complexity[28].

Other key sources of financing include equity and loans. Developers seek equity financing from a range of investors like angels, private equity firms, impact investors, and development finance institutions (DFIs). **Table 1** shows types of equity investors and their funding criteria. For loans, DFIs offer the most favourable concessional terms, but high transaction costs may not suit small-scale mini-grids—in some cases DFIs can act as guarantors[18]. Risk-averse commercial banks often wait to lend until business models are proven and risks mitigated. African banks frequently lack cash-flow lending experience and demand substantial collateral[29]. International lenders can be deterred by foreign exchange risks and relatively small transaction sizes[22]. Successfully securing financing often requires credit guarantees to assure investors of projected revenues and contract performance. By demonstrating financial viability, guarantees can enhance mini-grid projects' creditworthiness[20]. The financial viability relies on the prospects of electricity uptake in a particular location and the tariff charges.

***Table 1:** Types of equity investors and their funding criteria[29]*

Equity investor	Funding criteria
Angel investors and venture capitalists	Early-stage seed capital
Private equity	Offering expansion capital
Impact investors	Seek both social and financial returns and may invest in either early or later stages, depending on the investor
Development finance institutions (DFIs)	Invest in equity directly or through third-party funds, focusing on development impact and seeking some evidence of potential commercial viability

2.4. Tariff setting in mini-grids

Regardless of the financing structure used to facilitate energy services in RHDs, ensuring the financial viability of mini-grids while keeping electricity affordable for its customers is crucial. Therefore, setting the right tariff is important. Tariffs play a pivotal role as they should not only attract investors but also render mini-grids sustainable. They serve as a strategic tool to align the interests of investors, operators, and consumers, fostering a sustainable and impactful energy infrastructure in the pursuit of broader socio-economic goals.

Mini-grid tariffs usually have two components: a connection fee and a usage or service fee, often paid monthly. The connection fee (partially or fully) covers the capital costs incurred by the mini-grid operator to connect a user. High connection fees also help to ensure a strong commitment from electricity consumers, increasing the economic viability of the mini-grid. Consumers who have paid a substantial connection fee are more likely to continue paying usage fees over the long term to keep the grid operating[30].

> “Flexible tariffs aim to strike a balance between consumer affordability, operator financial viability, and efficient energy utilisation.”

The usage or service, collected through consumer tariffs, can be structured in several ways. These include:

- **Energy-based tariffs:** Depend on measured electricity consumption, charging per kWh used.
- **Power-based tariffs:** Based on the maximum power capacity available to the consumer, charged monthly per Watt.
- **Fee-for-service tariffs:** Based on services provided rather than energy consumed, e.g., a fixed price for 1 hour of TV usage.

These tariffs can be either pre-paid or post-paid. Pre-paid tariffs increase planning certainty for both consumers and operators.

Flexible tariffs are the most common approach used in mini-grids[31]. A flexible tariff structure refers to a pricing system that adapts electricity rates based on different factors and conditions. This approach tailors pricing strategies to align with the mini-grid operator's goals, meet diverse consumer needs, and respond to changes in demand or costs. Key features of a flexible mini-grid tariff structure include:

- **Time-of-use (TOU) pricing:** Different rates for peak versus off-peak electricity consumption. This can help shift demand to maximise existing capacity.
- **Seasonal variations:** Adjusting tariffs based on seasonal fluctuations in energy demand or renewable resource availability. Setting higher rates during seasons with heightened energy usage can improve financial sustainability.
- **Customer categories:** Unique rate structures for different consumer groups like residential, commercial, and institutional users. This enables cross-subsidisation across groups.
- **Variable pricing models:** Adapting tariffs in response to changes in energy supply, demand, or operational costs. This allows operators to cover unexpected cost spikes or shortfalls in supply.

Flexible tariffs aim to strike a balance between consumer affordability, operator financial viability, and efficient energy utilisation. Careful planning is essential regarding rate setting, communication of pricing changes, and understanding the mini-grid’s context[32]. Achieving this delicate balance between affordability for consumers and maintaining the financial viability of mini-grids is challenging yet crucial for advancing energy access and promoting socio-economic development.

2.5. Factors of success and failure

While relatively few mini-grids have been implemented in RHDs, many have been implemented in LMICs more broadly. These mini-grids may offer lessons regarding factors of success and failure which apply to RHD contexts. In reviewing the literature, the project team synthesised lessons from 44 such mini-grid projects, which reveal several key themes driving failure and success.

Mini-grids in general face inherent financial challenges due to high costs, exacerbated by rural communities’ low and seasonal incomes. **However, projects that engage communities to develop income-generating activities and set appropriate tariffs can mitigate these issues**[33]. Lack of technical capacity and poor management also causes unreliability, underscoring the need for adequate training and maintenance plans. When projects become community-managed, ineffective handover processes often undermine sustainability.

Ensuring community buy-in and enabling productive uses of energy is vital.

The financial viability of mini-grid electricity is precarious. Rural communities' limited incomes strain developers and users alike. Successful projects tend to empower communities to create businesses, such as milling stations or welding shops, alleviating income constraints. Setting tariffs aligned with incomes and flexibility in fee collection also help balance affordability and sustainability. For example, the Kitonyoni and Mpeketoni projects (based in two off-grid rural market villages in Kenya) adopted adjustable “pay-as-you-go” approaches using mobile money infrastructure – M-PESA – enabling usage adaptation.

However, projects still struggle with technical reliability issues from insufficient technical training and spare parts mismanagement, resulting into black outs that severely impact emerging businesses and community perception[16]. Indeed, projects transferred to communities without proper handovers often rapidly fail, like the Shell Solar project in Lucingweni (South Africa) which was only operational for three months before the solar panels were moved into storage in 2007[34], with the community describing the system as “weak”, “inferior”, and “unreliable”[35]. Here, free equipment and absent user contracts caused confusion around ownership and little incentive for maintenance[36]. Continuous monitoring, maintenance scheduling, and community management from the outset may have prevented failure.

Evidence shows contributing project capital and labour boosts community buy-in and success probability. Mpeketoni users paid 30% costs[37] and Kitonyoni recruited resident technicians[38]. Ownership and empowerment foster sustainability, but the success of community-led models remains limited. Community engagement is more beneficial for community buy-in, revealing community needs, and illuminating intervention points for capacity building and training to the local developer.

Effective community engagement throughout project execution informs needs-appropriate design and establishes user understanding[39]. For example, the Shell Solar project initially lacked water purification, but this was addressed in early community consultations.

In summary, multifaceted challenges undermine mini-grid sustainability. However financial, technical, and social interventions centred on community involvement and income enable success. Monitoring, flexible financing, and technical capacity building are also instrumental.

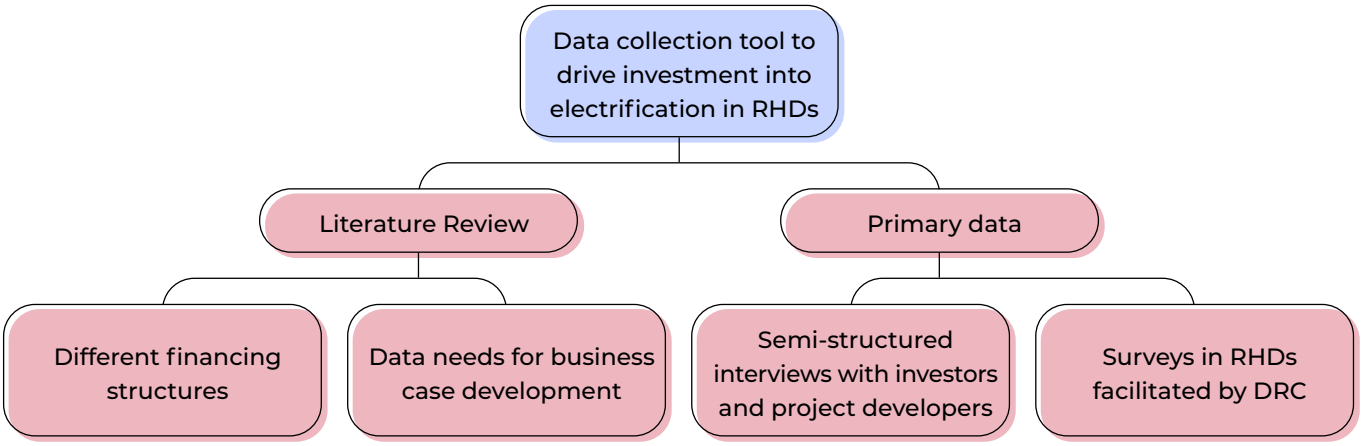
3 METHODS

This research aims to address the following questions:

- What are the **essential conditions** for a viable business case to invest in mini-grids in RHDs?
- What **data** are required to construct such a business case?
- What other factors may **influence** an investor's decision to engage in an RHD?
- Which **mechanisms and structures** can attract investors to engage in RHD energy projects?

To answer these questions, several research activities were undertaken. We started with a thorough literature review, as outlined in the previous Section. Then, we collected and analysed primary data from both project developers and businesses in RHDs. The activities are illustrated in **Figure 1.**

Figure 1: *A summary of the study method and how the different pieces build to the final framework.*



3.1. Semi-structured interviews

Semi-structured interviews were undertaken with mini-grid developers and investors working in LMICs, with a focus on displacement contexts and East Africa where possible. The aim of these interviews was to gain insights into how developers and investors select projects, to gain more detailed information on the financial structures and instruments they find to be essential for success and to understand their perceptions of the mini-grid market in RHDs. They encompassed a variety of questions, exploring existing business models that facilitate growth via energy service provision, and evaluating the scalability, replicability, and bankability of these models. The full list of prompts used to guide the interviews is included in **Appendix A**. However, these prompts were used flexibly to allow participants the space to answer in ways that best suited their own experience.

The interviews were semi-structured, lasting 45–60 minutes, and were conducted mainly online, except for one respondent who provided written responses. Our participant group included six males and one female, all of whom have been involved in or led mini-

grid development projects in Africa. While two of our interviewees have experience working specifically in RHD contexts, others are indirectly involved in RHD within their companies. A lead interviewer conducted the interviewing process, with an additional team member responsible for notetaking. Each interview was recorded and transcribed using Otter.ai, alongside manual transcription and checking by the authors.

Interviewees were identified via snowball sampling, stemming from the rich DRC network in RHDs in East Africa as well as the Oxford energy ecosystem. Their expertise lies in developing mini-grid projects across Africa, with an average working experience of 17 years[i]. Most interviewees hold senior management positions with specialised knowledge of operations, management, engineering, or finance. Note that the sample size was limited by the number of functional mini-grid operators in East Africa and relevant project developers/investors from which to sample.

The interviews were transcribed, anonymised, and annotated. They were systematically annotated using a mix of inductive and deductive coding (i.e., building upon the literature review, but allowing for new categories to emerge). To analyse the interview data, we employed template analysis[40,41] . As a first step, three key themes were defined (i.e., Challenges, Opportunities, and Business Model), which were then developed into a thematic template through inductive discussions among the interviewers. As work progressed, we coded additional sub-categories into the template, leading to the evolution of various thematic templates and sub-categories. Adjustments were made to the categories as necessary, either by subdividing them or introducing new ones. The coded interviews were analysed to identify the range of factors which can create viable business models and entice investors to engage in high-risk areas like RHDs.

3.2. Surveys

Primary data were also collected via surveys administered to individual business owners and entrepreneurs residing in Dadaab. The DRC facilitated these surveys. The aim of these surveys was to understand key energy demand for enabling economic growth in RHDs.

The research team developed the initial draft of survey questions for this purpose based on the literature review. These included socio-economics, demographics, and existing energy demand, among other factors. The tool was reviewed and trialled by enumerators in Dadaab, who then produced a simplified version for this data collection. Given the constraints in the RHDs and the limited research capabilities, the DRC initially conducted a partial implementation of data collection tools in Dadaab. While this version omits many of the factors the team wished to investigate, it provides useful indications on business viability, stability, finance access, and subsequent demand. The simplified tool is available in **Appendix B**.

A total of 199 surveys were conducted in Dadaab, targeting entrepreneurs and local business owners within the RHDs. The surveys were quantitatively analysed to identify how on-the-ground needs, values, and risk perceptions align with the business models and investment incentives extracted from the interviews. This includes statistical analysis across and within demographic groups. Note that not every respondent answered every question. Results therefore use the number of respondents who answered each specific question in percentage calculations. Where questions ask respondents to select all responses that apply, results are reported as percentages of the entire sample.

[i] The average year of working is calculated by checking the interviewee's LinkedIn starting from their first full-time job longer than one year.

For survey questions with ranked responses, weighted sums are employed to synthesise the rankings. These are defined in **Equation 1** as follows:

$$w = \sum_{r=1}^{n} s_r(n - (r - 1)) \qquad \text{[Equation 1]}$$

where *w* is the weighted sum, *r* is the ranking, *s* is the sum at that ranking, and *n* is the number of rankings.

3.3. Stakeholder mapping and tool synthesis

The findings from the analysis in Sections 3.1 and 3.2 were used to develop a tool to collect key qualitative and quantitative information to inform business model development for RHD mini-grids. This tool accounts for the experience of project developers and the needs of RHD residents.

As the critical information to be collected in this tool originates from many stakeholders, we undertook a methodical stakeholder mapping process. Matthey-Junod *et al.*[42] provide a framework for the development of energy-related business models in refugee settings. Building upon their stakeholder mapping and integrating additional background information on the Dadaab refugee complex from the United Nations High Commissioner for Refugees (UNHCR)[43], we conducted our own stakeholder mapping based on the literature review and collected data. We then designed survey questions and interview questions specifically for different stakeholders.

In line with this understanding, we designed our data collection strategy to collect two types of primary data: semi-structured interviews with energy providers of mini-grids; and surveys with energy users, especially targeting those small business owners residing in RHDs that potentially provide anchor load for the mini-grid developments.

3.4. Ethics

To ensure the study's integrity, a risk and ethics assessment was undertaken and evaluated by the Medical Sciences Interdivisional Research Ethics Committee (MS IDREC) at the University of Oxford in accordance with the procedures laid down by the University for Ethical Approval for all research involving human participants. It was completed and approved with Reference: R83092/RE001. Additionally, a risk and ethics assessment following the NACOSTI the National Commission for Science, Technology, and Innovation (NACOSTI) ethics board was undertaken for the User-Perceived Value data collected by CCG, with approval under licence No: NACOSTI/P/23/21652 in research involving human participants. To protect the participants' identity, all names were removed. Interviewees are referred to using numeric codes below (i.e., MG1 for mini-grid developer 1).

4 RESULTS AND DISCUSSION

This section presents an overview of the insights gained from the interviews and survey data. The interviews provide details on various business cases that integrate crucial investment components (e.g., off-taker agreements) and examine potential revenue streams for RHD residents. Information asymmetries identified during these interviews are used to inform the proposed data collection tool, which collects essential data for constructing robust business cases, thereby facilitating a strategic and sustainable approach to enhancing energy access.

In the sections that follow, we will initially analyse the interviews conducted with mini-grid developers, offering a broad perspective on the challenges and opportunities associated with deploying mini-grids in rural and RHD settings. Subsequently, we will examine Dadaab as a case study, presenting data collected by the DRC on energy users to illustrate the potential energy demand in the area. The semi-structured interviews were conducted from November 2023 through January 2024, and the surveys were carried out in October 2023.

4.1 Investor interviews

Following interview coding as described in Section 3.1, **Table 2** shows our thematic template in its final version. The results of the inductive thematic coding are analysed based on the structure of a business model: that is, value proposition, value network, and value capture. Finance is also discussed as a key element of business model viability. Thereafter, the core challenges and opportunities emerging from the thematic coding are discussed.

4.1.1. EXISTING BUSINESS MODELS

a. Value Proposition

The diverse priorities of off-grid energy businesses have led developers to adopt different business models in the energy sector. These models are shaped by the purpose of the business, which is influenced by the customer target, financial structure, risk management, and the economic environment of the communities they serve. For instance, some interviewees noted the importance of understanding community needs, and therefore setting prices accordingly to ensure sustainability, affordability, and community involvement, despite the fact that this may lengthen payback periods. Others prioritised anchor customers by setting prices slightly higher than the entry tariff but lower than diesel prices to remain competitive while reducing risk. This approach is considerably more scalable, as one developer reported, ❝ *businesses always have money at some level... and households don't always have money* ❞ [MG3], making tariffs for businesses usually higher than for households.

The value proposition of mini-grids in the current energy sector revolves around offering more efficient, sustainable, and cost-effective alternatives to traditional diesel generators. This presents both opportunities and challenges. Businesses currently using diesel generators are already familiar with the cost and logistics of energy use, making them more receptive to a more efficient and potentially cheaper energy source. As one of our interviewees noted, ❝ *if there are already businesses with diesel generators, it's easier to convince these customers to move to electricity* ❞ [MG4]. This highlights the ease of transition for these customers due to their existing energy expenditure and infrastructure. However, there are stakeholders who financially benefit

***Table 2:** The thematic template used in the inductive coding of interviews.*

1. Challenges	1.1. Finance
	1.2. Capacity
	1.3. Bureaucracy and political will
	1.4. Misconceptions
	1.5. Logistics
	1.6. Information access and transparency
	1.7. Coordination with stakeholders
	1.8. Uncertainty
	1.9. Long timeframe
	1.10. Off-taker risk
	1.11. Technology risks
	1.12. Political preferences
	1.13. Impact measurement
	1.14. Competition or conflict with other providers
	1.15. Overloading and non-technical loss
	1.16. Safety risks
	1.17. Scalability
	1.18. Vandalism
2. Opportunities	2.1. In-camp capital
	2.2. Existing businesses
	2.3. Higher demand than other areas
	2.4. Duty- or impact-driven investment [ii]
	2.5. High revenue / ROI potential [iii]
3. Business model	3.1. Customer payments
	3.2. Financial instruments and structure
	3.3. Contractual framework
	3.4. Mini-grid design
	3.5. Collaborators and supply chain
	3.6. Community engagement
	3.7. Data needed
	3.8. Employment
	3.9. Demand: Productive use
	3.10. Demand: Household
	3.11. Demand: Commercial
	3.12. Demand: Public

[ii] A strategy that focuses on generating positive social or environmental change alongside financial returns.
[iii] Indication of the possibility of significant financial gains and a strong return on investment.

from the maintenance and fuel supply of the existing diesel generator. **Switching to mini-grid electricity could disrupt these financial streams, leading to resistance:** ❝ *...since quite some people can benefit financially from those diesel generators, also, in terms of maintenance. There can also be a local barrier approaching because a lot of people lose their source of income* ❞ [MG4]. This creates a challenge in convincing stakeholders to support the transition to mini-grids.

b. Value Network

The value network of mini-grid developers involves various stakeholders and processes to ensure successful implementation and operation. Engagement with the local community, government, and other stakeholders forms the core of this network.

Community

Developers interact with local communities to assess affordability and stimulate demand. In some cases, they directly collaborate to establish agreed-upon tariffs. This ensures that tariffs are both economically feasible for the community and acceptable to all parties involved. However, this is easier when the community already has higher income levels: as one interviewee stated, ❝ *we always try to look at what's affordable... the sort of communities that you can work in without subsidy* ❞ [MG1]. Even where tariffs are not established in full cooperation, baseline data are collected from communities to inform planning: ❝ *within these baseline surveys, we have asked these businesses how much they're spending on their existing source of energy, then how much they're willing to pay, and all those factors have been considered during the determination of the price* ❞ [MG2].

The baseline engagement with the community can also be used to determine the strength of community governance structures, which can be critical to selecting an appropriate grid management strategy. As one interviewee stated, in their rural off-grid electrification work, ❝ *we go there, we have a set of criteria, ... and then actually speak to the community to see how good the feel of the community governance. We run a series of tests of little studies in the community to see what the priorities are* ❞ [MG1].

With an understanding of existing community structures, mini-grid operators are better equipped to choose a grid ownership and operation structure. Depending on the context, it may be most productive for communities to form a cooperative or company to operate the grid: in this model, ❝ *the local community, they employ themselves, they set up committees or little operated companies* ❞ [MG1]. However, the viability of this model depends on the community in question. One interviewee expressed hesitation about this type of model, indicating that the ❝ *community model, they look good, but over the years, they tend to fail down the line because... business acumen may be failing* ❞ [MG5]. **So, it is important to understand existing community capabilities and governance structures before deciding on a mini-grid ownership and management structure – no structure is a silver bullet.** The literature also highlights the nuanced outcomes of community-operated mini-grid projects, indicating that while such models can lead to success in some contexts, they may not be effective in others.

Despite beliefs that residents of RHDs lack the self-governance needed to manage their energy systems or to hold each other accountable, this is not necessarily the case. ❝ *even if a refugee settlement has been established for a while, and there is some sort of internal structure, there's still not [...] long-term kind of bonds of loyalty* ❞ [MG1].

However, others with experience working in camps had differing opinions. One in-camp developer explained how, in their camp *"each area of the camp has elected some of its residents to [...] represent them and they have some subcommittees. So whenever we're doing a new project or new expansion, we meet with those committees and get their approval for anything we're doing"* [MG3]. While of course this only speaks to the one camp where this developer works, it may indicate a misconception by those who work outside camps that should be treated with scepticism[44].

When a community's economic activity is not enough to support grid development on its own, mini-grid developers play an active role in stimulating demand. As one interviewee stated, *"you have to play a much more active role in stimulating the demand, especially the productive uses, then you're talking about potentially needs, providing business incubation programmes and services, even including selling branded appliances on a lease basis, and so microfinance activity as well"* [MG4]. This interviewee indicated that in modelling, they project that demand stimulation should increase household energy demand by nearly 7% over time.

Local leaders

Engaging with local community leaders is also critical for developers to verify local communities' credibility and reliability (i.e., defined here as the likelihood they can make payments consistently and on time). One example of establishing such credibility that interviewees discussed is the sometimes-effective approach of appointing a local community electricity leader or committee who, among other functions, may collect payments. This can streamline the payment process while creating active local participation and ownership and fostering a sense of responsibility and engagement. As one interviewee noted, when a local committee is in place, *"it's their responsibility to talk to their neighbours to collect the funding, and then they, as a single entity make the payments to our partners or us"* [MG1]. However, as further discussed in the value capture section, such setups are not effective in every context. Engaging with local leaders was also seen by another interviewee as a way to **increase community buy-in and to reduce vandalism risk**; as they said with regards to vandalism, *"we are working with local leaders, we have technicians who are looking after the infrastructure"* [MG2].

Anchor loads

Strong local anchor loads were highlighted by multiple interviewees as critical to mini-grid success to **minimise off-taker risk**. Several mentioned the Anchor Business Community (ABC) model, a suggested approach for rural energy development where energy companies utilise anchor customers to minimise business risks in areas with unpredictable demand. This strategy encourages the electrification of various customer types within a community. An interviewee illustrated this concept as follows: *"Every time I lecture, there's something that I used to tell people about the ABC of mini-grids... The rule states that 60% of your power must be off-take by the anchor load. So it means that before I put any mini-grid somewhere, I must have a guaranteed 60% uptake."* [MG5]. Some of the critical anchor loads mentioned by interviewees included telephone companies (i.e., towers), health clinics, NGOs, UNHCR (excluding in camps where they run their own generation systems), banks, vocational schools (e.g., which run many computers or other appliances), and local businesses.

Governments and regulators

In addition, developers must **seek government support for the development of mini-grids**. As one interviewee noted *"...any projects are in refugee camps, I would start with an MoU (Memorandum of Understanding), signed by whoever... political representative of the country..."* [MG4] This involves obtaining approvals and, in some cases, negotiating the regulation with the government. Some models involve providing energy services to government entities without direct charges, as part of broader agreements or concessions. Negotiating the regulation landscape can cause challenges, as further discussed in Section 4.1.2.

Humanitarian agencies and organisations

Humanitarian organisations can assist mini-grid developers in **community engagement and attracting finance**, but their relative capacity varies across camps. Given their in-camp presence, they can be critical for operations: as one interviewee discussed, *"this partner organisation, they are always in the camp. When we need to convey a message to the leaders, we go through this partner organisation, when we need to talk to local people we go to this organisation"* [MG2]. However, their usefulness in operations may vary based on the relative capacity of the staff on the ground in each camp. A different interviewee working in a different camp, for instance, indicated that *"the humanitarian partners have kind of been happy with us, but not really been terribly helpful"* [MG3]. As such, **business models should not count on humanitarian partners without first validating their capacity**. Humanitarian organisations were also discussed by one interviewee as critical to the fund-raising needed for mini-grid construction. Specifically, they spoke about how their organisation *"and this humanitarian organisation... collaborated to raise funds from American donors to bring this system into the refugee camp"* [MG2]. The perception of humanitarian organisations as impact-driven may therefore be important.

c. Value Capture

Two community payment models were mentioned during the interviews: (1) mobile-money and smart meter systems and (2) cash-based systems.

Mobile money and pre-paid smart meters were used by all in-camp mini-grid operators we spoke to, as it has reduced the labour involved in collecting payments door-to-door. This was highlighted by two interviewees operating mini-grids in different refugee camps in the quotes below:

"They are given a smart meter, where they pre pay some amount and they use... when [they] run out of money and then the power cuts, then they need to add." [MG2]

"We charge a very small fee for connecting people to the power lines, and then we sell them pre-paid electricity. So everybody pays us using the mobile money service. ...Every customer has a smart meter that's connected to the internet. And so when they pay us on [service], their payment processes automatically and their power turns back on if it had run out. And so we don't charge any monthly fees or any fees at all like that." [MG3]

Such a pre-paid metering setup seems to be the norm in the mini-grid sector more broadly. A similar configuration was discussed by an interviewee working in a non-refugee area. However, this interviewee's setup did allow for a post-paid configuration for anchor clients, as described in the following quote:

❝ *Only the anchor customer was paying, like, only use based, I mean, postpaid. So they used, and then they got an invoice and they paid electricity. But all the other customers who were pre-paid, they would buy for $5, or $10, with their mobile phone. Mobile money would automatically charge their meter.* ❞ [MG4]

Alternatively, some companies engage with community leaders or set up committees or companies within communities to collect payments. When locally appropriate, these can help to ensure **accountability for payment**. As one interviewee put it, ❝ *when you work with individuals, it's a nightmare. My colleagues... have to speak to 60 different households to try to collect tiny amounts of money from them all. It's much better to have you set up a committee or a company in a community* ❞ [MG1]. That said, such a setup, which may create efficiency and accountability in some communities, can make room for **corruption** in others. As another interviewee said, ❝ *before [smart metering], you would have people consuming electricity, and one person going house to house to collect cash for the electricity consumed, and the cash collected would disappear* ❞ [MG4].

Establishing credibility and the ability to pay are crucial for business revenue generation. This process involves community credit assessments with questionnaires or indirect questions about business ownership, asset ownership, and housing status to gauge capacity to pay. This information is critical even in cases where grants are the main source of funding, because it enables the structuring of micro-loans.

Mini-grids operators active in different refugee camps take different approaches to customer recruitment. Some are selective about who can become connected due to system capacity constraints. However, this may backfire by inducing non-official connections and overloading, as illustrated in the following quote:

❝ *The baseline survey we have conducted before the project, we have found more than 150 businesses operating in the refugee camp, but they were only able to connect just 12. Because initially, yes, that was, what was in the scope of the project. ...the remaining power was not enough to connect to more ...So the initial, the 12 connections we have made, they have also, they also did extra connections, so they were adding more connection to the connections that were given to them and they, there had been an issue because systems were overloaded and there had been some power outages, and we had to do a control strategy just to disconnect non-official connection.* ❞ [MG2]

Other mini-grid operators in refugee camps do not limit their grids to a select number of customers. Instead, they charge a nominal connection fee to indicate commitment: ❝ *We don't filter at all, except that we charge the signup fee. So apparently, that signup fee is about $6. So the marginal cost of connecting a new customer to our power lines is about $92. So the $6 is not really intended to help with that cost. It's just to show commitment* ❞ [MG3]. This aligns with the likelihood of a connection fee to generate commitment found in the literature review.

Critical to value capture for mini-grid operators is negotiating a trade-off between tariff affordability, finance type, and scale of impact. Traditional tariff calculations to ensure value capture do not work properly in this context. As one interviewee put it, ❝ *I could sell electricity for $1 per kilowatt hour and not need any grants. It's just probably people wouldn't use very much so then the system would be small and...the impact would be so much lower* ❞ [MG3]. Furthermore, even when tariffs are set

to a level which people could typically afford, the fact that services are often provided for free in a refugee camp causes an extra level of complication in tariff setting. As one interviewee put it, ❝ *for the end user, he doesn't want to pay a tariff if he can get it for free. There's a bit of mind shift and orientation that has to happen there* ❞ [MG5].

d. Financing

Mini-grid development in RHD requires concessional and patient capital which can bear long payback periods. Most companies currently operate on a mix of grants, concessional debts, and impact investment, while some also include equity in the mix. Even for companies that have been operating for decades, grants remain an important source of funding for their projects. **In extremely rural areas without infrastructure, interviewees reported that grants may account for 60% to 70% of making the project viable**. However, funding generally arrives after customers are connected to the grid, resulting in a gap in the project that requires pre-financing. Interviewee quotes illustrating these financing structures are provided below for context.

❝ *Historically, we've mostly funded our projects through a mix of grants and equity. And so we've in our modelling tried to set the tariff to target a return for the equity investors that matches what they want, which recently has been around 16% IRR [internal rate of return]... I would love to pay for this entire project with loans if the loans were super low interest, right? That would be great.* ❞ [MG3]

❝ *Our financial instrument has been structured around debt equity and grants, where the debt component has covered in some cases up until 70% of the total capex cost. And then in some other cases, the minimum threshold has always been 50% of the capex cost. And the idea is to use the grant to unlock private investment.* ❞ [MG5]

❝ *We've been using our own money, little bit of philanthropic money, and then a lot of grant funding so far to develop these technology and business models* ❞ [MG1]

A number of innovative financial tools are available, including blended finance and result-based financing, which can be viewed as a public-private partnership with blended finance. Additionally, **portfolio financing can be leveraged instead of project financing to garner investment into riskier settings**. Creative mini-grid developers often diversify their business portfolios to attract funding, using their credibility and successful models to secure capital for scaling their portfolio. This was illustrated for the case of including Internally Displaced People (IDP) projects in a portfolio in the quote below:

❝ *So they don't have just only one line of business. There are multiple businesses under their portfolio. So for instance, you will hardly see a mini-grid developer only going for IDP mini-grids. They will probably be building multiple mini-grids and IDP will just be one of the use cases, right. ...So usually, they don't typically go for like project financing, they can go for business financing to attract working capital or debt, and they now use that debt to now develop a multiple project portfolio which the IDP can be one of the portfolio... Because at the project level, you may not be viable. But at the portfolio level, it may be attractive for any investor.* ❞ [MG5]

Another critical element brought up by this interviewee is the **need for risk guarantees**:

❝ *One other thing that I also think is very important, is partial risk guarantee, right.*

For some of those funding, also they could be creatively utilised to fund some form of partial risk guarantee, where the private investment can then be utilised to develop the project, but in case there's a failure on the part of the end users or the off-taker, those partial risk guarantees can then kick in in order to be able to guarantee the funding for whoever the investors are at the end of the day. ❞ [MG5]

4.1.2. CHALLENGES

During our interviews, challenges associated with mini-grid development were frequently mentioned. We discuss the five most commonly mentioned challenges in the subsections below. These are: (a) Finance, (b) Capacity, (c) Bureaucracy and political will, (d) Information access and transparency, and (e) Coordination with stakeholders

a. Finance

Funding remains critical and challenging to mini-grid developers. **The difficulty lies not only in securing the initial capital for construction but also in navigating the conditionalities of funding agencies**, which may restrict funding for actual construction. This challenge is compounded in refugee camps and off-grid scenarios where **traditional funding models are insufficient due to the high initial capital expenditure (capex) and operational costs**. The gap between signing grant agreements and receiving funds exemplifies the need for innovative financing solutions that can pre-finance these types of grants.

Leveraging grants, concessional debts, and impact investments that mitigate the financial risks associated with mini-grid development were often mentioned as solutions to address such challenges. Additionally, one interviewee also mentioned a strategic approach to financing mini-grid projects by leveraging **portfolio diversification** and seeking business financing rather than seeking project-specific financing. This approach benefits from the strength and diversity of the portfolio to attract investment, mitigating the risks and transactional costs associated with financing individual projects and enhancing the overall appeal to investors.

There is a **need for investors who can shoulder long payback periods, known as patient capital, at lower interest rates**. However, financial institutions currently are unfavourable to these conditions. As one interviewee describes, ❝ *[... the banks are] only interested in projects that can bring all the funding back within five years and that can pay an interest rate of 28% or 30%.* ❞ [MG5]. The interviewee went on to say that payback periods of upwards of seven years and single-digit interest rates are needed. Consequently, many developers turn to grants for funding their projects due to this financial gap.

The scarcity of proven, commercially viable business models exacerbates the challenge, leading to a shortfall in suitable financing mechanisms. This situation presents a classic chicken-and-egg problem, where the lack of evidence for commercial viability discourages the development of appropriate financial products, and vice versa, hindering the progress of sustainable mini-grid deployment. This **overreliance on grants distorts the market and results in unsustainable practices perpetuating short-term visions**. This situation calls for a shift in how funding for mini-grids is structured. As one interviewee puts it:

❝ *...To have a successful market, we need to regulate the amount of grants that goes into a project. When you oversubsidise a project, somebody doesn't see any reason why he has to be committed to sustainability on that*

project. If he cashes out from day one, he will do the project and abandon it, making it a contractual project and not an investment project. ❞ [MG5]

Despite the relative oversaturation of grants in the mini-grid market, **accessing funding for mini-grid developments in long-term RHDs can be particularly challenging**, even including grants. For example, funding allocated to humanitarian settings may be prioritised for emergency situations rather than for long-term refugee camps, where the urgency is perceived as less immediate. One interviewee discussed how this ❝ *incredibly long-term crisis* ❞ received less funding than new camps in more recent emergencies. The refugees in longer-standing camps are:

❝ *...not in any immediate danger, and it just doesn't really qualify as an emergency, I think, for most funding priorities. So I'm not saying that's a bad thing. ...But that is just kind of a challenge, you know, because I think... if we had had enough funding, we could have built a power plant to cover the entire refugee camp.* ❞ [MG3]

b. Capacity

Another key challenge highlighted by interviewees was the capacity to implement and run energy systems in RHD contexts.

There is debate about whether capacity to implement and run mini-grids should originate from community members or technical staff. Community engagement is vital for the success of mini-grid systems in LMICs, ensuring communities understand the benefits of the project while operators respect local customs and norms. The concept of community ownership, which involves transferring project ownership to the community, leads to community-operated schemes commonly found in LMICs[44]. This approach necessitates deeper engagement to ensure communities are equipped to manage and operate these systems effectively[45]. However, this report's focus on commercially viable business models suggests an **operation framework where projects are managed by the mini-grid business and its technical staff, rather than by community members directly**. There are numerous challenges that mini-grid developers face with regards to this.

One challenge faced by mini-grid developers operating in non-refugee rural settings is that capacity gaps exist among local companies in deploying and managing mini-grids. Interviewees discussed some of these issues: ❝ *building the team, the talents, it's complicating, operating in remote areas, with the road infrastructure, which is sometimes lacking* ❞ [MG4].

However, RHDs actually offer an opportunity on this front. To overcome this challenge while promoting local income, some developers are interested in recruiting refugees with relevant technical backgrounds. Unlike rural settings, where people are likely to have low levels of education, they perceive that **the RHD setting is actually more likely to hold people with technical expertise**, as people of all social classes and backgrounds can become displaced. These people are also likely to be seeking employment given the lack of in-camp opportunities, and there is a high population density. This is illustrated in the following quote:

❝ *So far we've trained everybody and I really want to find some engineers this time. Because I think you're speaking at something that must be true, right? There must be well trained engineers in there, you know; maybe, maybe most engineers had enough money to flee conflict in a different direction or*

something, but there must be engineers in there. So if we can find them, I would love to hire them. ❞ [MG3]

Interviewees without RHD experience, however, had a different perception of refugee abilities. One, for instance, indicated a belief that refugees will not have a huge amount of entrepreneurial activity or experience: ❝ *So in a place like a refugee settlement... there's not a huge amount of entrepreneurship going on. So you do need a bit of a Business Incubation Centre, like we've got here, to get businesses starting and to get people thinking along those lines* ❞ [MG1]. As other interviewees have indicated previously that there were many active businesses in RHDs, and a belief in refugees' technical abilities, this may be a misconception. Regardless, support for businesses should certainly be investigated as a capacity-building measure.

Interviewees also indicated that when capacity-building is undertaken, it sometimes is not useful. Despite substantial investments from donor cooperation in developing tools and conducting extensive training, local developers can be reluctant to adopt these tools, adhere to best practices, or apply knowledge acquired from training sessions, undermining capacity-building benefits. As our interviewee put it, such an ❝ *attitude* ❞ issue requires a concerted effort from all stakeholders involved in mini-grid development to promote a culture of continuous learning and adaptability: people need to ❝ *take responsibility for the knowledge that you have acquired* ❞ [MG5]. There will be limited success for capacity-building initiatives if a change in attitude and leadership is not achieved.

c. Bureaucracy and political will

Bureaucracy and political will were highlighted as further key challenges to mini-grid development in RHDs. This includes complexities of regulatory frameworks, permitting processes, and governmental negotiations. These can create substantial barriers to project initiation and execution, affecting the sector's overall efficiency and scalability.

Tariff setting in coordination with government bodies can be complicated and unreliable. They spoke about the relative randomness of this bureaucratic process. This situation creates significant difficulties for mini-grid developers in financial planning and establishing fair, sustainable pricing structures for their services. It is illustrated in the following quote from one of our interviewees:

❝ *So, how we set [the tariff] is complicated because actually the government sets it and the government has a terrible process for basically setting and approving the prices of electricity. At some point in the last few years, they hired a consultancy to make them an Excel model and we mini-grid developers are supposed to put all of our sort of cost inputs in and the assumptions about electricity usage and all of this, and then they, the, you know, the model gives some result, which should be the tariff that we apply for. But the national government in [country] usually ignores that number and makes up their own random number that's just something completely different. So that's very difficult.* ❞ [MG3]

The process of obtaining permits for mini-grid deployment in RHDs presents significant challenges for the private sector. Developers are typically required to secure camp access permits, involving extensive coordination with humanitarian organisations and government agencies. Given the sensitive nature of refugee environments, this necessary process is

intricate and demands not only the drafting of convincing project proposals but also the establishment of trust with key stakeholders, for example agencies responsible for providing assistance to refugees (e.g., UNHCR) and governmental decision-makers. One interviewee shared his experience:

> *I have spent four weeks to deploy a mini-grid but I have spent one year to get every actor to align. Because once you are through with one for regulatory approval, then you move to the [next] one for permission. Then when you are through with that one, then you move to the other one who is responsible for... licensing...a typical mini-grid right now, the regulatory process can take more than six months.* [MG5]

The lengthy bureaucratic process may also result in **friction between developer and funders** and slow fund disbursements, as one interviewee describes:

> *I think the biggest friction I feel with our investors right now is on the regulatory side. They want us to have a lot more permits and approvals before they disperse any funding versus what we already have... but some of them just won't come until after construction and some of that is even by design.* [MG3]

Although due bureaucratic process is necessary to protect refugees who have experienced significant trauma, the length of this process makes it challenging for the private sector to develop mini-grids in camps. This difficulty in navigating the bureaucratic landscape hampers the successful implementation of mini-grid projects in these contexts. This challenge applies to both grant-funded and blended finance, but it is particularly acute for the latter.

The challenges of licensing are not exclusive to RHDs but also extend to mini-grids more broadly. The potential for spare power availability and the **technical feasibility of extending electricity to nearby areas often remain unrealised** due to the cumbersome and time-consuming process of obtaining the necessary licences and permits. For instance, a developer who recently electrified an agricultural processing centre in Uganda explained how theoretically they could use the same installation to electrify neighbouring shops. However, since this expansion was not included in the original licence, it would necessitate enduring another year of lengthy licensing processes. This shows how technical and economic feasibility is not enough; political and bureaucratic buy-in is also necessary.

> *There's lots of spare power, it'd be dead easy to run a couple 100 metres of cables out and connect to all those shops. But it doesn't do that at the moment, because we'd have to spend a year banging our head into the wall. With all the guys in [city] that we need to get the licences and permits from.* [MG1]

Lack of political will significantly hinders efforts to improve living conditions in RHDs through electricity provision. There is a perception that **governments are not interested in facilitating electricity access** for refugees, as one interviewee explained in the following quote:

> *So the government does not want, seems like, I'm not sure why, but seems like government has no interest in bringing electricity into the refugee camp* [MG2].

This experience of government was shared by another interviewee, who indicated a sense that **the government does not want to create an image of permanent infrastructure**

which encourages the refugees to settle permanently. The interviewee perceived that the trade-off in diesel expenditure was worth it for governments to prevent this permanent image, as illustrated in the following quote:

> *We developed an offer and we went quite far in the discussions, and ultimately, there was no funding. It was political. …The government didn't want to invest in basic comfort for refugee camps because they actually didn't want the refugees to settle there. Even if it were refugee camps that were meant to exist for 10 or 15 years, they still didn't want to invest in this basic comfort. They'd rather continue running gensets. And spending a lot of operating costs in diesel than investing in a modern solar installation, which would have [cost] much less, which looks permanent in terms of infrastructure.* [MG4]

d. Information access and transparency

Interviewees highlighted information access issues which both hinder mini-grid operators from designing grids appropriately and limit investor confidence.

The main information access issue affecting mini-grid developers is **a lack of accessible data to enable appropriate grid design**. To estimate demand, interviewees reported needing data on community needs, existing productive use activities, and most-likely major off-takers. Such data are not available at present. While existing projects with smart meters are starting to fill this gap, such data are not necessarily made publicly available. Additionally, to price energy appropriately, they need information on willingness to pay. One interviewee discussed how despite collecting data on willingness to pay, *"after installing several mini-grids, I have then found that some mini-grids are just 23% capacity utilised"* [MG5]. This indicates (in line with the literature) that existing data on willingness to pay may be unreliable or overestimated. To design and cost mini-grids, developers also require location information, including the sites of potential connection points (i.e., homes or businesses). While some refugee areas have been well mapped (e.g., through the efforts of the Humanitarian OpenStreetMap team), this is only the case in select locations. Finally, to implement and operate grids, mini-grid developers reported needing more transparency into relevant bureaucratic processes. They said that information about such processes (e.g., tariff setting and licensing) was hard to access at present, in line with sub-section C above.

The interviewees also noted **several information access challenges which they believe would limit investor confidence** in mini-grid developments in refugee settings. Interviewees reported that in some mini-grid projects, there is a lack of data collection for monitoring/evaluation. This makes it difficult to establish the impact of mini-grids, limiting access to impact-driven finance. They said that this is exacerbated by the grant-dominated mini-grid financing space, and the lack of monitoring and follow-up that grants involve. This is illustrated in the following quote from an interviewee:

> *Monitoring is also a very big issue. …People are just giving them projects and dumping them and taking a walk right? Especially when you don't have the right stake in it. So you, across board, you don't really see someone who is taking the responsibility for monitoring to ensure that sustainability is achieved at the end of the day* [MG5].

Interviewees further noted that sometimes operators report impact metrics which do not necessarily establish the full potential benefits of impact. For instance, they may report connections instead of actual energy

use, or even more abstractly, studying at night versus teachers attracted to a community due to power access. Finally, in terms of cost efficiency, one interviewee reported that there is a lack of benchmark data for expected project costs for a mini-grid installation in different contexts. They discussed how this makes it easier for potential mini-grid developers to inflate their costs in grant proposals and benefit from excess funds.

It is important to note that these information access issues are not due to ill intent. According to most interviewees, various complications limited their ability to collect relevant information during data collection. For instance, one interviewee discussed how COVID disrupted an endline survey which was intended to monitor impact. Furthermore, some stem from the inherent uncertainties of the refugee camp setting, including about the refugee camp duration, risk-level, and consumer dynamics. Further information characterising these elements of refugee camps could help build investor trust.

e. Coordination with stakeholders

Interviewees reported that stakeholder coordination takes a lot of effort and time. This is unsurprising, particularly working in hectic and under-resourced contexts. This is illustrated in the following quote:

> *It's a lot of hard work. Hard work. I mean, if I need to quantify the scale of what has to be done from one to 10 I will say like seven out of 10 will go into that stakeholders management, right? It's difficult to pull everybody together. ...I have spent four weeks to deploy a mini-grid but I have spent one year to get every actor to align.* [MG5]

The difficulty in stakeholder coordination may be related to stakeholders' differing objectives, as discussed by some interviewees. **It is particularly difficult to align stakeholder objectives in such a sector where some are profit-driven while others are impact-driven**, and these players must cooperate, as illustrated in the following quote:

> *How do we meet everybody's objective? Because everybody has one objective. And then how do you now coordinate and bring all those objectives together so that the common objective can serve individual objectives. ...For a private developer, he's also not running a charity business. He wants to make money. For the end user, it doesn't want to pay a tariff if he can get it for free. ...For the regulators, he just wants to regulate.* [MG5]

Coordination with stakeholders was also found to be related to the key challenge of mobilising funding. One interviewee indicated that partners are critical to mobilise funding, and that *sometimes it doesn't work to get those partners* [MG2]. This may point to some issues regarding the company's partner scoping and its strategy. Additionally it could point to the fact that there is limited availability of partners willing to disburse funds at the existing conditions. Another interviewee had a more pessimistic take on such funding related connections, stating: *the only way it will work, if you're in off-grid energy in Africa, is if you tell a lot of things to your investors* [MG1]. The meaning of "telling things" was not explicitly stated by the interviewee, but could be assumed in context and by tone to potentially relate to exaggerations or untruths.

There are **tensions across stakeholders** also stymieing coordination. Interviewees working in camps expressed tensions between developers and the host community, which causes difficulties in getting things done. Surprisingly, they even stated this directly:

❝ *The non-refugees who live nearby basically, it seems like everywhere around the world are often quite difficult and often really don't like the refugees and don't like when refugees get any benefits.* ❞ [MG3]

Tension also arises across implementing stakeholders about who gets credit for the hard work needed to implement mini-grids, and it can be perceived that the credit given is ❝ *not balanced* ❞ [MG5]. This is exacerbated by reports that partners sign onto projects even when they do not ❝ *have enough time to really invest in that partnership* ❞ [MG4] and work in silos, ❝ *just trying to do his own thing in his own space* ❞ [MG5]. Others discussed competition, for instance with existing energy businesses within the camp.

4.1.3. OPPORTUNITIES

The key opportunities or benefits of mini-grid development in RHDs discussed by interviewees are (1) the high-value potential market that can be found in camps, (2) the costs which can be saved via the transition to renewable energy, and (3) the social and environmental impact of electrification.

a. High-value market potential

Interviewees indicated that **refugee camps have a strong existing market for electricity consumption**. They highlighted the **variety of existing businesses** within refugee camps, including hair salons, cinemas, repair shops, refrigeration activities, welding, manufacturing, and bank branches. They also highlighted humanitarian organisation offices and cell towers as key off-takers. To illustrate, one interviewee described business demands within the camp, and indicated that even with a relatively expensive tariff the businesses they have connected keep buying electricity:

❝ *We have found more than 150 businesses operating in the refugee camp, but they were only able to connect just 12. …Most of their businesses – their hair salon, their cinema, their electronic devices repairs, their refrigerations – all those, all those services are essential, and that all refugees were going outside the camps to look for those services. Now… all these more than 50,000 people that were going outside of the camps to look for these services, they are going to these people. …Mini-grid is at double the cost of the national grid but, despite that, people are still paying. No one of the 12 connections we have have stopped paying. They keep adding money as they run out of credit, they keep adding top-up.* ❞ [MG2]

Another interviewee operating a refugee camp mini-grid described how **the density of power consumption in the camp by businesses and other off-takers is larger than in surrounding rural towns**. This made it preferable to work in refugee settings as compared to rural areas, and one factor impacting people's consumption was increased remittances, which are financial transfers typically sent by refugees' families from abroad. These sentiments are illustrated in the following quotes:

❝ *There's a lot of activity going on. And I think that just kind of happens anytime that you have [a number of] people in the same place. That's a pretty large town really, right. So there's people making furniture and welding metal and repairing motorcycles and all sorts of things like that. And there's even a bank branch. There's a lot of humanitarian organisation offices. Both of those have a lot of air conditioners. There are something like 10 cell towers, and those take a ton of power kind of surprisingly. So there actually are way more than what we see in our mini-grids outside of this refugee camp, like in just normal rural villages. There's a lot more heavy users of power.* ❞ [MG3]

> *At our other mini-grids... those people, they hardly use any electricity. ...They're basically just using their light bulb and charging their phone, not doing anything of economic value with it. So would I rather work in those places or the refugee camp? Definitely the refugee camp where people have remittance money and there's just so many of them together that local economies have sprung up and local, even small industry has sprung up.* [MG3]

b. Cost savings

Interviewees indicated that **installation of solar-based mini-grids can reduce costs, particularly relative to diesel**. These costs are currently fielded by the generator owner/operators, be that camp agencies (e.g., UNHCR) or local people/businesses. These savings are mentioned in the following interview quotes:

> *The first phase was to provide a solar system to power the health clinic that was originally being powered 100% by diesel generator, which was not only dirty, but also was consuming a lot of money to run. Because at the time, back in 2019, they were incurring more than $1,000 every month for the diesel generator... so in the very first month of the project, if I recall well, we have been able to help UNHCR to cut that cost down to up to a couple hundred a month.* [MG2]

> *For [UNHCR], it's a way of reducing their costs. Building a solar grid is cheaper than running those 600 kilowatt diesel generators. And also, much less hassle.* [MG4]

c. Social and environmental benefits

The social benefits to refugees and environmental benefits of reduced fuel-burning can **attract duty- or impact-driven investment**. This is illustrated in the following quote from a mini-grid developer:

> *We kind of see it just as our duty if, I mean, we hope we can make money off of selling electricity to the businesses but we really want there to be economic development at every level in the camp and when the households have electricity too, the ability of people to relax better by watching TV, their ability to, you know, for the kids to do their homework at night, things like that. ...Also the enhancements to safety. It just all means a lot to us.* [MG3]

Interviewees discussed how, as there are impact-driven funds available without the same profit-driven incentives of traditional funding, it is important to frame your project in this way:

> *Now, you just want to ensure that they have some sort of improved living condition, right? And they are able to be supported productively right. So for such a venture, you can't go in directly only from a typical way you will look at an investment that like, like, you know, profit-making investment, but you have to [put] a social, you know, flavour into that conversation. So it means that the kind of funding you're looking at will be some sort of funding that focuses on impact, on social welfare, and have those kinds of social construct, right.* [MG5]

However, while attracting impact-driven investment is a great opportunity, one interviewee also importantly highlighted that it's critical that these projects not become *impact-washed*:

> *I wouldn't say it's probably not intentional, but there's, there's quite some impact washing space because like there's company wouldn't say our business, empowering people and transforming communities. But then when you ask, what does that actually mean? What does that mean empowering people?* [MG4]

Renewvia RHD Mini-grid Case Study

Renewvia stands out as a notable success in the development of mini-grids within the African RHD context. More than 500 households, businesses, and institutions have benefited from the project since 2019. Drawing on our interview with a representative from Renewvia and information available in the public domain, we have compiled a case study that details the company's business model and identifies the critical factors contributing to its success.

Renewvia Energy Corporation has been instrumental in fostering community development in the Kalobeyei settlement, Western Kenya, through its solar mini-grid initiative. The project has not only provided clean and affordable energy but also supported local businesses, serving as a catalyst for economic growth. With over 500 customers, including households, businesses, and institutions, benefiting from these energy services, Renewvia's impact has been significant. This success is bolstered by substantial financial support, including a US$630,000 grant from the UK's Foreign, Commonwealth & Development Office (FCDO) and performance-based incentives from Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), among others .

As the interviewee put it, central to Renewvia's approach is its community engagement and a business model that prioritises accessibility and affordability. By keeping connection fees low and allowing flexible payments, Renewvia ensures that clean energy remains within reach for all.

This commitment is echoed in our interviewee's explanation of their business model, emphasising pre-paid electricity and smart meter technology:

"I can say our business model is that we... build the power plant, we build the power lines, we charge a very small fee for connecting people to the power lines, and then we sell them pre-paid electricity. ... Every customer has a smart meter that's connected to the internet. And so, when they pay us on M-PESA, their payment processes automatically and their power turns back on if it had run out. And so, we don't charge any monthly fees or any fees at all like that. We keep the signup payment low. Like I said, it really is just about selling the energy to people as they want to use it" – Renewvia representative.

Renewvia's success is also closely tied to the economic vibrancy within refugee camps. As noted by a company representative we spoke to, various activities such as furniture making, metal welding, and motorcycle repair contribute to this dynamic. Remarkably, in 2022, the company expanded its mini-grid size tenfold, positioning them as one of the largest mini-grid operators in East Africa, serving 2,500 community members . Overall, Renewvia's holistic approach, combining community engagement, a business model that prioritises support for local economic activities, and strategic partnerships with financial backers has contributed to the company's mini-grid success in providing clean energy while fostering community development in the Kalobeyei settlement.

Energy – solar mini grids

PHOTO: RENEWVIA

4.2. Business surveys in Dadaab refugee complex

To understand the potential for energy-enabled growth in refugee camps and how this affects mini-grid viability, 199 surveys were conducted in Dadaab. The survey sample included 65% refugees and 35% host community members. 60% of respondents were male and 40% were female (N=194). 92% of respondents were business owners. The results of these surveys which are pertinent to mini-grid development are presented in the following subsections. Additional results are presented in **Appendix C**.

4.2.1. BUSINESS STRUCTURES

Existing businesses in Dadaab are found to cover a wide range of sectors, as listed in **Table 3**. The top three most common business types were small kiosks selling everyday items, small restaurants, and groceries. While some of these businesses do not explicitly require energy to function, others (such as the electronic repair shops) do. This diversity of businesses is helpful in building a mini-grid business case, as a diversity of demand types can increase capacity utilisation of the grid. While these businesses are typically small (i.e., 85% individually-owned) and young (62% operational for less than three years), this means **they have the potential to grow via increased energy use.**

***Table 3:** Representation of business types throughout the survey sample*

Business type	Count	Percentage
Small kiosk selling everyday items	61	31%
Small restaurant	29	15%
Grocery shop	22	11%
Livestock seller	20	10%
Electronics shop	19	10%
Private pharmacy	15	8%
Other	12	6%
Large Restaurant	6	3%
Farming	4	2%
Private clinic	3	2%
Hawala/Money remittance	3	2%
Private school	2	1%

Interestingly, 74% of the businesses surveyed were found to be located in buildings with access to electricity (N=179). As Dadaab does not have any formal electricity connection, this access must stem from stand-alone generators or solar home systems. This speaks very well to mini-grid viability, as **there is proven electricity demand**, and these solutions are known to be more expensive than mini-grid energy in many cases.

In-camp businesses sell to both refugee and host-community members. The most frequent customers of the surveyed businesses were reported to be individual refugees (42%), followed by individual members of the host community (27%) or both individuals and organisations (27%). Only 4% indicated that other businesses, organisations, or institutions were their main customers (N=197). The businesses reported weekly customer counts ranging from 5 to 350. **The ability to permeate the camp boundary via sales can increase productive activity** and subsequently energy demand.

The surveys showed that there are supply chains crossing the refugee camp boundaries. **Table 3** shows the businesses' responses when asked from where they sourced their supplies. While the most commonly selected answers are within Dagahaley (27%) or within Hagadera (23%) camps, showing the versatility of the intra-camp market, the third most common location is Nairobi (16%). This is promising for mini-grid development, as the mini-grid components are likely to need to be imported. Additionally, the presence of businesses with supply chains beyond camp borders indicates a higher intensity of business activity than intra-camp trade only.

***Table 4:** Sources of supplies for RHD businesses as found in the survey results.*

Location	Count	Percentage
Within Dagahaley	54	27%
Within Hagadera	45	23%
Nairobi	32	16%
Garissa Town	28	14%
Within Ifo	14	7%
Within Dadaab town	13	7%
Other parts of Kenya	10	5%
Other parts of Somalia	1	1%

Businesses in RHDs are reported as having access to financial services, albeit frequently informal ones. The most common financial provider used by business owners was loans from friends and family, with 57% of respondents saying they had such loans (N=199). The rates of uptake for finance from other sources is listed in **Table 5**. Many respondents also indicated that they had finance from a village savings and loan association (VSLA) (45%), with other sources used by 10% of respondents or less. **The ability to access finance speaks well to the ability of businesses to purchase energy for more capex-intensive productive use activities**.

***Table 5:** Financial providers that were used by surveyed businesses. Respondents could select multiple choices for this question. VSLA means village savings and loan association, while SACCO means savings and credit cooperative.*

Financial provider	Count	% of sample using it
Loans from friends and family	139	70%
VSLA	105	53%
Formal loans	23	12%
Supply chain finance	18	9%
Insurance	14	7%
SACCO	13	7%
Micro finance	3	2%
Others	0	0%

4.2.2. BUSINESS RISKS AND SHOCKS

While there is a perception of refugee camps being risky investment environments, the risks that in-camp businesses expect are quite commonplace and occur at a normal frequency. The businesses were asked to rank eight potential shocks from most to least likely affecting their business. The rankings were summed for each shock, and a weighted sum was created to reflect the overall likelihood of the shock as defined in Section 3.2, normalised into the range 1–10. The summary of rankings and the normalisation are shown in **Table 6**.

The most likely shock that businesses expect is fire, followed by robbery or theft, insecurity, and loss of demand to round out the top half. The less likely shocks (bottom half) are sudden increases in prices, supply issues to the camps, family expenses, and flooding/droughts. Perhaps surprisingly, supply issues ranked six out of eight; respondents are relatively unconcerned about issues with their supply, despite perceptions of refugee camps as having difficult supply chains. This perception is also supported by the data showing multiple potential supply sources listed in Table 4.

When asked about the frequency of main shocks, the most common response is that these shocks happen annually (48%, N=199), as shown in **Figure 2**. After a shock, respondents indicated a wide range of timescales for which their businesses are *directly* affected; these are relatively evenly distributed across quarters up to a year, as shown in **Figure 3**. However, there was a clearer trend about how long it takes their businesses to *recover* after a shock, which takes much longer (i.e., frequently more than a year) as also shown in Figure 3. As such, mini-grid developers may need to be cognizant of longer-term dips in demand during shock recovery.

***Table 6**: Business rankings of the likelihood of each shock affecting their businesses. The numbers in the cells are the number of times the given shock was ranked at that position. Shocks are ordered from highest to lowest normalised weighted sum value.*

	Rankings									
Shock	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**Weighted sum**	**Norm.**
Fires	115	16	8	9	6	12	13	20	1231	10.00
Robbery or theft	26	26	35	46	22	12	19	13	1005	8.16
Insecurity	11	59	22	24	37	16	14	14	991	8.05
Loss of demand	7	61	24	20	27	21	19	20	956	7.77
Sudden increase in prices	18	12	27	24	21	59	17	21	826	6.71
Supply issues (to the camps)	5	9	47	26	31	32	32	17	816	6.63
Family expenses e.g., medical and school expenses	7	10	21	17	36	23	35	50	670	5.44
Flooding/Droughts	10	6	15	33	18	23	50	44	662	5.38

***Figure 2**: Frequency of the main shocks identified by respondents. Note that respondents could select more than one option.*

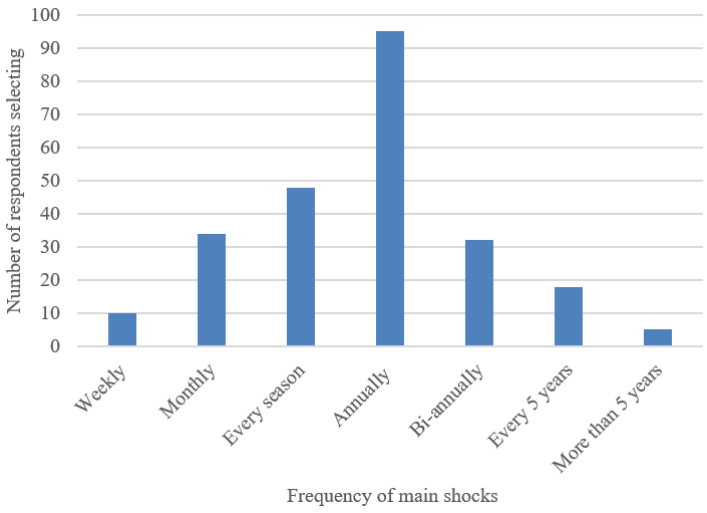
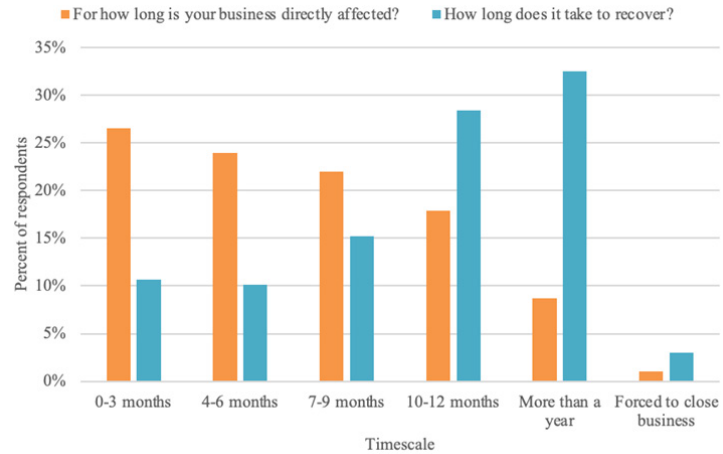


***Figure 3**: Timescale over which a shock directly impacts the business versus the time required for the business to recover, for the surveyed businesses.*



Solar Light in Kakuma Refugee Camp, Kenya

> “The key opportunities or benefits of mini-grid development in refugee hosting districts discussed by interviewees are the high-value potential market that can be found in camps, the costs which can be saved via the transition to renewable energy, and the social and environmental impact of electrification”

PHOTO: DANISH REFUGEE COUNCIL

5 SYNTHESIS OF DATA COLLECTION TOOL ACROSS STAKEHOLDERS

Based on the results of this study, we developed a data collection tool that helps capture the information to design business models in refugee settings. To ensure data integrity and depth, this tool addresses pivotal questions underpinned by five related themes (i.e., consumer profile, current energy demand, challenges, current business model, and future demand) and cross-checks among stakeholders. The themes are:

- **Who are the potential energy consumers?** To understand the profile of the potential energy consumer, we delved into their demographic background, living arrangements, and financial status. This information was cross-checked with financial transfer systems like Western Union and grassroots funding entities to validate financial data and infer energy investment potential.
- **What is the current energy demand?** We assessed energy demand by examining household and business energy usage. Four main energy uses are considered: cooking, lighting, entertainment, and the productive use of energy.
- **What are the challenges in project delivery in the RHDs?** To investigate project delivery, our tool explores the general and business environments, opportunities within the business sector, and government attitudes. These factors are critical in identifying and navigating the obstacles faced in the camps.
- **What are the current business models and trusted supply chains?** We also aim to understand the existing business models and supply chain reliability, involving general and energy entrepreneurs. This helps us assess the feasibility and resilience of energy-related ventures.
- **Does future energy demand have a high potential for growth?** Finally, we explore future prospects by assessing household energy usage and energy use aspirations, alongside the entrepreneurial environment. This predictive aspect is crucial for designing adaptable and forward-looking business models.

Each of these themes can be addressed by different key stakeholders. These stakeholders are mapped based on the literature and data collected in this study. This mapping delineates stakeholders into four primary categories: energy users, energy providers, financial institutions, and the supporting ecosystem. Each of these categories is further broken down as follows:

- **Energy users** are categorised into private users, predominantly households, and business users. While small family-owned businesses are common in the Dadaab camp, these entities are recognised as both household energy consumers and entrepreneurs.
- **Energy providers** encompass entities such as mini-grid developers, operators, and informal energy businesses.
- **Financial institutions** are classified into grassroots funders, developers and investors, and other formal financial service providers. The study distinguishes grassroots funders from formal financial entities, acknowledging the unique role of informal financial services within refugee camp settings.
- **The supporting ecosystem** includes NGOs (while separating the United Nations who are strongly involved in the camp from others) and government representatives, ensuring a comprehensive representation of all parties involved.

This mapping enables a nuanced understanding of the stakeholder landscape, which is essential for the effective planning and implementation of mini-grid projects in refugee camp environments.

The full data collection tool is provided publicly at *https://doi.org/10.5281/zenodo.11286168*.

6 CONCLUSIONS AND RECOMMENDATIONS

In this section, we present practical conclusions and recommendations based on the analysis that will assist the Danish Refugee Council (DRC) in identifying refugee hosting districts (RHDs) where business case development is more likely to yield investment in mini-grid electrification. They are provided in the context of the core questions driving this report:

What are the essential conditions for a viable business case to invest in mini-grids in RHDs?

- Essential conditions to create a viable business case to invest in mini-grids in RHDs include evidence of existing density of demand (i.e., currently met via informal expensive solutions), a pathway for this demand to grow, off-take guarantees from key anchor clients, confirmed cooperation of regulating bodies, confirmed support from political bodies (i.e., via a signed MOU), and patient capital available to allow grids to scale to profitability. Risk must be minimised by mapping camp longevity and consumer dynamics. Furthermore, the business case must be based on an operation and ownership model which matches existing community capacity and norms.

What data are required to construct such a business case?

- To construct such a business case, data are required on RHD demographics (including their change over time to understand camp longevity), community leadership and governance structures in-camp, existing businesses and their current energy usage, potential anchor clients and their desired usage, existing regulations on mini-grid energy provision, political sentiment on refugee camps and electrification thereof, and the payback period and interest rate expectations of funders interested in supporting the effort.
- Another important consideration is the existing sources of energy in the refugee camp, such as diesel generators. Understanding the dynamics of these generators is crucial for sizing the mini-grid appropriately. Moreover, the diesel genset owners/operators play a pivotal role in shaping the business case for mini-grids, as they are already engaged in selling energy services. Therefore, integrating them into the new energy system, rather than viewing them as adversaries, is essential for the success of the transition. This collaborative approach fosters partnerships and ensures a smoother transition to more sustainable energy solutions within the refugee camp.

What other factors may influence an investor's decision to engage in an RHD?

- Investors who wish to engage in mini-grid development in an RHD must be able to shoulder long payback periods (i.e., patient capital) at a low interest rate. This is not typically the case in finance available from commercial banks; it is more likely to be found from a grant structure, angel investor, or venture capitalist. However, these options can be blended with commercial financing to produce viable funding portfolios (albeit with a strong concessional component). Private sector investors may wish to seek evidence as to whether the mini-grid developer has plans for other financing streams to blend their finance. Additionally, they must note that mini-grid developers in RHDs may not be able to meet their standard funding conditions. For instance, due to lengthy and opaque bureaucratic processes in these settings, obtaining licensing before grant disbursal may not be pragmatic.

Which mechanisms and structures can attract investors to engage in RHD energy projects?

- The lengthy and uncertain **bureaucratic process** makes it challenging for the private sector to develop mini-grids in camps. **Agencies operating in camps could help developers to navigate this difficult landscape and help streamline licensing for mini-grid developments.** They could, for example, streamline mini-grid development in camps by establishing a unified licensing portal with clear and transparent guidelines and procedures, setting up a dedicated support team to guide developers, and advocating for policy reforms to simplify the licensing process, based on developer feedback and pilot project insights albeit maintaining the necessary protection of refugees.

  Interview data and the UN-Habitat/Dadaab Socio-economic Survey (2021)[46] both indicated that RHD residents are likely to hold **higher technical expertise** than rural residents outside the camps, facilitating mini-grid development. **To leverage this human resource, agencies could provide support in locating and recommending highly skilled refugees to developers.** Such a match-making programme would ease the burden of locating technical staff for external developers and companies entering the market, making it more attractive. As RHD energy projects require **patient and generous capital**, impact-driven investors and venture capitalists may be better equipped to help projects begin to scale than commercial lenders. However, these investors require strong impact evidence, and monitoring and evaluation in the sector is limited. By encouraging **monitoring and evaluation in existing projects and encouraging those who already do this to publish their data**, the impact case to attract these investors could be solidified.

  There is a **lack of public-facing information** available about the practices which have led current RHD mini-grids to financial viability. By creating **succinct financial summaries of existing RHD mini-grids as case studies** and making them publicly available, investors may be better equipped to understand the structures that are most practical in this context, and whether they are equipped to meet such needs.

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Appendices

A. Semi-structured interview prompts

MINI-GRID BUSINESS BACKGROUND

- What camps does your organisation work in?
- How long have you been active in those camps?
- How many mini-grids does your company operate?
- What motivated you to start working in the mini-grid business in refugee camps?

MINI-GRID OPERATIONS

- What types of generation equipment do your mini-grids use?
- What are your supply chains? Do technologies/ fuels come from inside or outside the camp?
- Who are your biggest consumers? (e.g., households, businesses, public sector)
- How do you set your energy prices and what tariff structure/rate do you charge to consumers?
- Is your energy service available 24/7? If not, what days of the week & hours is it available?
- How much electricity/energy service do you sell per month on average?

MINI-GRID FINANCIAL STATUS:

- What kind of payment is primarily used in your business (e.g., cash, mobile money, barter)?
- How many people are employed in your mini-grid operations? Are they based inside or outside the camp? What are their wages?
- What are the top three expenses for the mini-grid business? Could you provide an estimate of your monthly operating costs?
- What is the average monthly income of the business? So far, has the mini-grid been profitable?
- What is your main source of capital for mini-grid development? Has your business used any financial services in the past year? Does it have any loans?
- What are the top 3 challenges to the long-term sustainability of your mini-grid business?
- Is your company trying to grow their mini-grid business? If so, by what percent/metric? (e.g., increase in number of connections, percent increase in profit, etc)
- What types of support would be required for your mini-grid business to flourish?

INVESTMENT

- Has your company invested in anything else in the refugee camp aside from the mini-grids?
- What are the top three factors that impact your investment decisions in refugee camps? What are the key benefits and challenges to investing in this context?

PERCEPTIONS AND LESSONS LEARNED

- What is the energy demand potential that you perceive in the refugee camps you've worked in? (e.g., low - solar lanterns, medium - mini-grids, high - grid)
- Specifically for mini-grids, what potential market size do you see in the refugee camps you've worked in? (e.g., very small < 50 households, small 50–100, medium 100–500, large 500+)
- When starting a new mini-grid, would your organisation be interested in partnering with existing in-camp energy businesses? Why or why not? What would be the key considerations in that kind of partnership?
- What are the top three biggest challenges you have faced in setting up or running a mini-grid project in a refugee camp? What are the top three biggest benefits?
- What kind of data would you like to see if you were considering the potential for mini-grid investment in a refugee camp? What would be useful?
- What are the key lessons or pieces of advice you would give to someone starting an energy business in a refugee camp?

B. Survey questions implemented in Dadaab refugee complex.

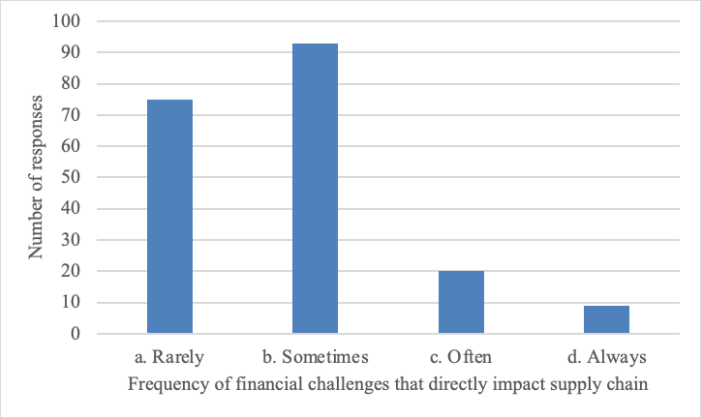
Consent
Type of respondent ▪ Refugee or host community? ▪ Male or female?
What is the type of business? ▪ If farmer: what do you farm?
What is the size of the business?
Does the building have electricity?
Are you the owner of the business?
How long have you been in business?
Who are the main customers?
How many customers do you get on a weekly basis?
From the list below, rank the following from the most to least common shocks that impact your business?
Are there any missing shocks from that list that have a significant impact on your business?
How regularly do the main shocks occur?
What external shocks do you see happening in the coming year?
Which shock has the greatest impact for the continuation of your business?
For how long is your business directly affected?
How long does it take to recover?
How many businesses/providers in the area are similarly affected?
Which suppliers can you not access during a shock that you rely upon?
How does the shock affect your income and cash flow?
Are you able to take any actions to minimise the impacts of this shock? ▪ If yes, what actions do you take to minimise the impacts of the shock? Select all that apply ▪ If no, why don't you take any action?
What would be the most impactful way to reduce the risk of this shock on your operations?
Do any other agencies or authorities in the camp support with recovering from these shocks? ▪ If yes, how?
What actions do you take to recover from the shock?
Do you use any types of financial providers for your business?
Are you able to repay finance after shocks?
Where do you source your supplies from? (select all that apply)
What is the name of your main supplier of goods for your business/shop?
Do infrastructure issues (e.g., road conditions, transportation facilities) directly affect your trading activities?
How often do infrastructure-related delays affect your business? Ex. Frequency per month
Over the past year, have there been any regulatory changes that have impacted your business? ▪ If yes, specify.
Over the past year, how often have you faced financial challenges that directly impacted your supply chain activities?
Are you currently using any loans or credit to buy stock? ▪ If yes, is the finance fit for purpose? (e.g sharia compliant, affordable, flexible) ▪ If no, what are the reasons for not using such finance?
How much loan did you borrow for business or amount of goods bought on credit?
What methods do you use to lower the transportation costs for your produce?
Are there any major transportation groups that we should know about? Especially if these groups offer any form of financing to businesses to facilitate their activities.

C. Supplementary survey analysis

The vast majority of businesses in the sample were small-sized enterprises. 85% were individually owned, 15% had one to two staff, 4% had three to five staff, and only 1% had six to fifteen staff (N=196). Most of the businesses were relatively young: 16% had been in business less than one year, 46% for one to three years, 22% for four to six years, and 16% for more than six years (N=197).

The results indicated that business operations may be challenging without finance access. 69% of respondents indicated that, at the time of interview, they were using loans or credit to buy stock (N=197). Additionally, when asked if they had any financial challenges which disrupted their supply chain over the past year, 47% indicated that they did sometimes (N=197), as shown in **Figure A.1**.

***Figure A.1**: Frequency of financial challenges that impact the business supply chain over the past year. N=197.*



Respondents indicated some awareness of strategies to minimise shock impact and facilitate recovery. 91% of respondents perceived that they could take some action to minimise the impact of shocks (N=197). The top three strategies that those people indicated they would use were to build savings (52%), reduce prices for customers (24%), and look for ways to increase their customer base (24%). Respondents were also asked what actions they would take to help their business recover from a shock. Their top selections were to borrow money from informal (40%) or formal (37%) sources, and to sell off assets (18%). 87% also indicated that they are able to repay finance aftershocks (N=193). Interestingly, only 27% of respondents indicated that other agencies/authorities in the camp support with recovering from the shocks (N=173).

Respondents were asked if any regulatory changes had impacted their business over the past year: 50% said yes (N=193). By far the most frequently cited was high taxation rates, which was mentioned by 53% of those who said yes (N=78).

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