WORLD RESOURCES INSTITUTE

WORKING PAPER

CASE STUDY OF AN ENERGY PROJECT IN HEALTH FACILITIES IN KENYA: HOW TO IMPLEMENT DEMAND-BASED APPROACHES

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EXECUTIVE SUMMARY

Highlights

- A demand-based approach for energy access must include a thorough exploration of the user's needs, specifically, for technology, finance, and other capacity building services.
- The World Resources Institute (WRI) partnered with Population Services Kenya (PS Kenya) to study a set of clinics that were offered loans to invest in rooftop solar photovoltaic (PV) systems or grid batteries to supplement their grid electricity supply. Roughly half of the clinics succeeded in loan repayment. The rest failed, and in some cases, defaulted on their loans.
- Our case study analyzed the factors that underpinned the loan repayment, highlighting the importance of the demand-based approach when designing energy access projects.
- One factor of success was tailoring technical solutions to suit business needs. While some clinics used the technology as a stand-alone energy solution, others that were more successful customized the use of the electricity system and integrated it into their business strategies. Other factors included financial readiness, justification of technical solution, and quality customer support.
- The case study's findings were extrapolated to develop an assessment framework for strategic planning. This framework aims to help operationalize a demand-based approach and maximize benefits for energy end users.

CONTENTS

Working Papers contain preliminary research, analysis, findings, and recommendations. They are circulated to stimulate timely discussion and critical feedback, and to influence ongoing debate on emerging issues. Working papers may eventually be published in another form and their content may be revised.

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About This Paper

From 2016 to 2017, PS Kenya implemented a pilot energy access project that provided 23 privately owned clinics two options to supplement their electricity supply. All the clinics are located in areas where grid power is available but not fully reliable. The participating clinics took loans offered by PS Kenya to invest in rooftop solar photovoltaic (PV) systems or grid batteries with the aim of ensuring more reliable electricity inputs. These options served to supplement the grid electricity supply and diversify the energy mix available to the clinics. As of mid-2018, when the case study started, most of the clinics in this program were satisfied with the technical solutions; however, PS Kenya experienced mixed results for loan repayments. While half of the clinics repaid their loans on schedule, the other half fell behind on their repayment commitments or defaulted altogether. Loan repayment is shaped by a series of underlying factors, including the chosen technical solution, customer support, the clinic's readiness to take finance, and its business strategy. As an indicator of project result, successful loan repayment not only reflects the financial outcome but also the multidimensional project success. Therefore, it serves as the entry point of our analysis, which sought to uncover the factors contributing to the project outcome.

This paper documents the key findings from the case study with PS Kenya on the pilot energy access project (referred to as "energy project" below). The work with PS Kenya is part of WRI's Energy for Development project, which aims to expand electricity access in East Africa and India to meet the developmental needs of underserved people and local development institutions. In partnership with WRI, PS Kenya sought to better understand the reasons behind the mixed results of the energy project. The study worked closely with the participating clinics that were responsible for managing their investment in the electricity systems and received support from PS Kenya on business advice and vendor communications. Through our interviews with the clinics, we learned about the goals of their investments, whether and how the procured electricity systems helped achieve these goals, and how the setting of the project influenced the outcomes for each clinic.

This user-engaged study provides valuable material to develop a strategic assessment framework for future energy access interventions—a tool that can help operationalize a demand-based approach and design impactful interventions. The findings of our case study were extrapolated into a strategic assessment framework, useful for identifying end users' demands for electricity and for complementary services necessary to attain impact goals.

Case Study Approach and Purpose

Together with PS Kenya, we conducted systematic interviews with clinics and other stakeholders to understand what drove the project outcome. Taking a sample of the participating clinics, we administered a questionnaire (Appendix A) asking about their experiences. We then summarized the factors that had contributed to their loan repayment outcomes. The sampling captured various characteristics of the clinics, such as clinic size, the purchase price of the systems, the repayment outcomes, and so forth. We examined data from the interviews to look for patterns across the sample clinics. The field managers from PS Kenya accompanied us during the interviews. As they had already been working with the clinics on the energy project, they were able to verify the soundness of the information provided by the interviewees.

The energy access community broadly agrees on the importance of demand-based approaches as opposed to the supply-driven model. However, demand-based approaches are still not clearly defined in terms of implementation and how best to maximize the benefits for the end users. The strategic assessment framework extrapolated from the case study is intended to help fill this gap.

Key Findings of the Case Study

The case study compared the experiences of the clinics and suggested two categories of factors that had contributed to the project outcomes. External factors, which include technology design and models of customer support, are outside of, or only partially within, the control of the end users. Internal factors, on the other hand, are aspects of an energy access project under the direct control of the end users. These factors include the degree to which technical solutions can be integrated into business strategies and end users' internal capacities to manage the finance, including the loans.

External factors

Technology design. Not all technical solutions are appropriate for the end users' energy needs, even for those operating the same business at similar scales. In our case study, there were three considerations related to technology design: energy resources, built environment, and system size. On the energy resources, all the health clinics we sampled are in areas with abundant sunshine, where a solar PV system can be a feasible solution. On the built environment, 2 of the 13 clinics we interviewed were located in buildings without access to the roof. These clinics, therefore, turned to a grid power storage solution to provide continuous power during blackouts. Lastly, the size of the chosen electricity system should also be appropriate to meet the operational needs and budget of the end user.

O&M service. Appropriate operations and maintenance (O&M) service models, following initial design and delivery of the electricity systems, are essential to the success of the energy access interventions. End users may not have full information about how O&M works until the need arises. They should, however, be provided assistance to evaluate the available O&M models ahead of time, including the vicinity of O&M support, the communications process, and the management of the parts of the equipment. In our case study, the adopted O&M service models were not universally applicable. This led to inadequate technical support, which resulted in equipment being idle, end user dissatisfaction, and, in turn, delayed or defaulted repayment of loans.

Internal factors

Technology's business impacts. It is crucial for the end users and investors in the interventions to understand how a new energy technology can be used to achieve their business or performance goals. More than half of the clinics we investigated that failed to integrate technical solutions into their business strategies failed to repay the loans. In addition, the integration of the technical solutions should consider the change of business strategies over time. As the business grows and business model evolves, the way in which technical solutions are integrated should evolve, too. This process may not be straightforward for the end users, however, and technical assistance may be needed. In this case study, a business advisory program provided by PS Kenya filled this need for 6 of the 13 clinics we studied, while 70 percent of the remainder failed to repay their loans.

End users' readiness for finance. In our case study, readiness for finance reflects the clinics' capacity to manage the finance needed to operate the business and to pay for the installation and operation of the electricity systems. Almost all the clinics that had a history of defaulting on loans failed to repay their loans in this project. Apart from the issues inherent in the business models, management capacities contributed to the outcome of loan repayment.

All these factors described above are critical to the project's success. A demand-based approach would require a thorough assessment of the gaps and conditions related to the factors to help maximize impacts for the end users.

DEMAND-BASED APPROACH FOR ENERGY ACCESS

The United Nations' Sustainable Development Goal #7 (SDG7) targets universal access to affordable, reliable, sustainable, and modern energy by 2030 (United Nations 2015). Future population growth is projected to occur almost entirely in the least developed countries, especially in Sub-Saharan Africa where access to energy is already limited. This poses an increasing challenge to meet SDG7 for the globe. There is an urgent need to understand how to improve energy access (OECD 2012). Traditionally, the measurement of energy access has been binary—end users, whether they are individuals or institutions (for example, development organizations, networks of service providers, etc.), are either connected to an energy supply or they are not. Interventions have focused on increasing the number of connections, either to the grid or distributed systems (Bhatia and Angelou 2015; Broto et al. 2017). This approach successfully connected many people who formerly had no access. However, focusing on the supply side will not be adequate as supply-side deficiency is, firstly, responsible for only part of the access gap. Many populations remain underserved because of the low demand in the area where they live, which makes it a challenge to justify extending the infrastructure (Blimpo and Cosgrove-Davies 2019). Second, a supply-driven approach tends to lack a good understanding of energy demand and how energy can be used. It thus lacks an understanding of the economics of energy access from the user's perspective. This can risk uptake and consumption of any energy solutions, and in turn, the overall energy access intervention (Blimpo and Cosgrove-Davies 2019).

An alternate approach endorsed by the energy access community focuses on energy demand. This demand-based approach recognizes the importance of the linkage between energy needs and broader development needs (Schillebeeckx et al. 2012; Odarno et al. 2017). It does not propose technical solutions based on donors' preferences, nor does it depend on the "connection" alone to gauge success. Instead, it develops interventions around the impacts it seeks to achieve. Based on the understanding of end users' demands on energy and how they can be met within present constraints (Broto et al. 2017), demand-based interventions provide tailored technical solutions alongside complementary services, such as credit and training, toward development impact goals; for example, livelihood opportunities and poverty reduction (Morrissey 2019). The demand-based approach, as described in this paper, refers to the strategy of filling energy access gaps by addressing end users' multifaceted needs, proposing solutions that are fit for purpose, and designing interventions that seek to make an impact.

As yet, there is little consensus on the methodology for operationalizing the demand-based approach. Even though there have been discussions on issues overlooked by the supply-driven approach—for example, the insufficient attention to post-installation operation, maintenance, and coverage (Sehjpal et al. 2012; Jaeger and Michaelowa 2015; United Nations Foundation and Sustainable Energy for All 2019)—these issues have not been addressed systematically. The first step, as practitioners and thought leaders advocate, is the identification of "attribution gaps" (e.g., Attigah and Mayer-Tasch 2013; Bhatia and Angelou 2015; Morrissey 2017; Jain and Shahidi 2019), the missing linkages between energy access and the development impacts. Under the framework of energy access for development (United Nations 2019), identifying attribution gaps requires a comprehensive understanding of the impact goals among targeted geographies and populations. In practice, understanding and interpreting impact goals necessitates a shift of focus from modeling supply to studying the behavior of electricity users. Only then can a demand-based approach be operational, generating relevant market information to drive supply modeling and to steer technical design toward long-term impact goals instead of intermediate results such as grid connection or appliance distribution.

Through a case study, this paper highlights the importance of the demand-based approach. The study's findings also generate a framework that helps gather relevant market information to design impactful energy access interventions.

PURPOSE AND APPROACH OF THIS WORKING PAPER

This paper presents a case study carried out in Kenya, where we studied an energy access intervention that provided two technical solutions to health clinics to ensure reliable electric power. The clinics were offered loans to expand electricity options, supplement their electricity supply, and diversify their energy mix. Though given a limited set of technical solutions from which to choose, the clinics followed their own methods to implement the technologies. The different implementation models resulted in different outcomes.

Some clinics benefited tremendously while others failed to even repay the loans. By studying and comparing these use cases, we identified a series of factors that drove the varied outcomes, in particular, the repayment of loans. Based on the case study, we suggested how to lay the foundation for designing impactful interventions by conducting strategic assessments.

We studied a pilot energy access project undertaken in Kenya from 2016 to 2017. Population Services (PS) Kenya is the Kenyan chapter of Population Services International, a nonprofit global health organization. It offered 23 private health clinics in the Tunza network, an existing social franchise for health, the opportunity to invest in expanded electricity systems to improve business performance and patient services. We worked with PS Kenya to collect primary data from vendors of the electricity systems and a sample of the participating clinics (13 out of 23). The engagement with the clinics provided us insight into their finances, business performance, and patient services to help with the analytics of their project outcomes.

As the first step of the study, we laid out a roadmap of the investigation that included a series of hypotheses on factors that can influence the project's success. Second, we developed a questionnaire to guide the interviews with the clinics and the vendors to examine whether, and if so how, the underlying factors work to facilitate or impede success in each clinic. Third, we drew comparisons among the different cases to summarize similar lessons and experiences, extracting common factors that contributed to the outcomes of loan repayment. Lastly, we extrapolated the findings from the case study to develop a tool that helps with strategic assessment of energy access interventions. This tool provides a framework to navigate the information about the characteristics of the end users, products, and services. The underlying factors can then be identified to unpack the desired impacts and how to achieve them.

Discussions around the energy suppliers' finance and business models are beyond the scope of this paper.

A COMPARATIVE STUDY OF TUNZA CLINICS' ENERGY ACCESS INTERVENTIONS

PS Kenya's energy project sought to improve clinics' business and capacity to provide health care services. While the clinics in the Tunza network could continue to use any existing energy source for electrification, PS Kenya offered two technical solutions to supplement the electricity systems: rooftop solar PV system with battery and grid battery backup. After choosing one of the two solutions, clinics took different approaches to utilizing the systems. Some took a demand-based approach and tailored the use of the technical solution to suit their business needs. Others simply implemented the technology as a stand-alone energy solution without integrating it to benefit business as a whole. Through a comparative study, we explored the initial designs of the technical solutions, how they were administered through two different approaches, and why the clinics did not benefit equally. Our findings shed light on how a demand-based approach can benefit the end users (in this case the health clinics) the most, and how this approach can be used to shape intervention designs so that similar projects can maximize the impacts of electricity access interventions for future energy end users.

Overview of the Project

In 2016, PS Kenya launched an 18-month pilot project involving clinics in its Tunza network. The network's principal goal is to provide access to family health care services for low-income and underserved populations. The 23 privately owned clinics in the pilot project were offered loans to procure one of the two given technologies—solar PV systems or grid battery backup systems—to supplement their electricity supply. The objective was to ensure reliable electricity and, in turn, improve the continuity of health services focused on women and children.

The 23 clinics are located in six regions of Kenya where grid power exists but is not fully reliable. While all 23 clinics are connected to the grid, some of them had no electricity backup during grid blackouts. Others depended on traditional backup systems such as kerosene lamps or diesel generator sets. Typically, a blackout lasted from several hours to one week, and such a blackout could strike once or twice a month. Even with the backups, the clinics constantly struggled with various issues ranging from cost to pollution. As a result, the clinics' business can be seriously interrupted. In addition, the services they provide to the communities also are limited by the energy challenges. PS Kenya's energy project sought to improve the clinics' business and service capacities by addressing the energy challenges.

Project Setup and PS Kenya's Role

PS Kenya understood that building energy infrastructure is capital-intensive. The financial burden is even greater for clinics in rural and semi-rural areas and in city slums where the average profitability is low. Therefore, the organization offered participating clinics loans with repayment periods of two or three years. Typically, the clinics paid 20 percent of the total price upfront and took out loans from PS Kenya to cover the balance. A 12 percent interest rate was charged, lower than market rates, which were around 17 percent in 2016. Before granting the loans, PS Kenya evaluated the clinics' creditworthiness as well as their need for assistance. Because PS Kenya is a nongovernmental organization (NGO), the loan was considered to be noncommercial, and the repayment record was not going to affect the clinics' credit history.

PS Kenya also functioned as an intermediary by bringing together the users (clinics) and energy suppliers who were corporate vendors of the solar PV systems and batteries in the country. PS Kenya worked with two corporate vendors (referred to as Vendors #1 and #2). Vendor #1 has a footprint across the country. It provided either solar or backup systems, as well as O&M services, to 20 out of 23 clinics. Vendor #2 is a Nairobi-based firm that initially worked with four clinics (one clinic later switched to Vendor #1).

The intermediary role played by PS Kenya was twofold. First, at the procurement stage, the organization coordinated customized system sizing through discussions and negotiations, enabling the vendors to provide electricity systems sized for individual needs. This was crucial since the clinics had different electricity needs and budgets. Second, after purchase, PS Kenya set up vendors' visits and regular check-ins to ensure the equipment was properly managed and functioning. PS Kenya also facilitated clinics' communications with the vendors about O&M needs.

Another important feature of PS Kenya's role was that it provided business advisory services through a dedicated program. Not intended to serve the energy project exclusively, this advisory program was initiated in 2010 mainly to help with business operations of small- to micro-scale private clinics. The goals of clinics enrolled in the program include attracting and stabilizing the numbers of visiting patients, expanding service areas, and becoming or remaining financially sustainable. The program reaches approximately half of the clinics in the Tunza network. For the energy project, PS Kenya mentored the clinics enrolled in the advisory program in technical use of the equipment and how to take advantage of it to reduce energy costs and explore new service areas.

Project Outcomes

Through mid-2018, most of the clinics participating in the energy project appreciated the technical solutions. When the equipment functioned properly, clinics were able to operate during the grid blackouts, thus extending business hours. They were also able to lower energy bills. Depending on the size of the original electricity bill, cost reduction varied from 30 percent to 90 percent for grid power. Most clinics phased out fossil fuel–based backup power. In one clinic, grid power was replaced by solar power and served as backup only in the evening or whenever the solar battery had drained.

On the other hand, only some of the clinics achieved their initial goals of improving business and service capacities. The investment was proved to not be viable in other cases. Despite electricity systems that brought many benefits, including financial benefits through lowered energy bills, for many clinics these benefits were not enough to offset the investment cost and capital cost they had committed to pay each month. Over time, the investment had been deteriorating rather than improving the businesses. Clinics' capacity to provide quality health care services to the communities was, in turn, negatively affected.

Loan repayment, an indicator of financial viability, shows that until mid-2018, 12 of the 23 clinics (i.e., the "success cases") had remained current on their loan repayments but the remainder (i.e., the "problem cases") had encountered problems meeting repayment obligations. While loan repayment is a key financial indicator, studying it helps unpack the underlying factors that contributed to the project's multidimensional success, ranging from the technical models to the operations and management.
In the analysis below, we lay out a series of contributing factors to parse the status of loan repayment with the aim of providing insights into what may lead similar projects

to succeed. Fundamentally, it is a question of the value proposition of an electricity system from the user's (clinic's) perspective. This question must include the assessment of benefits and financial burdens that users perceive, and of the factors that can influence potential outcomes.

Reports from the ground on health outcomes were positive. Our interviews revealed a linkage between continuous power and the capacity to serve more patients. As a result of the new systems, many electricity-dependent services that previously had to be refused due to power reliability issues can now be provided on time. When the systems functioned properly, the number of served patients increased by 10 percent to 50 percent from 2016 to 2017, depending on the service area. In particular, for maternity services, the monthly attended infant delivery dramatically increased by at least 50 percent. With on-site electricity generation, three additional clinics started to provide maternity services.

More comprehensive health outcomes—safer infant delivery, more timely vaccination of children—were also anecdotally reported. However, attributing these quality-related outcomes to electricity access is not as straightforward. While better health outcomes should be expected, a systematic research into the causality between energy access in clinics and health outcomes is beyond the scope of this study.

How to Think about Designing Impactful Energy Access Interventions

When launching the project, PS Kenya ran a survey-based study to understand the clinics' energy use as well as general willingness to invest in new electricity systems. Two technical options, rooftop solar PV system with battery and a grid battery backup, were introduced as ways to supplement existing grid power and fossil-fuel backups. Clinics hoped that adopting either one of the two new solutions would bring the benefits they wished to achieve. During our interviews, business continuity, energy cost reduction, and, ultimately, business improvement stood out as the main investment goals. While clinics were given a limited set of technical options from which to choose, which might or might not fit their goals to begin with, they did enjoy a high degree of freedom to decide how to design and implement the systems, including choosing a more suitable option, balancing the budget and system size, and optimizing the energy mix.

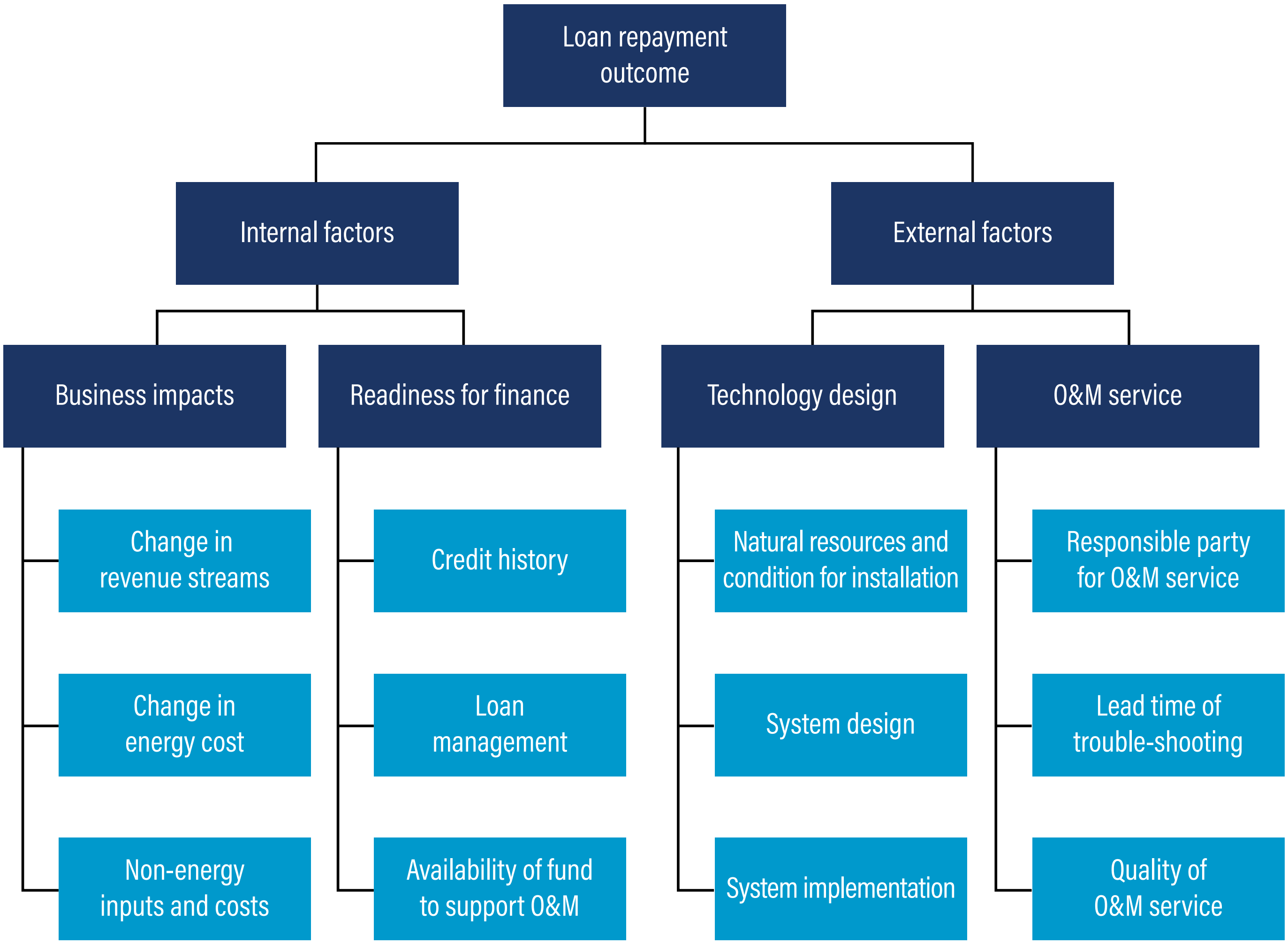
Given that no common guideline existed to walk them through the individual decision-making processes, we have seen a variety of different approaches that the clinics chose to design and use the electricity systems. These different implementation approaches resulted in different outcomes in the form of loan repayment. Our interviews revealed that while some of the clinics only considered technical factors to gauge the suitability of technologies, others thought through where and how to plug in alternative electricity solutions before system sizing and actual procurement. The latter, demand-based, approach enabled the clinics to unlock more benefits.

Alongside the consideration of technology design and business impacts, our study also found the quality of O&M support and the clinics' readiness for finance to be important. These are major factors that also underpinned the success of the interventions.

No single clinic was able to consider these factors altogether beforehand, nor did one factor alone guarantee success. We aggregated the lessons and experiences of the clinics to offer insights to end users and project planners, including funders, to understand what a demand-based approach would entail.

Below we show how the project outcome can be explained by these factors. Using the indicator of loan repayment as the entry point for our analysis, we map the factors of success that are relevant to the Tunza network clinics (Figure 1).

Figure 1 | **Factors Shaping the Clinics' Loan Repayment Outcomes**



Source: Authors of this study.

Internal factors

- **Business impacts:** Will electricity investments improve the business by reducing cost and increasing revenue? Does the business operate in a favorable ecosystem where the impact of the electricity investments can be maximized?
- **Readiness for finance:** Are the clinics ready to take on a loan? Do they have enough internal capacity to ensure proper budgeting and management of repayments?

External factors

- **Technology design:** Are participating clinics located in areas where solar resources are sufficient for solar power? Do the clinics have the appropriate space and orientation to install solar equipment and make the use of the equipment feasible? Is the equipment provided appropriately designed, sized, and installed?
- **O&M Service:** Is the equipment supported by satisfactory customer service, including post-installation follow-ups and O&M?

We chose a sample of participating clinics to study these four questions. Thirteen sampled clinics were chosen within Nairobi City County and surrounding counties, and in the counties in the Lakeside region for the in-person interviews. The sample represents clinics of different sizes, monthly loan repayment plans, loan histories, vendors, and the type of system procured.

Table 1 provides an overview of the 13 case study clinics.

Table 1 | **Location, Size, Energy Profile, and Finance of Case Study Clinics**

CLINIC	COUNTY	NUMBER OF ROOMS	ELECTRICITY SYSTEM	ENROLLED IN BUSINESS ADVISORY PROGRAM	VENDOR	VALUE OF THE SYSTEM (KES)	POWER CAPACITY OF THE SYSTEM	LOAN DATE	DOWN PAYMENT (KES)	MONTHLY INSTALLMENT PER AGREEMENT (KES)	REPAYMENT STATUS	HISTORY OF LOAN DEFAULTING
Clinic #1	Nairobi	4	Battery backup	Yes	Vendor #2	156,312	1,000 Watts	May 26, 2016	16,000	6,737	In arrears	Yes
Clinic #2	Migori	4	Solar	No	Vendor #1	238,734	375 Watts	April 28, 2016	24,000	10,310	In arrears	Yes
Clinic #3	Migori	4	Solar	No	Vendor #1	238,734	375 Watts	April 28, 2016	24,000	10,310	In arrears	Yes
Clinic #4	Kiambu	4	Solar	Yes	Vendor #1	332,839	780 Watts	October 13, 2016	100,000	11,180	Payment was on schedule	No
Clinic #5	Kiambu	6	Solar	Yes	Vendor #2	222,176	1,000 Watts	May 18, 2016	22,217	9,601	Loan was cleared	No
Clinic #6	Vihiga	6	Solar	Yes	Vendor #1	238,734	375 Watts	June 9, 2016	24,000	10,310	Loan was cleared	No
Clinic #7	Murang'a	6	Solar	No	Vendors #1 and #2	259,978	500 Watts	October 10, 2016	25,000	12,427	Loan went into default; equip-ment was removed	Yes
Clinic #8	Nairobi	6	Solar	Yes	Vendor #1	289,883	500 Watts	July 28, 2016	29,000	12,526	Payment was on schedule	Yes
Clinic #9	Vihiga	6	Solar	Yes	Vendor #1	342,019	585 Watts	April 28, 2016	100,000	11,620	Loan went into default	Yes
Clinic #10	Nairobi	8	Battery backup	Yes	Vendor #1	381,770	8 12 V-500 Ah battery system	N/A	38,200	16,497	In arrears	Yes
Clinic #11	Nairobi	8	Solar	Yes	Vendor #1	453,758	1,170 Watts	December 15, 2016	46,000	19,386	Payment was on schedule	No
Clinic #12	Nairobi	10	Solar	Yes	Vendor #2	503,323	6,000 Watts	May 18, 2016	51,000	21,728	Loan was cleared	Yes
Clinic #13	Nairobi	20	Solar	No	Vendor #1	611,977	1,920 Watts	October 26, 2017	100,000	26,983	In arrears	Yes

Source: PS Kenya

Business impacts

Key Takeaway: Understanding how the technologies could be of help to the business was a differentiator between the success and problem cases. An intervention with an electricity system that is well integrated into business strategies is more likely to succeed.

The actual business impacts of the investment drove the end user's capacity and willingness to continue servicing the loan. When the systems functioned properly, all 13 clinics in our interviews experienced savings from eliminating fossil fuel spending or lowered electricity bills or both. However, four clinics reported negative net impacts on their bottom lines. If money saved in energy bills was not enough to completely offset the financial cost of loans as well as the monthly installment to cover the capital cost, the intervention could not attain the goals of improving business and capacities for service delivery.

We found the following common experiences among the clinics that experienced positive business impacts:

- **Choosing the right type of appliances to power:** The procured systems were used to power appliances to support these clinics' core services; for instance, vaccinations, lab services, or medical procedures. Though some of these areas may have small margins, the clinics were able to boost the volume of service to such an extent that they could significantly ramp up profit (Box 1). Many clinics, however, only considered providing backup power for lighting, mobile phone charging, even TVs, without intentionally taking advantage of the linkages between extra energy resources and business strategies. Most of these clinics could save backup fuel and sustain the business during grid blackouts; however, they were unable to use the procured systems to grow business and eventually provide better services.

- **Keeping good business records:** These clinics kept good financial and patient records in each service area. As a result, they planned and managed business effectively. In addition, helped by business advisers, clinics also benefited from the procured systems by digitizing records, thus better managing business information. On the other hand, 3 of the 13 clinics in our study were unable to maintain a record-keeping process. They ended up running into difficulty as they often lost track of the cash flow, failed to explain the ups and downs of the business, and, after installation of the system, encountered big challenges in managing the economics of the investments. Only when they discovered that they had no cash to service the loans did the three clinics realize that they could no longer ensure the financial viability of their investment.

- **Using extra energy resources to expand service areas:** These clinics knew where they wanted to expand service areas and how the procured systems could help with the growth. Clinics stayed focused on their core businesses and developed plans to provide more related services to better meet the community's needs. They leveraged the procured energy for greater benefits, such as powering ultrasound equipment for their existing pre-natal services or planning to upgrade the systems to power an entire mother-baby unit for their infant delivery services (Box 2). Using the procured systems as the starting point to climb up the energy ladder revealed some clinic owners' incredible capacity to think hard about the value proposition of their investments. Even though very few clinics had such aptitude, the ones that did provided powerful examples of how to streamline the investment decision-making and business planning.

All the clinics that were able to integrate energy solutions into their business strategies were enrolled in PS Kenya's business advisory program. The program prepared them with more advanced business skills to manage the business and plan for growth. When the additional electricity systems were procured, it was easier for these better prepared clinics to understand how to follow the demand to more effectively use the systems.

Box 1 | A Small Clinic Procured a Battery Backup System and Boosted Profits

Clinic #1 is a micro-sized, two-room clinic located in an urban slum. Apart from other medical services, it handles a high volume of immunizations, earning the clinic a marginal profit of US$1 per vaccine. The clinic procured a battery backup system to ensure continuous refrigeration and preserve vaccine quality. Once the system was set up, the clinic continued providing quality vaccines even when grid power was out. The backup system also provided continuity for more basic medical services, such as lab analysis, simple consultation and examination, and small operations. In an area with an average income of $50 per month (estimate provided by PS Kenya staff), the clinic owner earned a $1,500 monthly income (estimate provided by the clinic owner)—a nearly threefold increase after the installation.

Box 2 | **Two Clinics Expanded Their Core Businesses**

After Clinic #6 cleared the loan from PS Kenya for solar procurement, the clinic owner managed to secure additional loans from Kenya Commercial Bank to construct a new delivery room and a mother-baby unit with accessibility, a nursing station, hot water, a heater, and many other facilities. Recognizing that the electricity system had benefited her customers and business, the owner was going to scale up solar installation for her new, more power-intensive appliances such as the heater and water boiler in the new delivery room.

After a solar power system was installed in Clinic #5, the owner procured ultrasound devices to enhance service quality. While these devices are not yet connected to the current solar equipment, the clinician planned to connect them in the near future once system capacity has been increased.

PS Kenya's business advisory program did not focus on the new electricity systems specifically but provided advice to the clinics and effectively helped them improve the business impacts of the systems. The advisory services helped empower clinics to run more financially sustainable businesses. For the energy interventions alone, the program provided a number of specific services, including the following:

- Business advice based on the digitized financial record that clinics were able to keep and maintain thanks to more reliable electricity.
- Electricity use monitoring to inform adjustment of the loan repayment plans.
- Assistance to clinics in the national insurance network or other private networks, enabling them to collect stable payments and to serve more patients.

PS Kenya's business advisory program was an important driver in shaping the business strategies of the clinics, providing critical complementary services that directly contributed to the intervention outcomes. Providing similar support programs is a strategy worth emulating for many other organizations that seek to maximize the impacts for electricity users.

Readiness for finance

Key Takeaway: Understanding the clinic's readiness for finance boosted the chance of success in terms of loan repayment. Providing capacity building for the end users to improve management skills can help implement business strategies more effectively.

PS Kenya, unlike commercial lenders, has to consider many factors when choosing candidates to receive loans. Instead of ignoring loan requests from low-performing clinics, it supports these clinics by prioritizing their applications. Creditworthiness was only one consideration in PS Kenya's loan decisions. As a result, clinics that historically underperformed financially still received loans to support their business development and their interest in trying alternative technical options for electricity. However, as Table 1 reported, there was a strong overlap between a clinic's loan repayment history and its performance in this project. Only two clinics with a record of defaults succeeded in maintaining repayments on schedule, and, as of 2018, all the clinics that did not honor the repayment commitment had defaulted on loans at least once in the past.

Despite getting the loans, the clinics that lacked adequate management skills could not build this capacity overnight. They still struggled with their businesses and were unable to maintain a healthy cash flow. Typically, clinics of this kind did not receive business advisory services due to remoteness and PS Kenya's limited human resources. But if business support had been available, even before the loan was made, it could have boosted the likelihood of repayment, hence the financial viability of the investment. On the other hand, there were clinics that ran viable businesses with well-functioning electricity systems but failed to honor the repayment schedule simply because they would "forget" or "think they could pay several installments altogether later," according to the clinic owners. Awareness building and automated payments might encourage more effective financial management and repayment, eventually contributing to project success. Some of these strategies should even be built into the extended advisory services in the future.

Through 2018, all the clinics were covered by the product warranty, so none needed additional financial resources to support O&M needs. However, this could become an issue after the equipment warranty expires, especially for the clinics experiencing difficulty repaying their loans.

Technology design

Key Takeaway: The electricity system's suitability was the technical condition of the intervention's success for the clinics. Understanding the local energy resources, the physical condition of the user sites, and electricity demand is necessary to design systems that are fit for purpose.

Some participating clinics did not have any electricity backup during grid power outages, and the rest depended on traditional backup systems, such as kerosene lamps or diesel generator sets. All 13 clinics in the study are located in counties where global horizontal irradiance levels are above 1,900 kWh/m^2, creating abundant opportunities to install solar equipment (Appendix B). As far as the conditions for solar installation are concerned, two clinics (Clinics #1 and #10) were renting lower levels in buildings without access to rooftops. As a result, they chose the power backup system that allows battery charging while grid power is available. During grid power outages, they were still able to keep key appliances in the clinics running to ensure business continuity. All the other clinics had unshaded rooftop space that enabled the implementation of the solar option.

System designs were coordinated by PS Kenya and implemented by the vendors. Vendors undertook system sizing processes that involved initial site visits, proposal development and modifications, and plan finalization. The major uses of electricity in participating clinics include lighting, cell phone charging, vaccine refrigeration, lab equipment operation, powering appliances for maternity services, and so forth. These needs were communicated to the vendors before solutions were proposed and discussed repeatedly to fit the budget. Whether the clinics chose the most relevant appliances to power depended on their awareness of the value proposition to their business. As mentioned in a previous section, significant variations existed as to such awareness. Facilitated by PS Kenya, the vendors provided system sizing service and information about the associated capital costs.

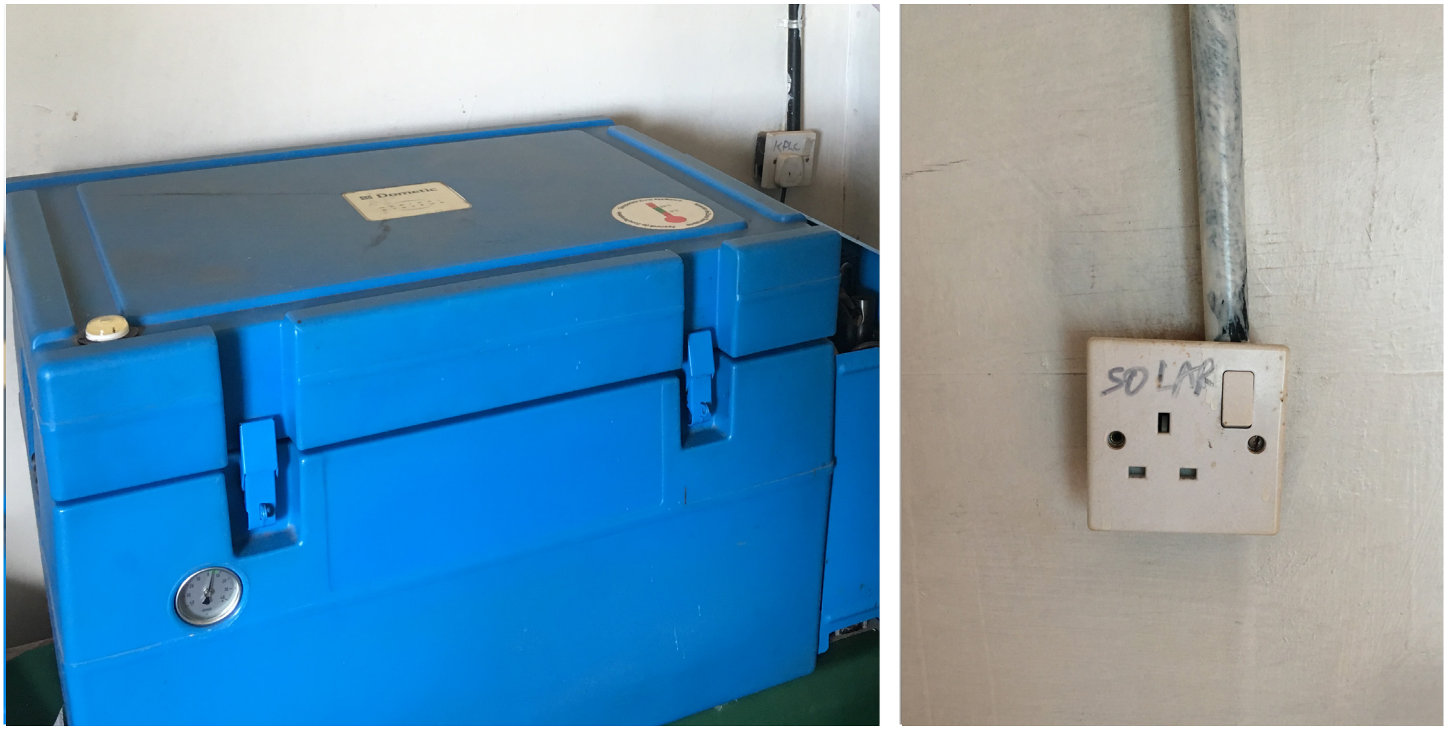
After several rounds of discussions with the vendors, clinics could usually find a balance between budget and system size. For most of the clinics, the systems were properly sized. But there were cases where a thorough understanding of the electricity demand was lacking, which caused the system to fail (Box 3). As part of the PS Kenya process, vendors provided the clinics guidelines regarding what could safely be connected to the systems based on the decisions of system sizing. Clinics were then advised to connect only assigned appliances to the appropriate power outlets. Figure 2 shows how one clinic followed the recommendations. According to the system design, in this particular case, the vaccine refrigerator was recommended to be connected to the national grid (i.e., Kenya Power and Lighting Company, KPLC). The power outlets, shown in the picture, were clearly marked to ensure the appropriate connections. Even though this kind of clear marking was not common practice, most clinics were able to respect the capacity of the systems and follow the guidelines. However, some clinics did not adhere to the guidelines. They ended up burdening the system with greater demand than the system sizers (i.e., the vendors) were aware of before the installation, causing the system to fail (Box 3).

Box 3 | **Overload at Clinic #7**

When vendor guidelines were not followed, the systems could not be sustainably operated, which led to failure. Clinic #7 is an example of such an outcome. The clinic realized that the system size agreed on with the vendor was unsatisfactory. In order to meet extra electricity demands, the clinic kept plugging in more appliances than recommended, despite being advised not to several times. The overloaded system repeatedly stopped working. The clinic decided to opt out of the project and asked PS Kenya to remove the system.

Presumably, demand growth may also lead to overloading the system. We have not seen this among the clinics we interviewed, but if the current systems prove to be a success and the clinics' electricity demands grow as a result of business development, a system that can easily be upgraded would better serve the end users. Some failures can be avoided in the future if flexibility can be built to allow for system upgrading and meeting growing needs.

Figure 2 | **Connecting to Solar Power or the Grid—Adhere to the Vendor's Recommendation**



Source: Authors of this study.

O&M service

Key Takeaway: The O&M model adopted by the energy project was not universally beneficial. Helping end users understand strengths and drawbacks of any O&M model helps improve the chance of success.

The project had a unique O&M model. Within the warranty period, when customer support was needed clinics reached out to PS Kenya for help. PS Kenya then sent the O&M requests to the vendors.

Usually, minor technical troubleshooting could be done quickly over the phone. But some clinics experienced long delays, waiting for several months to a year for O&M support. This delay was sometimes caused by poor management of machinery parts if the parts needed to be replaced and if they had to be imported from manufacturers abroad. But the O&M model was a more relevant cause. Because the clinics' first point of contact was PS Kenya, they did not have a direct relationship with the vendors, let alone vendors' local branches. Their O&M requests were always submitted to the vendor's headquarters in Nairobi, and technicians were then sent from Nairobi to the clinic that is sometimes remotely located. This model was consistently followed to manage O&M services even though in one case a local branch was under an hour away from the clinic.

This O&M model, however, worked well in some cases. It sought to make the process easier for several micro-sized clinics that sometimes felt intimidated when left alone to handle communication with the corporate vendors. But the drawback of the model was obvious, leaving most of the clinics without sufficient support: it complicated the overall communication chain and reduced efficiency for most of the clinics. From what we learned, the model created some long-lasting negative impacts. Clinics went back to business as usual while waiting for the communication to take place. They again relied on grid power supplemented by fossil fuel–based backups during blackouts. If problems persisted for months—as was the

Box 4 | **The Impact of Technical Problems on Business Management at Clinic #9**

Clinic #9 experienced multiple technical challenges with its solar equipment. Only two months after it was installed, lightning hit one of the three solar panels. The issue was not completely resolved before the inverter went down. In early 2017, while the clinic owner was waiting for the system to be restored, there was a nationwide strike across public hospitals, which created more demand for services from private clinics. As they had continuous power, some of the clinics nearby that provided similar services—for instance, maternity and infant care—saw a big increase in their business (e.g., Clinic #6). Some experienced a four- to fivefold increase in their infant deliveries. With a faulty system, however, Clinic #9 was not able to respond to the demand spike and missed an opportunity for growth.

case for two clinics—their operations were significantly impacted. Business hours were reduced, fewer patients were served, and growth opportunities were missed (Box 4).

This frustration can be avoided by setting up direct, real-time communication between the vendor's local branches and the clinics. The micro-sized clinics' needs in terms of extra communication support can be met individually and separately. Fine-tuning the O&M models, however, requires a user-oriented assessment of how different ways to support O&M services can impact the interventions. Understanding how O&M can influence the usage of the electricity systems is as important as gathering information about and understanding other factors laid out previously.

DISCUSSION

This analysis of the PS Kenya case study, following the factor mapping (Figure 1), enabled us to draw comparisons among the clinics that participated in the energy project. Taking loan repayment as the entry point, the case study highlighted the importance of a demand-based approach. We found that it is crucial to understand the characteristics of the end users, the products and the services, as well as the end users' multifaceted needs before designing the interventions. We studied 13 cases, 6 of which were successful and 7 of which had problems repaying their loans.

We found that PS Kenya's energy intervention could only succeed when all the following conditions, which speak to the four factors of success uncovered through the case study, were met:

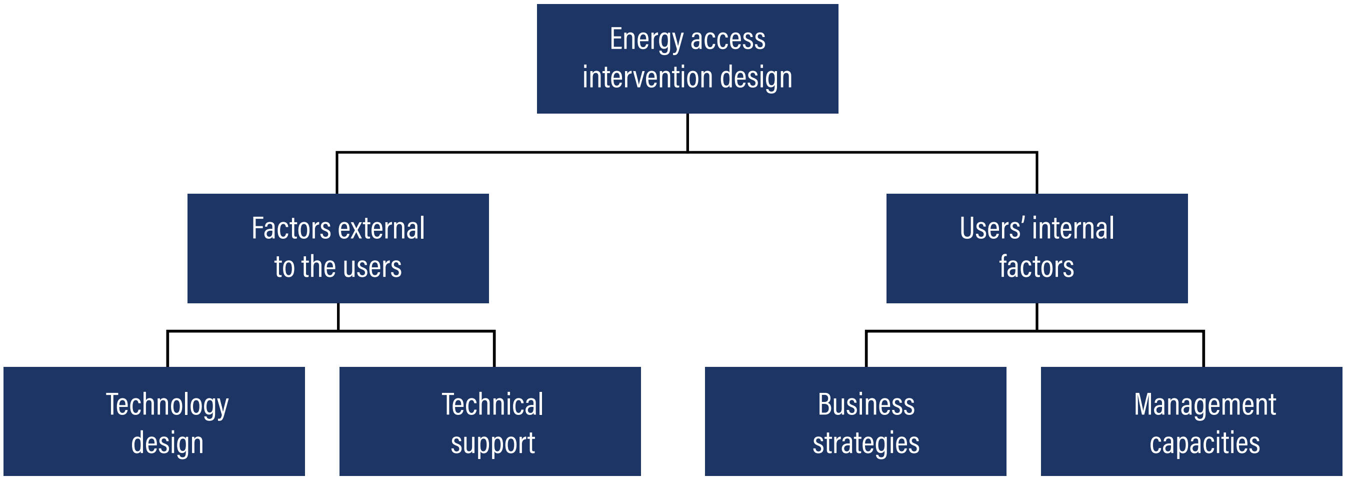
- Systems needed to be designed for purpose and properly sized in order to meet the demand.
- O&M support needed to be timely and adequate in order to sustain regular uses.
- Systems needed to be integrated into the clinics' business strategies and help with business growth in order to maximize the benefits.
- Clinics needed to be ready to receive loans, willing to service the loans, and have enough capacity to manage finance.

We extrapolated the four factors to develop a strategic assessment framework to guide the demand-based decision-making on energy access interventions (Figure 3). The strategic assessment framework aims to assist the intervention design from a user's perspective in the broad context of energy access. Though this case study has focused on the impacts of an energy access project targeting health clinics, the framework developed can be adapted to guide planning in other private sector businesses and for planners and funders as they invest in end users' energy security.

The following four questions are generalized from the case study:

- **Technology Design:** Does the investment target the right technical solutions? (E.g., does the location have sufficient solar irradiance and orientation to install solar equipment? Does the system sizing meet the needs and allow any degree of flexibility to accommodate future needs?)
- **Technical Support:** Is the investment supported by qualified technology providers who can ensure the quality of the systems and proper O&M services?
- **Business Strategies:** Are the technical solutions going to be integrated into the users' business strategies? Is the use case situated in a favorable ecosystem where integration of the technology can help achieve end users' strategy goals?

Figure 3 | **Strategic Assessment Framework for Energy Access Intervention Design**



Source: Authors of this study.

- **Management Capacities:** Do the end users have sufficient capability to manage the finance, including additional financial commitment such as financing the O&M support?

Answering the four questions is critical to understanding the potential benefits and risks of the investment. Stakeholders can then have information to design the intervention properly, including the complementary services needed to fill the capacity gaps, helping maximize the benefits and control the risks.

As the framework considers both internal and external factors that lead to project outcomes from the user's perspective, it enables a bottom-up needs assessment that identifies both electricity needs—as an integrated part of the overall business strategy—and non-energy needs. Table 3 provides an example of what specifically should be known prior to the interventions. This detailed information sheet will prepare information gathering so that the four questions can be answered in depth to assist with the intervention design.

Overall, we recommend two related issues be considered when stakeholders design the intervention: first, what technology to choose? This is a technical assessment. Depending on the estimation of critical load, how much of the current load should and can be replaced, and by what means? Second, stakeholders should understand the costs and benefits of the investment. This is a strategic assessment, depending on not only the costs and benefits when the investment is made but also how costs and benefits may change once reliable electricity is adopted. If reliable energy supply allows businesses to grow, their energy demand will increase as well.

If the assessment has to be done by the end users themselves, some of them may not have the capacity to consider all these issues. They will probably need help from dedicated advisory services to navigate the technology choices as well as the new strategies. Generally, a business adviser can help end users understand the financial benefits of a properly sized electrification solution. But, more specifically, advice can include how to grow financial management capacities, to direct energy to support key business areas, and to maximize energy savings.

The strategic assessment framework is developed specifically around the economic impacts of electricity access for end users. It identifies the factors and key interventions that contribute to achieving economic benefits for users. Gauging the size of energy demands by focusing on the end users' needs involves broader assessments than the supply-driven approach, which typically starts with technical needs and solutions. Even though the demand-based approach also tries to understand the users' technical needs, these needs are considered as just part of the planning and are complemented by mapping the financial, business (including personnel, knowledge, skills, and business models), and policy needs wherever applicable. All of these elements come together to maximize the impacts of

Table 2 | **Information Sheet for the Strategic Assessment**

FACTORS TO CONSIDER	KEY QUESTIONS TO ASK	DETAILED INFORMATION TO COLLECT	SOURCES OF INFORMATION
Business Strategies	1. How can the technology solution be integrated into the user's existing (evolving) business model to improve user's business performance?	User's current business strategy and balance sheet Areas where the demanded electricity/backups would contribute, aiming for maximum benefits for end user Projected benefits of the demanded electricity/backups Total electricity budget Current electricity cost and performance, including power quality and reliability Projected changes of the designed electricity/backup system on the bottom lines, considering the extra capital costs, financial costs, and business benefits Risks to the business and other complementary services needed to maximize the business impacts	User, project manager
Management Capacities	2. Does the user have sufficient capability to manage the technical solutions as well as the additional financial burden, including financing O&M support?	Needs and resources requirement for boosting financial readiness; that is, credit worthiness when granting loan access Loan repayment awareness building Repayment collection mechanism Warranty period and projection of resource requirement for future O&M needs	User, project manager
Technology Design	3. Does the investment target the right technical solutions?	Availability of natural resources Technology and energy policies Space and building conditions for installation Critical loads according to current demand needs Possible needs growth in a foreseeable future, including the possible deployment of efficient appliances Room to allow technical improvement and design flexibility in terms of system capacity, with or without budget constraints	External technical sources, vendors, user
Technical Support	4. Is the investment supported by qualified technology providers who can ensure the quality of the solution and proper O&M services?	Responsible parties for efficient O&M support Travel distance of the responsible O&M technicians Vendors' track record or strategies for parts management Expected resolution in the event of delayed O&M problem solving	Vendor, project manager

Source: Authors of this study.

the intervention for the users. The demand-based approach can thus benefit both the users when they make their purchase decisions, and funders, including development aid agencies, philanthropies, and public sector officials, as an instrumental part of strategic planning.

A strategic assessment that uses the framework discussed above also supports project implementation by enabling the identification of the gaps for project success. It helps plan project activities needed to fill these gaps. Thorough understanding of the end users' needs can facilitate project-level planning around interventions, whether it is about capacity building to enhance financial readiness or business advisories to boost viability of the energy investments. Implications on both project finance and strategies can be derived to support the overall project implementations.

It is worth noting that the framework and its implementation are currently relevant only at the project level. The magnitude of data required and the degree to which the framework needs to be customized to fit in various contexts may limit its applicability for policy discussions at the sectoral and jurisdictional levels. To facilitate policy decisions, more works need to be in place to scale out the assessment tools and test their viability in broader policy contexts, including the broader enabling environment and the general investment climate.

APPENDIX A: INTERVIEW QUESTIONS

A. Management of this loan (with clinic)

1. Who identified the need for solar power and who decided that there is the need for a loan?
2. What was the purpose of the loan? (This is to understand if at this stage there was some level of miscalculation based on wrong estimations of revenue increases due to capital investment/loans, which may mean wrong planning or improper planning.)
3. How did the repayment work?
4. Who is managing the repayment and following what process?
5. At what stage of the process did repayment fall short (for clinics late in repayment)?

B. The purpose of energy procurement (with clinic)

1. With which service area does solar help? (This elaborates on Question A2.)
2. How were these service areas powered during blackouts before the clinic was solarized?
3. What was the change in the number of hours of service before and after solarization?
4. Was any new equipment procured as planned or was a new room built as planned? (This is to understand if at this stage the procured solar system was doing its job as expected, corresponding to Question A2.)
5. Depending on answers to Question B1, ask about examples of changes in service areas.
6. Depending on answers to Questions C2a and C2b, ask about examples of changes in patient number in total and, if possible, by service area.
7. Depending on answers to Questions C3 and C4, probe on the changes in revenue and ask if it is as expected. Confirm "how" and "why." If relevant, touch upon the other non-medical revenue streams.

C. Revenue streams (with PS Kenya and clinic)

1. What services did/does the clinic provide before and after being solarized?
2. What was the change in the number of patients served, if possible, in each service area?
3. Average number of patients served before and after solarization
4. Number of patients that the clinic currently serves
5. Segmentation of the patients by demographics and income level, if possible
6. How much revenue came from medical services?
7. What are the sources of other revenue?

D. Change in energy cost (with clinic)

1. What was the energy bill before and after solarization?
2. Itemized bills, probing on value (e.g., unit cost of diesel) and delta value of costs for each energy type. Ask "why"—for example, if the cost of diesel increases does the disruption of solar increase the diesel cost since more equipment is being operated?

E. Non-energy inputs and costs (with clinic)

1. Itemize non-energy inputs.
2. What were the changes in non-energy inputs and costs before and after solarization?
3. Depending on answers to C1 and C2, understand if non-energy inputs bottlenecked business growth.

F. Function of the electricity system (with clinic and vendor)

1. General satisfaction with the product. (with clinic)
2. How many times has the system been down since installation? (with clinic)
3. What to do during downtimes, and implications on revenue and cost if not touched upon so far? (with clinic)
4. Should any discretion be involved when using the product? Any training done for users? (with vendor)

G. Responsibility for tech support (with both vendors and clinics)

1. Who is supposed to provide technical support when equipment is reported down?
2. Who currently provides support?

H. Lead time and ease of fixing problems (with both vendors and clinics)

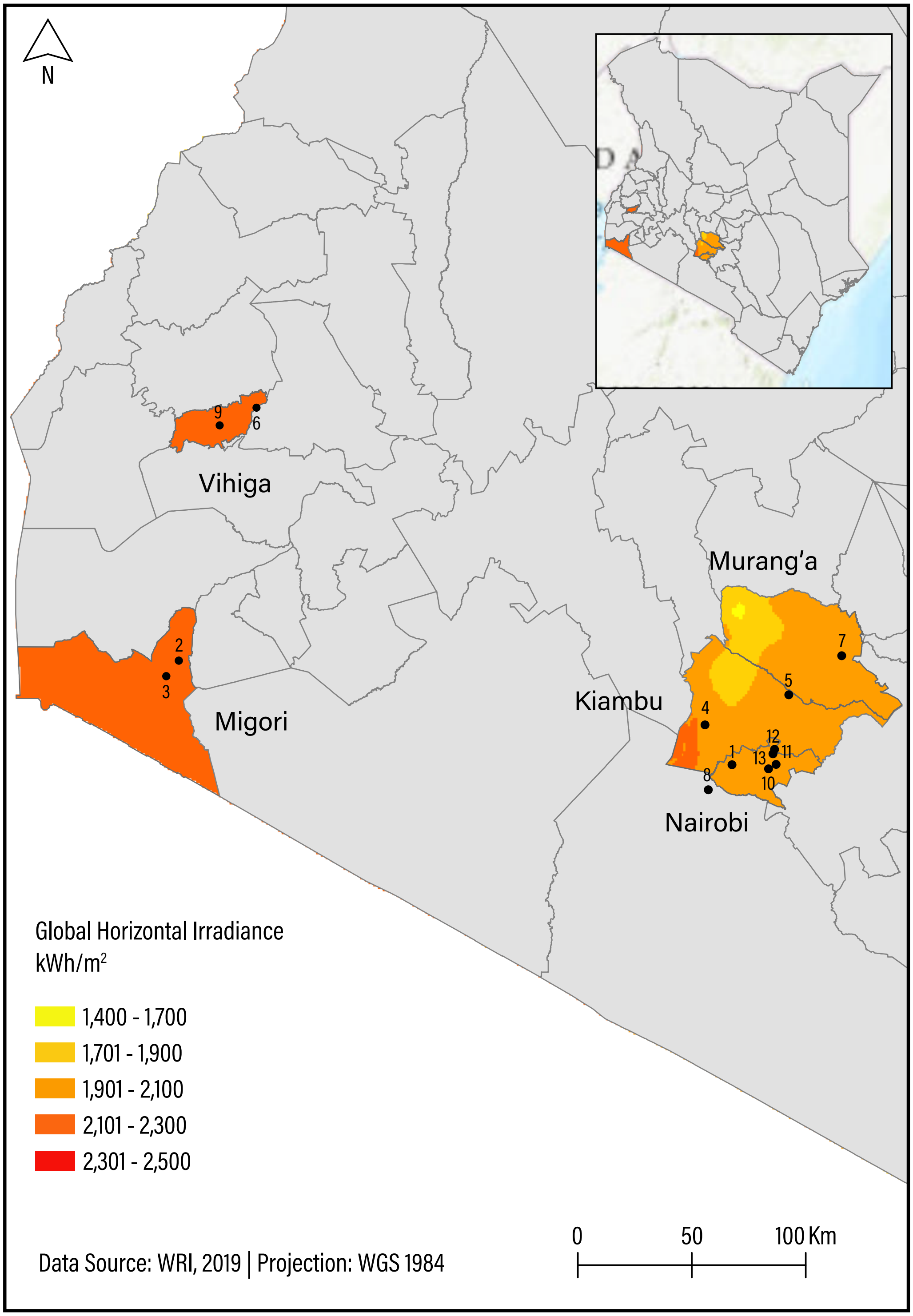
1. How easy was reporting problems?
2. How long did it take to order maintenance support? ("Why" question for vendors)
3. How long did it take for problems to be fixed?
4. I. Quality of O&M services—with both vendors and clinics
5. Clinic's satisfaction with quality. What are typical issues during the tech support process?
6. For the clinics that had problems with loan repayment and complained about O&M support—if O&M services had been timelier, what would you have done differently in terms of the repayment? (Discuss with PS Kenya to see if this is a sensitive question to ask.)

J. Abundance of solar resources (with PS Kenya and clinics)

1. What is the abundance of solar resources? (Time of sunshine, seasonal changes)

APPENDIX B: LOCATION OF SAMPLED CLINICS

Locations of Tunza Network Clinics in Kenya



Note: Solar irradiance is the power per unit area (kilowatt hour per square meter, kWh/m^2) received from the sun in the form of electromagnetic radiation.
Source: Global horizontal irradiance level data are from Global Solar Atlas. 2018. Retrieved from http://globalsolaratlas.info/. Accessed through Energy Access Explorer, World Resources Institute, 2019.

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